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Detailed Morphology of the Incisive or Nasopalatine Canal

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Abstract: (1) Background: The nasopalatine canal (NPC), or the incisive canal (IC) of maxilla, unites the anterior nasal floor with the anterior palatine region. Different morphological variables of the NPC were investigated, indicating it is either anatomically variable or constant. It was therefore decided to perform an additional study of the NPC. (2) Methods: A retrospective cone beam computed tomography (CBCT) study was performed on 89 patient files: 38 males and 51 females. The study documented the presence or absence of a well-defined NPC, the number of openings, and the anatomic variables of the canal (number, course, and secondary canaliculi). (3) Results: the NPC/IC in the coronal plane was classified into five types: (I) NPC present with two superior, nasopalatine foramina (NPFs) (66.29%); (II) NPC absent with two NPFs (2.25%); (III) NPC present and single NPF (17.98%); (IV) NPC present with three NPFs (3.37%); (V) both absent NPC and NPF (10.11%). (4) Conclusions: The anatomical possibilities of the NPC are numerous and diverse; they include the absence of the canal. Therefore, a standardized description of this canal could not be assumed and a radiological assessment is recommended before surgical treatment in the premaxilla area.

Keywords: maxilla; cone beam computed tomography; hard palate; incisive canal; anatomic variation

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1. Introduction

The nasopalatine canal (NPC), or the incisive canal (IC) of maxilla, unites the anterior nasal floor with the anterior palatine region. It is commonly described as consisting of two upper canals (proper NPCs/ICs) that join inferiorly to form the common NPC/IC opening at the incisive foramen (IF) of the hard palate [1]. This results in a "Y" morphology of the canal. The two proper NPCs/ICs are separated by the nasomaxillary, or septo-premaxillary crest [2]. It is commonly assumed that the NPC is traversed by the nasopalatine nerves and arteries. However, histologically, the NPC content is represented by numerous small veins, arteries, and nerve bundles [3].

While the inferior opening of the NPC/IC is indicated as the incisive foramen, the superior openings of that canal are not named in *Terminologia Anatomica* and may be suitably regarded as nasopalatine foramina [4].

Song et al., (2009) invariably found two superior foramina (nasopalatine foramina) and one inferior foramen (incisive foramen) of the NPC/IC while studying 56 anterior maxillae in computed tomography (CT) [3]. We were intrigued by such constant morphology. Abrams et al., (1963) discussed that although the location of the NPCs/ICs is quite constant, their anatomy is not [5]. The large spectrum of anatomical variations of the NPC was confirmed by later studies [6]. Anatomical variations of the NPC remain poorly documented [7].

The topography and morphology of the NPC may impact surgical treatment planning, be it implant restorative treatment, congenital defects repair (cleft palate, congenital syndromes like Down syndrome or cleidocranial dysplasia), traumatic lesions repair, or in orthodontic purpose (orthognathic treatment, palate expanding).

It was therefore decided to perform a cone beam CT (CBCT) retrospective study to check whether or not the morphology of the NPC/IC is constant or variable.

2. Materials and Methods

A retrospective CBCT study on 89 patient files was performed (38 males, 42.69% and 51 females, 57.3%). The patients were all adults who had undergone different dental procedures that required a maxillary CBCT analysis. None of the patients presented maxillary pathological morphology signs (no trauma, congenital defects, or tumor-like lesions) and all the CBCT scans were accurate without signs of distortion.

The subjects were positioned according to the manufacturer instructions and had been scanned using an iCat CBCT machine (Imaging Sciences International (Hatfield, PA, USA)) with the settings at resolution 0.250 pixels/inch, field of view 130 mm, and image matrix size 640 × 640 pixels. The CT data were analyzed using the iCatVision software. The CBCT files were exported as DICOM files, which were additionally analyzed with the Planmeca Romexis Viewer 3.5.0.R software as in other previous studies [8–10]. The two-dimensional multiplanar reconstructions (MPRs) were evaluated in sagittal and axial anatomical planes; coronal slices through the NPCs were used to determine the morphological variables that were aimed. Three-dimensional volume renderings of specific areas were also evaluated. Relevant anatomical features were exported as image files (*.tif).

