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(RESEARCH ARTICLE)

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Anatomical variations of the inferior nasal turbinates, Computed Tomography (CT) based study

Hisham Abdelkarim Al-rashdan [1,*], Faten Zaied Bani ata [1], Mohammad Saeed Sababhah [1], Mo'men Nayel Al-Saraireh [1], Ahmad Khaldun Ghawanmeh [1], Anas Mohammad Elamaireh [1] and Mohammed Hassan Alsmadi [2]

[1] *Department of Otorhinolaryngology, Jordanian Royal Medical Services, Amman, Jordan.*
[2] *Department of Radiology, Jordanian Royal Medical Services, Amman, Jordan.*

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Abstract

Introduction The lateral nasal wall bony structures named the turbinates or concha plays an important anatomical and physiological role in the nose, also they are considered an important surgical land marks in the era of endoscopic sinus surgery. Those turbinates are prone to a variety of structural anatomical variations. Most of the studies are focusing on the middle turbinate anatomical variations with few studies that have been done on the inferior turbinate.

Objective Investigate and report the incidence of inferior turbinate anatomical variations using computed tomography imaging.

Methods This is a retrospective study reviewing the computed tomography imaging of 200 patients that came to our otorhinolaryngology clinic. Images were reviewed for inferior turbinate anatomical variations namely: serrated, pneumatized, paradoxical and hypoplastic. Each variation was reported regarding its presence and the site of its existence.

Results our study group consisted of 103 males and 97 females aged between 18 and 60 years with mean age of 34.79±11.56. Anatomical variations of the inferior turbinate were found in 11 patients (5.5%). The observed rate of variations was as the following: serrated 2.5% (5 patients), pneumatized 1.5% (3patients), paradoxical 1% (2 patients) and hypoplastic 0.5% (1 patient).

Conclusion The inferior turbinate anatomical variations seem to be more prevalent than what is known about them to be extremely rare. Identifying and reporting those variations is important from both medical and surgical point of view.

Keywords: Inferior Turbinate; Pneumatized; Serrated; Paradoxical; Computed Tomography; Variations

1. Introduction

The nasal turbinates are anatomical structures that are located at the lateral wall of the nasal cavity. Mainly there are three turbinates; the inferior, the middle and superior and in some cases, there is a fourth turbinate named the supreme turbinate. (1)

These structures responsible for a variety of functions in the nose including humidification, filtration, thermoregulation. All of these turbinates originate and part of the ethmoid bone except the inferior turbinate which is being a separate bone. (2)

* Corresponding author: Hisham Abdelkarim Al-rashdan.

The nasal turbinates are prone to many anatomical variations which is important to be recognized when they are present at the computed tomography images as they may be the cause of the patient problem or as part of the road map when an endoscopic nasal surgery to be done. (3)

Most of the studies have been focusing on such variations that present in the middle turbinate as it plays a major role in the sinuses drainage pathway, however such anatomical variations are also present in the inferior turbinate and have not been studied and investigated in details in the literature.(4) When inferior turbinate anatomical variations are present, they are asymptomatic at most of the time and being discovered incidentally when imaging for the paranasal sinuses are done, however they may be of clinical importance as a predisposing factor of nasal problems such as nasal obstruction and rhinogenic headache.(5)

Such anatomical variations on the inferior turbinate are being recognizable due to using sinus computed tomography (CT) as the gold standard diagnostic radiological tool for sino-nasal diseases, but still the mechanism and etiology for developing of inferior turbinate variations are unknown. (6) Generally, the accepted theory regarding the presence of inferior turbinate anatomical variations is attributed to the embryological development of the inferior turbinate. The inferior turbinate develops at 6-8 embryonal weeks from the prochordal plate at the lateral wall of the nose. At 5-7 months two chondral lamella appear in the inferior turbinate and also appears two ossification centers in it and they continue to develop also after birth. (7)

Due its rare presence, inferior turbinate variations weren't studied, investigated and even classified thoroughly in the literature. Here in our study, we aim to investigate and report the incidence of inferior turbinate anatomical variations using computed tomography imaging.

2. Methods

CT scans of nose and paranasal sinuses of a total 200 patients who came to our otorhinolaryngology clinic in Prince Rashed Ben Al-Hasan Military Hospital between August 2023 and December 2024 will be analyzed and studied retrospectively. All CT scans that are being requested will be for patients who present to our otorhinolaryngology clinic complaining of sino-nasal symptoms. Images are taken in the axial plane and reconstructed to the coronal and sagittal plane.

