

Computed Tomographic Observation of Anatomic Variants of Nasal Turbinates

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Abstract

Background: Nasal turbinates (conchae) are bony plates of the lateral wall of the nasal cavity. Few variants of the turbinates (e.g., supreme turbinate, septated concha bullosa (CB), superior turbinate (ST) pneumatization, etc.) are only accessible in the tomography study and thus necessitate a consideration. **Materials and Methods:** The aim of the study is to identify the variants of nasal turbinates and to determine their overall and individual prevalence. It is an observational, retrospective study where CT data of 130 subjects are analyzed according to the definitions and classifications existent in the literature to determine their frequency. **Results:** Nasal turbinate variants are appreciated in 96% of the subjects. Pneumatization of middle turbinate (MT) is the most prevalent 55.38% ($n = 72$) variant among all. However, if only “True or Extensive” type is considered then it is 18.07% ($n = 47$). Septations in the pneumatized MT, a rare variant, are found in 14.61% ($n = 19$) of subjects. We also have identified novel variants, “Triple Divided CB” and “Quadra Bullosa,” that are reported only once in the literature before. Pneumatization of ST is found in 14.61% ($n = 19$) subjects. Inferior turbinate (IT) hypertrophy is noted in 40.77% ($n = 53$) subjects which makes it second most prevalent variant of turbinates. Paradoxical middle and ITs are observed in 8.46% ($n = 11$) and 7.69% ($n = 10$), respectively, along with a rare case of unilateral “Bifid MT”. **Conclusion:** Thorough knowledge of variants of nasal turbinates is a prerequisite for the interpretation of CT or CBCT data.

Keywords: Accessory turbinates, Bifid turbinates, Concha bullosa, Hypertrophied turbinates, Paradoxical turbinates, Quadra bullosa, Secondary turbinates, Trifurcated middle turbinate, Triple divided concha bullosa.

INTRODUCTION

Computed tomography (CT) imaging, when advised to study the pathologies of maxillary bone or indicated to plan a surgical procedure, supplements three-dimensional details of the sinonasal region in the data set. Nasal turbinates with a corresponding meatus are central structures of the ostiomeatal complex pneumatization of nasal turbinates and superior turbinates are not accessible in nasal endoscopy. Pneumatization, hypertrophy, or altered shape of these turbinates are having association with several pathological consequences such as sinusitis,^[1] obstructive sleep apnea, and headache.^[2,3] This demands sound knowledge of the turbinates and its variants while interpreting the volume, as reporting of the same is crucial for an oral and maxillofacial radiologist.

MATERIALS AND METHODS

This observational study is conducted at the municipal dental hospital of Ahmedabad, Gujarat. After obtaining the institutional review board approval and waiver for patient's

consent (AMC Dental College, Khokhra-Ahmedabad. Reg. no: ECR/236/Indt/GJ/2015/RR-18), 130 multidetector computed tomography scan volumes are collected from the affiliated medical hospital over a period of 3 years (2018–2020). All CT paranasal sinuses data volumes are taken from MX 16 Slice machine (Philips Health Care) (120 kV, 250 mA s, and 1mm slice thickness). Scan volumes of pediatric subjects and patients with the previous history of mid-facial trauma, sinus malignancy, or surgery are excluded from the study.^[4]

Objectives of the study are –(1) To identify the variants of nasal turbinates and determine their overall prevalence

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rate, (2) to study the prevalence of pneumatization (type, septations), size alteration (hypertrophy), and shape alterations (paradoxic, bifid, or trifurcation) individually, and (3) to observe the presence of supreme, secondary, or accessory turbinates.

Definitions and classifications taken from the literature to identify and report the frequent and rare forms of variants of nasal turbinates are as follows –

