

## Original Research Article

# COMPUTED TOMOGRAPHIC EVALUATION OF CONGENITAL ANATOMICAL VARIATIONS OF PARANASAL SINUSES

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Received : 03/12/2025  
Received in revised form : 09/01/2026  
Accepted : 26/01/2026

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DOI: 10.70034/ijmedph.2026.1.396

Source of Support: Nil,  
Conflict of Interest: None declared

Int J Med Pub Health  
2026; 16 (1); 2289-2293

**ABSTRACT**

**Background:** Chronic sinusitis is a common condition frequently associated with anatomical variations of the paranasal sinuses. Computed Tomography (CT) of the paranasal sinuses (PNS) plays a crucial role in identifying these variations and guiding Functional Endoscopic Sinus Surgery (FESS). **Aim:** To study the anatomical variations in CT paranasal sinuses. To evaluate the role of anatomical variants in the occurrence of recurrent sinusitis.

**Materials and Methods:** This cross-sectional study included 200 patients presenting with headache and suspected chronic sinusitis who were referred for CT PNS. Unenhanced CT scans were performed in the coronal plane with axial and sagittal reconstructions. The paranasal sinuses were evaluated for mucosal disease and anatomical variations.

**Results:** Most patients belonged to the 30–50 years age group (55%). The most common presenting symptom was headache, followed by nasal obstruction and nasal discharge. Deviated nasal septum (DNS) was the most common anatomical variation (77%), followed by concha bullosa (68.5%). Other variations included paradoxical middle turbinate (10%), agger nasi cells (12.5%), Haller cells (9%), and Onodi cells (1%). Mucosal thickening suggestive of sinusitis was observed in 95% of patients, while 5% showed no sinus involvement. At least one anatomical variant was present in all patients, with most demonstrating multiple variations.

**Conclusion:** Anatomical variations of the paranasal sinuses are highly prevalent in patients with chronic sinusitis and may predispose to sinus pathology as well as intraoperative complications. Preoperative CT evaluation is essential for identifying these variants, providing a surgical roadmap, minimizing complications, and improving the outcome of FESS.

**Keywords:** Chronic sinusitis; CT Paranasal Sinuses; Anatomical variations; Deviated nasal septum; Concha bullosa; Functional Endoscopic Sinus Surgery (FESS); Mucosal thickening.

**INTRODUCTION**

Chronic rhinosinusitis pathology is multifactorial.<sup>[1]</sup> CT demonstrates the anatomical variants and surrounding structures so that predisposing factors can be found and treated.<sup>[2]</sup> The key feature involved in pathology is osteomeatal complex obstruction.<sup>[3]</sup> This needs to be relieved by surgical means for which detailed anatomical knowledge is essential. This is done by CT evaluation. Comprehensive understanding of anatomical variants in PNS is critical for surgeons performing FESS because

Osteomeatal complex blockage is the underlying key concept for this surgery.<sup>[4]</sup> In a study by Perenz – Pinas J Sabate et al. DNS was the most common variant with a very mild predominance towards the right side.<sup>[5]</sup> Other special cells include Aggernasi cell, Haller cell, Onodi cell, Concha bullosa, etc. Hypo plasticity of various sinuses was also noted earlier of which hypoplasia of the maxillary sinus is of more importance due to its predisposition to orbital penetration during FESS. A Prior intimation of maxillary hypoplasia to the surgeon can avoid orbital injury.<sup>[6]</sup> The aim of our study is to tell the importance

of anatomical variations of PNS and their relevance in surgical treatment so as to avoid unnecessary complications.

## MATERIALS AND METHODS

The study was conducted at Great eastern medical school and hospital, Ragolu. It was a prospective observational study. We included patients cinically diagnosed with sinusitis, who were referred for CT scan of PNS in our hospital during a period of 18 months. Unenhanced CT of the PNS was performed for 200 patients in the coronal plane, complemented by axial and sagittal reconstructions. The investigations were performed by using MDCT GE Revolution 16 slice spiral CT machine. Post processing – reformatting in AXIAL, SAGGITAL and CORONAL planes.

