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CLINICAL PRACTICE

Bilateral pneumatization of middle and superior nasal turbinates

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Abstract: *The pneumatization of all nasal turbinates is an extremely rare finding. Several previous reports have presented the bilateral superior, middle, and inferior conchæbullosæ. We report the bilateral pneumatization of middle and superior nasal turbinates. The variant was documented in cone beam computed tomography (CBCT) in all three dimensions. The inferior concha bullosa was a bilaterally moderate subtype of lamellar pneumatization that presented as a conchal recess of the maxillary sinus. The concha bullosa media was bilaterally of the extensive or true type and associated unilaterally with an uncinate bulla. The concha bullosa superior was asymmetrical bilaterally, narrower on the right side, and larger on the left where it was also septated and tri-cameral. The supreme conchæ were rudimentary, as were their pneumatizations. For an accurate anatomic diagnosis of conchæbullosæ in computed tomography, sagittal, coronal, and axial cuts, as well as three-dimensional reconstructions, should be used to ensure adequate planning of functional endoscopic sinus surgery.*

Keywords: *agger nasi; ethmoid bone; nasal fossa; nasal concha; nasal turbinate; anatomic variation*

INTRODUCTION

The lateral nasal wall attaches the nasal turbinates or conchæ. The inferior one is an independent bone. The middle, the superior, and the inconstant Santorini's supreme turbinates are the ethmoidal turbinates that are attached on the nasal side of the ethmoidal labyrinth [1].

A concha bullosa defines the pneumatization of a nasal turbinate. Although the term is commonly used to indicate the pneumatization of the middle turbinate, other nasal turbinates (inferior, superior, and supreme) have also been found to be pneumatized [2-15].

Sagit et al (2008) reported the first case of the pneumatization of six turbinates [16]. Fidan (2012) also assumed that the "pneumatization of all turbinates in a person has not been published yet" and suggested the term "panconcha bullosa" for such pneumatization of all six turbinates [17]. Ozturan et al (2013) failed to document these two previous reports and presented a case with "bilateral triple turbinate pneumatisations," noting, "Despite an extensive search of the medical literature, we could locate only one description of extensive turbinate pneumatisation involving anywhere near as many conchae as in our patient" [18].

Moreover, Bergman's Comprehensive Encyclopedia of Human Anatomic Variation [19] indicated only that the "pneumatization of several turbinates in the same patient has been reported," citing the reports of Sagit et al (2008), Ozturan et al (2013), and a third paper in which Pittore et al (2011) reported only a case of concha bullosa inferior [10], and not a panconcha bullosa. The reports of Fidan (2012) and Toplu et al (2013) were omitted [15, 19].

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We therefore report the fifth known case in the literature of the pneumatization of all nasal turbinates. To our knowledge, it is the first such case being documented in cone beam computed tomography (CBCT) and not on coronal CTs, as well as the first case in which findings were equally documented with bi-dimensional multiplanar reconstructions (MPRs) and three-dimensional volume renderizations (3DVRs). Nevertheless, we hereby report the pneumatization of eight, and not six, turbinates, as well as Santorini's first supreme turbinate was also found to be bullous.

ANATOMIC VARIATION

A retrospective CBCT study of the archived files of a 52 years old female patient was performed.