- Concha bullosa (CB) is the partial or total pneumatization of concha/turbinates.^[5,6] It is frequently observed in the middle turbinate (MT) followed by the superior turbinate (ST) and rare in the inferior turbinate (IT).^[5,7] It usually occurs bilaterally; however, degree of pneumatization varies from one side to the other side in a given patient.^[5] Thus, in the present study, the type of pneumatization is noted according to the subjects as well as sides (130 subjects = 260 sides).^[8]
- According to Bolger's classification, three different types of pneumatization is defined on the basis of its location:^[6]
 - Type I: Lamellar (Pneumatization of thin vertical lamella; also described as "Grunwald's cells," "lamellar bulla," or "conchal air neck")
 - Type II: Bulbous (Pneumatization of inferior bulbous segment) and
 - Type III: Extensive type (True type; involvement of entire turbinate).
- Thin bone septations inside the CB divide the cavity (pneumatized concha) into two, three, or four compartments/cells and are termed as double divided CB, triple divided (two septa inside the pneumatization) CB, and Quadra Bullosa respectively.^[6]
- On the basis of the results of the studies conducted by El-Anwar *et al.*,^[9] (Year 2017, CT measurement of ITs in asymptomatic adults) and Shetty *et al.*,^[10] (Year 2021, Analysis of the width of hypertrophied and non-hypertrophied IT), in the present study, we have considered >10 mm width of IT as hypertrophy.
- Paradoxically curved turbinate means lateral convexity^[11] or bent in the reverse direction.^[1] Small paradoxical MTs are often bilateral.^[6]
- When the two bony lamellae share the same root, they are reported as "bifid turbinate." Along with MT, this variant is also been observed in IT.^[11]
- Supreme turbinates are the fourth pair of turbinates, situated above the STs. Secondary MT, a supernumerary turbinate, is a bony projection covered by soft tissue, arising from the lateral nasal wall. The variant is reported to occur bilaterally and it differs from the accessory MT, being the latter one an anterior fold of the uncinate process.^[11,12]

Following these definitions and classifications, we recorded the observations of 130 subjects (260 sides). Sample size is selected using a purposive sampling technique. Collected

data are analyzed by SPSS 29 (Software for Statistical Package) IBM software for frequency and percentage distribution.

RESULTS

Variants of nasal turbinates are identified in 96% ($n = 125/130$) of the subjects; 96.43% ($n = 81/84$) males and 95.65% ($n = 44/46$) females. Total 185 variants are recorded in 125 subjects. Probability of occurrence of nasal turbinate variant in a subject is reported as 1.5 (minimum one variant per subject).

Pneumatization of MT is the most prevalent variant with a frequency of 55.38% ($n = 72/125$). Prevalence in males is 50.00% (42/84) and in females is 65.21% (30/46), with 20.77% (27/130) unilateral and 34.61% (45/130) bilateral occurrence. To study the different types of pneumatization, 260 sides of 130 subjects are observed separately and bilaterally asymmetrical patterns are noted separately. Total 117 sides of 72 subjects are identified with pneumatization and amid them Type I (Lamellar variant) and Type III (Extensive or true variant) are present in 18.07% ($n = 47$ sides) and Type II (Bulbous variant) is recorded in 08.84% ($n = 23$ sides). ST pneumatization is recorded in 14.61% ($n = 19/130$) subjects while pneumatization of ITs is not recorded in the study.

Septations in the MT pneumatization, in the form of "Double Divided CB," "Triple Divided CB," and "Quadra Bullosa" are also recorded in the study.

IT hypertrophy, the second most prevalent variant with a frequency of 40.77% ($n = 53$) is present in 47.62% (40/84) male and 28.26% (13/46) female subjects, with 29.23% (38/130) unilateral and 11.54% (15/130) bilateral occurrence.

The prevalence of paradoxic MT and IT is noted in 08.46% (11/130) and 07.69% (10/130) subjects. Paradoxic MTs are recorded with 06.15% (08/130) unilateral and 02.31% (03/130) bilateral occurrence while all the cases of paradoxic ITs are unilateral. In the present study, we have also identified a case of ST pneumatization and a case of unilateral bifid MT.

DISCUSSION

In the present study, the most prevalent variant of nasal turbinate is CB of the MT (55.38%). The finding is similar to that of Turna *et al.* (2014),^[5] who studied the variant in different population and found 57.2% prevalence and of Awasthi *et al.* (2016),^[8] who studied CB in Indian population and rated the prevalence of 57%. The observation affirms that when all the three types of pneumatization are considered in defining the variant then its prevalence is more than 50% of the subjects, irrespective of the gender or ethnicity (Figure 1).