**Inclusion Criteria:** Patients clinically diagnosed with sinusitis and headache.

Both men and women 20 years and above in age.

**Exclusion Criteria:** Previous history of trauma, Previous nasal/PNS surgeries and Nasal/ PNS tumors.

In all cases, systematic studies of the nasal sinus region were performed in coronal, complemented by axial and sagittal reconstructions. Analysis of anatomical variants was performed both using a soft tissue window and a bone density window.

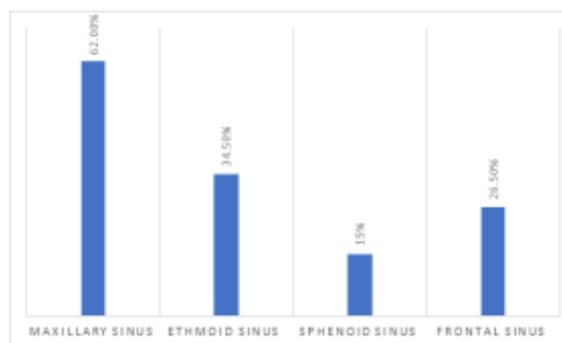
In all cases, the existence of the following variants was investigated: nasal septum: septal deviation; turbinates: concha bullosa, paradoxical middle turbinate; uncinat process: pneumatisation, medialized, lateralized; ethmoid air cells: agger nasi cells, Haller cells, ethmoid bulla, Onodi cells; Associated anatomy of the paranasal regions such as the course of optic nerve, dehiscence of cribriform plate and asymmetry of ethmoidal roof were also investigated.

Excel software was used to analyze the statistical data.

## RESULTS

During the period of 18 months of the study, 200 patients who fulfilled inclusion criteria were studied. Most of the patients are in 30-50 years of age group. The commonest symptom being headache and next commonest being nasal obstruction and nasal discharge. Out of the 200 patients that were studied, except for 10 of them rest all showed mucosal thickening invariably in at least one of the paranasal sinuses. While, at least one anatomical variant was seen in each and every patient in the present study group, in many individuals, more than one variant was present in the same patient.

The CT Scan images of all the 200 patients were studied for sinusitis except for 10 of them, sinusitis was noted in all the remaining patients invariably in at least one of the paranasal sinuses constituting 95% of the study population. Maxillary antra is the most commonly involved (62.0%), next being ethmoid sinuses (34.5%), sphenoid sinuses (15.0%) and the frontal sinuses (26.5%). 95% of patients had involvement of at least one of the sinuses, most of them having involvement of more than one sinuses.



**Figure 1: Sinus involvement in present study**

**Maxillary sinus was the most commonly involved sinus.**

A Chi-square goodness-of-fit test showed that maxillary sinus involvement was significantly higher compared to other sinuses (df = 3, p < 0.001).

**Table 1: Anatomical variants in present study**

Anatomical variants	Percentage
Concha bullosa	68.5%
Aggernasi	33%
Haller cell	9%
Hypoplastic frontal sinus	8.5%
Paradoxical middle turbinate	10%
Pneumatised anterior clinoid process	4.5%
Onodi cell	1%

Deviated nasal septum was the most commonly seen variation, seen in 77% of the patients followed by concha bullosa in 68.5% patients. Other variations

seen were Paradoxical middle turbinate in 10%, Agger Nasi cells in 33 %, Haller cells in 9% and onodi cell 1%.

**Table 2: Deviated Nasal Septum (DNS)**

Type	Number (n)	Percentage
Right	69	34.5%
Left	60	30%
S-shaped	20	10%

DNS was classified into various types i.e. right sided, left sided and 'S'-shaped. In this study right sided DNS was seen in 34.5% of patients, followed by left

sided DNS in 30% and 'S'-shaped DNS in 10 % of patients.

**Table 3: Kero's Classification (Depth of Olfactory Fossa)**

Type	Number (n)	Percentage
Type I	47	23.5%
Type II	126	63%
Type III	22	11%

The depth of olfactory fossa was categorised into three types known as Kero's classification. Type I was noted in 23.5%, type II in 63% and type III in 11% patients.

