“ROLE OF MULTIDETECTOR COMPUTED TOMOGRAPHY IN THE EVALUATION OF DISEASES OF PARANASAL SINUSES”

By

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Dissertation submitted to the

B.L.D.E. UNIVERSITY VIJAYAPUR, KARNATAKA

In partial fulfillment of the requirements for the degree of

DOCTOR OF MEDICINE

IN

RADIO-DIAGNOSIS

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ACKNOWLEDGEMENT

I express my deep sense of gratitude and heart felt thanks to & Dr Ramesh Pattanshetti. Department of Radio-Diagnosis, Shri B M Patil medical college, Vijapura for there valuable guidance and constant encouragement in bringing out this dissertation.

I express my sincere thanks to Dr Bhushan N Lahakar, Professor & HOD, Department of Radio-Diagnosis, Shri B M Patil medical college,Vijapura for his timely advice and valuable suggestion in preparing this dissertation.

I sincerely thank to Dr.Bhushita Guru, Veeresh.Hanchinal & Satish Patil Assistant Professor, Shri B M Patil medical college,Vijapura for valuable advice in preparing this dissertation.

I also express my thanks Dr Rohit Dept of PSM & Mujawar, (Biostatistics) for helping in statistical analysis of this research work.

I devote my thesis work to all my respected teachers, colleagues, my wife, parents, sister and friends with out their help it would have not been possible for me to complete the thesis work successfully.

Lastly my sincere thanks to all the patients, who with their excellent cooperation became the backbone of this dissertation.

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INTRODUCTION

Diseases of the Paranasal sinuses include wide spectrum ranging from inflammatory conditions to neoplasms, both benign and malignant.

The conventional plain radiography readily demon- strates maxillary and frontal sinus disease they provide limited views of the anterior ethmoid cells, the upper thirds of the nasal cavity and the frontal recess.

Imaging of the PNS has progressed from conventional radiographs (plain films) almost exclusively into the realms of computed tomography (CT) and magnetic resonance imaging (MRI). Technological advances in these two imaging modalities have provided more precise differential diagnosis and greater detail about the anatomic extent of the diseases of PNS. These provide sufficient information for diagnosis and surgical planning for the otolaryngologist.

CT has replaced conventional radiographs as imaging modality of choice for assessment of PNS diseases. CT resulted in the widespread development of endoscopic sinus surgery (ESS) for inflammatory sinonasal diseases.

CT Plays an important role in the evaluation of pre-operative patients considered for FESS called SSCT (Screening sinus CT). It is now mandatory and a medico legal requirement to evaluate PNS and nose before FESS, guides the otolaryngologist during surgery and serves to direct the surgical approach.

CT determines the distribution and extent of disease and detect those anatomic variations (like septal deviation, spur formation, concha bullosa, paradoxical curve of middle turbinate etc.) which places patients at increased risk for intra operative and post operative FESS complications and also reducing the morbidity and mortality of patients.

CT excels over MRI at evaluating fine bone details, assessment of fibro- osseous lesions of PNS and sino facial trauma. Orbital and brain anatomy is visualized better at MR imaging than at CT.

With the unique ability of CT to image both the bones and soft tissues, direct coronal scanning and sagittal reconstruction, imaging the space occupying lesions has been revolutionalised. Accurate extent of disease and micro anatomic locales provide a reliable preoperative guide for endoscopic sinus surgery. A combination of CT and diagnostic endoscopy has become the corner stone in evaluation of the paranasal sinus diseases. Hence CT has immense value and offers standard imaging of paranasal sinus diseases.

OBJECTIVES OF THESTUDY

1. To know the detailed anatomy, anatomic variations and pathology of PN Swhich help the otolaryngologist during surgery, there by reducing the risk of FESS complications.
2. To correlate the clinical diagnosis with CT diagnosis.
3. To know the exactlocation and extent of the disease of PNS which is very important indeciding the management.
4. To diagnose accurately and in staging of any neoplasm of PNS,its site and extensionof tumour spread into the surrounding structures.