The patients have given written informed consent for all radiological data to be used for research and teaching purposes, provided the protection of the identity and personal data is maintained. The study was approved (no. 456/04.05.2021) by the responsible authorities (2nd affiliation of the 2nd author).

During the study, the following variables were assessed: (a) the presence or absence of a well-defined NPC/IC; (b) the number of the nasopalatine foramina (NPFs); (c) the number of incisive foramina; (d) the variables of the proper (superior) NPCs/ICs: number, course, parallel or convergent, and intrinsic septa determining secondary canaliculi.

The NPC/IC was classified into 5 different types according to the morphological findings: (I) NPC present with 2 NPFs; (II) NPC absent with 2 NPFs; (III) NPC present with single NPF; (IV) NPC present with 3 NPFs; (V) both absent NPC and NPF.

Subtypes of the NPC/IC classification are presented in Table 1.

Table 1. Characteristics and numbering of the types and subtypes of the nasopalatine/incisive canal.

Type of the NPC/IC	Characteristics of Types	Subtypes	Characteristics of Subtypes
I	NPC/IC present, 2 nasopalatine foramina	Ia	"Y"-shaped NPC/IC, with no secondary canaliculi
		Ib	"Y"-shaped NPC/IC, with secondary canaliculi separated by a sagittal septum
		Ic	"Y"-shaped NPC/IC, with unilateral secondary canaliculi separated by a coronal septum
		Id	"Y"-shaped NPC/IC, with bilateral secondary canaliculi separated by a coronal septum
		Ie	"Y"-shaped NPC/IC, with an added superiorly blind-ended median canal
		If	parallel proper NPCs/ICs separated by septum
		Ig	parallel proper NPCs/ICs unseparated by septum (NPC/IC unique, two nasopalatine foramina)
II	NPC/IC absent, 2 nasopalatine foramina		
III	NPC/IC unique, 1 nasopalatine foramen	IIIa	unique median nasopalatine foramen, inferior to the nasomaxillary crest
		IIIb	unique median nasopalatine foramen, on one side of the nasomaxillary crest
IV	NPC/IC present, 3 nasopalatine foramina, 1 median and 2 lateral		
V	NPC/IC proper absent, absent nasopalatine foramina		

3. Results

Within the study, all types of NPC/IC were found in variable proportions. The incisive foramen was invariably unique in all cases that presented an NPC.

Within the 89 cases that were investigated, Type I of NPC was found in 59 cases (66.29%), Type II in 2 cases (2.25%), Type III in 16 cases (17.98%), Type IV in 3 cases (3.37%), and Type V in 9 cases (10.11%).

In the male lot, the NPC/IC distribution was as follows: Type I in 26 cases (68.42%), Type II in 2 cases (5.26%), Type III in 8 cases (21.05%), and Type V in 2 cases (5.26%). In the female lot, there were no Type II NPC/IC cases found and the other variants were as follows: Type I in 33 cases (64.71%), Type III in 8 cases (15.69%), Type IV in 3 cases (5.88%), and Type V in 7 cases (13.73%).

Type I of NPC/IC had various morphologies (Table 1). In the general lot of 89 cases, we found Subtypes Ia (Figure 1A) in 17 cases (28.81%), Ib (Figure 1B) in 2 cases (3.39%), Ic (Figure 1C) in 7 cases (11.86%), Id (Figure 2) in 1 case (1.69%), Ie (Figure 3A) in 1 case (1.69%), If (Figure 3B) in 19 cases (32.2%), and Ig (Figure 3C) in 12 cases (20.34%). In males, Subtypes I were found as follows: Ia in 10 cases (38.46%), Ib and Ie in one case (3.85%) each, Ic in 5 cases (19.23%), If in 7 cases (26.92%), and Ig in 2 cases (7.69%). We found in females Subtypes: Ia in 7 cases (21.21%), Ib and Id in one case (3.03%) each, Ic in 2 cases (6.06%), If in 12 cases (36.36%), and Ig in 10 cases (30.3%).

