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Role of computed tomography in the assessment of anatomical variations of ethmoid sinus

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Abstract
Introduction: Anatomical variations of ethmoidal sinuses are complex and surgically very important. Preoperative detection of these variants is important to prevent surgical complications. Multidetector Computed Tomography (MDCT) is the modality of choice for evaluation of these variants of ethmoidal sinuses.
Aim: To study the normal anatomical variations of ethmoidal sinuses by 16 slice MDCT.
Materials and Methods: This was a retrospective analysis of paranasal sinuses in 70 cases by MDCT in adults. Axial and coronal images of Paranasal Sinuses (PNS) were taken by 16 slice MDCT. Statistical analysis was done using SPSS version 20.0.
Results: Present study shows haller cells as the most common anatomical variant with 21 (30%) cases, followed by onodi cells in 10 (14.29%) cases, agger nasi cell in 9 (12.86%) cases and supra orbital cell in 8 (11.43%) patients.
Conclusion: Ethmoidal sinuses form a major component of paranasal sinuses that have high prevalence of anatomical variations. These ethmoid sinus anatomical variants are frequent causes for complicated sinus inflammatory pathologies and failed sinus surgeries. The surgeons must be aware of the anatomical variations to avoid untoward surgical complications and for better surgical outcome.

Keywords: Agger nasi, Haller cell, onodi cell, supraorbital cell, Paranasal sinuses and MDCT (Multidetector computed tomography)

Introduction
Paranasal sinuses are group of airfilled cavities that start developing from intrauterine life to early adulthood. Ethmoidal air cells are present at birth and are one among the paranasal sinuses having highest anatomical variations [1]. Anatomical variants are important to know as they are associated with higher risk of inflammatory process and post sinus surgery outcomes [2]. The success of functional endoscopic sinus surgery depends upon adequate details of anatomy of ethmoidal and other paranasal sinuses. MDCT is the modality of choice for evaluation of normal anatomical variations of ethmoidal sinuses. Acute and chronic rhinosinusitis are the most common medical problems encountered in day today practice and understanding the ethmoidal sinus anatomy and its variations will help surgeons for better outcome of medical or surgical management [3].

Aims and Objectives
To evaluate the normal anatomical variations of ethmoid sinus using Computed Tomography.

Materials and Methods
It is a retrospective study and was carried out for a period of 12 months. The CT PNS of 70 patients were performed who were referred to the Department of Radio diagnosis at sree mookambika institute of medical sciences, kulasekharam, kanniyakumari. The clinical and demographic data were recorded after due consent.
All the patients were subjected to computerized tomography of the PNS with CT (Seimens 16 slice Somatomscope) machine. Direct scans of 1 mm thickness with an increment of 0.5 mm were made.
Multiplanar reconstruction was done in axial, coronal, and sagittal planes. For the axial scans the orbito-meatal line was taken as reference with the patient in supine position.
The exposure settings used were 100 kVp and 300 to 325mAs.

Statistical analysis
All the data was entered in Microsoft excel sheet for analysis. Analysis was done using Microsoft Excel 2013, SPSS 20.0.

Results
Out of 70 cases, 36 (51.43%) were males and 34 (48.57%) were females, age of the cases ranged from 19 to 75 years with a mean age of 35 years. Distribution of anatomical variants is shown in [Table/Fig-3] with bar diagram.
Haller cells (figure 4,5) were the most common variant, being present along the medial part of the roof of maxillary antrum, inferior to ethmoid bulla and lateral to uncinate process, found in 30%. Onodi cells (figure 6), the posterior most ethmoid cells were present in 14.29%. Agger nasi cells (figure7) were identified in the sagittal plane by their anterior most location among the ethmoid groups of air cells in 12.86% cases. The least common variant encountered in our study was supraorbital cell (figure 8) in 11.43% of cases.
The study was done among 70 individuals. Among them, 36 were males and 34 were females. This is given in the following table.