Our exclusion criteria will be of CT scans of a patients under the age of 18 and above 60 years, history of sino-nasal surgeries, history of facial trauma, presence sino-nasal nasal neoplasm or with gross disease.

Each CT scan will be reviewed by two author doctors, each doctor will write report individually and then being compared, in cases of discrepancy radiologist opinion will be considered.

Each CT scan will be reviewed for the presence of the following inferior turbinates anatomical variations: pneumatized inferior turbinates (concha bullosa of inferior turbinate), paradoxical inferior turbinate, hypoplastic inferior turbinate, serrated inferior turbinate. Each side of the CT scan will be evaluated and the reporting will be as presence of variation (right, left and bilateral) or as absence.

The results were calculated and analyzed statistically using IBM SPSS for Windows, version 24 (IBM Corporation, Armonk, NY, USA). We used descriptive statistics such as frequencies, percentages, means, and standard deviation (SD) to represent the categorical data.

3. Results

Our study was done on 200 patients aged between 18 and 60 years with mean of age being 34.79 ±11.56. Our group study consisted of 103 male (51.5%) and 97 females (48.5%).

Inferior turbinate anatomical variations were observed in 11 patients (5.5%) only, 5 of them (2.5%) presented on the right side, 3 of them (1.5%) presented on the left side and 3 of them (1.5%) showed inferior turbinate variations on both sides, **Table 1**.

Table 1 inferior turbinate anatomical variation analysis

		No. of patients	**percentage**
Presence of variation	*Yes*	11	5.5%
	No	189	94.5%
	Total	200	100%
Side of variation	*Right*	5	2.5%
	Left	3	1.5%
	Bilateral	3	1.5%
	Total	11	5.5%

Of those 11 patients the findings were as the following: 5 patients (2.5%) with serrated inferior turbinate, 3 patients (1.5%) with pneumatized inferior turbinate, 2 patients (1.0%) with paradoxical inferior turbinate and 1 patient (0.5%) with hypoplastic inferior turbinate, **Table 2**.

Table 2 types of inferior turbinate anatomical variation

Type of variation	**Right sided**	**Left sided**	**Bilateral**	**Total & percentage**
Serrated	2 (1.0%)	1 (0.5%)	2 (1.0%)	5 (2.5%)
Pneumatized	1 (0.5%)	1 (0.5%)	1 (0.5%)	3 (1.5%)
Paradoxical	2 (1.0%)	---	---	2 (1.0%)
Hypoplastic	---	1 (0.5%)	---	1 (0.5%)
Total & percentage	5 (2.5%)	3 (1.5%)	3 (1.5%)	11 (5.5%)

4. Discussion

Inferior turbinate plays a great role in the physiology of nasal cavity, since it makes part of the internal nasal valve and also their response to allergic stimulation which will affect the patency of the nasal cavity. (8) Even being that important, it is not studied thoroughly like the middle turbinate regarding the presence of anatomical variations and their effect when they are present. Most of the inferior turbinate variations are being presented as case reports this is attributed to its rarity. (9)

Despite being rare, inferior turbinate variations shouldn't be ignored specially in the recent era of rhinology surgery in which surgeries on the inferior turbinate has gained importance and become a major part in cases in which nasal obstruction is the main issue to deal with. (10)

In our study we found no statistical significance of inferior turbinate variations between males and females even the variations were present more in males. The most anatomical variation that was found is serrated inferior turbinate and the least to be found was hypoplastic inferior turbinate.

We found in our study that 5.5% (11 patients) had inferior turbinate variations, these variations were as following: 2.5% (5 patients) serrated inferior turbinate, 1.5% (3patients) pneumatized inferior turbinate, 1% (2 patients) paradoxical inferior turbinate and 0.5% (1 patient) hypoplastic inferior turbinate.

Few studies in the literature have been done to investigate inferior turbinate anatomical variations *Demir et al* (2022) (7) has investigated inferior turbinate anatomical variations and it was 4.5%, also *Yasan et al* (2006) (11) study found that inferior turbinate variations to be 2%. *Nautial et al* (2020) (12) in his investigation showed the rate of inferior turbinate variations to be 13.37%. The results of our study are generally is keeping up with the range of results presented in the literature and such slight range difference can be attributed to ethnicity reasons. Serrated inferior turbinate **Figure 1**.

