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**ANATOMICAL VARIATIONS OF THE NASAL TURBINATES, COMPUTED TOMOGRAPHY (CT) STUDY**

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**ABSTRACT**

**Objectives:** We report the frequency of nasal turbinate anatomical variations in patients suffering from sinonasal symptoms.

**Methods:** We reviewed computed tomography (CT) images of the nasal and paranasal sinuses of 150 patients aged 18–70 years who were seen between January 2023 and January 2024. We looked for the presence of several nasal turbinate anatomical variations: pneumatized inferior turbinates (concha bullosa of the inferior turbinates), paradoxical inferior turbinates, pneumatized middle turbinates (concha bullosa) and its subtypes (bulbous, lamellar, and extensive), paradoxical middle turbinates, pneumatized superior turbinates, and the presence of supreme nasal turbinates.

**Results:** The most commonly identified anatomical variation was pneumatized middle turbinates (56%) and its subtypes extensive (53.57%), lamellar (39.28%) and bulbous (7.14%). Paradoxical middle turbinates were noted in (19.33%) of cases. Pneumatized superior turbinates were observed in (23.33%) and supreme turbinates were observed in (52%) of cases. Inferior turbinate variations were extremely rare: pneumatized inferior turbinates were observed in (1.33%) of cases, and paradoxical inferior turbinates were observed only in (0.66%).

**Conclusion:** Nasal turbinate anatomical variations were very common in the patients we analyzed. A proper evaluation of such variations, either as a probable cause or road map for future surgery, is critical in order to avoid unnecessary complications.

**Key words:** concha, pneumatized, paradoxical, supreme, turbinate.

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**INTRODUCTION**

Nasal turbinates, located on the lateral wall of each nasal cavity, are considered to be important anatomical and physiological structures. Each lateral wall contains three turbinates: the inferior, middle, and superior turbinates.(1) Sometimes a fourth turbinate, the supreme turbinate, may be present as well. (2)From an anatomical point of view, nasal turbinates are projections from the nasal lateral wall; they are composed of bony core covered by soft tissue and mucosa.(3)The superior turbinate(the smallest

turbinate) and the middle turbinate are part of the ethmoid bone; however, the inferior turbinate, which is the largest turbinate, is considered to be a separate bone.(4) Physiologically, nasal turbinates play an important role in humidifying and warming inspired air and regulating nasal airflow.(5) Nasal turbinates function as important anatomical landmarks when performing endoscopic nasal surgery; turbinates are related to four spaces on each side of the nasal cavity: The inferior meatus is

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where the nasolacrimal duct opens, the middle meatus is where the maxillary, frontal, and anterior ethmoidal sinuses open. Furthermore, anatomical variations are present in nasal turbinates that may affect that road map, however. Such features can be referenced in sinus surgery or may be related to patient complaints of nasal obstruction.<sup>(7)</sup> The widespread use of nasal endoscopes and the availability of computed tomography (CT) scans in sinonasal disease evaluations have facilitated the identification of turbinates and their variations. We aim in this article to study anatomical variations of nasal turbinates based on CT scans.

### Methods

This retrospective observational study focused on CT scans of 150 adult patients with ages between 18 and 70, who visited the otorhinolaryngology clinic at Queen Alia Military Hospital between January 2023 and January 2024 were reviewed and analyzed. All of the patients had complained of sinonasal symptoms, and the CT scans were obtained to evaluate the sinonasal region. We excluded patients with a history of sinonasal surgery, under the age of 18, history of facial trauma, patients diagnosed with sino-nasal neoplasms, and patients with gross pathologies were excluded from our study. Each CT scan was reviewed by two of the authors. Each person wrote his report individually. The findings were then compared, and discrepancies were resolved by consulting a radiologist. Each CT scan was reviewed for the presence of the following turbinate anatomical variations: pneumatized inferior turbinates (concha bullosa of inferior turbinates), paradoxical inferior turbinates, pneumatized middle turbinates (concha bullosa) and its subtypes (bulbous, lamellar and extensive), paradoxical middle turbinates, pneumatized superior turbinates, and the presence of supreme nasal turbinates. We documented every anatomical variation as being on the right side, left side

