*Vora S et al. GAIMS J Med Sci 2023;3(1) (Jan-Jun):13-18*
*Online ISSN:2583-1763*

**Original Research Article**

# Prospective Cross-Sectional Study on Anatomical Variation with Special Emphasis on Critical Anatomical Landmark in Patients Undergoing Multi Detector Computed Tomography of Paranasal Sinuses

Sandip Vora[1], Mital Patel[2], Bhaven Shah[3], Ronit Patel[4]

Department of Radiodiagnosis, Gujarat Adani Institute of Medical Sciences and GK General Hospital, Bhuj, Kachchh, Gujarat-370001

* Correspondence: Dr Sandip Vora (drsandipvora2141@gmail.com)

**ABSTRACT**

**Introduction:** Paranasal sinuses are best evaluated by multi-detector computed tomography. Evaluation of sphenoid sinus pneumatization, lamina papyracea, onodi cell, cribriform plate, types of optic canal and supraorbital pneumatisation are useful for evaluation of the surgical anatomy of paranasal sinuses for the radiologist which guides the surgeon to take a correct approach for surgery without major complications of crucial structures. CT is recently used as a investigation of choice in the assessment of the paranasal sinuses and surrounding structures.
**Aims and Objective:** To study the types of anatomical variation of paranasal sinuses and osteomeatal complex and clinical importance of these various of paranasal sinus on pre-operative computed tomography.
**Materials and Methods:** Over a period of 18 months, 104 patients referred for CT scan of PNS region G.K.General hospital were evaluated for the presence of normal variants of the paranasal region. Unenhanced CT of the PNS was performed for these patients in the coronal plane, complemented by axial views in selected cases.
**Results:** Out of 109 patients who fulfilled inclusion criteria were studied from that most common is type II cribriform plate found in 80.7% of patients, Presence of haller cells was noted in 11.01% of individuals. Most of the uncinate process was attached to lamina papyracea in 88.9% individuals. Onodi cell was identified among 41% patients. Depending on the pneumatization of the sphenoid sinus, type I course of optic nerve was most common. Sellar variety of sphenoid sinus was more common observed in 82.5% patients. Presence of supraorbital pneumatization was identified in 72.4% patients among total subjects.
**Conclusion:** The presence of anatomical variants does not indicate a predisposition to sinus pathology but these variations may predispose patients to increased risk of intraoperative complications.

**Key words:** computed tomography; anatomical variations

## INTRODUCTION

The paranasal sinuses (PNS) are air-filled cavities located in bones of skull and face. There are four types of paranasal sinuses: maxillary sinus, sphenoid sinus, ethmoid sinus, and frontal sinus. The PNS decrease the weight of the head, plays a role in air humidification and helps in voice resonance.[1]

Computer tomography (CT) detects different variants in sinonasal region.

Most commonly detected anatomical variants are deviated nasal septum (DNS), agger nasi cells and Onodi cells, Haller cells, concha-bullosa (CB) and different types of cribriform plates. The most anterior ethmoidal air-cells are agger nasi cells which are situated anterior and inferolateral to frontal recess. The infraorbital ethmoidal cells extend downward underneath the medial floor of orbit lying adjacent to and above the ostium of maxillary sinus and lateral to the infundibulum. The posterior ethmoidal-cells extend superolateral, and posterior to the sphenoid sinus cavity, these cells are closely related to optic nerve. DNS is any bending of the nasal-septa. Concha bullosa (CB) is defined as pneumatization (development of air-cells) of middle turbinate, mostly occur bilateral and inferior bulbous part is involved. Surgery without detection of various anatomical variants of PNS may result in serious complications while performing surgery.[2]

There are many anatomical variations seen in nasal cavity and PNS. Many anatomical variants can interfere with mucociliary drainage pathway of osteomeatal complex

