# Role of Computed Tomography in Evaluation of Anatomical Variations of the Paranasal Sinuses - CT Findings in 350 Patients

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**Abstract:** ***Objective**: To study the diagnostic accuracy and efficacy of CT scan in evaluation of various anatomical variations of the paranasal sinuses in 350 patients. Design: A prospective study of anatomic variations of paranasal sinus was done on 350 patients with sinusitis and non-sinusitis patients who undergo for computed tomography (CT) for various regions. **Results**: Various types of anatomical variations were observed in the study. The most frequent anatomical variation found was septal deviation (60.8%), followed by presence of concha bullosa (34.3%). Other variations found were paradoxical middle turbinate(10.6%), agger nasi cell (36.1%), haller cells (11.7%) onodi cells(17.1%), uncinate process pneumatization (5.4%), superior attachment of uncinate process to lamina papraycea, to middle turbinate(11.7%), to skull base (17.4%) and free(21.1%), anterior clinoid process pneumatization(15.4%), frontal sinus hypoplasia (2.1%), crista galai pneumatization (1.1%). **Conclusion**: Computed Tomography of the paranasal sinus has improved the visualization of paranasal sinus anatomy. The radiologist must pay close attention to anatomical variants in the preoperative evaluation. It is important for surgeon to be aware of variations that may predispose patients to increased risk of intraoperative complications and help avoid possible complications.*

**Keywords:** computed tomography; anatomical variations

## 1. Introduction

The Paranasal sinuses are hollow, air-filled spaces located within the bones of the Face and surrounding the nasal cavity, a system of air channels connecting the nose with the back of the throat. There are four pairs of sinuses, each connected to the nasal cavity by small openings. They comprise the frontal, ethmoidal, maxillary and sphenoid sinuses. The paranasal sinuses decrease the weight of the skull, warm and moisturize the inhaled air, regulate speech resonance and intranasal pressure, and improve the sense of smell.

As human, anatomy is subjected to a large number of anatomical variations; the same rule applies to the paranasal sinus region too. The anatomical variations of lateral nasal wall and Para nasal sinuses are surgically and patho-physiologically important because they narrow the drainage pathway of the para nasal sinuses, which in turn lead on to stagnation of secretions, then infection and inflammation of the mucosa lining the sinuses. some of the anatomical variations such as septum deviation, concha bullosa, paradoxical curvature, big Agger nasi cell, Haller cell, uncinate process variations could play roles in the etiology of the disease, other such as Onodi cell is important for determination of limits during functional endoscopic sinus surgery (FESS). After the arrival of sinus surgery, great attention has been directed towards analysis of paranasal sinus anatomy through CT imaging. This investigation was done to determine the mucosal abnormalities and bony anatomic variations of paranasal sinuses and assess the possible pathogenecity of these findings in patients undergoing evaluation for sinusitis or sinus surgery. While conventional plain radiography readily demonstrates maxillary and frontal sinus disease but these provide limited views of the anterior ethmoid cells, the upper two thirds of the nasal cavity and the frontal recess.[1] CT imaging provides detailed information of the paranasal sinuses and established as an alternative to standard radiographs.[2]

Hence, the safe and effective performance of any surgery is dependent on a sound knowledge of anatomy of paranasal sinus. This is most true during endoscopic sinus surgery because of the intimate association with such vital structures as the orbit, optic nerve, anterior and posterior ethmoidal vessels, skull base and internal carotid artery. The difficulty is compounded by the occurrence of variations in sinonasal anatomy. So present study to evaluate the anatomical variations of paranasal sinuses by CT scan.

## 2. Materials and Methods

The present study was carried in the department of anatomy, in collaboration with department of Radio diagnosis, S.M.S medical college, and Hospital, Jaipur. Before starting study all ethical consideration for the subjects were taken in accounts permission was obtained from ethical committee of college. An informed consent was obtained from each patient for inclusion in this study. Total 350 patients (chronic sinusitis and non- sinusitis) were selected with age ranges between 20 to 70 years who fulfilled inclusion criteria in present study. sinonasal malignancy or past h/o surgery in the paranasal region were not included in this study. Patients selected for the study were subjected to detailed history. Patients referred to the department of Radio diagnosis for CT scan from various outpatient departments for evaluation of anatomical variations of paranasal sinus region. CT scan was performed in a Philips ingenuity CT scanner in Soni hospital CT & MRI Centre, S.M.S medical College and hospital, Jaipur.

