ORIGINAL RESEARCH PAPER

Radiodiagnosis

DETECTION OF ANATOMICAL VARIATIONS OF PARANASAL SINUS ON MULTIDETECTOR COMPUTED TOMOGRAPHY

KEY WORDS: anatomical variations, complications, computed tomography, deviated nasal septum, functional endoscopic sinus surgery, osteo-meatal unit, paranasal sinus scan.

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ABSTRACT

Aim and objectives :Detection of anatomical variations of paranasal sinus on Multidetector Computed Tomography
Materials and methods: A prospective study was carried out over a period of 8 months from September 2019 to March 2020. Adult patients between 18 year and above of age were recruited. A total of 100 patients referred for CT scan of PNS region to the department of radio diagnosis MGM hospital, kamothe, Navi Mumbai were evaluated for the presence of normal variants of the paranasal sinuses. Unenhanced CT scan of the PNS was performed in all these patient using TOSHIBA Activion 16 slice spiral CT.
Results :DNS (deviated nasal septum) was most common variation in 80(80%) followed by concha bullosa in 31(49.20%) ,paradoxical curve in 5(7.93%), atrophic nasal turbinates in 9(14.28%)and hypertrophy in 18(28.57%) patients.
Other variations found in osteo-meatal unit in the OMU, the maxillary sinus widened 9(9%), blocked maxillary sinus 12(12%) and in frontal sinus the widened 8(8%), blocked frontal sinus is 16(16%).
The other variation in bulla ethmoidalis 6(6%), haller cells 10(10%), agar nasi cells 5(5%), onodi cells 8(8%), frontal cells 9(9%) and the variation in sinuses is hypoplastic 7(7%).The variation in bony walls of PNS is 15(15%).
Conclusion:-CT scan of the paranasal sinuses has improved the viewing the sinuses anatomy and has allowed great accuracy in evaluating paranasal sinus disease. It evaluates the osteomeatal complex anatomy which is not possible with the plain radiographs. CT scan evaluates both soft tissue and bony details of nose and paranasal sinus. Due to complex anatomy, radiographic evaluation of paranasal sinuses has major limitations and hence cost-effective CT is most common and widely used investigation to study the various anatomical variations.

The CT scanner is a triumph of creativity in designing and connected material science.

Its unparalleled advancement in the course of recent years is a demonstration of the intensity of scholastic and industry cooperation crosswise over numerous orders in medication, science, and building. In New 1974 depiction of the main Electric and Musical Industries (EMI) scanner in the United States, the securing of one 80 × 80 transverse segment required 5 minutes of checking.[1]

The narrative of clinical CT checking starts with the EMI scanner, concocted by Godfrey N. Hounsfield, Nobel Laureate.[2]

Through the 1980s, CT scanners gained pictures in a steady advance and-shoot mode to such an extent that the examination table was stationary amid obtaining of a transverse picture from a 360° pivot of the gantry. The table would then move to the following filtering position before another sweep was started, accordingly forcing an interscan deferral of 10 seconds in the mid 1980s that diminished to 1–2 seconds by 1990. Despite the fact that this method of procurement was the foundation of early CT applications, it had critical weaknesses. For instance, it brought about longitudinal misregistration because of discontinuities between transverse areas, it was inclined to movement ancient rarities, it was unfeasible for the procurement of adjoining segments more slender than 5– 10 mm, and it blocked steady imaging through exceedingly unique periods of vascular and parenchymal improvement.

This all changed in 1990 with the presentation of nonstop gantry revolution on a slip ring with related consistent table interpretation following a winding or helical way.[3,4]

With the coming of multidetector computed tomography (MDCT), imaging of paranasal sinuses preceding functional endoscopy sinus surgery has turned out to be compulsory.

Multiplanar imaging, especially coronal transformations, offers exact data with respect to life systems and variations of paranasal sinuses.

The accomplishment of valuable functional endoscopy surgery depends upon adequate learning of the confounded life frameworks of the paranasal sinuses, which is variable. It is basic to see the clinical and cautious centrality of these assortments. Certain anatomic assortments are accepted to slant factors for the improvement of sinus afflictions and along these lines it winds up fundamental for the radiologist to think about these assortments, especially if the patient is a contender for down to earth functional endoscopic sinus surgery.

Since the presentation of Multi Detector CT Scan in most recent 5 years in MGM Hospital Kamothe Radiological office there is increment in the utilization of CT filter in instances of Paranasal sinus illnesses.Computed tomography of the PNS is the guide for the specialist. An investigation of the typical hard example of the Paranasal sinuses alongside the mucosal covering of the hard structures is required before setting out on functional endoscopic surgery which is finished utilizing CT.[12]

AIMS AND OBJECTIVE

- Aim of this thesis is to study the anatomical variations of paranasal sinuses on multidetector computed tomography.
- Objective is to find out incidence of each of the anatomical variation.

Review of literature

1- In the study of anatomical variations of the nasal fossae and paranasal sinuses in 110 Spanish subject, using CT coronal images, they has observed the variants of the septum ,middle turbinate bone , ethmoid unciform process and ethmoid bulla, along side others of less frequency. The population that studied show greater anatomical variations ,and high percentage (67%) obtained 1 or more anatomical variants. it is not continued agger nasi air cells and not symmetrical of both cavities of the sphenoidal sinus, which was present in all together in cases, the variations most often observe were, in order, deviated nasal septum , the presence of a concha bullosa, bony spur and Onodi air cells.[13]

2- It was concluded that the Anatomical variations are common within the osteomeatal complex. Prevalence of multiple anatomical variations was more common in our study as compared to single anatomical variation. Deviated septum was the foremost common anatomical variation encountered in our study followed by concha bullosa and paradoxically bent middle turbinate.(14)

3- it was postulated that variations within the anatomy of the sinus cavity lead to obstruction and mucous stasis which is able to cause infection. Other authors have also proposed these concepts to clarify how anatomical variants like concha bullosa and pneumatized superior turbinate might produce similar symptoms.[15,16,17]

4- Congenital anomalies and normal anatomical variations during this region, though rare, are important as they'll have pathological consequence or could also be the source of difficulty during surgery. CT scan of paranasal sinuses acts as a pre-operative road map to clearly define the anatomy of osteomeatal complex. It also shows the extent of mucosal disease deep in the osteomeatal complex. It is mandatory to have this study before the patient is to undergo a surgical procedure.[18,19]