(OMC) which includes deviated nasal septum, Concha bullosa, uncinate process variants, paradoxical middle turbinate, various ethmoidal air-cells, different types of optic canal.[3]
Osteomeatal complex is the vital area for extension and pathogenesis of rhinosinusitis. Rhinosinusitis reduces the movements of cilia leads to mucus collection within sinuses. However, if there is an anatomical variant, which leads to narrowing of crucial area which is OMC, then a minimal amount of mucosal distention may cause recurrent infections can leads to significant inflammatory changes in the mucus membrane of sinonasal region.[4,5]
Detailed information about anatomical variants in every patient is important before planning of surgery to avoid injury to adjacent vital structures such as orbital structures like eyes and brain parenchyma. Computed tomography of paranasal sinuses and function endoscopic sinus surgery have become choice of modalities for radiological evaluation and treatment of sinonasal anatomy with pathologies.[6,7,8]

**Aim:** To study the types of anatomical variations of paranasal sinuses and osteomeatal complex.

**Objectives:** To particularly assess variations of cribriform plate, Lamina papyracea, Onodi cell, Sphenoid sinus pneumatization, anterior Ethmoidal artery, supraorbital pneumatisation and optic canal types which might pose complications intraoperatively.

To determine the frequency of occurrence of these variations of paranasal sinuses studied on 16 slice MDCT.

## MATERIAL AND METHODS

This Prospective Cross-sectional study was carried out on all patients who were referred for MDCT evaluation of paranasal sinuses in G.K. General Hospital, Bhuj in the Department of Radio-diagnosis during the period of 2 years (October 2020 to July 2022) filling in the inclusion and exclusion criteria for this study.

**Inclusion Criteria:**
All patients who are referred to our department for imaging evaluation of paranasal sinuses.
**Exclusion Criteria:**
Patients with history of previous nasal surgery or trauma.
Patients with Paranasal sinus malignant neoplasm.

Parameters used for sinus CT:
Patient position: Supine in axial. Coronal and sagittal reformatted images as well as 1.5 mm thickness images were remonstrated from the 5 mm slice data.
Gantry Angulation: Perpendicular to infra-orbito meatal line in coronal selections. Parallel to infra-orbitomeatal line in axial sections.
Thickness: 5mm with 5mm incrementation in coronal,
5 mm in axial sections. 1.5 mm sections were taken particularly at the osteomeatal complex and frontal recess.
Exposure: 120 kV, 1.5 second scans time, 300 mA
Window width (Approximately): 2500 – 3000
Window level: 250 – 300
Soft tissue window width: 80
Soft tissue window level: 40
Extent of the study: From the posterior margin of the sphenoid sinus to the anterior most aspect of nasal cavity in coronal from hard palate through frontal sinus in axial sections.
All films are taken without contrast. No intravenous contrast was used.

## RESULTS

In all cases, the existence of the following variants was investigated:
1.Different types of cribriform plate
2.Presence and absence of haller cells in different individual
3.Uncinate process: attachment to lamina papyracea or skull base or middle turbinate.
4.Presenence and absence of onodi cells.
5.Type I to IV optic canal.
6.Types of sphenoid sinus.
7.Supra orbital pneumatisation.

Excel software was used to analyze the statistical data.
During the period of 18 months of the study 109 patients who fulfilled inclusion criteria were studied, out of which 28 (74.3%) were female and 81 (25.6%) were male.
Of the 109 cases studied, type I cribriform plate was found in 13 (11.9%) of patients, type II cribriform plate was found in 88 (80.7%) of patients, type III cribriform plate was found in 8 (7.3%) of patients.
Presence of haller cells was noted in 12 (11.01%) of individuals. Uncinate process was attached to lamina papyracea in 98 (88.9%) individuals, to skull base in 11(10.09%) patients and middle turbinate in 1 (0.91%) patient.
Onodi cell was identified among 45 (41%) patients. This was identified in the right side alone in 26 (23.8%), in the left side alone in 19 (17.4%).
Depending on the pneumatization of the sphenoid sinus, type I course of optic nerve was noted in 48 (44.03%) on the right side and 51 (46.7%) on the left side. Type II course was seen in 46 (42.2%) on the right side and 47 (43.1%) on the left side. Type III course was seen in 6 (5.5%) on the right side and in 6 (5.5%) on the left side. Type IV course

was seen in 9 (8.2%) on the right side and 5(4.5%) on left side.
Sellar variety of sphenoid sinus was observed in 90 (82.5%) patients. Whereas, 19 (17.4%) patients had presellar variety of sphenoid sinus.
Anterior ethmoidal notch abuts the fovea ethmoidalis in 89 (81.6 %) and lateral lamella in 20 (18.3%) patients.
Presence of supraorbital pneumatization was identified in 79 (72.4%) patients among total subjects.