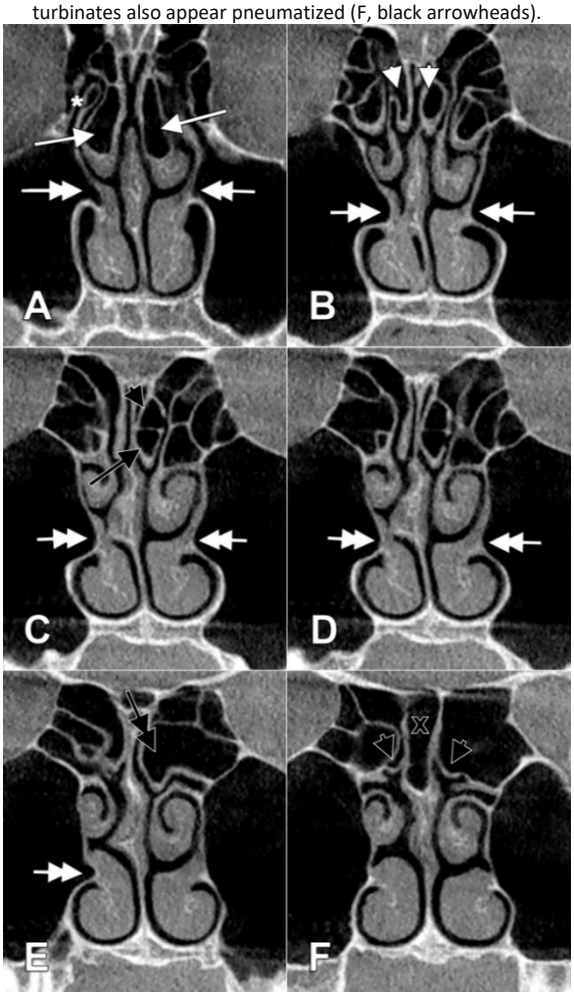
The subject had been scanned using a CBCT machine – iCat (Imaging Sciences International), the DICOM file being further documented with the Planmeca Romexis Viewer 3.5.0.R software, according to a previously detailed protocol of study [20-23]. We evaluated the nasal turbinates in all the three anatomical planes, as well as the three-dimensional volume renderizations. Relevant anatomical features were exported as image files. The patient has given written informed consent for all medical data to be used for research, provided they are anonymized.

In the case hereby reported, a Type 5 Mladina nasal septal deformation was found, with a horizontal septal spur sticking laterally and deeply in the right nasal fossa between the middle and inferior turbinates (Figure 1). The postero-superior part of the nasal septum accommodated an anterior (septal) recess of the right sphenoidal sinus. However, the septum did not appear deviated.

The inferior turbinates were bilaterally pneumatized by conchal recesses of the maxillary sinuses (Figures 1A–E, 2, 3F, 4, 6). The conchal pneumatization penetrated the horizontal segment of the lamellar part of each turbinate (Figure 6), with a 6.10 mm depth on the right side, and 3.02 mm depth on the left side (on coronal slices). These inferior conchæ bullosæ were located between the ethmoidal and maxillary processes of the inferior turbinate (Figure 6).

We also found bilateral pneumatizations of the middle turbinates (Figures 1A, 3, 4). These were both extensively pneumatized (true or extensive concha bullosa media) and were draining in the middle meatus on that side. An uncinate bulla was found unilaterally on the outer side of the right concha bullosa media (Figure 1A). It was pneumatized from an anterior adjacent lacrimal cell located, in turn, posterior to the agger nasi cell.

Figure 1: Anterior to posterior series (A–F) of coronal MPRs identifying the eight turbinates' pneumatizations. The beaked-shape pneumatization of each inferior turbinate is identified (A–E, white double-headed arrows). The bilateral concha bullosa of the middle turbinates (A, white arrows) is of extensive type, lamellar and bulbous. A right uncinate bulla is found (A, *). The superior turbinates are bilaterally pneumatized (B, white arrowheads). A horizontal septum divides the anterior part of the left superior concha bullosa in two chambers, superior (C, black arrowhead) and inferior (C, black arrow). Both drain into the upper nasal meatus (C, D). A third posterior chamber of the left superior concha bullosa (E, black double-headed arrow) appears as a medially evaginated posterior ethmoid air cell. On both sides of an anterior (septal) recess („X") of the right sphenoidal sinus the rudimentary supreme turbinates also appear pneumatized (F, black arrowheads).



We also observed a bilateral concha bullosa superior (Figures 1B–E, 3-6). The conchal air space was narrow in the right side (1.75/4.01 mm on coronal slices). The left concha bullosa superior was larger (4.81/11.35 mm on coronal slices) and septated by an overturned "Y"-shaped septum (Figures 3A, 5).

Thus, it consisted of three chambers: antero-superior, antero-inferior, and posterior. The anterior chambers were draining in the left superior nasal meatus (Figures 1C, D).

Figure 2: Axial MPR demonstrating the bilateral inferior concha bullosa (double-headed arrows).