**Table 4: Optic Nerve Classification**

Type	Right (n)	Left (n)
Type I	152 (76%)	168 (84%)
Type II	30 (15%)	18 (9%)
Type III	20 (10%)	10 (5%)
Type IV	2 (1%)	2 (1%)

Optic nerve was classified into four types based on their course and association with the adjacent sphenoid sinus. Type I optic nerve was noted in 76% of patients on right side and 84% of patients on left

side. Type II was seen in 15% of patients on right side and 9% on left side. Type III was seen in 10% on right side and 5% on left side. Type IV was seen in 1% on both sides.

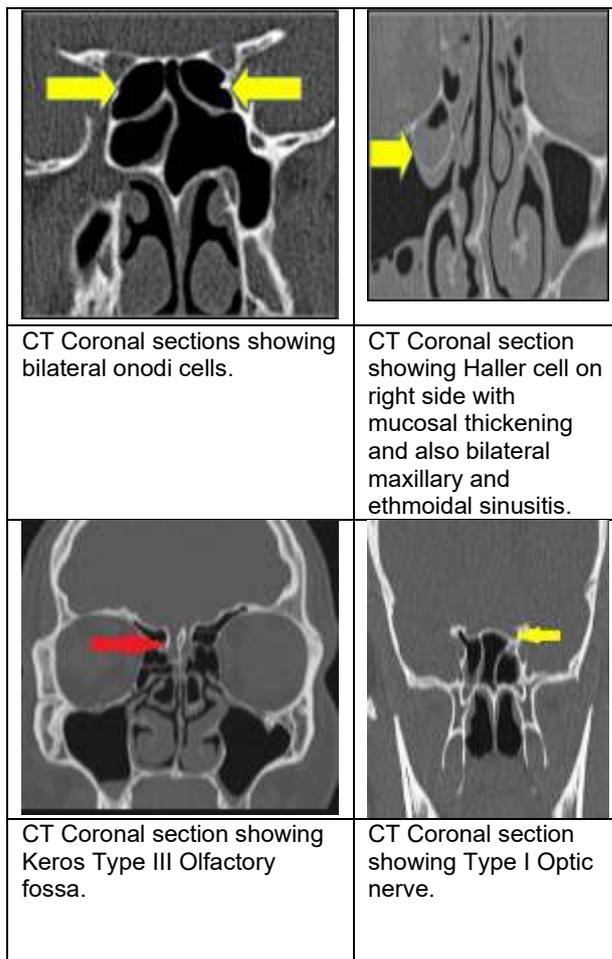
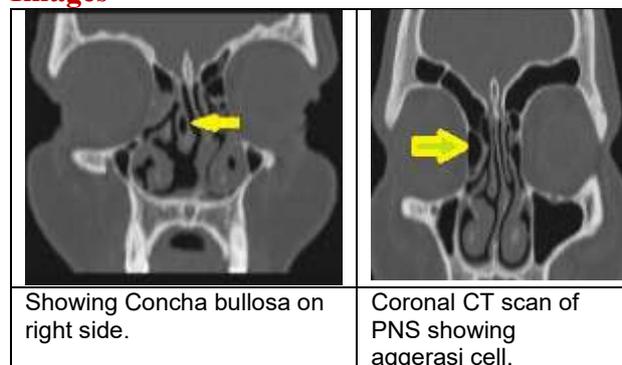
**Table 5: Concha Bullosa vs Maxillary Sinusitis**

	Maxillary Sinusitis Present	Absent	Total
Concha bullosa Present	A	B	137
Concha bullosa Absent	C	D	63
Total	124	76	200

If the proportion of maxillary sinusitis is higher among patients with concha bullosa compared to those without, it suggests a possible association. Chi-square test yields  $p < 0.05$ , the association is statistically significant. Odds Ratio  $> 1$ , concha bullosa increases risk.

Some of the danger points that were assessed in this study were the dehiscence of cribriform plate, lamina papyracea and carotid canal wall. No abnormality was detected in cribriform plate, lamina papyracea and carotid canal wall.