bilateral or absent; the exception was the supreme nasal turbinate, which was only documented as being present or not. When pneumatized middle turbinates were found, we documented their subtype (i.e., bulbous, lamellar, or extensive). Using Cochran's sample size formula, we estimated the sample size for a confidence level of 95% and a margin of error of 8%. We used descriptive statistics such as frequencies, percentages, means, and standard deviation (SD) to represent the data. We also used IBM SPSS for Windows, version 24 (IBM Corporation, Armonk, NY, USA) to analyze the data.

### Results

Our study included 150 patients with age range from 18 to 70 years with a mean age was  $34.55 \pm 12.04$  years. The group consisted of 81 males (54%) and 69 females (46%). Concha bullosa (CB) of the middle turbinate was the most frequently identified turbinate anatomical variation; it was observed in 84 patients (56%) and was bilaterally present in 48 patients (32%). It was present on the right side in 19 patients (12.66%) and present on the left side in 17 patients (11.33%). We found that extensive CB was present in 45 patients (53.57%); the next most common sub-type was amellar in 33 patients (39.28%). The most least common type was bulbous, which was found in 6 patients (7.14%). Paradoxical middle turbinates were noted in 29 patients (19.33%) and were bilateral in 11 patients (7.33%). They were right sided in 8 patients (5.33%) and left sided in 10 patients (6.66%). Pneumatization of the superior turbinate was identified in 35 patients (23.33%) and was bilaterally present in 17 patients (11.33%). Pneumatization of the superior turbinate was right sided in 10 patients (6.66%) and left sided in 8 patients (5.33%). Supreme turbinates were present in 78 patients (52%). Inferior turbinate variations 1 were rare; paradoxical inferior turbinates were noted in just one patient, (0.66%) at it was on the right side.

Pneumatization of the inferior turbinate was noted in two patients (1.33%) being bilateral in one patient and right sided in the other patient). A summary of these anatomical variations of the nasal turbinates is provided in Table 1.

### Discussion

Pneumatized middle turbinates (Figure 1) were the most frequently encountered nasal turbinate anatomical variation. This condition was described for the first time in 1793 by Santorini.(8) The term “concha bullosa” was used for the first time by Zuckerkandl. This anatomical variation had been more frequently noted after the introduction and widespread use of CT images and endoscopic sinus surgery; the middle turbinate is considered to be a cornerstone landmark in endoscopic surgery.(9) The prevalence of CB has been noted to be between 14 and 80% in the literature, this wide range is attributed to differences in ethnicity.(10) In our study, we observed CB of the middle turbinate in 84 patients (56%); a large fraction of the cases were bilateral (32%). These results agree with the findings of Al-Qudah (i.e., 18%).(11) Of the 29 patients with paradoxical middle turbinates, this condition was observed on both sides in 11 patients (7.33%), on the right side in 8 patients (5.33%), and on the left side in 10 patients (6.66%). Messerklinger first reported a pneumatized superior turbinate (Figure 6).(18) The incidence of pneumatized superior turbinates ranges from 12.2% to 50%.(19,20) We noted this variation in 35 of our patients (23.33%); that finding is consistent with the results of Al-Qudah (i.e., 25%) (11) and other values in the literature (Table 2). This variation was observed to be bilateral in 17 patients (11.33%), right sided in 10 patients (6.66%), and left sided in 8 patients (5.33%).