5- Computed Tomography of the sinus paranasales es has improved the visualisation of sinus paranasales anatomy and has allowed greater accuracy in evaluating paranasal sinus disease. It evaluates the osteomeatal complex anatomy which isn't possible with plain radiographs. Anatomical variations studied on CTScan are found to obstruct the OMC and cause chronic sinusitis. The blockade within the OMC results in impaired drainage of maxillary, frontal and anterior ethmoid thus causing chronic sinusitis. Thus, this study has re-emphasized the concept that Osteomeatal complex is that the key think about the causation of chronic sinusitis. Removal of disease in Osteomeatal complex region is that the fundamentals of FESS which is best appreciated on CT scan. There was high concordance between anatomical variants detected by each of the 2 observers. Less than 10% of the cases required the participation of the third observer to discuss and adopt a final resolution which in all cases was reached unanimously,(5)

6- CT scan of the sinus paranasal has improved the visualization of sinus paranasales anatomy and has allowed greater accuracy in evaluating para nasal sinus disease. It evaluates the osteomeatal complex anatomy which isn't possible with plain radiographs. Improvement in Functional Endoscopic Sinus Surgery and CT technology has concurrently increased interest in the paranasal region anatomy and its variations. The present study has it's own limitations of getting less sample size and it's suggested to extend sample size to offer significant contribution for clinical implications. Clinical studies shown that prevalence of concha bullosa in general population is more but very few subjects are symptomatic. To conclude, In view of the presence of these significant variations, we reemphasize the need for proper preoperative assessment in every patient in order to accomplish a safe and effective endoscopic sinus surgery. The present study is a step to provide suggestive findings to surgeons regarding various parameters involved and our contribution to the enormous work of other research workers.[6]

Anatomy of paranasal sinus

Paranasal sinus are air filled spaces present within some bones around nasal cavities. The PNS develop as outgrowths from the nasal cavities and erode into the encompassing bones. The sinuses are frontal, maxillary, sphenoidal and ethmoidal. All of them open into the cavity through its lateral wall. Because of communication each sinus is normally filled with air.

The function of the sinuses is to make the skull lighter and add resonance to the voice.

The sinuses are rudimentary or even absent at birth. They enlarge rapidly during the ages of 6 to 7 years i.e time of permanent teeth and then after puberty.

From birth to adult life, the growth of the sinuses is due to enlargement of the bones; in old age it is due to resorption of the surrounding cancellous bone.

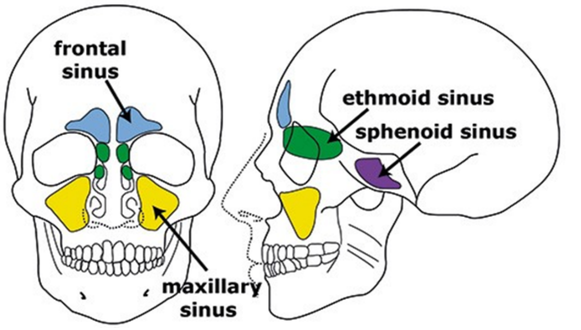


Figure-1 Anatomy of paranasal sinus

Classification:-

There are four paranasal air sinuses on each side and are names after the bones containing them, namely

1. Frontal air sinus
2. Ethmoidal sir sinuses
3. Maxillary air sinuses
4. Sphenoidal sinuses

The frontal sinus present in the frontal lobe. The ethmoidal sinuses present in the ethmoid bone. The maxillary sinuses present in the maxilla and the sphenoidal air sinuses present in the sphenoid bone.

The paranasal air sinuses are arranged in pairs expect the ethmoidal air sinuses, which are arranged in three groups, namely anterior, middle and posterior on each side.

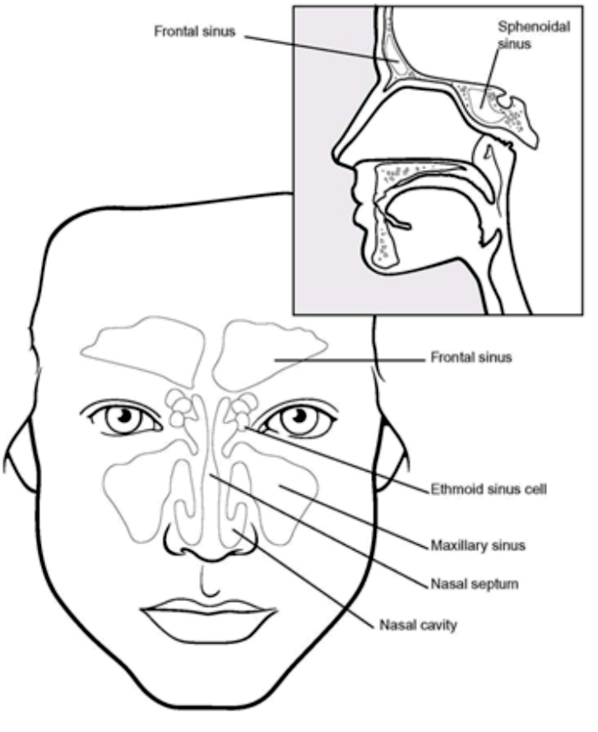


Figure-2
Overview images of paranasal sinus

Frontal sinuses:-
The frontal sinuses, one on all sides, are variable in size and are the foremost superior of the sinuses. Each is triangular in shape and is within the part the of frontal bone under the forehead. The bottom of every triangular sinus is oriented vertically within the bone at the midline above the bridge of the nose and therefore the apex is laterally approximately one third of the way along the upper margin of the orbit.

Each sinus drains into the lateral wall of the center meatus.

- **Frontal cells:** Frontal cells are anterior ethmoid air cells present in the anterior aspect of the frontal recess. Frontal recess cells are anterior ethmoid air cells that pneumatize frontal recess. The clinical relevance of frontal cells lies in their potential to obstruct the frontal recess outflow.

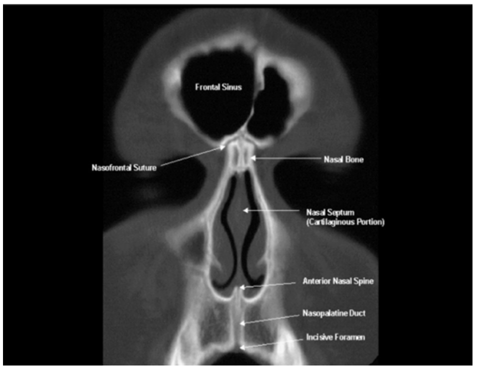


Figure- 3 A CT scan axial image showing frontal sinusEthmoidal sinuses

The ethmoidal air sinuses are made from variety of air cells present within the labyrinth of ethmoidal bone, thus they're located between the upper a part of the lateral nasal wall and the orbit.

The ethmoidal cells are formed by a variables number of individual air chambers, which are divided into anterior, middle and posterior ethmoidal cells based on the location of their apertures on the lateral wall of the nasal cavity.

They are divided into the following three groups:
1. Anterior
2. Middle
3. Posterior

The first two groups anterior and middle drain into the middle meatus and the posterior into posterior part of superior meatus. The anterior opens in the hiatus semilunaris and middle on the surface of bulla ethmoidalis.