Table 1: Distribution of study population according to sex (n = 70)

S. No	Sex	Number	Percentage (%)
1	Male	36	51.43
2	Female	34	48.57
	Total	70	100

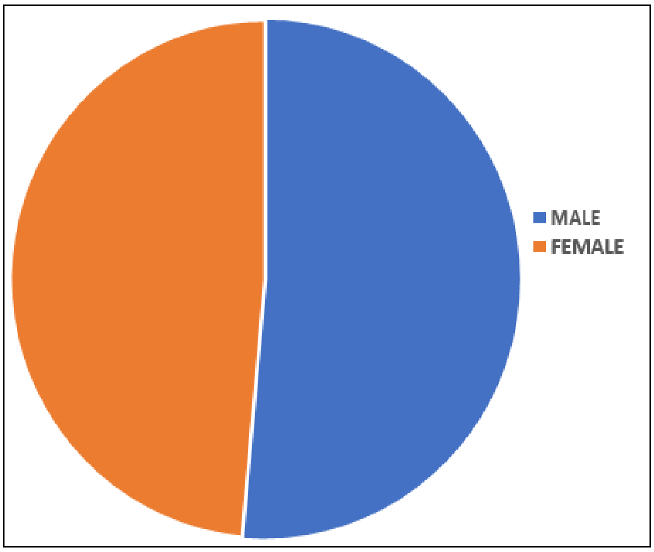

Fig 1: Distribution of study population according to sex (n = 70)

Table 2: Distribution of study population according to age (n = 70)

S. No	Age in years	Number	Percentage (%)
1	18 – 20	4	5.71
2	21 – 30	11	15.71
3	31 – 40	22	31.43
4	41 – 50	16	22.86
5	51 – 60	10	14.29
6	≥ 70	7	10
	Total	70	100

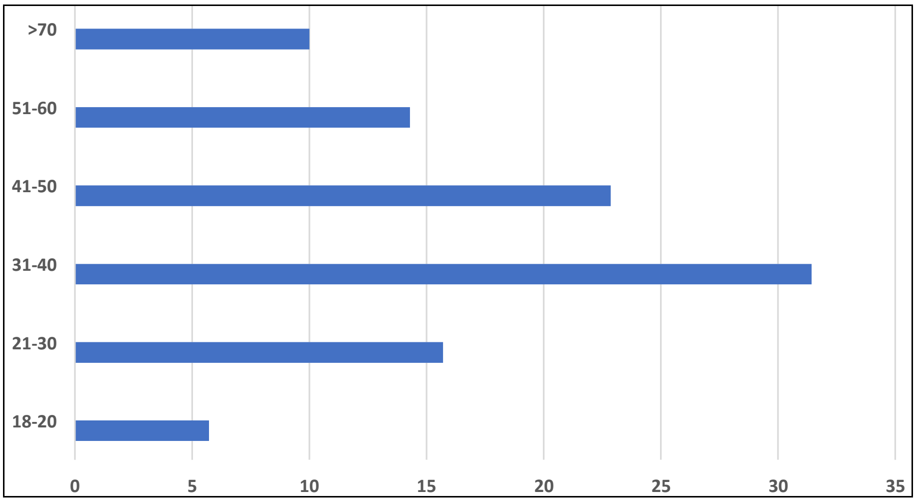

Fig 2: Distribution of study population according to age (n = 70)

Ethmoidal cell variations
The ethmoidal cell variations present in the study population is given in the table 3.

Table 3: Distribution of study subjects according to ethmoidal cell variations (n =70)

S. No	Ethmoidal cell variations	Normal (%)	Right (%)	Left (%)	Bilateral (%)	Total (%)
1	Haller	49 (70)	14(20)	5 (7.14)	2 (2.86)	70 (100)
2	Agger nasi	61(87.14)	5 (7.14)	4(5.72)	0 (0)	70 (100)
3	Onodi	60 (85.72)	6 (8.57)	4 (5.71)	0 (0)	70 (100)
4	Supra orbital cell	62 (88.57)	4(5.72)	1(1.43)	3(4.28)	70 (100)