**Table 1- demonstrates most common prevalence of type 2 cribriform plate with gender predominance in females**

| Cribriform Plate | Male | Female | %M | %F |
|---|---|---|---|---|
| Type 1 | 10 | 3 | 12.34% | 10.71% |
| Type 2 | 64 | 24 | 79.01% | 85.71% |
| Type 3 | 7 | 1 | 8.77% | 3.57% |
| Total | 81 | 28 | 100% | 100% |

**Table 2 -demonstrates relationship of attachment of uncinate process with number of males and females from my study population**

| Uncinate process attachment | Male | Female | Total | % |
|---|---|---|---|---|
| **LP** | 97 | 18 | 98 | 89.90% |
| **SB**<br><br>**MT** | 1<br><br>0 | 10<br><br>1 | 11<br><br>1 | 10.09<br><br>0.9% |
| **TOTAL** | 89 | 28 | 109 | 100% |

**Figure 1 : CT PNS showing type II cribriform plate**

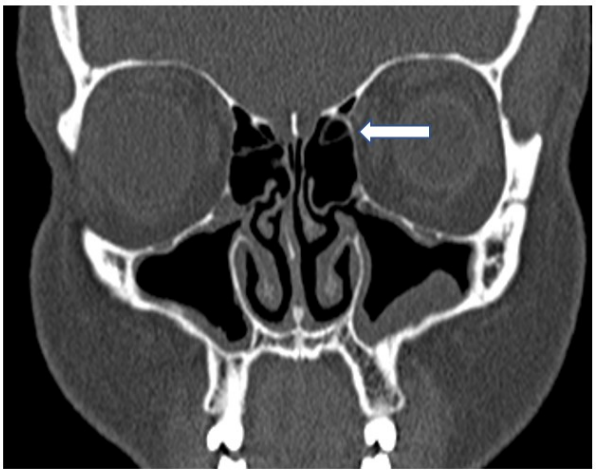


**Figure 2: CT PNS showing uncinate process attaching to lamina papyracea on right side**

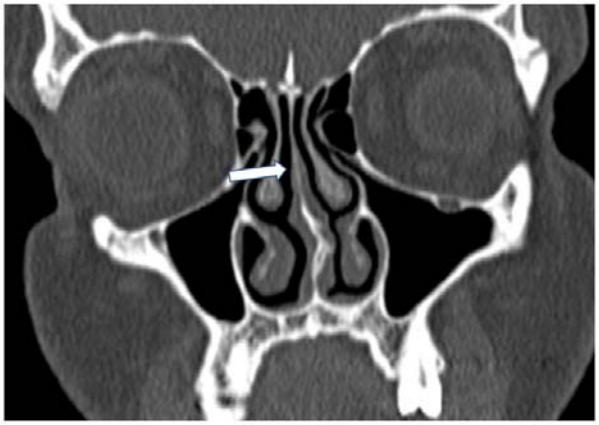


**Table 3 -demonstrates relatively more occurrence of supraorbital pneumatization in males as compared to females from total subjects**

| Supra-orbital pneumatisation | Male | Female | Total |
|---|---|---|---|
| P | 59 | 20 | 79 |
| Ab | 22 | 8 | 30 |
| Total | 81 | 28 | 109 |

**Table 4- demonstrates numbers of Onodi cells as anatomical variation in reference with gender from total subjects.**

| Onodi Cell | Right | Left | Bilateral | Total |
|---|---|---|---|---|
| Male | 12 | 5 | 8 | 25 |
| Female | 1 | 1 | 5 | 7 |