**Images**



## DISCUSSION

The normal anatomical variations in paranasal sinuses region are implicated in the etiology of sinusitis. They might be the source of difficulty (or) complication during surgery. Stumberger et al stated that stenosis of the osteomeatal complex, from the anatomical configuration or hypertrophied mucosa, may cause obstruction and stagnation of secretions that may become infected or continue the infection process. In this study Computed tomography images of a group of 200 patients with headache were studied to evaluate paranasal sinuses, with emphasis on anatomical variants.

The youngest patient in this study was 24 years old, the oldest being 72 years old. Maximum number of patients were in the age group of 30 -50years. In this study the mean age is 40 years which is slightly higher than what was stated by Bolger et al<sup>[7]</sup> in a study comprising 202 patients in which the mean age was 37.1 years.

In this study the symptoms with which patients presented were headache, followed by nasal obstruction and nasal discharge. In a study by Stammberger et al<sup>[8]</sup> in 100 patients with chronic sinusitis encountered nasal obstruction in 82% of patients, followed by nasal secretion in 64% and mild facial pain in 62%. In a study by Zinreich et al,<sup>[9]</sup> frontal sinus disease was reported in 34%, anterior ethmoid in 72% , maxillary sinus in 65%, posterior ethmoid in 40% and sphenoid sinus in 29%. In this study maxillary sinus was predominantly involved constituting 62%, followed by ethmoid in 32.5%, sphenoid in 15% and frontal sinuses in 26.5%. Bolger et al,<sup>[7]</sup> reported that the maxillary sinus involvement is seen in 77.7%, posterior ethmoids in 38.6%, sphenoid sinus in 25.4% and frontal sinus in 36.6%. There is a wide variation in prevalence of anatomical variations among investigators. Differences in reported prevalence may be attributed to observer variation and racial variations. In this study the most commonest variation was DNS, which was seen in 77% of patients. It is followed by Concha bullosa (pneumatized middle turbinate) which is seen in 68.5% and has been indicated as a possible causative factor for recurrent chronic sinusitis. It is due to its negative impact on mucociliary clearance and PNS ventilation in the middle meatus region. The presence of a concha bullosa is seen between 4% and 80% in different studies; This wide range of incidence is due to the criteria of pneumatization adopted.

The middle turbinate might be paradoxically curved i.e. it is seen bent in the reverse direction. This may cause impingement of the middle meatus and thus leading to sinusitis. In this study it was noted in 10% of patients. In a study by Peres et al,<sup>[5]</sup> the incidence was also 10 %. Combination of some anatomic variations such as uncinata bulla and Haller's cell may increase pathogenic effect compared to the effect of single variant.

Haller's cells are the ethmoid air cells which project beyond the limits of the ethmoid labyrinth and grow into the maxillary sinus. These were considered as ethmoid cells that grow into the floor of orbit and may narrow the adjacent ostium. The incidence of Haller cells in this study was 9%. Kenedy and Zinreich<sup>[9,10]</sup> stated an incidence of 10%. The incidence in this study is much less than that reported by Bolger (45.9%) and Asruddin (28%).<sup>[7,11]</sup>

Agger nasi cells lie anterior to the anterosuperior attachment of the frontal recess and the middle turbinate. These can invaginate into the lacrimal bone or the ascending process of maxilla. These cells were present in 33% of patients in this study. The incidence is less when compared to 98.5% by Bolger et al,<sup>[7]</sup> and 40% by Dua K et al,<sup>[12]</sup> In anatomic dissections, Messerklinger,<sup>[1]</sup> encountered the Agger nasi cells in 10-15% of the specimens, Mosher,<sup>[13]</sup> in 40% of specimens and Davis in 65% of specimens.

Onodi cells are the posterior most ethmoid cells that extend laterally, posteriorly and sometimes superior to sphenoid sinus, lying medial to the optic nerve. The chances of peri-operative damage to optic nerve are increased when they are adjacent to the bony canal of the optic nerve. Only 1% incidence was noted in this study. An incidence of 10.9% and 11% were reported by Pere et al and Bogler et al respectively.<sup>[5,7]</sup>

Depth of the olfactory fossa was classified according to Kero's classification, which consists of three types. In this study Type I was noted in 23.5%, type II in 63% and type III in 11% patients. In a study by Abhijit et al,<sup>[14]</sup> Type I in 18.5%, Type II in 74.5% and Type III in 11%. Olfactory fossa is a variable depression in the cribriform plate that is bounded medially by perpendicular plate and laterally by lateral lamella. Type III exposes more of the very thin cribriform plate to potential damage by local nasal surgery.