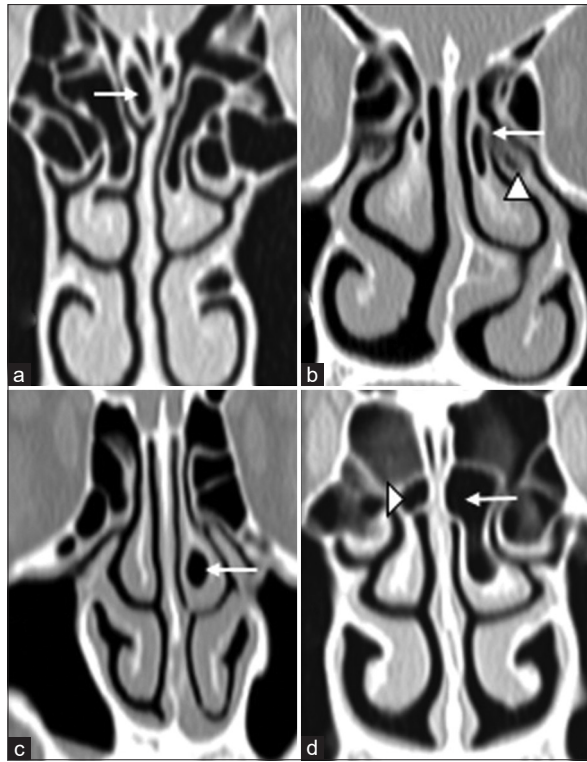


Figure 1: (a) Bilateral superior concha bullosa (CB), (b) bilateral lamellar CB; additional finding – bilateral uncinate bulla (Arrow head), (c) unilateral (Left side) pneumatization of bulbous part of turbinate, and (d) bilaterally asymmetrical pattern – Extensive type on left, Lamellar type on right (Arrowhead)

However, when the occurrence of pneumatization is noted side wise, it is found that type III and I are the most frequent types with 18.07% (47/117 sides) prevalence. In literature, pneumatization of MT and its severity is been associated with the nasal septum deviation and mechanical obstruction due to nasal blockage.^[4,6,8] According to that, Type III (True or Extensive pneumatization) CB has more potential to affect the adjacent structures of ostiomeatal complex and thus should be given necessary emphasis when present. Our results are similar to that of the results of *Bolger et al.* who studied all the three types and stated 15.70% prevalence for Type III.^[13]

While studying the septations in pneumatized MT, we recorded few rarest cases of “Triple Divided CB” (Two septa in a pneumatized turbinate) and “Quadra Bullosa” (Three septa in a pneumatized turbinate). Both the variants reported only once in the literature. *San et al.* (2013)^[6] reported the first case of Triple divided CB and stated that only two cases of “Double Divided CB” have been reported previously by *Yanagisawa et al.* (2008) and *Peric et al.* (2009). Other than that, we found another case report of “Double Divided CB” by *Ertugrul* (2017).^[14] “Quadra Bullosa” is also reported only once by *Tranchito and Chhabra* (2021).^[15] Thus, in the present observational study, the authors report both the rarest variants of septated CB for the 2nd time along with double divided

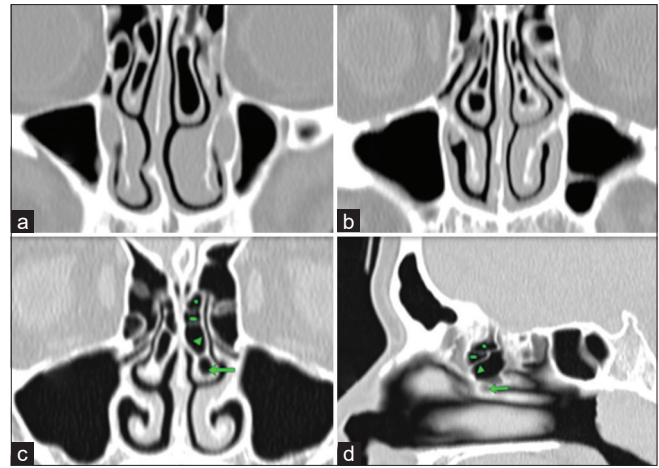


Figure 2: (a) Double divided concha bullosa on the right side with one septa, (b) bilateral triple divided concha bullosa, and (c and d) coronal and sagittal sections of quadra bullosa. Four cells/compartments are marked by a dot, a line, a triangle, an arrow

CB and conclude that thorough assessment of the CT data aids in uncovering many variants which are documented less commonly (Figure 2).

The second most prevalent variant documented in the present study is hypertrophy of IT (Prevalence rate: 40.77%; Males: 50%; Females: 28.26%) which is comparative less than the study result of *Clark et al.* (2018), who reported the prevalence of 72%.^[16] This difference is justified on the basis of the different definition and classification system applied to record the variant. We have not included mild cases of hypertrophy as we have taken the mean width of moderate and severe cases, an objective and measurable criteria, to define turbinate hypertrophy. We also found that the variant is highly prevalent (ratio: 2:1), in the male subjects when compared to female subjects.

In our study, we have noted that enlarged MT with or without pneumatization is seen in association with the deviated nasal septum in many cases. *Tomblinson et al.* (2016)^[4] in his study noted that CB width has statistically significant correlation with septal deviation present at the MT region. Average width of CB reported in the mentioned study is 7.5 mm (2.2) and deviation is observed on the contralateral side of the dominant CB. Thus, we conclude that hypertrophy of the MT in the absence of pneumatization should also be studied with this regard (Figure 3).