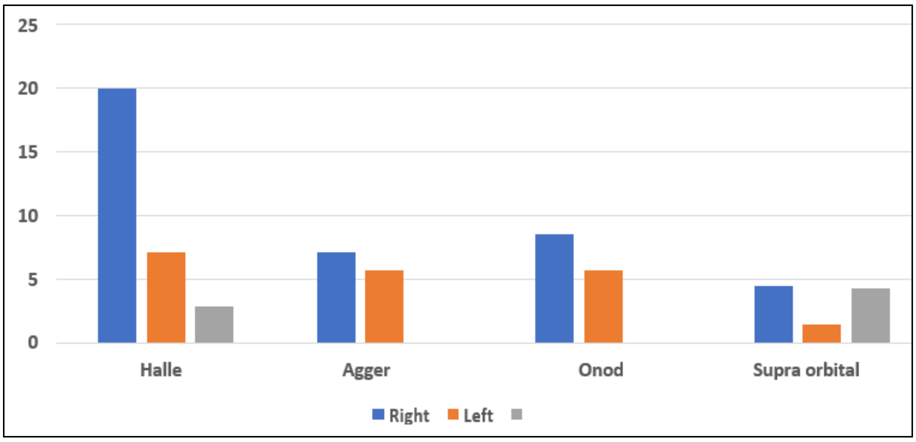

Fig 3: Distribution of study subjects according to ethmoidal cell variations (n =70)

Fig 4: coronal section of CT PNS shows haller cell (Right side)

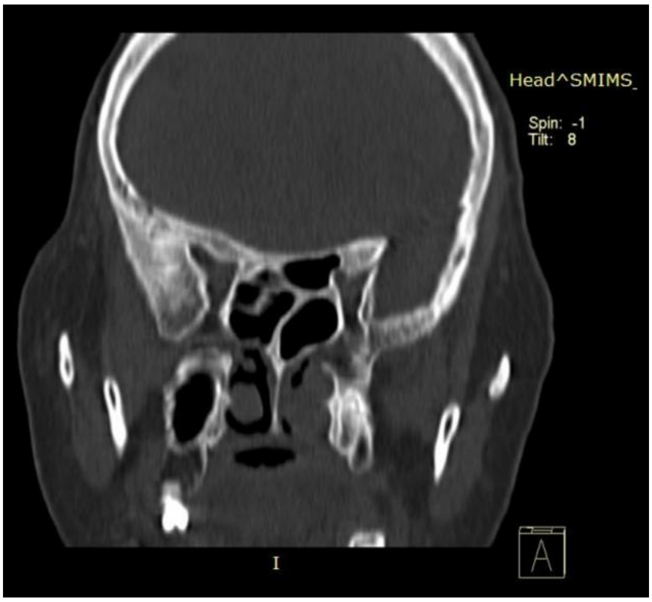

Fig 6: coronal section of CT PNS shows onodi cell.

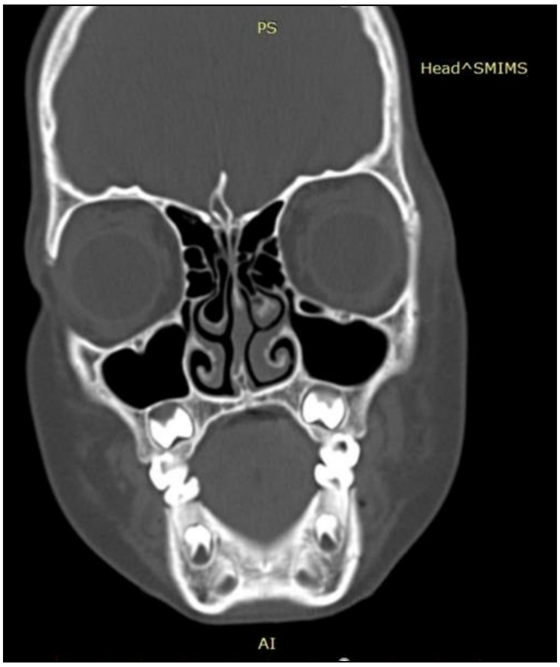

Fig 5: coronal section of CT PNS shows haller cell (Left side)