**Parameters Used For Sinus CT**

Patient position: Prone in coronal, Supine in axial.
Angulation: Perpendicular to infra-orbito meatal line in coronal selections,
Parallel to infra-orbito-meatal line in axial sections.
Thickness: 0.9mm with 3mm incrementation in coronal and axial sections.

Extent of the study: For axial studies, sections were taken from hard palate to upper margin of frontal sinus. For coronal studies, sections were taken from anterior margin of frontal sinus to posterior margin of sphenoid sinus.

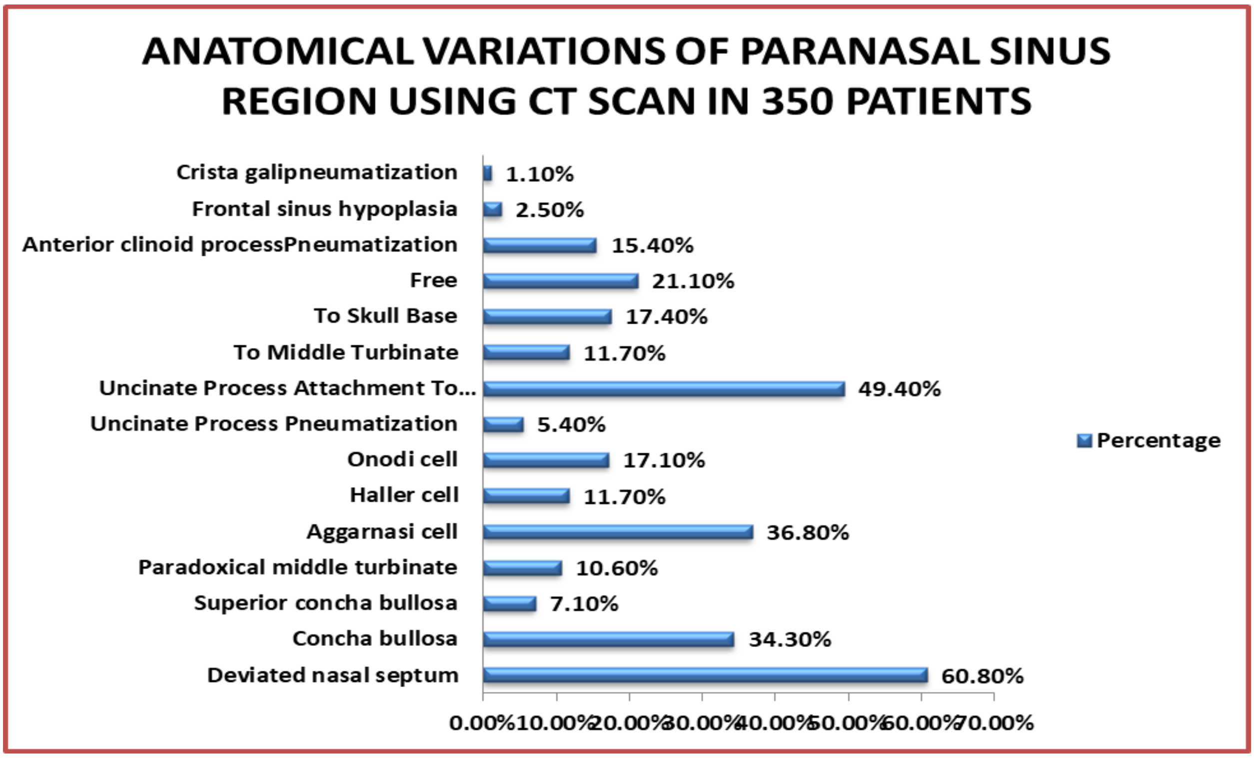
The scans were recorded in the form of DICOM (Digital imaging and Communications in Medicine) format. The CT scans was evaluated for the presence of anatomic variants of the paranasal sinus region. While studying the coronal scans antero-posteriorly, parallel to the osteomeatal unit, first the frontal sinus was visualized followed by nasal septum, inferior concha, middle concha along maxillary air sinus, anterior ethmoidal air cells. As moved posteriorly the superior concha along with posterior ethmoidal air cells and the sphenoidal air sinuses were visualized. In this way the anatomical variations such as agger nasi cells, nasal septal deviation, septal pneumatization, middle concha variations such as concha bullosa and paradoxical middle turbinate, inferior concha, Haller cells and Onodi cells were studied. Accessory maxillary ostium, uncinate process variatians, anterior clinoid process pneumatisation, sinus hypoplasia and other uncommon variations were also studied. The axial scans were studied infero-superiorly, these were parallel to the hard palate and perpendicular to the osteomeatal unit, were helpful mainly in identifying the septal deviation, concha bullosa and the sphenoidal sinus along with the Onodi cells. Anatomical findings of each patient was carefully scrutinized and recorded on the patient's data sheet.