Optic nerve was classified in to four types based on their course and association with the adjacent sphenoid sinus. Type I optic nerve was noted in 76% of patients on right side and 84% of patients on left side. Type II was seen in 15% of patients on right side and 9% on left side. Type III was seen in 10% on right side and 5% on left side. Type IV was seen in 1% on both sides. Delano et al,<sup>[15]</sup> also found that 85% of optic nerves associated with a pneumatized anterior clinoid process were of the Type II or Type III configuration, and 77% were dehiscent indicating the vulnerability of optic nerve during FESS. A study by Uma devi et al,<sup>[16]</sup> showed that Type I is the most common type accounting for 76% of patients.

Danger points like dehiscence of lamina papyracea, cribriform plate and carotid canal wall though have a lesser incidence rate but are very necessary to be identified. In this study no obvious abnormality is detected regarding dehiscence of lamina papyracea, cribriform plate and carotid canal wall. The clinical importance of anatomical variants of the nasal sinus region is well established. Majority of the anatomical studies regarding the paranasal sinus region have been undertaken in patients suspected of any

inflammatory pathology clinically. Zinreich,<sup>[10]</sup> found that around 62% of his patients who presented with either of one anatomic variant, while it is only 11% in the normal control group. All the above features are suggestive of a positive correlation between the anatomical variants and its relation to inflammatory sinus pathology. However, Bolger et al,<sup>[9]</sup> in a series of 202 patients studied by CT, observed 131 anatomical variants, but he found that the incidence in patients with sinus pathology was comparable to that in patients who were studied for other reasons. Bolger et al,<sup>[9]</sup> and Stammberger & Wolf,<sup>[8]</sup> detected the appearance of anatomical variants both in the patients studied for sinus problems as well as in those studied for other reasons.

They concluded that the mere presence of variants does not mean a predisposition to sinus inflammation, except when other associated factors are present. This opinion is not shared by Yousem et al,<sup>[17]</sup> who claimed that the anatomical variants might be the risk factors, depending on their size.

From the current study, anatomical variants not only have a tendency to cause sinus pathology but probably lead to intraoperative complications. Hence a surgeon has to be aware of these variations which may alter the outcome of treatment. The radiologist should pay close attention to anatomical variants in the preoperative evaluation to help avoid possible complications and improve the success of management strategies.

**Table 6: Comparison of outcome of various studies on anatomical variations of PNS on CT**

	Perez-Pinas et al[5]	Dua K et al[12]	Zinreich S et al [10]	Rajneesh et al[18]	Present Study
Year	2000	2005	1993	2017	2018
Number of Patients	115	55	230	50	200
Concha Bullosa	24.50%	16%	36%	32%	68.5%
Paradoxical middle Turbinate	10%	10%	15%	11%	10%
Dns	58%	44%	21%	66%	77%
Haller Cells	2.70%	16%	10%	6%	9%
Onodi Cells	10.90%	6%	8%	-	1%
Agger Nasi Cells	98%	40%	-	72%	33%

## CONCLUSION

This study has demonstrated that Computed Tomography plays an important role in visualization of anatomical variations in paranasal sinuses and has re-emphasized the concept that anatomical variations especially is the key factor in the causation of sinusitis. Computed Tomography of the paranasal sinuses has improvised the visualization of paranasal sinus anatomy and has allowed a greater accuracy in evaluating paranasal sinus disease. It helps in evaluating the complex anatomy of paranasal sinuses which is not possible with plain radiographs. Improvement in FESS and CT technology has concurrently increased interest in the paranasal region anatomy and its variations. The radiologist must pay close attention to anatomical variants in the preoperative evaluation as it is important for the surgeon to be informed of these variations which may predispose patients to increased risk of intraoperative complications thereby helping avoid possible complications.

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