In 2 out of 89 cases, both male, Type II (Figure 4) of NPC/IC was found.

Type III of NPC/IC was also divided into Subtypes IIIa (Figure 5A), found in 10 out of the 16 Type III cases, and IIIb (Figure 5B), found in the remaining 6 cases. Seven males and three females presented Subtype IIIa, while Subtype IIIb was found in one male and five female patients. Type IV of NPC (Figure 5C) was found only in female patients. Type V NPC/IC—absent nasopalatine canal and NPFs (Figure 6)—was discovered in two male and seven female patients.

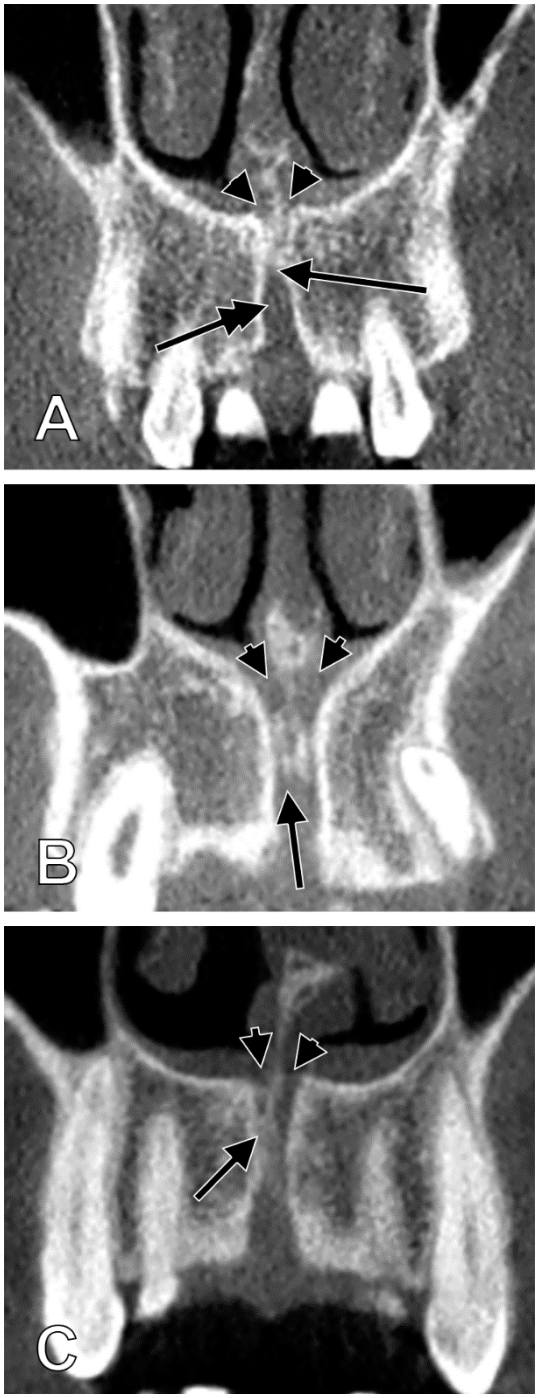

Figure 1. (**A**) Coronal CBCT slice through Type Ia of nasopalatine/incisive canal. The canal is "Y"-shaped, with two superior (nasopalatine) foramina (arrowheads) and one inferior incisive foramen (arrow). The incisive fossa is indicated (double-headed arrow). (**B**) Coronal oblique CTCB slice through Type Ib of nasopalatine/incisive canal. The canal is "Y"-shaped, with two superior (nasopalatine) foramina (arrowheads). A sagittal septum (arrow) separates two secondary canaliculi. (**C**) Coronal CBCT slice through Type Ic of nasopalatine/incisive canal. The canal is "Y"-shaped with two superior (nasopalatine) foramina (arrowheads). A coronal septum (arrow) is found in the right side.