## 3. Results

A total of 350 CT scans of nose and paranasal sinuses were reviewed. The patients were between 20 to70 years of age. Among the 350 subjects 125 (35.7%) of patients were female and 225 (64.3%) of patients were male. Among the various bony anatomic variations seen on CT scan, Deviated nasal septum was the commonest one seen in 213 (60.8%) patients. Concha bullosa was seen in 120 (34.3%) patients. Superior concha bullosa was seen in 25 (7.1%) patients. Paradoxical curvature of middle turbinate was seen in 37 (10.6%) patients. Agger nasi cells were seen in 129 (36.8%) patients. Haller cells were seen in 41 (11.7%) patients. Onodi cell was seen in 60 (17.1%) patients. Uncinate process peumatization was noticed in 19 (5.4%) patients. Superior attachment of uncinate process to lamina papracea in 173 (49.4%) patients, to middle turbinate 41(11.7%), to skull base 61(17.4%) and free type in 74 (21.1%) patients. Anterior clinoid process peumatization was seen in 54 (15.4%) patients. Frontal sinus hypoplasia and crista gali penumatization was in 9 (2.5%) and 4 (1.1%) patients respectively.

**Table 1:** Anatomical Variations of Paranasal Sinus Region Using CT Scan In 350 Patients

| Anatomical Variations Of Paranasal Sinus Region Using Ct Scan In 350 Patients | | |
|---|---|---|
| Anatomical variations | Number | Percentage |
| Deviated nasal septum | 213 | 60.8% |
| Concha bullosa | 120 | 34.3% |
| Superior concha bullosa | 25 | 7.1% |
| Paradoxical middle turbinate | 37 | 10.6% |
| Aggar nasi cell | 129 | 36.8% |
| Haller cell | 41 | 11.7% |
| Onodi cell | 60 | 17.1% |
| Uncinate Process Pneumatization | 19 | 5.4% |
| Uncinate Process Attachment<br>To Lamina Papyracea | 173 | 49.4% |
| To Middle Turbinate | 41 | 11.7% |
| To Skull Base | 61 | 17.4% |
| Free | 74 | 21.1% |
| Anterior clinoid process Pneumatization | 54 | 15.4% |
| Frontal sinus hypoplasia | 9 | 2.5% |
| Crista gali pneumatization | 4 | 1.1% |




## 4. Discussion

The Anatomical variations in human paranasal air sinuses and lateral wall of the nose have been studied since centuries, but with advent of recent imaging techniques which is computerized tomography scanning (CT scan), variations have been identified much more extensively and precisely. Appropriate radiologic imaging and accurate interpretation of anatomical variants play an important role in the diagnosis and management of the chronic rhinosinusitis. The prevalence of anatomical variations of nose and PNS were presented differently in various studies and it could be due to the result of discrepancies in analyzing and studying methods, definitions, racial varieties and the accuracy of study.(M Daghighi, Stammberger HR)

As a deviated nasal septum is a normal occurrence in the population rather than an abnormal variation. Septal deviation causes lateral compression of the middle turbinate and uncinate process pushing them into the infundibulum and thus causes obstruction of osteomeatal complex. In various studies the finding of nasal septal deviation ranged from 14.1% to 80%. In present study, among all the anatomical variants deviated nasal septum is the most common variant, found in 213 study population accounting for 60.85% of cases. Similar results were in a study done by Mamatha et al. (2010), Aprajita Awasthi et al (2016) Parul Sachdeva et al (2017), and recently Mallikarjun M et al (2019) et al, prevalence of deviated nasal septum was reported to be 65%, 64%, 68%, and 62% , respectively.