Bulla ethmoidalis: The ethmoid bulla forms the posterior and superior walls of the ethmoid infundibulum and hiatus semilunaris. The ethmoid bulla is that the largest anterior ethmoid alveolus . It is also one of the most consistent air cells in the middle meatus and is therefore a reliable anatomic landmark.

Figure-4 A CT scan axial image showing ethmoid sinus

Maxillary sinus:
The maxillary sinuses, one on each side, are the largest of paranasal sinuses and completely fill the bodies of the maxillae. Each is pyramidal in shape with theapex directed laterally and therefore the base deep to the lateral wall of the adjacent cavity .

The medial wall or base of the sinus is made by the maxilla, and by parts of the inferior concha and palatine that overlie the maxillary hiatus.

The opening of the maxillary sinus is near the top of the base, in the center of the semilunar hiatus, which grooves the lateral wall of the middle nasal meatus.

The opening lies just below the bulla ethmoidalis. The sinus may have an additional opening behind the main one.

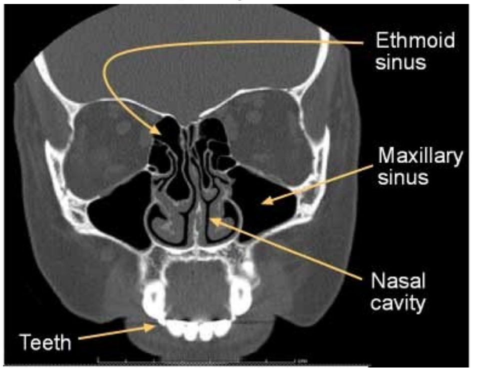


Figure-5 A CT axial image showing anatomy of sinus

Sphenoidal sinuses:
The right and left sphenoidal sinuses lie within the body of sphenoid bone. They are separated by a septum. The two sinuses are usually unequal in size. Each sinus opens into the sphenoethmoidal recess of corresponding half of the nasal cavity.

The apertures are high on the anterior wall of the sphenoidal sinuses.

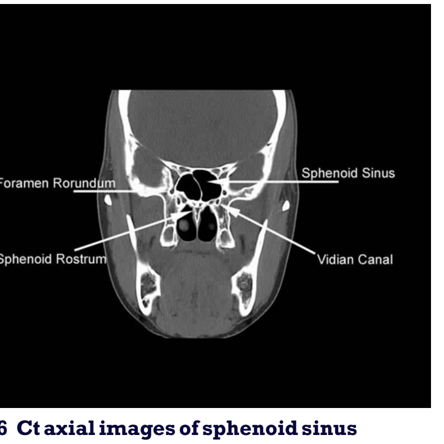


Figure-6 Ct axial images of sphenoid sinus

ANATOMICAL VARIATIONS IN PARANASAL SINUSES
Haller's cells:- 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 cell located in the ethmoid infundibulum.

Agar Nasi cells:-
These are the cells which are foremost anterior ethmoidal air cells present in the antero-lateral and inferior to frontal recess and anterior and above attachment of center turbinate. They are located within the bone and thus have as lateral relations the orbit, the tear sac and therefore the duct .

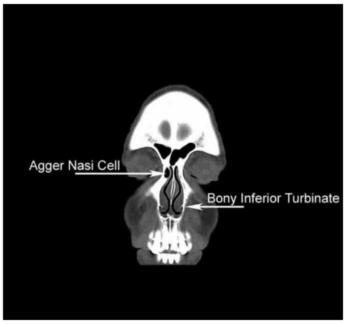


Figure-7 CT axial image of agar nasi cells

Onodi cells:- These are posterior ethmoidal cells extending into the sphenoid , either adjacent to or impinging upon the nervus opticus. When these Onodi cells abut or surround the nervus opticus , the nerve is in danger when surgical excision of those cells is performed. It is also a possible explanation for incomplete sphenoidectomy.[20]

OMU – Osteo-meatal complex represents the ultimate common pathway for drainage and ventilation of the frontal, maxillary and anterior ethmoid air cells [1, 2]. The obstruction of this narrow region may be a key think about the event of chronic sinusitis.

Presence of pneumatisation in middle turbinate, orbital floor and first ethmoturbinal constitutes concha bullosa, Haller cell and agger nasi cells respectively and regarded as variants among the distribution of structures of interest around osteo-meatal complex.

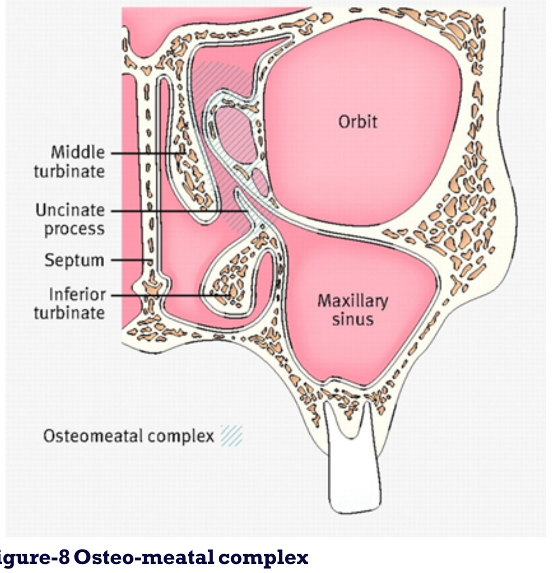


Figure-8 Osteo-meatal complex

Nasal septum:- The dividing wall which runs down the center of the nose, separating the 2 nasal 'cavities, each of which ends during a nostril. The septum consists of bone, cartilage, and 'membranes.

Deviation:- The course of the free edge of the uncinate process may be configured in a variety of ways. In majority of the cases, it either extend slightly obliquely toward the septum , with the free edge surrounding the infero-anterior surface of the ethmoid bulla, or it extend medially to medial surface of ethmoid bulla. If the free fringe of the uncinate is deviated during a more lateral direction, it's going to cause narrowing or obstruction of the hiatus semilunaris and infundibulum. Less frequently, a medial deviation or "curling" of the uncinate is encountered, which may result in the structure's contact with and subsequent obstruction of the middle