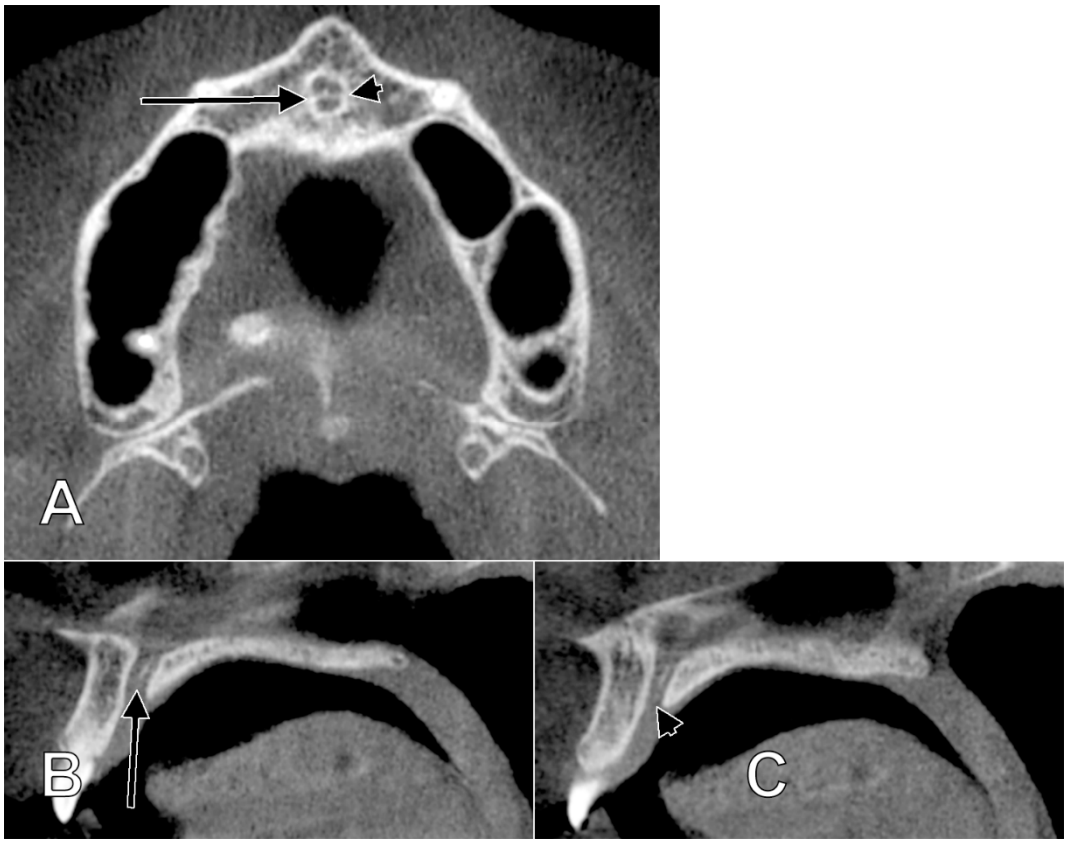

Figure 2. Axial (**A**), right paramedian (**B**), and left paramedian (**C**) CBCT slices through Type Id of nasopalatine/incisive canal. The canal is "Y"-shaped with bilateral secondary canaliculi separated by coronal septa, right (arrow) and left (arrowhead).