The middle concha bullosa is a result of pneumatization of the thin bony plate due to extension of ethmoidal cells. The presence of a concha bullosa has ranged between 4% and 80% in different studies. In our study, the incidence was 34.28% which is less compared to 53.6% observed by Bolger, Zinreich et al (36%) and more compared to incidence reported by Dua K (16%), Peres et al (24.5%) and Mamtha et al (16%). These differences in the incidence may depend on the criteria of pneumatisation and on the method of analysis by different researchers.

The middle turbinate may be paradoxically curved i.e. bent in the reverse direction. Normally, the convexity of the middle turbinate bone is directed medially, toward the nasal septum. When paradoxically curved, the convexity is directed laterally, toward the lateral sinus wall. The rates of PMC are ranging from 8 to 26 % in the literature. In present study it was found in 37 patients (13%). The incidence of 13% in this study is close to the10 % incidence described by Peres et al. other study results were 19.17% by Lakshmi Vijaya kumar and 27% by Bolger et al.

Agger nasi cells are the most anterior ethmoid cells located in the anterior floor of the frontal sinus, on the drainage pathway of the frontal sinus. The incidence of Agger Nasi cells on cadavers and CT images is reported in various rates in different studies ranging from 10 to 89 %. These cells were present in 129 patients (36.9%) in our study. Similar results were observed by 40% by Dua et al, 41.1% by Lakshmi Vijayakumar et al. The prevalence is less as compared to 98.5% by Bolger, 88.5% by Maru et al and in anatomic dissections; Messerklinger encountered the Agger nasi cells in 10-15% of the specimens, Davis et al found in 65% of specimens.

Haller cells were first described by Albert von Haller in the beginning of the 19th century as the cells extending out from the ethmoidal labyrinth to the maxilla. Haller Cell that develops into the medial floor of orbit adjacent to and above the maxillary sinus ostium, the rate of HC was ranging from 2 to 56.6 % in the literature. (Bolger, Yanagisawa)The incidence of Haller's cells in present study was 41(11.7%). Zinreich reported an almost similar incidence of 10%. This is again very less as compared to that reported Dua et al

16%, Mamatha H et al 17.5%, Perez-Pinas et al 20%, Maru et al 36%, and more as compared to Jaiger et al 8%, Tiwari R et al 3.50%. Possible reasons for this discrepancy include differences in interpretation of Haller cells, or in the technique of CT scanning.

Onodi cells or sphenoethmoidal cells are posterior ethmoid cells that extend posteriorly, laterally and sometimes superior to sphenoid sinus. The rate of OC in previous studies has a very wide range (3.4–51 %). These cells were present in 60 patients (17.14%) in our study. Similar results were found in Yadav RR at study. The frequency of Onodi cell was 18.8% with equal frequency in both male and female (9.4%). 10.9% by Pere, 11% by Bogler, Nitin V Deosthale et al 4.09% patients, Nouraei et al (4.7%) and Fadda et al (8.5%).

In present study Pneumatized Uncinate Process interestingly found in 5.4% cases, are compatible with the literature. Similar results were found in study of Nitin V Deosthale et al (6.55 %, ), Karthika Rajeev et al (5.75%), Superior attactment of uncinate process to lamina papracea in 173 (49.4%) patients, to middle turbinate 41(11.7%), to skull base 61(17.4%) and free type in 74 (21.1%) patients. Sushilkumar Kale et al noted that the superior attachment of the uncinate process to the lamina papyracea (84%) which was the most common attachment followed by to the skull base (8%) and then to the middle turbinate (6%). Free lying type of uncinate process was only in 2% of cases which was the least common.

## 5. Conclusion

Within the limits of our study we conclude that Computed Tomography of the paranasal sinus has improved the visualization of paranasal sinus anatomy. It helps in evaluating the exact anatomy and find out the congenital or abnormal anatomical variations. Anatomical variations are common in the paranasal sinus region. Awareness of the possibility of such variations helps in making therapeutic decisions. The radiologist must pay close attention to anatomical variants in the preoperative evaluation. It is important for surgeon to be aware of variations that may predispose patients to increased risk of intraoperative complications and help avoid possible complications.