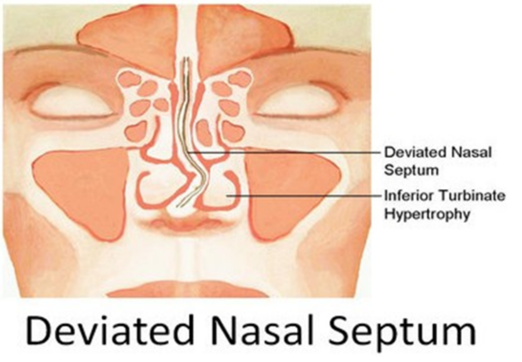


Figure-9 Nasal septum

Nasal turbinate:-

Turbinate's, which are also called nasal concha, are shell-shaped networks of bones, vessels, and tissue within the nasal passageways. The structures of turbinate's are responsible for warming, humidifying, and filtering the air we breathe. Normally there are three turbinate's including the superior (upper), middle, and inferior (lower) turbinate's. However, occasionally you can have a fourth turbinate (called the supreme turbinate) which is situated higher than the superior turbinate.[21]

In between each turbinate is space (known as meati), each with a name that coincides with the name of the turbinate that is directly above the space. These spaces form the nasal passageways direct air flow through the nose

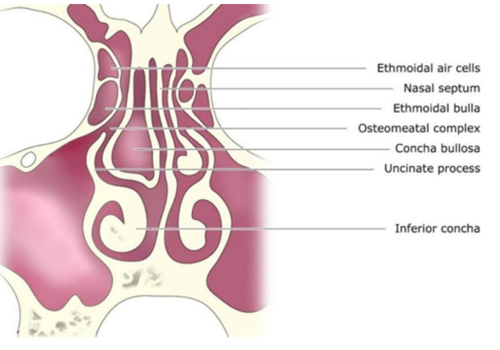


Figure-10 Nasal turbinateHypertrophy- 'The nasal turbinate are long, narrow passageways that help to warm and moisten the air that flows in through the nose. If the turbinate's are too large, they can block airflow. This conditions called turbinate hypertrophy.'

Atrophic:-

Its chronic inflammation of nose differentiate by atrophy of nasal mucosa, including glands, turbinate bones and nerve element supplying of the nose. Atrophy may be primary and secondary. Special sorts of chronic atrophic rhinitis are rhinitis sicca anterior and ozaena. It also can be described as empty nose syndrome

Concha bullosa:-

The middle turbinate plays an important role in proper drainage system of the maxillary sinus. Normally, this bony structure is lined by nasal respiratory mucosa. A variation of the middle turbinate is concha bullosa, which is pneumatization (air bubble) with in middle turbinate. The most ideal CBCT image to diagnose concha bullosa is coronal image of PNS. The middle turbinate plays an important role in proper drainage of the maxillary sinus. The middle turbinate is thin, boney structure; however, it can be aerated, in which case it is termed a concha bullosa.[22]

Paradoxical curve: - Paradoxical middle turbinate is a rare developmental cause of nasal obstruction. It refers to an infero-medially curved middle turbinate edge with concave surface facing nasal septum and usually occur bilaterally. This anatomic variant can lead to significant narrowing of the middle nasal meatus and impede the normal drainage of PNS due to ostio-meatal complex obstruction. When associated with a concha bullosa, it can potentially lead to nasal obstruction.[23]

Imaging of paranasal sinus

CT is currently the modality of choice within the evaluation of the paranasal sinuses and adjacent structures. It is able to display bone, soft tissue, and air and provides an accurate information of both the anatomy and therefore the extent of disease in and round the paranasal sinuses.

In contrast to plain radiographs, CT clearly shows the fine bony anatomy of the osteo- meatal channels. Since osteo-meatal unit (OMU) is best shown within the coronal plane, it's the first imaging orientation for evaluation of the sinonasal tract. This will be accomplished by direct coronal scanning or by reformatting data acquired within the axial plane into coronal plane images.

Coronal study optimally is performed with the patient within the supine position in order that any remaining sinus secretions don't obscure the OMU. The patient is placed within the supine position and therefore the neck is maximally extended.

When direct coronal study becomes difficult thanks to patient's positioning, spiral scanning or thin section, contiguous axial CT images with coronal reconstructions are performed.

Axial images complement the coronal study, particularly when there's severe disease (opacification) of any of the paranasal sinuses and surgical procedure is contemplated. The axial studies are needed, because the posterior walls of the varied sinuses aren't well seen, if at all, within the coronal plane.

Axial images are particularly important in visualizing the frontoethmoid junction and therefore the sphenoethmoid recess. For the axial scans, which are 5 mm thick, the orbitomeatal line is taken as reference. The introduction of spiral CT and multidetector CT scanners has allowed even more refined reconstruction in planes aside from the first scan plane.

EXAMINATION PROTOCOL

For direct scanning, the patient is placed supine on the scanner table, with the chin extended. The scanner gantry is angled perpendicular to the hard palate. The angulation of the scan plane is very important. Variations in scan angulation greater than 100 from the plane perpendicular to the hard palate result in significant loss of anatomic detail of the structures of the OMU. Scanning is performed as contiguous 3-mm-thick images from the anterior wall of the frontal sinus through the posterior wall of the sphenoid sinus. Contiguous 35 scans are essential to avoid loss of information through "skipped" areas. The exposure settings used are 140 kVp and 80 to 160 mAs.

MATERIALS AND METHODS

The study was conducted at MGM Medical college and Hospital, Kamothe Navi Mumbai . We included all patients who were referred for CT scan of PNS in MGM Medical College and Hospital during a period of 8 months from September 2019 through February 2020. Un- enhanced CT of the PNS was performed on 100 patients in the axial and coronal plane. The investigations were performed by using TOSHIBA ACTIVION 16 SLICE CT machine. For the axial scans, which were 5 mm thick, the orbito-meatal line was taken as reference with the patient in supine position then the axial images reconstructed in coronal and sagittal with the help of multiplanner reconstruction software. The exposure settings are used 140 kVp and 80 to 100 mAs.

Pediatric age group, pregnant women and patients with history of RTA, and trauma are not included in this study.

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

In all cases, the following variants was investigated: (1) nasal septum: septal deviation (2) Nasal turbinate's: Hypertrophy , atrophic, paradoxical curve and concha bullosa (3) ethmoid air cells: agger nasi cells, Haller's cells, ethmoid bulla, Onodi cells (4) other variants: the other variations like bony walls and OMU(osteo-meatal unit) and normal, blocked and widened maxillary and frontal sinuses.

Excel software was used to analyze statistical data.

RESULT

During the period of 8 months of the study 100 patients who fulfilled inclusion criteria were studied, out of which 66 were female and 34 were male **(Chart - 1).** Of the 100 cases studied, anatomical variation of PNS were noted in 91(91%) patients (**Chart – 2**).

CT scan detection of anatomic variations in nasal turbinate: In nasal turbinate's the variation in patient is 63(63%)(**chart-3**), DNS (deviated nasal septum) was most common variation in 80(80%)(**chart-3a**) followed by concha bullosa in 31(49.20%), paradoxical curve in 5(7.93%), atrophic nasal turbinates in 9(14.28%)and hypertrophy in 18(28.57%) patients(**table- 1**)and (**chart-3**).