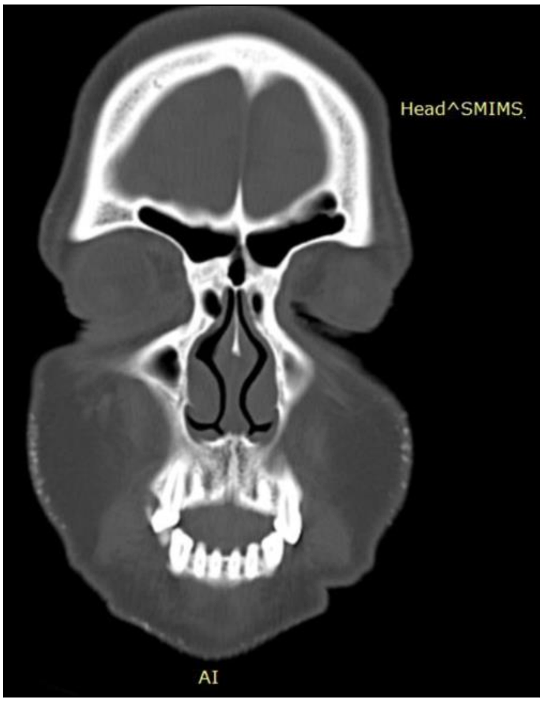

Fig 7: coronal section of CT PNS shows bilateral agger nasi cell.

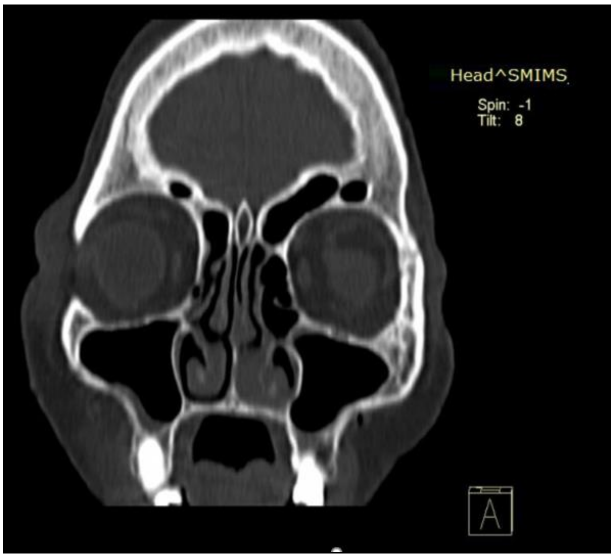

Fig 8: coronal section of CT PNS shows bilateral supraorbital cell.

Discussion:

The ethmoid sinus is fully grown at about 12 years and contains 3-18 cells at each side.

The ethmoid sinus consists of a left and right part where the air cells are located. They are located roughly between the eyes. The lateral limits are also the medial orbital walls. The roof of the superior meatus is formed by the cribriform plate. Immediately above it is the olfactory nerve, which gives off small filaments through microscopic foramina (fig.7).

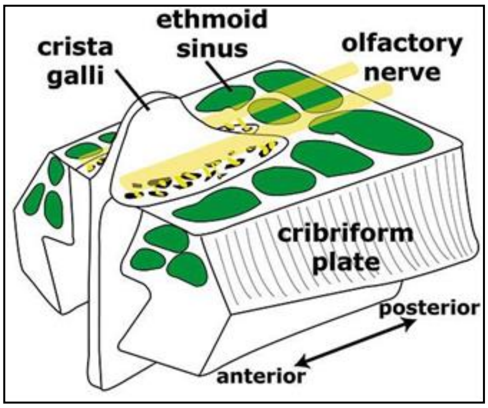

Fig 7: Schematic representation of the cribriform plate and the olfactory nerve.