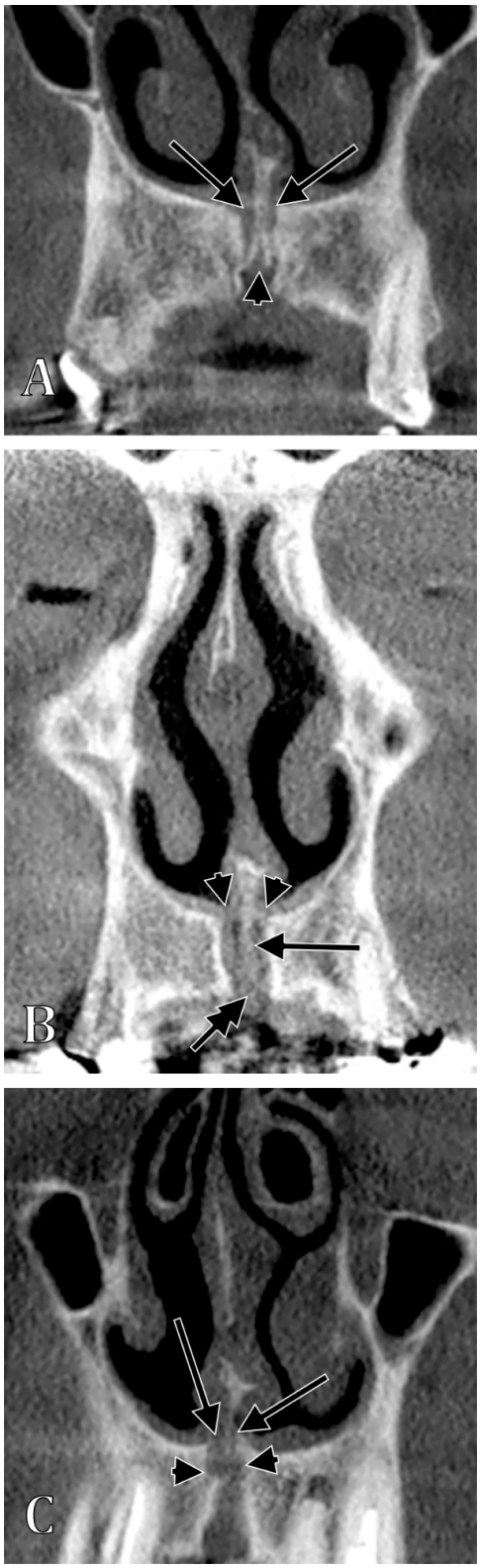

Figure 3. (**A**) Coronal CBCT slice through Type Ie of nasopalatine/incisive canal. The canal is "Y"-shaped with two superior (nasopalatine) foramina (arrows). A superiorly blind-ended median canal is added (arrowhead). (**B**) Coronal CBCT slice through Type If of nasopalatine/incisive canal. The canal has parallel proper NPCs/ICs (arrowheads) separated by a septum (arrow) that open info the incisive fossa (double-headed arrow). (**C**) Coronal CBCT slice through Type Ig of nasopalatine/incisive canal. The upper proper canals (arrowheads) are not separated by septum. Only the nasopalatine foramina (arrows) are separated between by the inferior end of the nasomaxillary (septo-premaxillary) crest.