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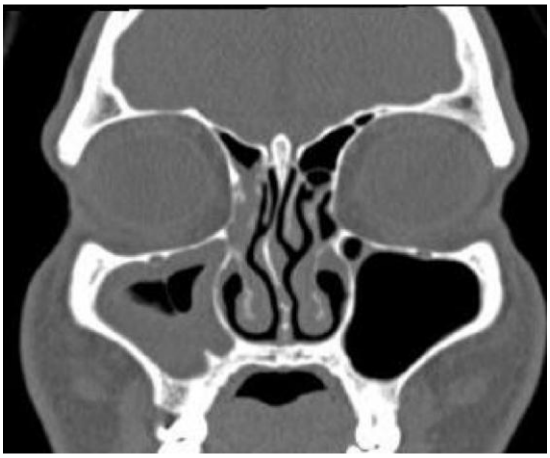

**Figure 1:** Coronal CT image showing deviated nasal septum

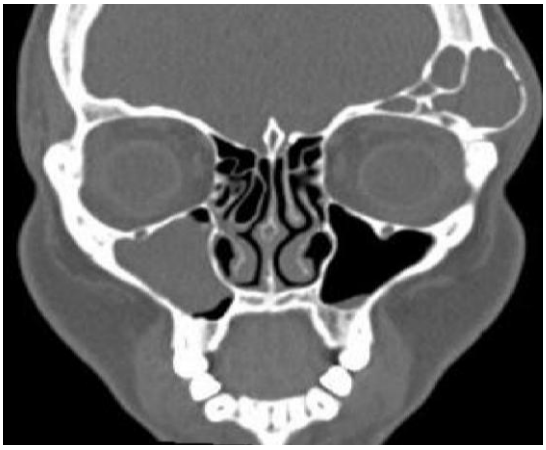

**Figure 2:** Coronal CT image showing right concha bullosa

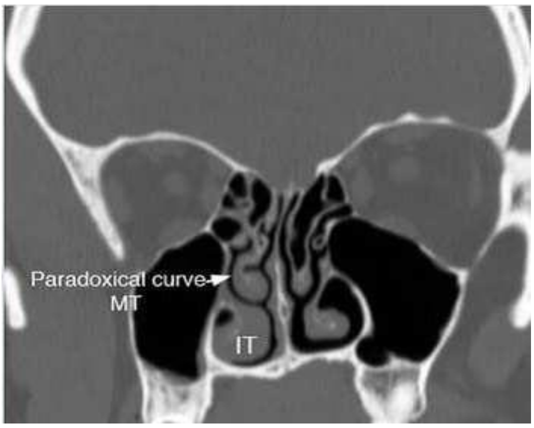


**Figure 3:** Coronal CT image showing paradoxical middle turbinate

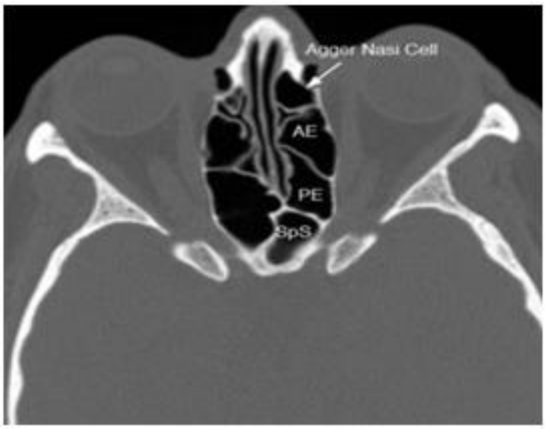


**Figure 4:** Axial CT image showing agger nasi cell

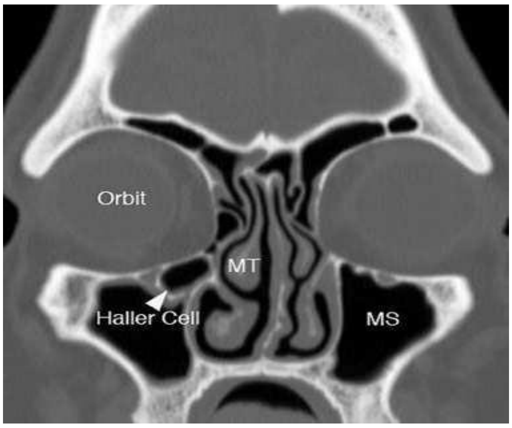


**Figure 5:** Coronal CT image showing haller cell

**Figure 6:** Coronal CT image showing onodi cell