Other variations found in osteo-meatal unit in the OMU (**table-2**), the maxillary sinus widened 9(9%), blocked maxillary sinus 12(12%) (**chart-5**) and in frontal sinus the widened 8(8%), blocked frontal sinus is 16(16%) (**Chart-6**).

The other variation(**table-3**) in bulla ethmoidalis 6(6%)(**chart-7**), haller cells 10(10%)(**chart-8**), agar nasi cells 5(5%)(**chart-9**), onodi cells 8(8%)(**chart-10**), frontal cells 9(9%)(**chart-11**) and the variation in sinuses is hypoplastic 7(7%)(**chart-12**). The variation in bony walls of PNS is 15(15%) (**Chart-4**).

Table and graphs

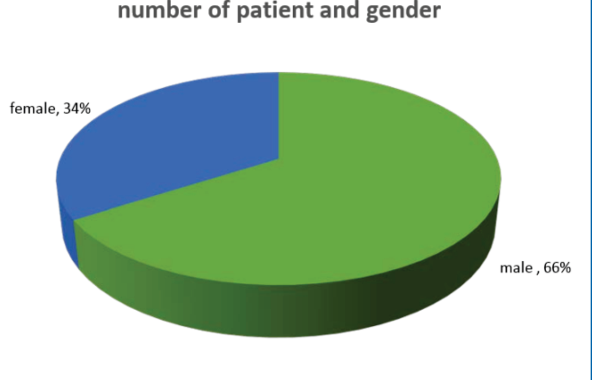


Chart -1

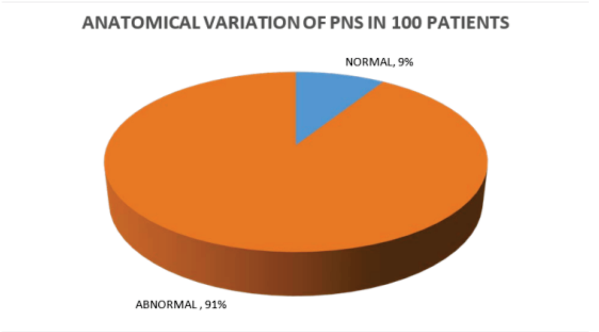


Chart-2

CT DETECTION OF ANATOMICAL VARIATION IN 100 PATIENT

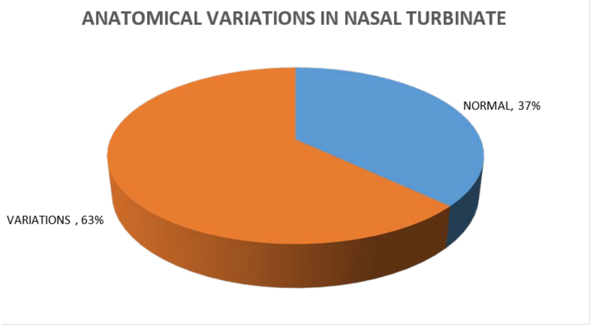


Chart-3

Table 1 Variation in nasal turbinate's

Anatomical variation	Number of patients	Percentage
Atrophic	9	14.28%
Hypertrophic	18	28.57%
Concha bullosa	31	49.20%
Paradoxical curve	5	7.93%

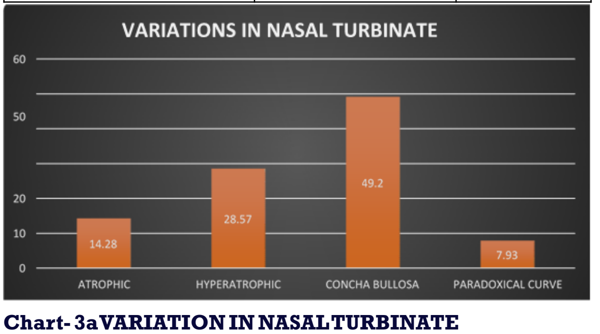


Chart- 3a VARIATION IN NASAL TURBINATE

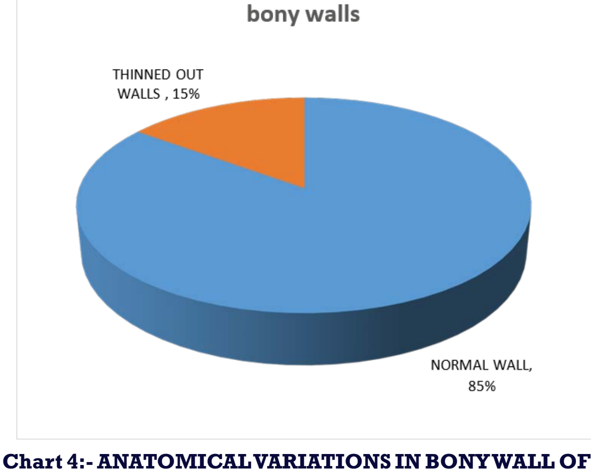


Chart 4:- ANATOMICAL VARIATIONS IN BONY WALL OF PNS

Anatomical variation's in Osteo-meatal unit:-

Table 2:-

Anatomical variations	Number of patients	Percentage
Frontal sinus		
Normal	76	76%
Widened	8	8%
Blocked	16	16%
Maxillary sinus		
Normal	79	79%
Widened	9	9%
Blocked	12	12%

Chart 5:- Osteomeatal unit-

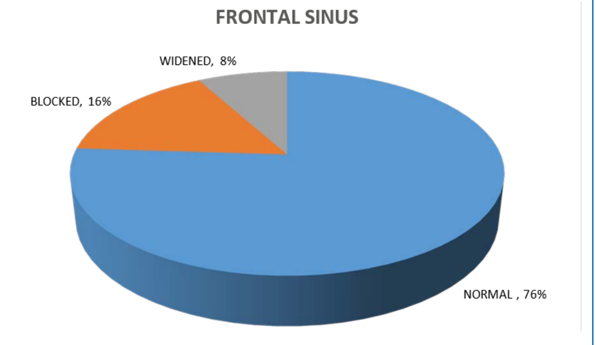


Chart 6:-

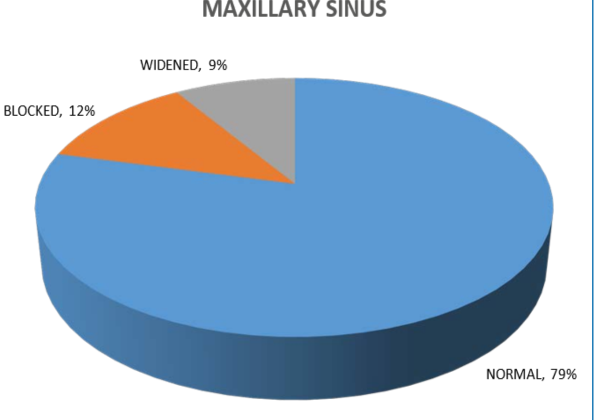


Table 3:- Anatomical variation in paranasal sinuses

variations	Number of patients	Percentage
Bulla ethmoidalis	**6**	**6%**
Haller cells	**10**	**10%**
Agar nasi cells	**5**	**5%**
Onodi cells	**8**	**8%**
Frontal sinus	**9**	**9%**
Sinuses	**7**	**7%**