**Figure-3: CT PNS showing supraorbital pneumatization**

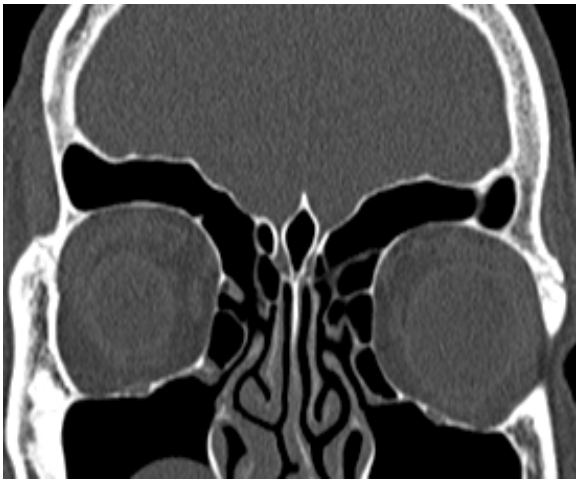
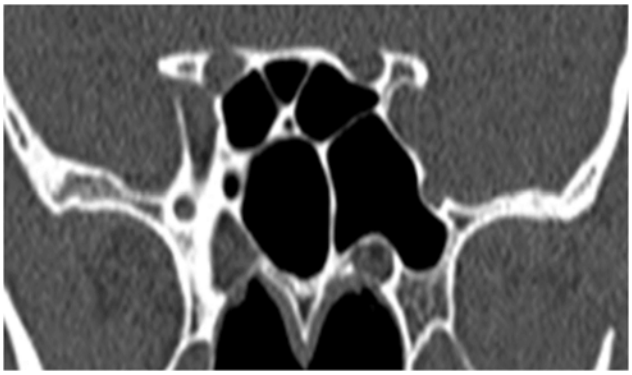


**Figure 4: CT PNS showing Onodi cell**



## DISCUSSION

Different lesions can occur in paranasal sinus region. Different anatomical variations and congenital anomalies are important because they can lead to pathological outcome or can causes difficulty while performing surgery of paranasal sinus. Stumberger et al observed that stenosis of the osteomeatal complex, from either the anatomical configuration or hypertrophied mucosa can cause obstruction and stagnation of secretions that may become infected or predispose infection. [9]

Cribriform plate is defined as horizontal lamina cribrosa, which is situated in midline and separates the roof of the nasal cavity from the anterior cranial fossa. It can be completely evaluated in the coronal plane. Type I cribriform plate was found in 13(11.9%) of patients, type II cribriform plate was found in 88 (80.7%) of patients, type III cribriform plate was found in 8 (7.3%) of patients.

Haller cells are defined as ethmoid air cells that project beyond the limits of the ethmoid labyrinth into the maxillary sinus. Haller cells are one type of ethmoid cells that grow into the floor of orbit and narrows the adjacent ostium. The incidence of Haller cells in our study was 12 (11.0%). Kenedy and Zinreich reported an almost similar incidence of 10%. It is less than that reported by Bolger (45.9%) and Asruddin (28%). [10,11,12]

The lamina papyracea is defined a thin layer of the ethmoid one that forms medial wall of orbit. Its detailed evaluation can be done in the axial and coronal planes. When dehiscent from a previous injury, the bony margin of the lamina papyracea is displaced medially into the ethmoid sinus, along with intraorbital fat and rarely portions of the medial rectus muscle. In my study Uncinate process was attached to lamina papyracea in 98 (88.9%) individuals, to skull base in 11(10.09%.) patients and middle turbinate in 1 (0.91%) patient.

Onodi cells are defined as posterior ethmoid cells that extend posteriorly, laterally and often superior to sphenoid sinus, lying medial to the optic nerve. The chances of peri-operative injury to optic nerve are higher when the bony optic nerve canal is dehiscent. Most authors have found an incidence of 8–14%, 10.9% by Pere and 11% by Bogler.[10,13]. Onodi cell was identified among 45 (41%) patients. This was identified in the right side alone in 26 (23.8%), in the left side alone in 19 (17.4%).

