ORIGINAL PAPER

The *sinus septi nasi* and other minor pneumatizations of the nasal septum

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Abstract

The osseous nasal septum (NS) consists of the perpendicular plate of the ethmoid bone (PPE) and the vomer bone. Few studies evaluated the possibilities of septal pneumatization of the PPE, or adjacent to it. We aimed to observe the anatomical possibilities of NS pneumatizations. A retrospective lot of cone-beam computed tomography (CBCT) files was used. One hundred seventy-one CBCT files from 51 males and 120 females were documented. There were found 46 files that were null for septal pneumatization. The other cases (73.1%) had different septal pneumatizations extended from neighboring air spaces. Pneumatized *crista galli* (CG) exclusively extended from a frontal sinus was found in 7.01% of cases. The frontal sinuses had minor extensions anterior to the PPE in 7.6% of cases. Unique or double pneumatizations of the sphenoidal rostrum extending within the posterior part of the PPE were detected in 71.34% of cases. In six cases were found ethmoidal pneumatizations of the PPE, either from an anterior ethmoid cell, or from a posterior one, or from a pneumatized CG. In this last case was found a *sinus septi nasi* of 25.37 mm sagittal size. The supra-septal recesses of the ethmoid air cells were roofing the respective nasal fossa. As all the morphological possibilities of NS pneumatization involve the upper part of the PPE, they should be adequately discriminated anatomically, as well as when the NS and the cribriform plate of the ethmoid bone are approached surgically.

Keywords: ethmoid bone, nasal septum, cone-beam computed tomography, sphenoidal sinus, frontal bone.

Introduction

The nasal septum (NS) mainly consists of the perpendicular plate of the ethmoid bone (PPE) and the vomer. The PPE reaches anteriorly the nasal part of the frontal bone (NPF) and posteriorly joins the sphenoidal rostrum (SR) of the body of sphenoid. The PPE is continuous above the cribriform plate (CP) of the ethmoid bone with the *crista galli* (CG).

Quite recently, Mladina *et al.* used 93 dry skulls which they scanned in cone-beam computed tomography (CBCT) to observe the pneumatizations of the NS. They found in 34.4% a pneumatization of the PPE, which they termed “*sinus septi nasi*” (SSN) [1]. As the respective authors wrote, “this is the first anatomical study on the incidence of SSN in human skulls” [1]. They hypothesized in conclusion that the SSN could be derived either from the frontal sinus, or from the sphenoidal sinus, or from the vomeronasal organ. This is because the origin of those SSN was not explicitly documented in that study. It is important to note that although Mladina *et al.* [1] used a “skull collection” of an Institute of Anatomy, evidence in most figures includes bone and soft tissues. Soft tissues, such as orbit content and covering mucosae, could not be scanned in dry skulls.

Aim

As the study of Mladina *et al.* [1] was indicated by

the authors as a pioneering one, further studies have to evaluate the anatomy of the NS pneumatizations on CBCT scans of living patients. We therefore aimed doing so, to observe the anatomical possibilities of NS pneumatizations, *i.e.*, the prevalence and sources of the PPE pneumatization.

Materials and Methods

It was performed a retrospective CBCT study of the archived files of 190 patients explored for dental medical purposes. Exclusion criteria, such as inadequate vertical length of scans and moved images, were applied. Therefore, the anatomical variables were documented on 171 files, of which 51 were males and 120 females. It was used an iCat CBCT machine (Imaging Sciences International [Hatfield, PA, USA]) with the settings presented previously [2]. The CT data were analyzed using the iCatVision and the Planmeca Romexis Viewer 3.5.0.R applications, as in other previous studies [3–5]. The patients have given written informed consent for all medical data to be used, provided the protection of the identity is maintained. Therefore, the evidence presented here was anonymized. The study was approved (No. 456/04.05.2021) by the responsible authorities (2nd affiliation of the first author).

The following variables were recorded in a Microsoft Excel file, descriptive statistic being further performed: (i) lack of pneumatizations of the NS (null septal pneumatizations); (ii) pneumatized CG (*sinus cristae galli*);

(iii) septal extensions of the frontal sinus; (iv) posterior septal pneumatizations of sphenoidal origin; (v) ethmoidal sources of pneumatization of the PPE. Based upon the findings, a critical review of specific literature was performed.

Results

In 19 male files and 27 female files, no pneumatizations of the NS were recorded. Therefore, 46/171 (26.9%) files were classified as null for septal pneumatization. The other cases (73.1%) had different septal pneumatizations extended from neighboring air spaces, as follows.