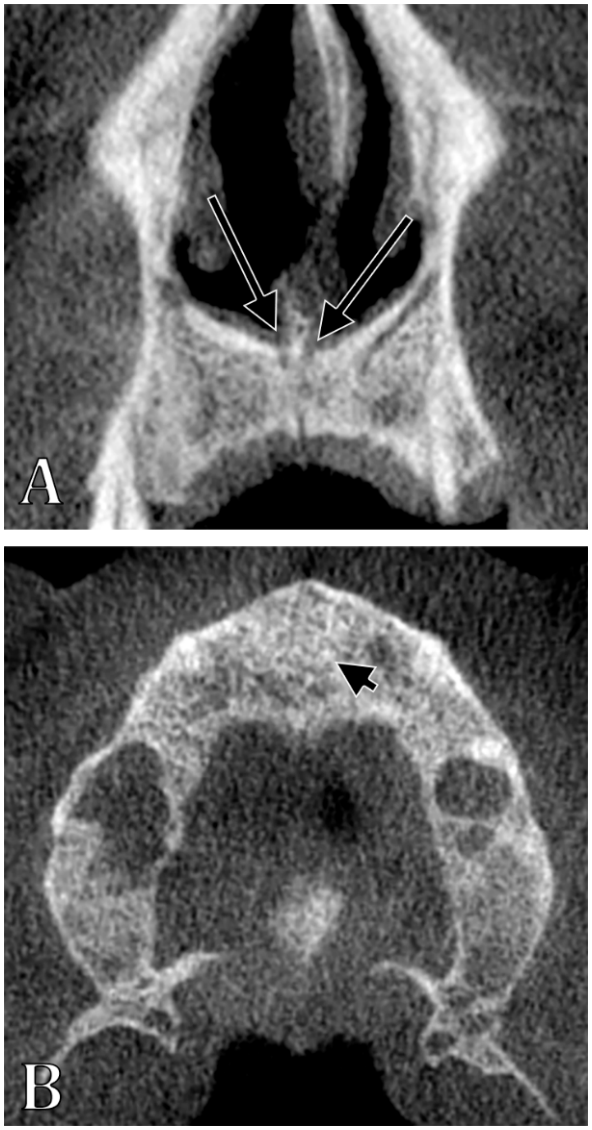

Figure 4. Coronal (**A**) and axial (**B**) CBCT slices through Type II of nasopalatine/incisive canal. Although the nasopalatine foramina can be distinguished ((**A**) arrows), a morphologically configured canal lacks ((**B**) arrowhead).