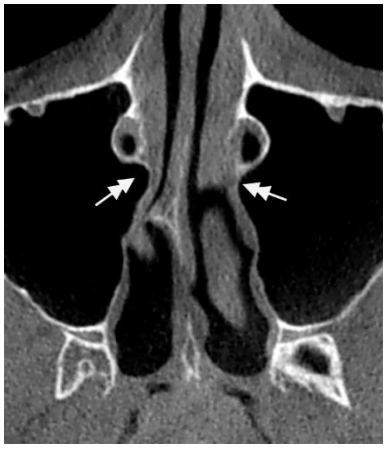
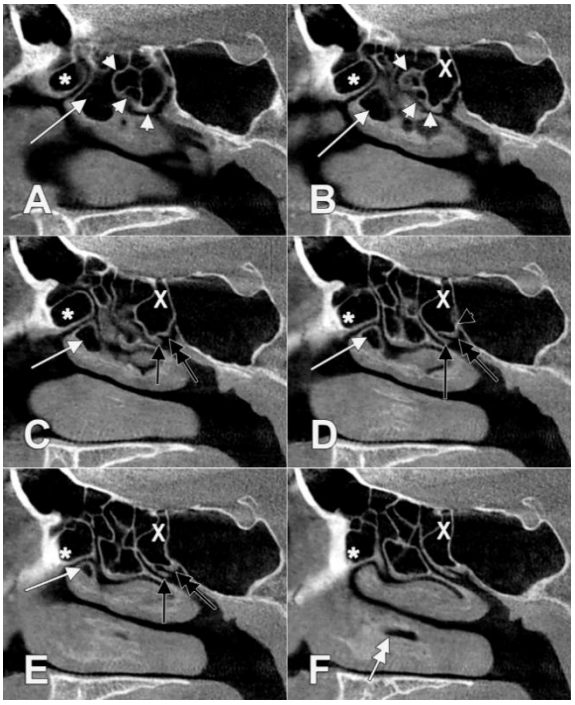


Figure 3: Lateral to medial series (A–F) of sagittal MPRs of the left lateral nasal wall. An agger nasi cell (A–F, *) is found anterior and superior to the anterior end of the middle nasal turbinate. Posterior to it lies the middle concha bullosa (A-–, white arrow). The inferior concha bullosa is indicated (F, white double-headed arrow). The superior concha bullosa is double-septated and consists of three chambers (A, B, white arrowheads): two anterior and one posterior. The posterior one is a conchal recess of a posterior ethmoid air cell (B–F, „X"), as is the supreme concha bullosa (D, black arrowhead). The superior (black arrow) and supreme (black double-headed arrow) turbinates are indicated (C–E).

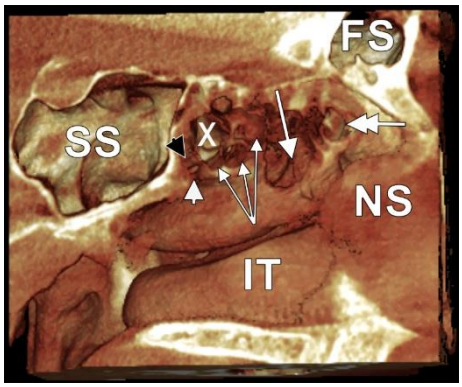


The posterior chamber appeared as the extension (conchal recess) of a posterior ethmoid air cell which, in turn, was also extending to form the left concha bullosa suprema (Figure 3).

As the concha bullosa suprema was also found on the right side (Figures 1, 3–5), we recorded this variation as bilateral. The rudimentary supreme conchæ bullosæ appeared as small diverticula of the respective posterior ethmoid air cells.

Figure 4: Sagittal MPR of the right lateral nasal wall crossing thorough all four conchal pneumatizations: inferior (double-headed arrow), middle (arrow), superior (white arrowhead), and supreme (black arrowhead).

Figure 5: Three-dimensional sagittal volume renderization of the left lateral nasal wall. The superior concha bullosa is separated by septa in three chambers (diverging thin arrows). A posterior ethmoid air cell ("X") pneumatize the posterior chamber of the superior turbinate (white arrowhead) and the supreme turbinate (black arrowhead). The thick arrow indicates the middle concha bullosa and the double-headed arrow—the agger nasi cell. FS: frontal sinus; SS: sphenoidal sinus; IT: inferior turbinate; NS: nasal septum (partly).



Agger nasi cells were found bilaterally. The right one was draining in the frontal recess and the left one in the ethmoidal infundibulum (Figure 7).

DISCUSSION

As was already discussed in the Introduction, reports of panconcha bullosa, such as this one, are rare. The nasal

septum typically deviates away from an asymmetrically enlarged dominant concha bullosa [7].