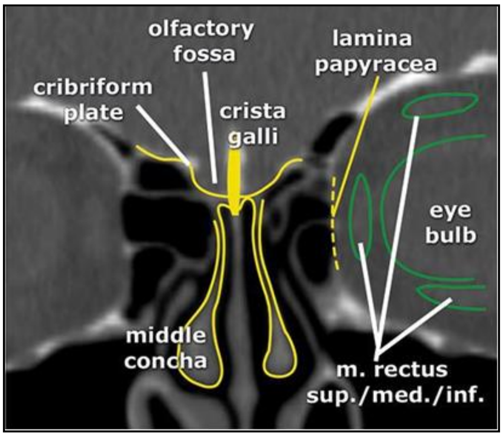

Fig 8: Coronal direction; upper limit and lateral limit (lamina papyracea) of the ethmoid sinus.

Finally, the ethmoid sinus is subdivided into an anterior complex and posterior complex.

The anterior ethmoid cells drain into the middle meatus. The posterior ethmoid cells drain into the superior meatus (fig. 9).

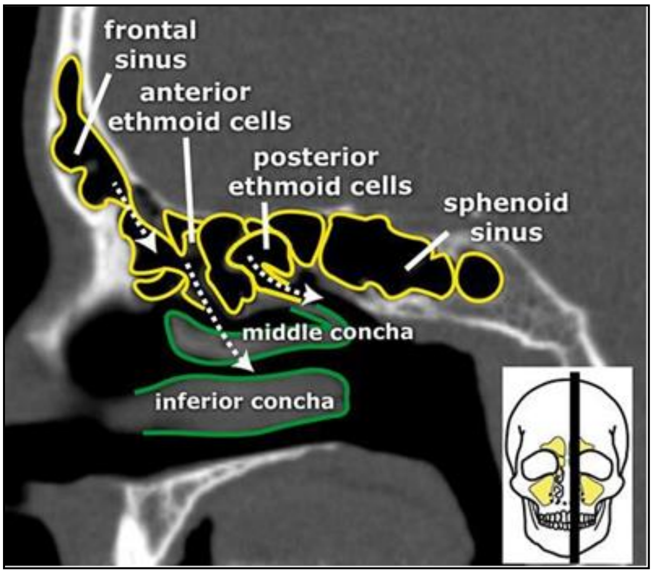

Fig 9: Sagittal direction. Drainage tract of the anterior/posterior ethmoid cells.

Note: The semilunar hiatus seems to reach above the middle concha on this sagittal image. However, this structure is the winding of the medial concha. The insertion of the concha is above this level, and therefore the area shown is the middle meatus.

Agger nasi cells

The agger nasi cells (Latin for 'nasal mound') are the most anterior ethmoid cells. They are extramural cells (not confined within the ethmoid bone) and extend anteriorly into the lacrimal bone. They are anterior to the anterior attachment of the middle turbinate to the skull base.

Viewed in the sagittal plane, they are located anteriorly and inferiorly to the frontal recess. On coronal CT, they appear as inferior to the frontal recess and lateral to the middle turbinate. The bulla ethmoidalis is a prominent anterior ethmoid air cell. A degree of pneumatisation may vary, and failure to pneumatise is termed torus ethmoidalis.

The number, size, and location of anterior ethmoidal air cells vary widely among individuals, although agger nasi cells vary least in this regard. By contributing to obstruction of frontal sinus drainage, the agger nasi cell may play a role in acute and chronic frontal sinus disease. Further, incomplete removal of this cell during ethmoidectomy may produce iatrogenic disease in a previously normal frontal sinus. This article presents anatomic, radiologic, and clinical information regarding the role of the agger nasi cell in the development and treatment of frontal sinus disease.

Pneumatization of the agger nasi can encroach upon and narrow the nasofrontal duct (NFD) and contribute to chronic frontal sinus disease.