Paradoxical shape or lateral curve is observed in 8.46% of MT and 7.59% of the ITs. The variant is more commonly found unilaterally ($n = 18/21$) with only three cases of bilateral occurrence are noted in the study and all of them are paradoxical MT. In our study, most of the cases of paradoxical IT are observed adjacent to the horizontal spur of nasal septum, a finding similar to that reported in the studies conducted by *Gibelli et al.*,^[11] *Shetty et al.*,^[10] and *Măru et al.*,^[17] (Figure 4).

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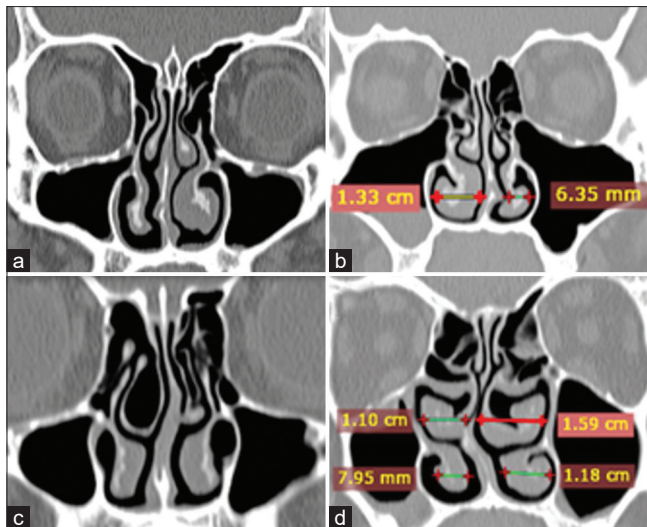


Figure 3: (a and b) Defining point for IT hypertrophy ≥ 10 mm width, (c) bilateral extensive concha bullosa – Note the dominant concha bullosa on the contralateral side of the deviated septum, and (d) large size of left inferior turbinate and middle turbinate contralateral to the side deviated septum and absence of pneumatization

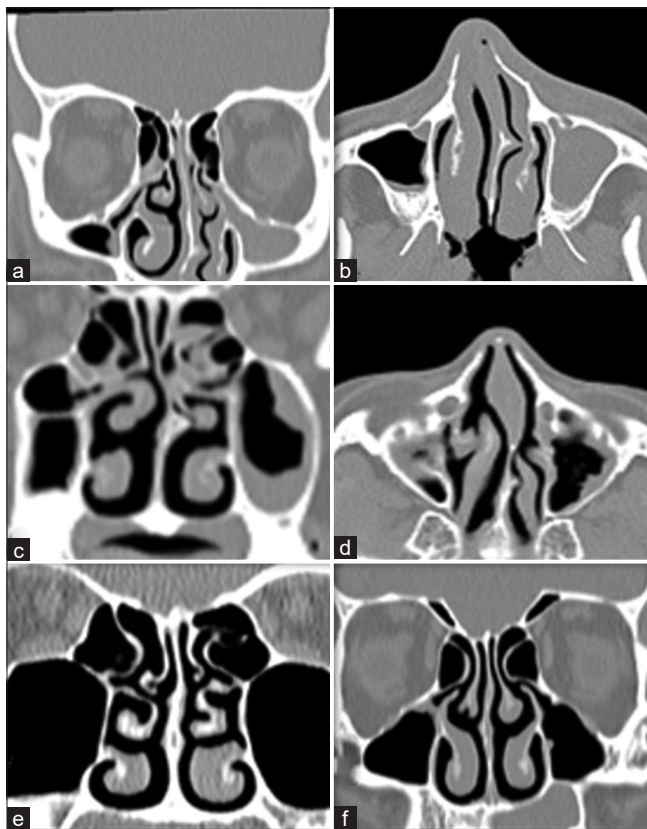


Figure 4: (a, b) Coronal, axial sections of paradoxical left inferior turbinate adjacent to a spur of septum, (c and d) coronal, axial sections of mild paradoxical middle turbinate adjacent to a spur, (e) paradoxical unilateral (left) middle and bilateral superior turbinates, and (f) Bifid middle turbinate (right)

One case of bifid turbinate is also reported in the study, the frequency of which is very less as reported by Ozcan *et al.* who found only one case in 384 patients.^[18] We have not found any case of “Trifurcated MT,” only one case of which has been reported by Eweiss *et al.* (2008) in the literature^[19] (Figure 4).

CONCLUSION

In this prevalence study, few rare variants like ST pneumatization and bifid turbinate and few novel variants like “Triple Divided CB” and “Quadra Bullosa” are identified along with the frequently occurring landmarks.

In addition to that hypertrophy of the IT is defined by the measurement of its size (width) and the potential of the enlarged MT without pneumatization is also discussed. Awareness of this varied alternatives/patterns of normal landmarks of the nasal turbinates is beneficial to carry out future research and to plan diagnostic and treatment strategies.

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