Nasal septum deformities were classified by Mladina, the left-sided deformities being more prevalent than the right-sided ones [24]. According to these authors, type 5 indicates "an almost horizontal septal spur that sticks laterally and deeply into the nasal cavity," the opposite side of the septum being flat [24].

This corresponds to the septal morphology we found in the present case. The absence of an important septal deviation indicates that we encountered a case of bilateral pneumatizations balanced in size.

Figure 6: Three-dimensional coronal volume renderization of inferior turbinates (ITs). On each side, conchal recesses of the maxillary sinuses (MS) penetrate the turbinate roots (double-headed arrows) to form communicating lamellar inferior conchæ bullosæ. These pneumatizations are located on each side between the ethmoidal process of the ITs (1), which further articulates with the uncinate process (2), and the maxillary process of the ITs (3).

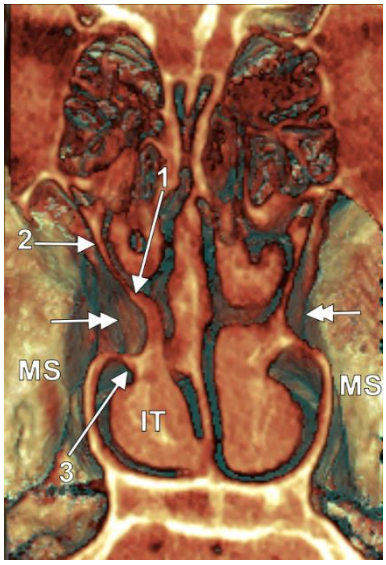


Figure 7: Sagittal MPRs demonstrate bilateral agger nasi cells (*). The right one communicates with the frontal recess (arrow), and the left one drains in the ethmoidal infundibulum (arrowhead).

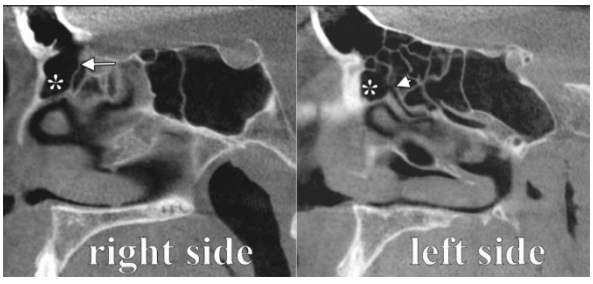
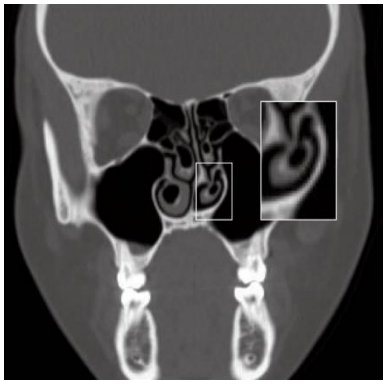


Figure 8: Reprinted from Hindawi – Turhan San, Selma San, Emre Gürkan, and Barış Erdoğan, "Bilateral Triple Concha Bullosa: A Very Rare Anatomical Variation of Intranasal Turbinates," Case Reports in Otolaryngology, vol. 2014, Article ID 851508, 2 pages, 2014. doi:10.1155/2014/851508, which is licensed under CC BY. We indicate (inset, digitally magnified) that the so-diagnosed left inferior conchal pneumatization is merely a strongly curved inferior turbinate, due to a septal spur that pushes the left inferior turbinate.



According to Kiroglu et al (2007), the pneumatization of the upper and middle nasal conchæ is commonly encountered, but a concha bullosa inferior is very rare [25]. Koo et al (2017) documented 1188 sides and found a unilateral concha bullosa media in 17.3%, a bilateral concha bullosa media in 36.4%, a unilateral concha bullosa superior in 11.3%, a bilateral concha bullosa superior in 27.4%, and concha bullosa inferior in only 1.0% [13]. A supreme concha bullosa was reported, to our knowledge, only once, by Măru et al (2015) [2].

The first report of an inferior concha bullosa as an anatomic possibility was that of Zinreich et al (1988), while the first paediatric case with a concha bullosa inferior was assumed by Kiroglu et al (2007).

Bolger et al (1991) evaluated in 202 patients the common anatomical variants of the middle nasal turbinate, such as its pneumatization and the paradoxical curvature [26]. In 53% of patients, the authors detected concha bullosa media [26]. They further classified the respective pneumatizations according to their location, within the lamellar part of the middle turbinate, or in its bulbous part, or in both these. It resulted in a classification of concha bullosa media, lamellar, bulbous, and extensive or true, respectively [26].