REVIEW OF LITERATURE

Hipprocrates in 5th century B.C. stated " In a person having a painful spot in head, with intense headaches, pus or fluid running from the nose removes the disease", which may be referred.to as describing sinusitis. Leonardo da vinci (1452-15 19) gave the accurate description and illustrations of the antrum and frontal sinus.

In 1895, Wilhelm Conard Roentgen discovered X-rays. Scheir (1897) was first to diagnose the presence of pus in the sinus by radiography and confirmed the diagnosis by lavage. Killan and Mosher (1929) published the radiological basis in the diagnosis of chronic maxillary sinusitis. They concluded that an opaque antrum on X-ray film was caused by an accumulation of fluid, which was free or fixed in the thickened mucosa.

Samuel (1963) stated that radiologically, opaque maxillary sinus is to be regarded as the sign and not as definitive diagnosis, as an opacity in the region of maxillary sinus could be of anatomical, technical or pathological nature. He further described the occipitomental projection as the best suited one for the evaluation of the state of maxillary sinus. Hounsfield and Ambrose devised computerized tomography in 1960's. Coronal plane computerized tomographic (CT) scanning has dramatically improved the imaging of paranasal sinus anatomy as compared to sinus radiographs. Increasingly subtle bony anatomical variations and mucosal abnormalities of this region are being detected.

W. E. Bolger et al[4] (1997) in their study of coronal CT Scan of 202 patients, directed special attention towards bony anatomic variations and mucosal abnormalities. Valerie J. Lund et al[5] (2000) conclude that computerized tomography (CT) offers the gold standard in terms of imaging the extent of disease and the fine detailed anatomy. Neither plain X-rays nor Magnetic Resonance Imaging (MRI) offer

optimal information in this respect.

CT scanning has allowed the radiologist to image paranasal sinus disease with accuracy and detail never before attainable. This information has made the imager an important member of the physician team that evaluates the operability and treatment planning of these patients.[6] Coronal CT scanning of the paranasal sinuses can accurately delineate anatomic abnormalities and sinus disease.[7]

CT scan is the appropriate radiological examination of patients with acute sinusitis associated with complications or chronic sinusitis.[8] In benign lesions CT adds only a little more information to that obtained by conventional radiological methods. In malignant lesions however CT provides additional valuable information.[9]

CT is now established as the overall best method for evaluation of patients who are suspected of having an aggressive lesion of the paranasal sinuses.

Chow J.M., Leonelti J.P., Mafee M.F., concluded that CT imaging is important to evaluate tumours of nasal cavity and PNS and CT imaging allows to evaluate the fine bony details and osseous tumours.[33]

G.A.S. Lloyd, V.J. Lund, G.K. Scadding reported that CT scanning is better in identifying anatomical landmarks of PNS preoperatively and thereby reduces the complications of FES S.[47]

Aygun N., Uzuner O., Zinreich SJ concluded that coronal CT imaging of PNS correlated with the endoscopic view and helps in better understanding of pathophysiology of specific pathologic process in the PNS diseases.[62]

Aygun. N., Zinreich S.J. reported that CT imaging of PNS is complimentary to the clinical and endoscopic evaluation of PNS disease and CT's ability to display bone, mucosa and air makes it a perfect tool for imaging of the PNS.[62]

Branstetter B.F., Weissman J.L. reported that conventional radiographs are of

limited diagnostic use in evaluation of PNS diseases and modern imaging techniques like CT and MRI provide greater detail about the exact location and extent of PNS disease and help better in the diagnosis and surgical planning in the sinuses. He also stated that CT is better than MRI in knowing the finer bone details and fibroosseous lesions of PNS.[63]

H. Chopra, reported that CT imaging proves to be indispensable tool in case of nasal polyps as it provides a "ROAD MAP" to the endoscopic surgeon and warns one of any existing or impending complications.[64]