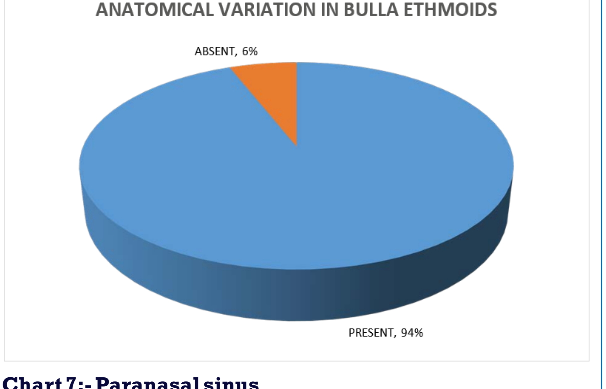


Chart 7:- Paranasal sinus

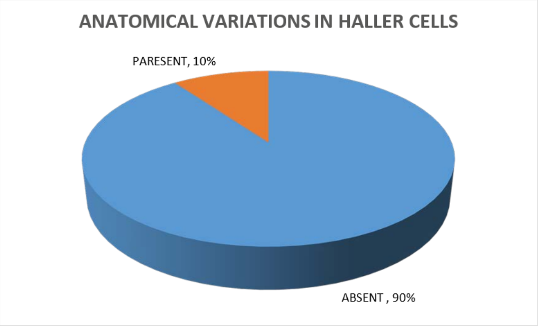


Chart 8:- HALLERS CELLS

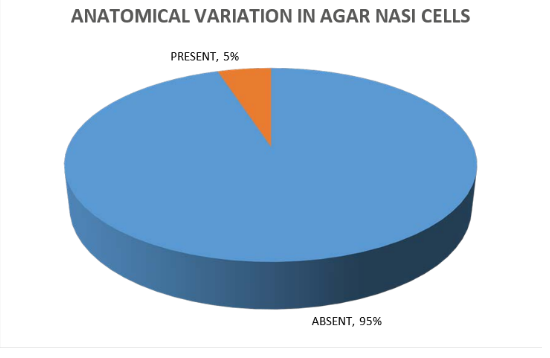


Chart 9:- AGAR NASI CELLS

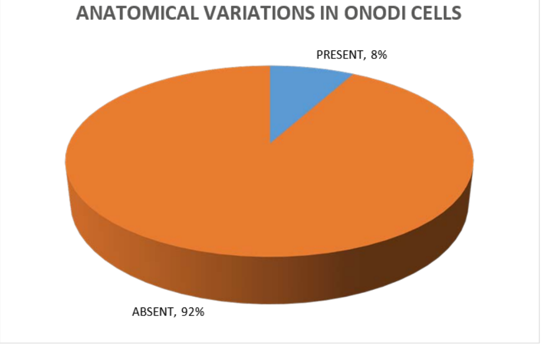


Chart 10:- ONODI CELLS

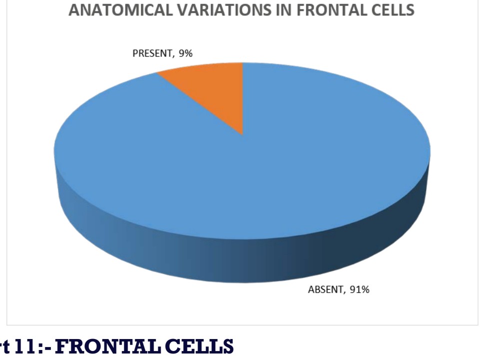


Chart 11:- FRONTAL CELLS

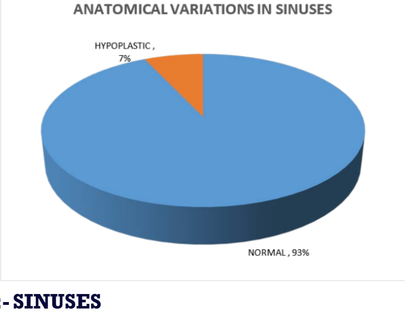


Chart 12:- SINUSES

Images of paranasal sinuses

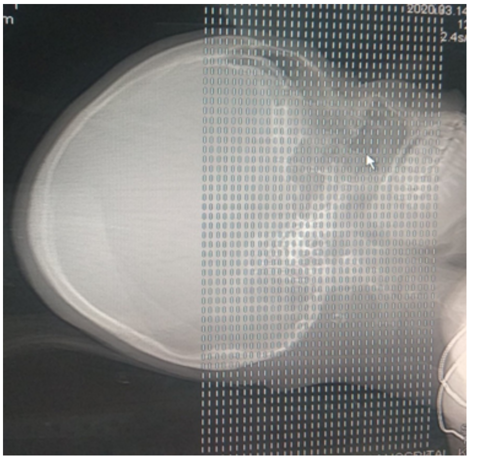


FIGURE- 1. CT scan PNS. Topogram and planning.

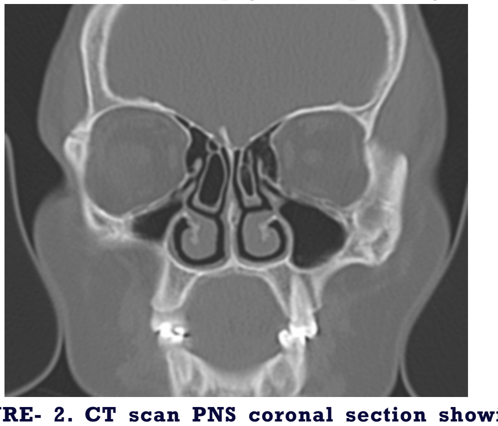


FIGURE- 2. CT scan PNS coronal section showing bilateral concha bullosa- right and left (arrows).

FIGURE- 3. CT scan PNS coronal section showing concha bullosa on the right side (curved arrow) and DNS to the left side (arrow).