Further, Yang et al (2008) extended the classification of Bolger et al (1991) to the inferior turbinate [27]. Yang et al (2008) evaluated 59,238 sinonasal CTs and contributed 16 patients with concha bullosa inferior (pneumatized inferior turbinate) to the 28 cases they had already documented as reported at that time [5, 28-41]. They found that in relation

with the maxillary sinus, a concha bullosa inferior can be either communicating or non-communicating [27]. This equally feeds the hypothesis of misinvaginated epithelium within the double chondral lamella of the developing inferior turbinate (the non-communicating type) and the hypothesis of maxillary sinus extension within the inferior turbinate (the communicating type) [27]. The communicating type of a concha bullosa inferior was found in 8/18 pneumatized inferior turbinates by Yang et al (2008), thus in 44% of the series. Yang further subdivided the communicating type of a concha bullosa inferior into three subtypes, according to the degree of communicative pneumatization (27). These are (a) a subtle type with a beaked shape of pneumatization, (b) a moderate type in which the pneumatization fills the superior part of the vertical plate of the inferior turbinate, and (c) a marked type, in which the pneumatization completely fills the vertical plate of the turbinate [27]. It is interesting to note in this context a study by Măru et al (2013) in which the authors investigated 100 cases documented by CBCT and found unilateral extensions of the maxillary sinus within the inferior turbinates in 6% and bilateral extensions in 16% , which they termed conchal recesses of the maxillary sinus. Although these last authors did not indicate these recesses as pneumatized turbinates, it is bona fide the same morphology previously described by Yang et al (2008) as pneumatized inferior turbinates. According to the Yang classification, in the case we report here, the inferior conchæ bullosæ we found are of the communicating lamellar type, i.e., the moderate subtype. They can be equally classified as conchal recesses of the maxillary sinuses, however. Such communicating conchal pneumatizations were also indicated as common cavities of the maxillary bone and inferior turbinates [42], thus antro-, or sino-conchal cavities.

One should keep in mind that, according to Yang et al (2008), pneumatized inferior turbinates could be either communicating with the maxillary sinus, or non-communicating. Therefore, a concha bullosa inferior that drains in the inferior nasal meatus is a false one. We support this comment with the report of a “bilateral triple concha bullosa” of San et al (2014), who documented such a concha bullosa inferior only on coronal CT in a four-reference paper in which the study of Yang et al (2008) was not quoted. This is a false concha bullosa inferior that communicates with the inferior nasal meatus, and not with the maxillary sinus; narrowing of the turbinate concavity is rather due to a septal spur on that side (Figure 8). The left nasal spur (Figure 8) corresponds to the apex of maximum left septal deviation and is higher than the right concha bullosa inferior. Therefore, the concha bullosa inferior was not bilateral, as is supported by Tomblinson et al (2016), who demonstrated that the apex of maximum nasal septal contralateral deviation is positioned more superiorly when a unilateral concha bullosa is present and that the severity of septal deviation increases in direct proportion to the concha bullosa’s width [7]. Therefore, studies of conchal pneumatization should be evaluated in three dimensions and carefully documented.

In this study, we documented a septated concha bullosa superior that was not, to our knowledge, previously reported. There were, however, a few reports of septated concha bullosa media. The first septated concha bullosa media was found unilaterally and reported by Yanagisawa et al (2008) in a patient elected for functional endoscopic sinus surgery [43]. The second such case was reported by Perić et al (2009), who found a unilateral tri-cameral concha bullosa media [44]. A tri-cameral concha bullosa media was also reported later, by San et al (2013), and was also unilateral [45]. Septation of the middle turbinate is not significantly related to sinonasal pathologies [46]. As supported by our results, the septation of turbinates is not a specific feature of the middle one. Further studies should carefully observe whether the observed conchæ bullosæ contain septa that determine multiple drainage pathways of such pneumatizations.

CONCLUSION

In conclusion, the pneumatization of all nasal turbinates appears as a rare anatomic variation that sums the individual possibilities of the pneumatization of nasal turbinates. Conchæbullosæ are better documented in CBCT and in all three dimensions and, in turn, are of better use for surgeons dealing with functional endoscopic sinus surgery.

Conflict of interests

The authors declare that they have no conflict of interest.

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