Supreme nasal turbinate (i.e., Santorini’s concha) refers to the presence of a fourth nasal concha. However, the role of such a turbinate is still debated. However, when the supreme concha is present the sphenoid sinus ostium is located medially to its posterior inferior attachment. The supreme concha can serve as an additional landmark in endoscopic sinus surgery.(21) The prevalence a supreme concha ranges from 8 to 50%.(22) We observed this condition in 78 patients (52%). Given reported variations in its prevalence, the supreme concha merits follow-up investigation. Inferior turbinate variations have been less frequently studied in the literature; focus has remained on the middle turbinate due to its relation to the osteomeatal complex and its status as a landmark in endoscopic sinus surgery.(23) Most cases of inferior turbinate variations have been reported as case studies. We observed two patients with pneumatized inferior turbinates (1.33%) (Table 3, Figure 5); one individual exhibited this condition bilaterally and the other patient had it only on the right side. The incidence of pneumatized inferior turbinates has been reported to be less than 1%; most cases are unilateral, Koo et al reported it as 1%.(24) Another inferior turbinate variation that has been observed is paradoxical inferior turbinate (Figure 7), which is considered to be the rarest. Its incidence is believed to be roughly 0.3%.(25) We observed this condition in just one patient (0.66%) being present on the left side. Nasal turbinates are important structures for nasal functioning; they also serve as critical landmarks for endoscopic sinus surgery. We noted that patients in our study exhibited more than one anatomical variation and even the same anatomical structure with different

Table 1: Anatomical variations of the nasal turbinates of 150 Jordanian patients.

Anatomical variation	Total n & percentage	Bilateral n & percentage	Right sided n & percentage	left sided n & percentage
Pneumatized middle turbinate	n=84, 56%	n=48, 32%	n=19, 12.66%	n=17, 11.33%
Paradoxical middle turbinate	n=29, 19.33%	n=11, 7.33%	n=8, 5.33%	n=10, 6.66%
Pneumatization of superior turbinate	n=35, 23.33%	n=17, 11.33%	n=10, 6.66%	n=8, 5.33%
Supreme turbinate	n=78, 53%	_____	_____	_____
Pneumatized inferior turbinate	<u>n=2, 1.33%</u>	n=1, 0.66%	n=1, 0.66%	_____
Paradoxical inferior turbinate	n=1, 0.66%	_____	_____	n=1, 0.66%

Table 2: Reported incidence of nasal turbinates radiological variants in different ethnic population.

Author	Country	No. of patients	CBm%	PxMT%	STp %
Al-Qudah et al(11)	Jordan	110	62	18	25
Alrumaih et al(12)	Saudi Arabia	121	55.4	12.4	----
Badia et al(26)	United Kingdom	100	28	20	----
Badia et al(26)	Hong Kong	100	9.5	6.5	----
Jones et al(27)	Austria	200	20	11.5	----
Lerdlum & Vachiranubhap(28)	Thailand	133	14.3	5.3	----
Dua et al(29)	India	50	16	16	----
Perez-Pinas et a(30)	Spain	110	24.5	5	----
Caughey et al(31)	USA	250	27.4	----	----
Tonai & Baba(32)	Japan	75	28	25.3	----
Mamatha et al(33)	India	40	15	----	----
Mazza et al(34)	Italy	100	29	11	----
Adeel et al(35)	Pakistan	77	18.2	14.3	----
Yazici et al(36)	Turkey	120	44.2	----	30.8
Devaraja et al(37)	India	151	49	----	3.9
Our study	Jordan	150	56%	19.33%	23.33%

Table 3: Reported incidence of inferior turbinate variations by different authors

Author	Pneumatized inferior turbinate	Paradoxical middle turbinate
Özcan et al (2008)(38)	2.50%	-
Yasan et al (2006)(39)	0.13%	1.01%
Koşar et al (2019)(40)	0.40%	0.03%
<u>Nautiyal</u> et al (2020)(41)	0.91%	-
Our study	1.33%	0.30%