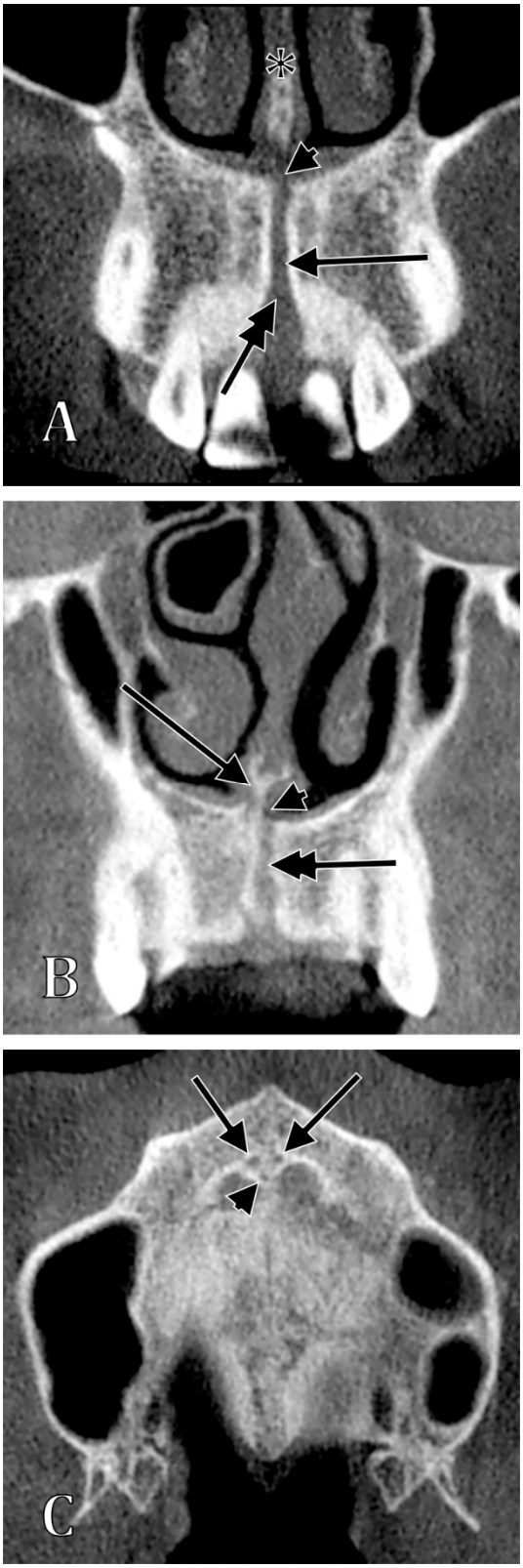

Figure 5. (**A**) Coronal CBCT slice through Type IIIa of unique nasopalatine/incisive canal (arrow) opened superiorly at the nasopalatine foramen (arrowhead) and inferiorly at the incisive foramen (double-headed arrow). (*): nasal septum (**B**) Coronal CBCT slice through Type IIIb of unique nasopalatine/incisive canal (double-headed arrow) opened superiorly at the nasopalatine foramen (arrowhead) located on the left side of the nasomaxillary crest (arrow). (**C**) Axial CBCT slice through Type IV of nasopalatine/incisive canal at the level of the nasal floor. There are three nasopalatine foramina, two lateral (arrows), and one median (arrowhead).

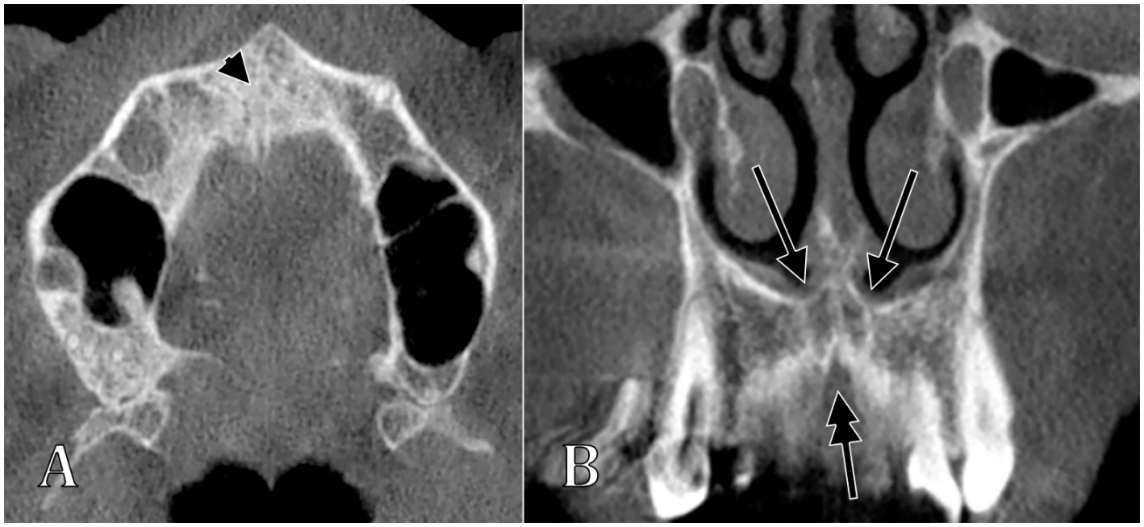

Figure 6. Axial (**A**) and coronal (**B**) CBCT slices through the hard palate in two different cases. Absent nasopalatine/incisive canal proper ((**A**) arrowhead) and nasopalatine foramina ((**B**) arrows) (Type V). The incisive fossa ((**B**) double-headed arrow) is anatomically blind superiorly.

4. Discussion

According to Radlanski, the literature describing the prenatal development of the NPC "is contradictory and partly even bizarre" [11]. This is because different authors indicate that the NPC courses at the border of the primary and secondary palate, which is erroneous [11]. The NPC is formed in the posterior part of the primary palate [12].

The edentulous anterior maxilla is a preferred site for complete maxillary rehabilitation by dental-implant surgery. Therefore, the amount of available bone, as well as the topography and morphology of the NPC, determine the personalized therapeutic plan. These variables are evaluated by CBCT. The resorption of the buccal alveolar plate in the anterior maxilla occurs after tooth extractions, local trauma, periodontal and periradicular pathology, as well as due to cysts or tumors [13]. Dental-implant rehabilitation of the anterior maxilla serves a double purpose: aesthetic and phonetic [14]. Insertion of implants in the vicinity of the NPC may jeopardize a successful procedure [7].