Paul. S. White, reported that a complete axial and coronal CT scan series provides an excellent and comprehensive evaluation of the paranasal sinuses.[65]

Jaswal. A. et. al., concluded that mucoceles are the most common benign expansible lesions of PNS and CT is the preferred imaging modality for diagnosis of mucoceles.[66]

Phillips C.D., reported that coronal high resolution CT of the sinuses has become widely accepted as a necessary part of the preoperative evaluation of patients scheduled for FESS. He also reported that CT and MRI play complementary roles in imaging PNS neoplasia.[67]

A.K. Devaiah reported that combined use of CT and nasal endoscopy is the most accurate approach in diagnosing the diseases of PNS.[68]

CLINICAL ANATOMY

DEVELOPMENT OF NOSE AND PARANASAL SINUSES:

Development of the nose is a continuous process that commences in the third week of gestation when the primordial structures first appear and continues until completion in early adulthood when sinus pneumatization and bony growth have ceased. [2,11,12]

The nose develops from the cranial ectoderm above the stomatodeum where paired thickenings - the Olfactory or Nasal placodes - become apparent in the fourth intra uterine week, when the embryo has a crown rump length of 5.6 mm.[2,11,12]

The maxillary sinus is first recognizable as a shallow groove expanding laterally from the infundibulum in the fourth intrauterine month. At birth, the sinus has commenced invasion of the maxilla with its lower border about 4 mm above nasal floor. Expansion and pneumatization continue until 8-9 years of age. At adult stage the antral floor becomes 3-4 mm lower than nasal cavity. [13,14.]

The ethmoids arise from preformed furrows between folds that develop on lateral wall of the nose and are discernible in the 4th intrauterine month. The cells are primarily invaginations of nasal mucosa which grow into lateral ethmoidal masses and by further growth of the sacs and absorption of bone, become established as cellular labyrinth which is well pneumatised at birth. Up to the age of 6 years they grow slowly but thereafter more quickly to reach their permanent shape by puberty.[14] The frontal sinus is absent at birth and only becomes obvious at 6 - 12 months of age. The sphenoid is recognizable from the third intrauterine month as an invagination of the spheno ethmoidal recess. At birth it is 5 x 2 x 2 mm and becomes ful1y aerated by age of 8 years.[14,15,16]

CLINICAL ANATOMY OF PARANASAL SINUSES AND THE ADJOINING AREAS

MAXILLARY SINUS (Fig 4) :

Each maxillary sinus is hollow and pyramidal in shape. It is based medially on the nasal cavity and projects laterally to form an apex in the zygoma. Its volume is approximately 15 ml. The average dimensions are:

- 34 mm antero-posteriorly.
- 25 mm transversely.
- 33 mm vertically.

When viewed from above, in a transverse section the sinus appears triangular. It has got 4 walls- Facial, orbital, nasal and infratemporal. It has got 4 processes - the alveolar, palatine, frontal and zygomatic. [14,17,18]

The walls are normally thin and delicate. The anterior or facial surface of maxilla is slightly concave and faces anterolaterally. This surface is marked by the infraorbital foramen in the superior aspect. The· orbital surface is not horizontal, it slopes to face anteriorly and laterally as well as superiorly. It is triangular and its anterior border forms the medial half of interior orbital margin. Zygoma accounts for the rest. The medial border bounds the important inferior orbital fissure. The medial border abuts the ethmoid labyrinth except anteriorly (the lacrimal bone) and posteriorly (the orbital process of palatine bone). [18]

The nasal surface of the maxilla is eminently accessible to inspection, palpation and biopsy. Infratemproal surface faces posteriorly (and laterally) towards infra temporal and pterygo palatine fossae. Fine grooves descent on the lateral half of infratemporal surface to foramina that transmit the posterior superior alveolar nerves. [18]

Processes of maxilla:

Alveolar Process: This process project downwards from the body and palatine process of maxilla. It is continuous in front with its opposite mate and ends posteriorly at the maxillary tuberosity. The alveolar process forms floor of the antrum and mucosa may contact the roots of any of the teeth posterior to canine teeth.