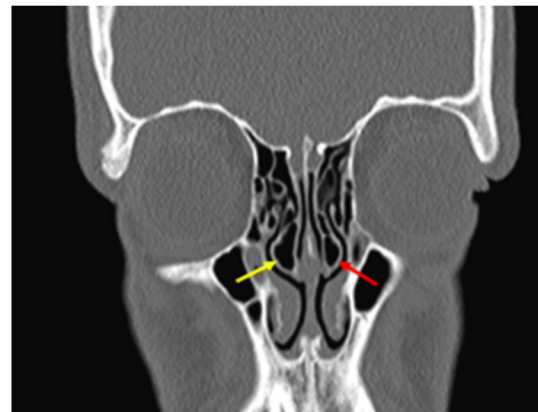
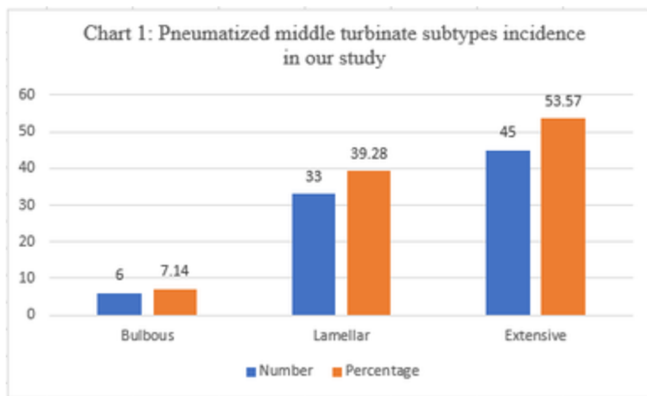
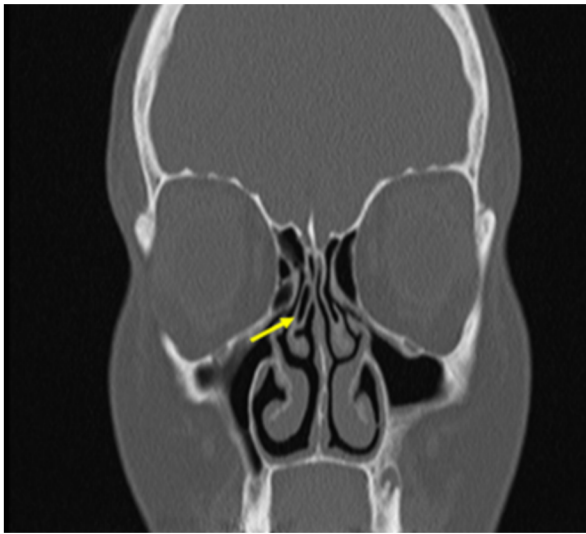


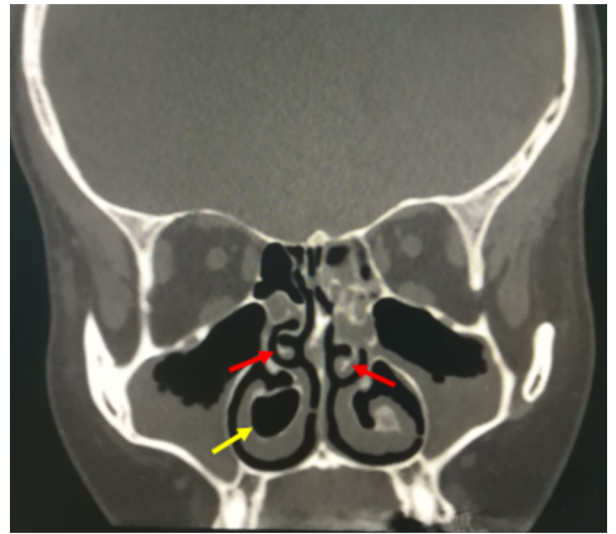
Figure 1: Coronal CT section showing right bulbous concha bullosa (Yellow arrow) and left sided extensive concha bullosa (Red arrow).