Haller cell

Haller's cells are defined as air cells situated beneath the ethmoid bulla along the roof of the maxillary sinus and the most inferior portion of the lamina papyracea, including air cells located within the ethmoid infundibulum [4]. Haller's cells, first described by the Swiss anatomist Albert von Haller in 1765, are also known as maxillo-ethmoidal or orbito-ethmoidal cells [5, 6]. Haller's cells are thought to arise in individuals with pneumatization of the lateral crus [7].

Although Haller's cells are anatomical variations in the development of the nose and paranasal sinuses, they have been held responsible for patient's symptoms and are thus clinically significant [4, 5]. In addition to distressing orofacial pain and sinusitis, numerous pathologies and symptoms associated with this entity include nasal obstruction, impaired nasal breathing, headache, chronic cough and mucoceles [4, 5, 8, 11]. Haller's cells can also restrict access to the maxillary sinus or the anterior ethmoidal cells during endonasal procedures, making it imperative for the surgeon to be aware of such variations that may incline the patient to increased risk of intraoperative complications [7, 8].

Infraorbital ethmoid cells have been described as well-defined, round, oval or teardrop-shaped radiolucencies (single or multiple), unilocular or multilocular with a smooth border which may or may not appear corticated, and are located medial to the infraorbital foramen according to a solitary panoramic radiographic study [5]. The clinical significance of these entities and the lack of noteworthy research initiated this study with an aim to determine the prevalence and scrutinize the characteristics of Haller's cells on panoramic radiographs.

Onodi cell

The Onodi cell was first described by Adolf Onodi in 1904 [12-15] and has varying definitions according to different sources. The Onodi cell is a posterior ethmoid air cell that lies superior to the sphenoid sinus and is in close proximity to at least one optic nerve or internal carotid artery (ICA). This close proximity of the onodi cells to the optic nerve and ICA is a risk factor for surgical complications. Identification of the onodi cell is therefore imperative to minimize perioperative morbidity.

In addition to being the posterior most ethmoid cell, common descriptions of the onodi cell include at least one of the following properties: having an endoscopically identifiable optic canal bulge (42-51% of studied specimens were found to have onodi cells according to this criterion) [16, 17] or having lateral and superior pneumatization relative to the sphenoid sinus and being in close association with the optic nerve, without prominence of the optic nerve tubercle or ICA being absolutely necessary [13, 15, 18]. These definitions distinguish the Onodi cell from the overriding posterior ethmoid cell as defined by Thanaviratananich *et al*. because of the close association of the optic nerve with the Onodi cell [19].

The best radiographic tool to analyze the sphenoid sinus and its surrounding structures is the computed tomography (CT) scan, looking in all three anatomic planes when possible [8]. The incidence of Onodi cells as detected by CT scans is commonly cited as 8-24% [15, 18, 20]. Preoperative CT examination of the sphenoid sinus can help plan the safest and most direct route to the sella and parasellar region and can detect anatomic variations that increase the risk for intraoperative complications, including vision loss, hemorrhage, and cerebrospinal fluid (CSF) leak. Operative difficulties and complications may result from a lack of thorough radiographic evaluation to fully understand the marked variability in the anatomy of the sphenoid sinus and its related structures.

Supraorbital air cells

Supraorbital cells originating from the anterior ethmoid air cells extending posteriorly and superiorly over the orbit from the frontal recess. They may mimic septated frontal sinuses as their posterior wall is the skull base.

When a supraorbital cell is present, care should be taken on pre-functional endoscopic sinus surgery imaging studies to identify the anterior ethmoidal notch as the anterior ethmoidal artery is usually seen freely traveling within the ethmoid air cells and thus at greater risk of intraoperative injury. Moreover, these cells may contribute to obstructing the frontal recess and may be mistaken preoperatively for the frontal recess.

Conclusion

Ethmoidal sinuses form a major component of paranasal sinuses and have higher anatomical variants compared to other sinuses. Their prevalence and anatomical variations should be known for operating surgeons to avoid untoward surgical complications also aiding in better medical and surgical outcomes. Such population studies give an insight into the true prevalence of the anatomic variations and provide valuable information to the operating surgeons.

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