Palatine process: It is a shelf of bone projecting medially from anterior 2/3rd of lower border of the nasal surface of maxilla. Anteriorly it is continuous with the alveolar process. Posteriorly it articulates with the horizontal process of palatine bone and two processes together completing the hard palate.

Frontal Process: It is a strong band of thick bone twisting upward from medial corner of the face of the maxilla. It articulates superiorly with frontal bone. Medially, the upper lateral cartilage and the nasal bone approximate it. Laterally, it forms the anterior lacrimal crest, posteriorly it articulates with the lacrimal bone and anterior end of the middle turbinate.

Zygomatic Process: The apex of the maxillary pyramid is an inclined roughened surface that articulates with the zygoma. The suspensory ligaments of the eye attach to witnall's tubercle on the medial side of zygoma's frontal process. [14,17,18,19]

ETHMOID SINUS (Fig 5) :

The ethmoid labyrinth, which is interposed between the maxilla and the anterior cranial fossa is a complicated assemblage of small air cells. It fills the 10 region between two orbits and extends from lamina papyracea of one side to that of the other side. It is pyramidal in shape with its base directed posteriorly. Its volume is approximately 1 4ml.[14,19,20]

Dimensions: 4 to 5 cms anteroposterior length, 2.5cms height 0.5cms wide anteriorly and 1.5 cms wide posteriorly

Roof: Fovea ethmoidalis is usually 2-3 mm above the paramedian cribriform plate. Medial limit is the middle turbinate. From its roof descend nine delicate laminae-Four on either side. They are uncinate, the ethmoid bulla, superior turbinate and middle turbinate. The midline lamina is the ethmoid plate of septum which is paper thin. The uncinate articulates with the maxilla. The bulla and both turbinates are free. The ethmoid plate descends in midline to join the vomer. The ethmoid air cells can be divided into intra mural and extra mural air cells. The fonner is within ethmoid.

The intramural cells are divided into anterior, middle and posterior groups. The anterior intramural cells are the frontal recess cells, which extend towards the frontal bone anterosuperiorly. The next most anterior group is the infundibular cells; from these arise the anterior extramural cells called agger nasi cells, which pneumatised the lacrimal bone. The other group of cells are the middle ethmoidal air cells and the posterior ethmoidal air cells. Posteriorly the ethmoid labyrinth contacts with the body of the sphenoid. The most posterior cell is usually the largest. The anterior group of cells contain 8-11 cells. The middle group generally compose 3-5 cells. The posterior group varies from 2-7 in number. [19]

RELATIONS

- Superiorly- Frontal lobe, Olfactory bulb
- Laterally- Orbit
- Posteriorly- Optic canal and optic nerve
- Medially- Nasal cavity

SPHENOID SINUS (Fig 6 & 7):

Sphenoid sinus spreads laterally to invade the greater and lesser wings and medial and lateral pterygoid plates of sphenoid. Occasionally even into the basilar part of occipital bone. Sinuses are separated by a septum which is seldom in the mid line and some times absent. Anteriorly these sinuses are covered by a thick plate of sphenoidal turbinates. This lies over the anterior part of the sinus and attached to the back of ethmoid bone. A foramen in the center of each turbinate allows the sinus of each side to communicate with the nasal cavity at the spheno ethmoidal recess. Its volume is approximately 7. 5ml.[15]

Dimensions: Height - 2 cm. Breadth - 1.8 cm. Depth - 2 cm.

FRONTAL SINUS (Fig 8):

The two frontal sinuses are found in the frontal bone above and deep to the superior ciliary ridges. The two sinuses are usually unequal in size and each has the shape of an irregular pyramid with its apex directed upwards. They are separated by a thin septum of bone, which is seldom deficient. The sinuses of men are usually larger than that of women. The anterior wall is formed by diploic bone and the thickness varies from 1-5 mm. Posterior wall is thinner but is composed of more compact bone. The floor slopes medially downwards and backwards towards the opening of frontonasal duct. The duct opens into middle meatus (Frontal recess area). Its volume is approximately 6- 7 ml.