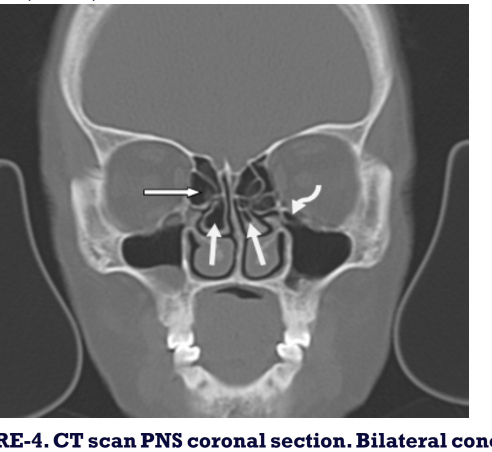
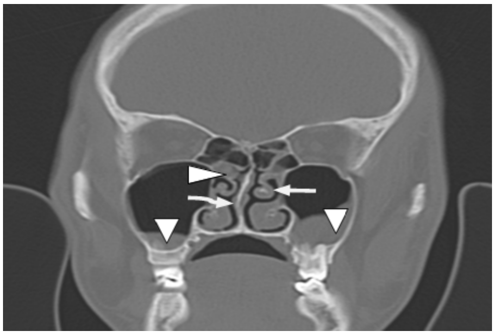


FIGURE-4. CT scan PNS coronal section. Bilateral concha bullosa (white arrow).

Overexpansion of the ethmoid sinus on right side (white arrow with black border). Right Haller cells (curved arrow).



5. CT scan PNS coronal section showing paradoxical curvature of middle turbinate on the left side (arrow) and DNS to the right side (curved arrow).

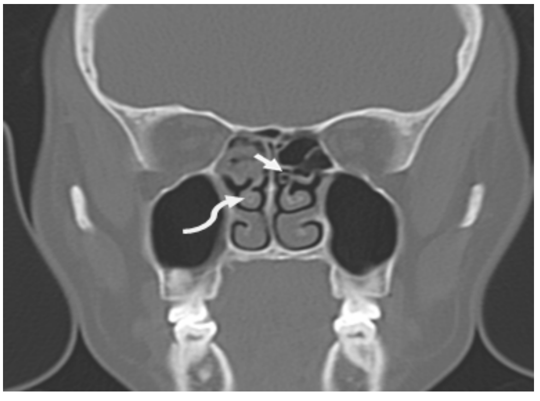


FIGURE- 6. CT scan PNS coronal section showing paradoxical curvature of right middle turbinate (curved arrow) and accessory middle turbinate on the left side (small arrow).

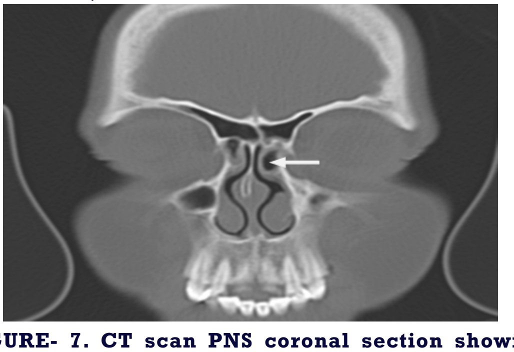


FIGURE- 7. CT scan PNS coronal section showing prominent Agger Nasi cells on the left side (arrow).

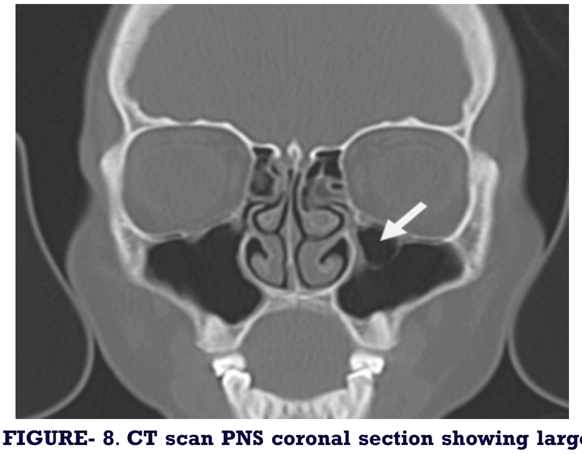


FIGURE- 8. CT scan PNS coronal section showing large Haller's cell on the left side (arrow)

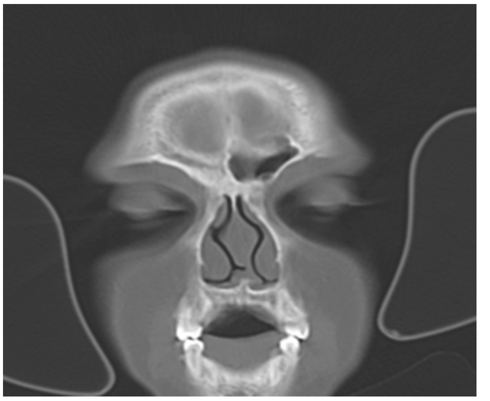
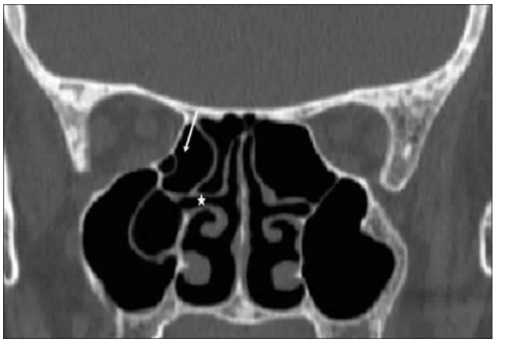
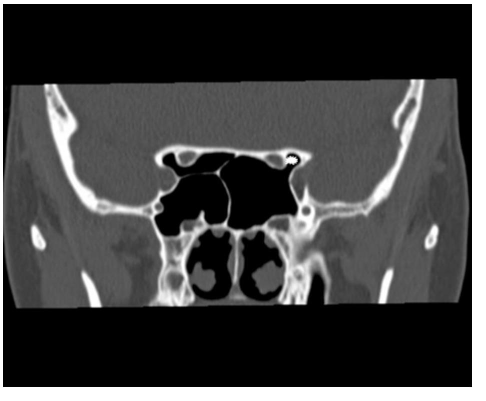


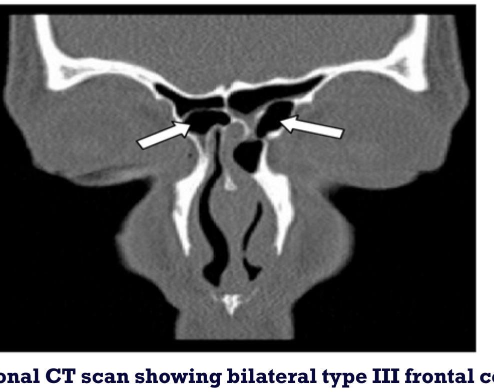
FIGURE- 9. CT scan PNS coronal section showing hypo-plastic right Frontal sinus.



Coronal CT shows ethmoid bulla (arrow) superior to the ethmoid infundibulum (star)



Ct Scan PNS Coronal Image Shows Onodi Cells (Star)



A coronal CT scan showing bilateral type III frontal cells (arrows) pneumatizing from the frontal recesses into the frontal sinuses.