Pneumatized CG (*sinus cristae galli*) were found in four male and eight female cases, thus in 12/171 (7.01%) cases. All these pneumatizations were extended from the frontal sinus. In three male cases, the source of the *sinus cristae galli* was the right frontal sinus and in another male case, the pneumatization of CG extended from the left frontal sinus. In the female cases, the origin of the *sinus cristae galli* was from the right frontal sinus in three cases and from the left one, in five cases. The maximum transverse diameter of the *sinus cristae galli* was further measured in these cases. A mean value of 4.085 mm was found. The values ranged from a minimum of 2.37 mm to a maximum of 5.25 mm.

The frontal sinuses had minor extensions anterior to the PPE (Figure 1) in three males and 10 females, thus in 13/171 (7.6%) cases. In eight of these 13 (61.53%) cases, those extensions originated from the right frontal sinus and in the remaining five (38.47%) cases, they originated from the left frontal sinus.

Figure 1 – Minor pneumatization of the NPF in front of the antero-superior angle of the PPE (arrows): (A) Mediosagittal slice; (B) Coronal slice; (C) Axial slice. NPF: Nasal part of the frontal bone; PPE: Perpendicular plate of the ethmoid bone.

Pneumatizations of the SR extending within the posterior part of the PPE (Figure 2) were detected in 32 male cases, being unique in 31 cases and double in one case. In female cases were found unique pneumatizations of the rostrum in 83 instances, while double such pneumatizations were recorded in seven cases. Therefore, from 171 cases, 122 (71.34%) had sphenoidal pneumatizations of the posterior NS. All the double pneumatizations of the rostrum were

extended from both sphenoidal sinuses, left and right. In 18 male cases, the rostrum was pneumatized from the left sphenoidal sinus and in 13 cases – from the right sphenoidal sinus. In 47 female cases, the rostrum was pneumatized from the left sphenoidal sinus and in 36 cases – from the right one.

Figure 2 – Pneumatized SR: (A and B) Double pneumatization (arrows) from both sphenoidal sinuses; (C and D) Unique pneumatization (arrowheads) from the right dominant sphenoidal sinus. A and C: Axial slices; B and D: Coronal slices. SR: Sphenoidal rostrum.

Two male cases were found with pneumatizations of the PPE supplied from ethmoid air cells, an anterior one and, respectively, posterior one. Four female cases were recorded with pneumatized PPE, two from anterior ethmoidal cells (Figure 3), one from a posterior ethmoidal cell (Figure 4) and one from CG.

Figure 3 – Pneumatization of the antero-superior angle of the PPE (arrow) originating from an anterior ethmoid cell (double-headed arrow): (A) Coronal slice; (B) Axial slice. PPE: Perpendicular plate of the ethmoid bone.

Figure 4 – Pneumatization of the postero-superior angle of the PPE (arrow) originating from a posterior ethmoid cell (arrowhead): (A) Mediosagittal slice; (B) Coronal slice. PPE: Perpendicular plate of the ethmoid bone.

In this last case (Figure 5), the left frontal sinus extended and pneumatized the NPF, CG and PPE. The measurements of that SSN revealed a sagittal extent of 25.37 mm, a transversal size of 5.75 mm and a height of 13.58 mm.

Figure 5 – Large pneumatization of the antero-superior angle of the PPE (true SSN): (A) Mediosagittal slice; (B) Coronal slice; (C) Axial slice. 1: Pneumatized NPF; 2: Pneumatized CG; 3: Pneumatized PPE; 4: CP of the ethmoid bone; 5: Sphenoidal sinus. CG: Crista galli; CP: Cribriform plate; NPF: Nasal part of the frontal bone; PPE: Perpendicular plate of the ethmoid bone; SSN: Sinus septi nasi.

Discussions

The CG is surgically relevant in transcribriform approaches of tumors with intracranial extension [6–9]. The infection of a pneumatized CG could determine frontal headache [10]. Pneumatized CG (*sinus cristae galli*) were found here in 7.01%. They were extended from one of the frontal sinuses. This was previously observed by Som *et al.*, who investigated 200 adult cases and found in 13% the CG pneumatized from one of the frontal sinuses [11]. We therefore agree with these authors that the *sinus cristae galli* is exclusively an extension of a frontal sinus and not of an anterior ethmoid air cell. Nevertheless, a different study assessed the origin of the CG pneumatization as either frontal, or ethmoidal [12]. The incidence of such air space of the CG was evaluated in different studies (Table 1) and it seemingly depends on the population which is studied [13].