The NPC courses through the premaxilla, or the anterior maxilla. It is traversed by the nasopalatine nerves and arteries. Therefore, injuries to the nasopalatine nerve may result in hypoesthesia, paresthesia, or pain within the premaxilla area (palate buccal and nasal floor mucosa) and the superior frontal teeth [15]. Hemorrhage may result if the nasopalatine artery is damaged, which can lead to local hematoma and compression on the nasopalatine nerves [15]. Such unwanted events could occur during dental-implant rehabilitation of the anterior maxilla or other surgical interventions in the area.

Different previous studies evaluated the NPC by means of CBCT [13,14,16–25]. Some of these did not make the distinction between the proper and common NPCs [7], others did [25]. The authors determined different anatomical variables of the NPC: (a) the diameter of the NPF [14,16–21,23]; (b) the diameter of the IF [14,16–21,23]; (c) the length of the NPC [14,16–24]; (d) the sagittal thickness of the buccal alveolar plate at different height levels (upper, middle, lower) of the NPC [14,16,19,21]; (e) the diameter of the NPC [7,22–24]; (f) the angulation of the NPC [13,18,20]; and (g) the number of NPF and IF [16,17,20]. The course of the NPC in sagittal slices is also variable: (a) vertical–straight; (b) vertical–curved; (c) slanted–straight; and (d) slanted–curved [13,25].

The shape of the NPC was previously determined on axial slices, being classified in six groups: (1) round with separation; (2) round without separation; (3) oval with separation; (4) oval without separation; (5) heart-shaped with separation; (6) heart-shaped without separation [14]. However, as we observed in the figure depicting those shapes (Figure 1 in [14]), there were interpreted axial CBCT slices taken at different heights of those NPCs.

In sagittal slices, the anatomic variants of the NPC shape were classified by Jain into four groups: (1) funnel; (2) cylindrical; (3) hourglass; and (4) banana-like [20]. Sekerci distinguished six different sagittal shapes of the NPC: (1) hourglass; (2) cone; (3) funnel; (4) banana-like; (5) cylindrical; and (6) tree branch-like [26]. Gorurgoz and Ostas created nine groups of sagittal shapes of the NPC: (1) hourglass; (2) spindle; (3) cone; (4) funnel; (5) banana-like; (6) cylindrical; (7) tree branch-like; (8) kink; and (9) other [18]. Other authors found just four of these types of the NPC: cylindrical, funnel, spindle, and hourglass [25,27]. In dry skulls the morphology of the NPC was either conical or cylindrical [6].

Commonly, the superior openings of the NPC are located on each side of the nasal septum [11]. More exactly, they are on each side of the nasomaxillary crest [2]. Their number is individually variable. Numerous authors indicate these NPFs as the foramina of Stensen/Stenson [12,13,17,25–27]. However, as documented by Bahşi et al., Niels Stensen described the IF and not the NPF [4].

The NPC was also evaluated on coronal slices through the premaxilla and was classified in three main types: (1) single canal; (2) two parallel canals; and (3) variations of the Y-type canal in which there was always found a single IF, but the NPF were either two, three, or more than three [13,16,20]. When comparing those three types with our findings, it results that another anatomic possibility should be considered additionally: the absent NPC with or without NPF. An absent NPC does not mean that the minute vessels and nerve bundles are lacking, but that they traverse minute canaliculi of the premaxilla without being gathered within a canal with well-defined boundaries. As the premaxilla is an anatomical situs for implant placement, the absence of the NPC should be of benefit as it increases the amount of bone available for implant placement.

5. Conclusions

The anatomical possibilities of the NPC/IC are numerous and diverse. Therefore, a standardized description of this canal could not be assumed, especially during dental medical anatomical training. The current study adds novelty to the existing scientific literature by including the variant of an absent maxillary incisive, or nasopalatine canal.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Ethics Committee of "Dr. Carol Davila" Central Military Emergency Hospital, Bucharest, Romania, (protocol code 456/4 May 2021).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author upon reasonable request.

Conflicts of Interest: The authors declare no conflict of interest.

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