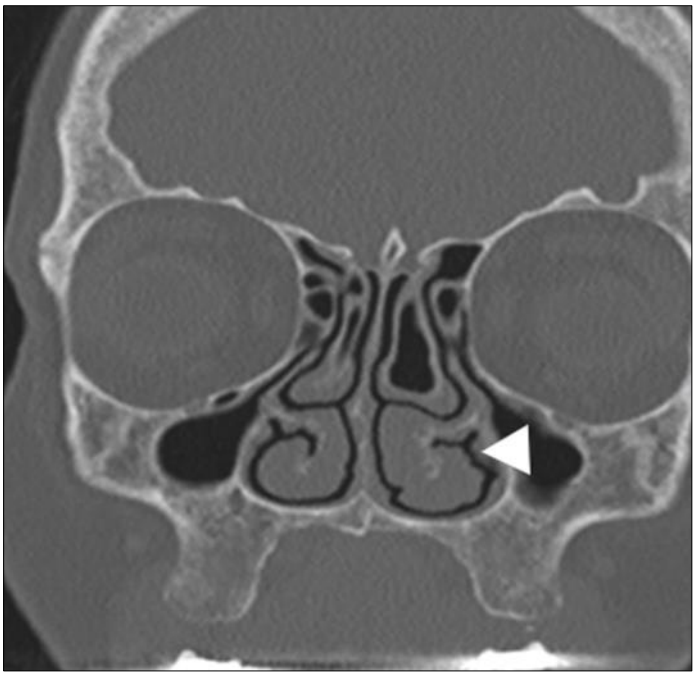

Figure 1 Coronal CT section showing left sided serrated inferior turbinate (White arrow head)

which was found in 2.5% in our study which has been investigated by *Demir et al* (2022) (13) and their results was 2.6% and according to their study it can be used as a radiological marker for diagnosing allergic fungal sinusitis. This entity of inferior turbinate variation needs to be investigated more in order to confirm its association with allergic fungal sinusitis. Pneumatization of the inferior turbinate (concha bullosa of inferior turbinate) is considered rare entity and discovered during radiological investigation incidentally, **Figure 2**.

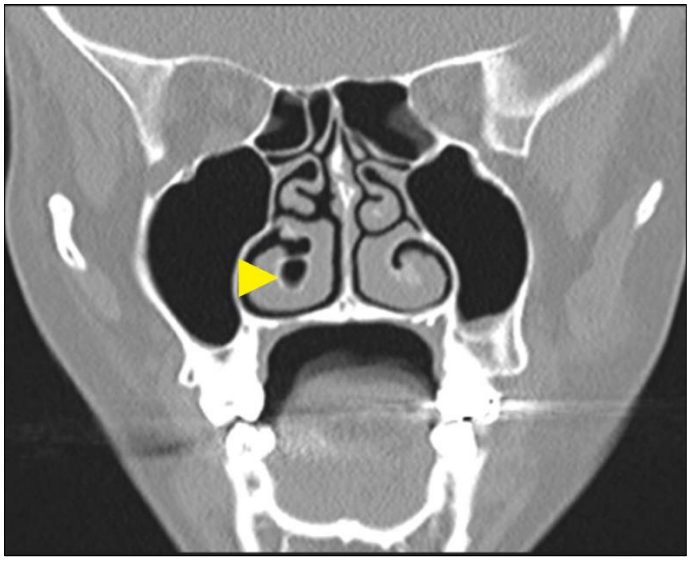

Figure 2 Coronal CT section showing right sided pneumatized inferior turbinate (Yellow arrow head)

The importance of recognizing this variation is that it can be the cause of nasal obstruction which being attributed to hypertrophied inferior turbinate while in reality it is just large because it is pneumatized in which intranasal drug treatment will not relieve the patient problem.(14) In our study pneumatization of inferior turbinate rate was 1.5% even in the literature it is reported to be less than 1% however *Özcan et al* (2008)(15) reported it to be 2.5% and *koo et al* (2017) reported its rate as 1%. Paradoxical inferior turbinate is being famous to be the rarest among inferior turbinate variations, **Figure 3**. (16)