Table 1 – Different rates of incidence of the pneumatization of CG were previously reported

Author(s), year [Ref.]	No. of cases	Method	Incidence of CG pneumatization
Bašić <i>et al.</i> , 1999 [14]	212	CT	2.4%
Dutra & Marchiori, 2002 [15]	71	CT	2.8%
Som <i>et al.</i> , 2009 [11]	200	CT	13%
Al-Qudah, 2010 [16]	110	CT	28%
Hajioannou <i>et al.</i> , 2010 [17]	99	CT	14.1%
Kim <i>et al.</i> , 2012 [18]	818	CT	12.2%

Author(s), year [Ref.]	No. of cases	Method	Incidence of CG pneumatization
Cobzeanu <i>et al.</i> , 2014 [19]	205	CT	22.92%
Poje <i>et al.</i> , 2014 [20]	527	CT	37.5%
Manea & Mladina, 2016 [21]	196	CT	30.1%
Mladina <i>et al.</i> , 2017 [22]	102	CBCT	66.6%
Akiyama & Kondo, 2020 [12]	300	CT	9.33%
<i>Present study</i>	171	CBCT	7.01%

CBCT: Cone-beam computed tomography; CG: *Crista galli*; CT: Computed tomography.

Before Mladina *et al.* study [1], Lei *et al.* performed a study in 32 patients to investigate the occurrence rate of pneumatization of the PPE and found the PPE pneumatization in six cases, thus in 18.75% [23]. Unfortunately, Mladina *et al.* [1], who reported later an almost double prevalence for this anatomic possibility, did not document the results of Lei *et al.* Nor did these authors document the report of Wang *et al.* who found 6/32 cases with pneumatized PPE [24]. It is interesting to note that Wang *et al.* published their report [24] one year before Lei *et al.* and found the same prevalences for the possibilities of NS pneumatization. Of the six cases of Lei *et al.*, in two (33.33%) patients were found pneumatizations of the anterior part of the PPE “near the frontal sinus” and in the other four (66.67%), pneumatizations of the posterior part of the PPE “near the sphenoidal sinus” [23]. The authors indicated these patterns as pneumatizations “of the frontal nasal septum” and, respectively, “of the sphenoidal nasal septum” [23]. Previously, Wang *et al.* described those morphological patterns as “frontal-septal pneumatization” and, respectively, “spheno-septal pneumatization” [24]. Unfortunately, Lei *et al.* reported their data in a “Letter to the Editor”, and the respective patterns of pneumatization were not supported by evidence [23]. Nevertheless, the terms “frontal nasal septum” and “sphenoidal nasal septum” are anatomically elusive.

As Lei *et al.* documented only six cases with pneumatized PPE, the resulting prevalences of frontal and sphenoidal pneumatizations nearing or within the NS could not be of trust. Indeed, the SR pneumatizations within the posterior NS prevail – we found this anatomic possibility in 71.34% of cases. However, minor frontal pneumatizations in front of the antero-superior angle of the PPE occurred in just 7.6%. Such minor septal pneumatization of the septum originating from the frontal sinus was termed in a case report “anterior nasoseptal cell of the frontal sinus” [25].

A long time ago, Cope classified the sphenoidal sinuses according to their extension backward into pre-sphenoidal sinuses, confined to the pre-sphenoid, post-sphenoidal sinuses, extended back to the clivus, and sinuses of intermediate size, with minor extensions into the post-sphenoid [26]. Cope described the “anterior recess of the sphenoidal sinus” as an antero-infero-lateral extension [26]. Such an “anterior recess” extending antero-laterally above the pterygopalatine fossa was also defined by other authors [27, 28]. Such an “anterior recess” was termed “maxillary recess”, as it projects towards the maxillary sinus [29–31]. It is different from a pure anterior recess within the SR, thus an “anterior median recess” of the pre-sphenoid, such as we found here. Such median anterior recesses of the

sphenoidal sinuses could be observed in figures in different publications, but they were neither discussed, nor classified [32–35].

Gore reported firstly a “supraseptal ethmoid sinus cell”, which he proved [36] being an anterior ethmoid cell extended above the PPE. In 171 cases, we found three (1.75%) such cases. Thus, Gore’s reported variant is demonstrated being a rare one. However, the term “supraseptal extension, or recess” of an ethmoid air cell is better describing this variant. This because Gore’s term “supraseptal ethmoid sinus cell” suggests that the main air space is supraseptal, not just the supero-medial recess of that cell. Moreover, we found such supraseptal recesses, but of posterior ethmoid cells, in 2/171 (1.16%) cases. Therefore, it could be concluded that, although rarely, any ethmoid air cell could extend a supero-medial supraseptal recess in the nasal fossa roof and above the PPE.

✉ Conclusions

As all the morphological possibilities of NS pneumatization involve the upper part of the PPE, being therefore located in the narrow part of the nasal cavity, they should be adequately discriminated when the NS and the CP of the ethmoid bone are approached surgically. Being extended from neighbor paranasal sinuses the pneumatized spaces of the PPE and CG could trigger clinical pictures of their anatomic pneumatic source.

Conflict of interests

The authors declare that they have no conflict of interests.

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Received: March 22, 2021

Accepted: August 10, 2021