Conclusion

CT scan of the paranasal sinuses has improved the viewing the sinuses anatomy and has allowed great accuracy in evaluating paranasal sinus disease. It evaluates the osteomeatal complex anatomy which is not possible with the plain radiographs. CT scan evaluates both soft tissue and bony details of nose and paranasal sinus. Due to complex anatomy, radiographic evaluation of paranasal sinuses has major limitations and hence cost-effective CT is most common and widely used investigation to study the various anatomical variations. The paranasal sinuses have many different anatomical variations. CT scan plays important role in the diagnosis of anatomical variations. It is also a very sensitive modality for detection, accurate localization and determinations of exact extent of paranasal sinus disease, hence is essential for preoperative evaluation. Various important anatomical variants can also be easily detected on CT of paranasal sinus. CT helps in assessing the extent of sinusitis and to know the presence of certain critical anatomical variants. Awareness of such variations may help in making surgical decisions beforehand and avoiding possible complications and hence improve success of management strategies. However, these advantages come at a cost of exposure to radiation. Hence CT scan of the paranasal sinuses should be advised foe every patient who will undergo invasive procedure like functional endoscopic sinus surgery. The recognition of these variations helps endoscopic surgeons to avoid major risk in advancing the anatomical structures. The radiologist plays an important role in providing the information required by the surgeons.

DISCUSSION

The paranasal sinus region is subject to a large variety of lesions. Congenital anomalies and normal anatomical variations in this region are important as they may have pathological consequence or may be the source of dissections, Messerklinger encountered the Agger nasi cells in 10-15% of the specimens, Davis in 65% of specimens and Mosher in 40% of specimens [24]. Onodi cells are posterior ethmoid cells that extend posteriorly, laterally and sometimes superior to sphenoid sinus, lying medial to the optic nerve. The chances of peri-operative injury to optic nerve are increased when the bony canal of the nerve is lying dehiscent. Most authors have found an incidence of 8–14%, 10.9% by Pere and 11% by Bogler [25,26]

Concha bullosa (pneumatised middle turbinate) has been implicated as a possible an etiological factor in the causation of recurrent chronic sinusitis. It is due to its negative influence on PNS ventilation and mucociliary clearance in the middle meatus region. The presence of a concha bullosa has ranged between 4% and 80% in different studies; our data gave 46.5% which is less compared to 53.6% observed by Bolger and more compared to incidence reported by Zinreich S et al**50** (36%), Dua K (16%) and Peres et al (24.5%). Such a wide range of incidence is due to the criteria of pneumatisation adopted.[13, 27, 28]

Deviated nasal septum causes a decrease in the critical area of the osteomeatal unit predisposing to obstruction and related complications. In our study 75% of cases had DNS, similar finding were observed by Perez, et al., who reported the prevalence of deviated nasal septum to the about 80%. Infarct in various studies the finding of nasal septal deviation ranged from 14.1% to 80%. Dua, et al. [30] and Asruddin, et al. [29], found prevalence of 44% and 38% of deviate nasal septum in their respective studies. Stallmann, et al. [24] also reported lesser prevalence of 60 % deviated nasal septum in chronic rhino sinusitis cases respectively. Concha bullosa was seen in 41.5%of the chronic rhinosinusitis cases which is almost similar to as reported by Bolger, et al., and Yousem, et al., respectively. Perez-Pinas, et al., Scribano, et al., reported higher prevalence of concha bullosa i.e.73% and 67% in chronic rhino sinusitis cases. The prevalence of concha bullosa in our study is on the higher side when compared to the findings of Stallmann, et al. [24] Maru, et al. [9] Wani, et al. [26] Dua, et al. [30] Asruddin, et al. [29] and Llyod, et al. [31] reported further less prevalence of about 36%, 30%, 28%, 16%, 15%, and 14% respectively.

Aggar nasi cells lie just anterior to the anterosuperior attachment of the middle turbinate and frontal recess. These can invade the lacrimal bone or the ascending process of maxilla. These cells were observed in 6.6% of patients in our study.

Similar results were observed by Liu X, et al. [36] and Llyod, et al. [31], who reported the prevalence of aggar nasi cells as 7.8% and 8.5% in chronic rhinosinusitis cases whereas in the study by Dua, et al. [30], agger nasi cells were found to be present in 9 patients (8%). The prevalence is very less as compared to 98.5% by Bolger [37] 88.5% by Maru [38], 86.7% by Tonai and Baba [39] and 48% by Asruddin [40]. The prevalence of Haller's cells in our study was 1.6%. Similar findings were observed by Liu X, et al. [41], who reported the prevalence of about 1% of Haller cells in 297 chronic rhino sinusitis cases in a study conducted in Sun Yat Sen University of Medical Sciences. This is again very less as compared to that reported by Kayalioglu, et al. [42], 5.5%, Dua, et al. [43], 16%, Llyod, et al. [44], 15%, Perez-Pinas, et al. [45].

Paradoxical middle turbinate i.e. bent in the reverse direction may lead to impingement of the middle meatus and thus to sinusitis. In our study it was found in (11.3%) cases and was close to the 10% incidence described by Peres et al. [47] Haller's cells were seen in (10%). Kennedy and Zinreich, 1988 reported a prevalence of 10% as well. [46]

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. [35] These findings seem to 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. [36] 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. [31,48] They concluded that the simple presence of variants does not mean a predisposition 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 62 their size. [49] In our study 94 (66%) patients had PNS mucosal abnormalities and 48 (34%) patients had no mucosal abnormalities. Anatomical variation were seen in 73 (77%) out of 94 patients with PNS mucosal abnormalities and 42 (85%) out of 48 patients without PNS mucosal abnormalities. From this observation our study also reveals that the presence of anatomical variants does not mean a predisposition to sinus pathology.

Zinreich first observed that the uncinate process may be curved or bent. It can impair sinus ventilation especially in the anterior ethmoid, frontal recess and Infundibulum regions. 9 In the present study curved uncinate was found in 10patients unilaterally (7%) and 11 patient bilaterally (7.7%), a total of 14.7%. It is slightly higher than that of 2.5% reported by Bolger. [32] A markedly medially bent or pneumatized uncinate process with a corresponding area of extensive contact with the middle turbinate can cause sinusitis. Combination of some anatomic variations such as uncinate bulla and Haller's cell may increase pathogenic effect compared to the effect of single variant.

We encountered uncinate bulla (Fig.9) in 5 (3.7%) patients, 4 unilateral and 1 bilateral. This is in consistence with 5% reported by Mecit et al and more compared to Zinreich (0.4%) and Bolger et al (2.5%). [33, 34, 27,51]

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