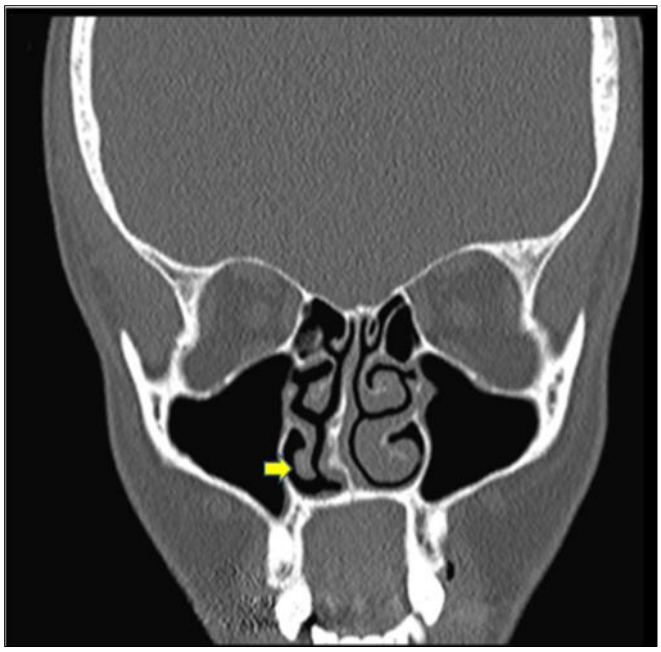

Figure 3 Coronal CT section showing right sided paradoxical inferior turbinate (Yellow arrow)

In our study it was present in 1% of the study group which is consistent with the rates in the literature. Such variation in our study was noted to be associated with septal bony spur toward the paradoxical inferior turbinate which can explain its presence. However, this association need further studies to confirm the cause and result and whether there is isolated paradoxical inferior turbinate not associated with such deviated septal spur on it and to be further studied as a possible cause of rhinogenic headache. (17)

In our study hypoplastic inferior turbinate was the least to be found at a rate of 0.5%, **Figure 4**.

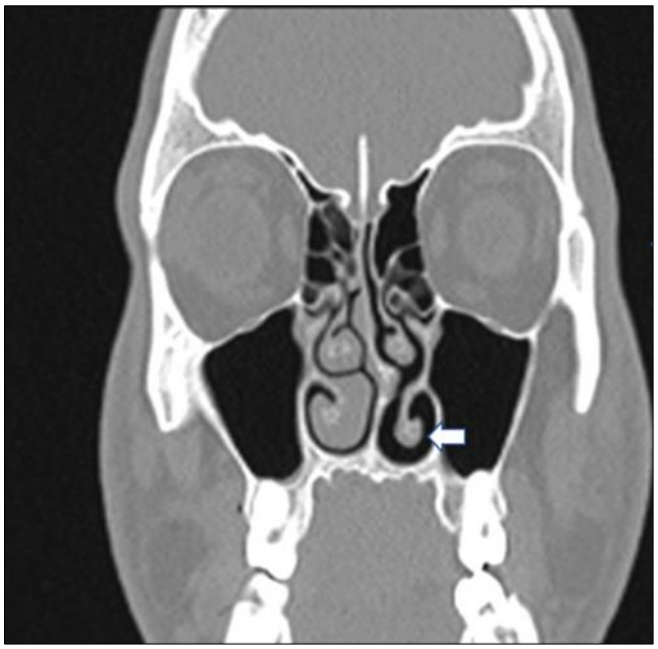

Figure 4 Coronal CT section showing left sided hypoplastic inferior turbinate (White arrow)

Our result is keeping up with the its rate 0.7% reported by *Yasan et al* (2006) (11) and the rate reported by *Demir et al* (2022) (7) which was 0.3%, even such variation was reported at a higher incidence being 11.55% by *Nautial et al* (2020) (12), this can be attributed to the possible effects of environmental factors or ethnicity variations.

It our study we focused the light on some of inferior turbinate anatomical variations in order to know their rates among our population and compare it with the rate among the literature, **Table 3**.

Table 3 Comparing our study results to other studies in the literature

	Serrated %	**Pneumatized %**	**Paradoxical %**	**Hypoplastic %**
Yasan et al (2006)(11)	---	0.13%	1.01%	0.70%
Özcan et al (2008)(15)	---	2.50%	---	---
Koşar et al (2019)(18)	---	0.40%	0.03%	---
Nautial et al (2020)(12)	---	0.91%	---	11.55
Demir et al (2022)(7)	2.60%	0.80%	0.30%	0.30%
Our study	2.50%	1.50%	1.00%	0.50%

Further studies are needed over a larger number of populations in order to have more precise rates and more studies are needed to investigate all the other possible inferior turbinate variations that could be present and to corelate their presence regarding the anatomical and functional issues of the nasal cavity.

5. Conclusion

The inferior turbinate is an important part in the lateral wall of the nasal cavity, so it is important to recognize the anatomical variations that may present in it even if they rare since they maybe the cause of patients complains that are not responding to medical management such as nasal obstruction, rhinogenic headache or even atypical facial pain. Also, such variations are important to be recognized from surgical point of view since the inferior turbinate makes an important landmark in endoscopic nasal surgery or when the inferior turbinate is being the operated nasal structure.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed

Statement of informed consent

Due to the retrospective nature of this study, Informed consent from patients was waived.

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