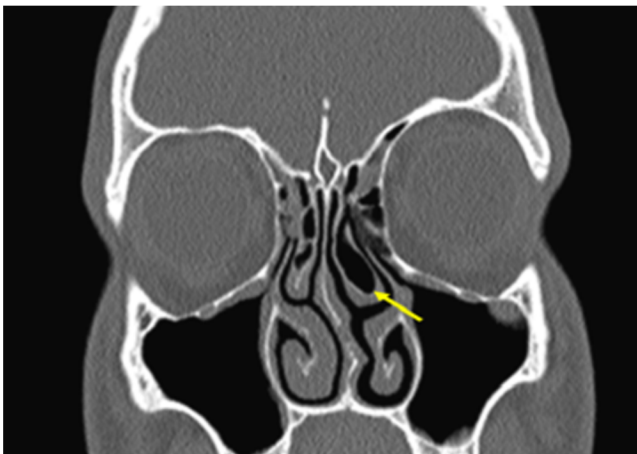
Figure 2: Coronal CT section showing left sided bulbous concha bullosa (Red arrow).



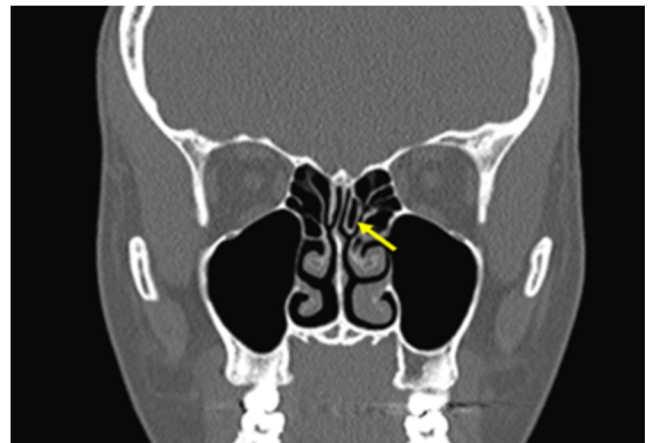
**Figure 3: Coronal CT section showing right sided lamellar concha bullosa (Yellow arrow).**



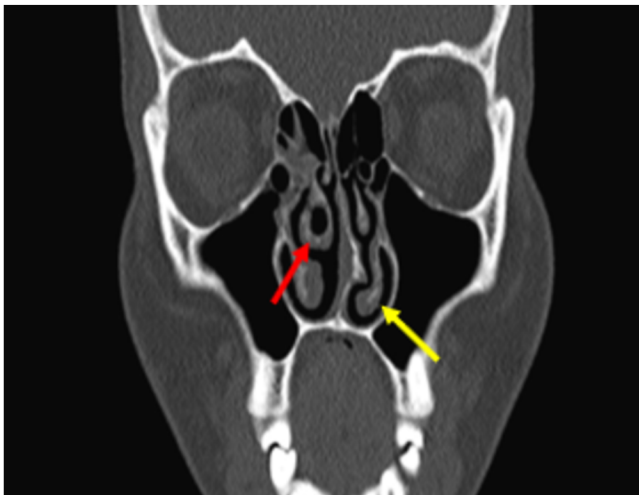
**Figure 5: Coronal CT section showing right sided pneumatized inferior turbinate (Yellow arrow) and bilateral paradoxical middle turbinate (Red arrow).**



**Figure 4: Coronal CT section showing left sided extensive concha bullosa (Yellow arrow).**



**Figure 6: Coronal CT section showing left sided pneumatized superior turbinate (Yellow arrow).**



**Figure 7: Coronal CT section showing right sided bulbous concha bullosa (Red arrow) and left sided paradoxical, inferior turbinate (Yellow arrow).**

variations on each side. These findings highlight the importance of examining each side of the nasal cavity when surgery is an option for patient management.

**Conclusion** Nasal turbinates and their anatomical variations were common in our patient cohort. These structures merit further study as explanations for patient symptoms or as landmarks for endoscopic sinus surgery in order to avoid complications.

#### **Conflict of interest**

None.

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