Depending on the pneumatization of the sphenoid sinus, type I course of optic nerve was noted in 48 (44.03%) on the right side and 51 (46.7%) on the left side. Type II course was seen in 46 (42.2%) on the right side and 47 (43.1%) on the left side. Type III course was seen in 6 (5.5%) on the right side and in 6 (5.5%) on the left side. Type IV course was seen in 9 (8.2%) on the right side and 5(4.5%) on left side. Delano et al, 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. Sellar type of sphenoid sinus was found in 90 (82.5%) patients. Whereas 19 (17.4%) patients had presellar type of sphenoid sinus. Anterior ethmoidal notch abuts the fovea ethmoidalis in 89 (81.6%) and lateral lamella in 20(18.3%) patients. Presence of supraorbital pneumatization was seen in 79 (72.4%) patients among total patients.

The clinical significance of anatomical variants of the nasal sinus region is controversial. Most CT anatomical studies of the sinus region have been made in patients suspected of a clinical syndrome suggesting inflammatory sinus pathology. Zinreich found that 62% of his patients presented at least one anatomic variant, against 11% in the normal control group. [14] These findings suggest a positive correlation between anatomical variants and the appearance of inflammatory sinus

pathology. However, Bolger et al., in a series of 202 patients studied by CT, observed 131 anatomical variants, but found the incidence in patients with sinus pathology was similar to that in persons studied for other reasons. 10 Bolger et al. and Stammberger & Wolf detected the presence of anatomical variants both in patients studied for sinus problems and in those studied for other reasons. [15,16.] They concluded that the simple presence of variants is not risk factor to sinus pathology, except when other associated factors are present. This opinion is not shared by Yousem, who claimed that the anatomical variants may be predisposing factors, depending on their size. [17]

However, it is important for surgeon to know about anatomical variations that may lead patients to increased risk of complications during surgery. The radiologist must mention anatomical variants in the preoperative evaluation and guide to avoid possible complications during surgery and aids to proper management.

## CONCLUSION

This study was undertaken to evaluate the anatomical variations in paranasal sinuses by CT scan and evaluate their clinical importance. The study includes 109 patients referred for CT PNS. Of the 109 cases studied, type II cribriform plate was found in 88(80.7%) of patients. Presence of haller cells was noted in 12 (11.01%) of individuals. Uncinate process was attached to lamina papyracea in 98 (89.9%) individuals.

Onodi cell was identified among 45(41%) patients. This was identified in the right side alone in 26(23.8%), in the left side alone in 19(17.4%).

Depending on the pneumatization of the sphenoid sinus, type I course of optic nerve was noted in 48(44.03%) on the right side and 51(46.7%) on the left side. Type II course was seen in 46 (42.2%) on the right side and 47 (43.1%) on the left side. Type III course was seen in 6(5.5%) on the right side and in 6(5.5%) on the left side. Type IV course was seen in 9(8.2%) on the right side and 5(4.5%) on left side.

Sellar variety of sphenoid sinus was observed in 90(82.5%) patients.

Anterior ethmoidal notch abuts the fovea ethmoidalis in 89(81.6 %). Presence of supraorbital pneumatization was identified in 79 (72.4%) patients among total subjects.

The presence of anatomical variants does not mean a predisposition to sinus pathology but these variations may predispose patients to increased risk of intraoperative complications. The radiologist must pay close attention to anatomical variants in the preoperative evaluation and provide a road map to the surgeon and help avoid possible complications and improve success of management strategies.

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**How to cite:** Vora S,Patel M,Shah B, Patel R. Prospective Cross-Sectional Study on Anatomical Variation with Special Emphasis on Critical Anatomical Landmark in Patients Undergoing Multi Detector Computed Tomography of Paranasal Sinuses. GAIMS J Med Sci 2023;3(1):13-18
https://doi.org/10.5281/zenodo.7488174

Source of support: Nil

Conflict of interest: None declared