Dimensions: Height - 28 mm. Breadth - 24 mm. Depth - 20 mm.

VASCULARIZATION, INNERVATION, AND LYMPHATIC DRAINAGE OF THE NOSE AND PARANASAL SINUSES

Region	Vascularization	Innervation	Lymphatic drainage
External nose	Facial a Maxillary a Ophthalmic a	Muscular innervation: N. VII Sensible innervation: N. V1/V2	Submental Ln Submandibular Ln (Parotic region)
Nasal septum	Poster inferior Sphenopalatinal a Anteroinferior Greater palatine a Superior branches of the facial Superior Anterior/Posterior ethmoidal a	Sensible innervation: N. Vs Superior Nasopalatine n Anterosuperior Nasopalatine n Anterior ethmoidal n Anteroinferior Superior anterior Alveolar n Olfaction N. 1	Anterior Submental Ln Submandibular Ln Posterior Retropharyngeal Ln Deep cervical Ln
Nasal Cvity	Superior Anterior/posterior Ethmoidal a Inferior/middle turbinate Sphenopalatine a Anteroinferior Greater palatine a Facial a	Sensible innervation: N.VI Nasociliary n Anterior Ethrnoidal n Infratrochlear n N.V2 Branches via Sphenopalatine foramen	Anterior Submental Ln Submandibular Ln Posterior Retropharyngeal Ln Deep cervical Ln
Paranasal sinuses			
Maxillary sinus	Branches of: Facial a Maxillary a Infra-orbital a Palatine a	N.V2 Infraorbital n Superior alveolar n Greater palatine n	Submandibular Ln
Ethmoidal cells	Anterior cells Anteior ethmoidal a Ophthalmic a Posterior cells Posterior ethmoidal a	N.V2 Anterior/Postrior Ethmoidal n Orbital branches of ggl Supraorbital n	Anterior cells Submandibular Ln Posterior cells Retropharyngeal Ln
Frontal sinus	Supra-orbital a Anterior ethmoidal a	Supraorbital n	Submandibular Ln
Sphenoidal sinus	Postrior ethmoidal a	Posterior ethmoidal n Orbital branches of ggl Sphenopalatine ggl	Retropharyngeal Ln

Abbreviations : a. artery ; ggl, ganglion ; Ln, lymph node ; N, nerve ; n, nerve

HISTOLOGY OF THE NASAL AND PARANASAL MUCOSA

The anterior part of the nasal cavity, corresponding to the nasal vestibule, is lined with a squamous epithelium with vibrissae or coarse hairs, sebaceous glands, and sweat glands. Inside the nasal cavity, three different types of epithelium can be observed. The first third of the nasal cavity is covered with squamous and transitional epithelium. This epithelium also is found at the anterior ends of the middle and inferior turbinate. This epithelium contains cuboidal cells with microvilli. In the posterior two thirds of the nasal cavity, a pseudostratified columnar epithelium (respiratory epithelium) is found, which is composed of four major types of cells: ciliated (columnar) cells, nonciliated (columnar) cells, goblet cells, and basal cells. This epithelium protects the upper and lower airways with the mucociliary clearance activity. Goblet cells produce an acidic mucin with a certain viscoelasticity, essential for good clearance. Ciliated cells are covered by cilia originating from basal bodies that also serve to anchor them to the cell. These cilia beat with a frequency of 1000 strokes per minute, and this beat consists of a rapid forward beat (effective stroke) and a slow return beat (recovery beat). Eighty percent of the cell population is ciliated cells. The ratio of the columnar to goblet cells is about 5:1.

Both of these epithelium lie on a basement membrane and a lamina propria. The basement membrane is penetrated by capillaries so that fluids can pass directly through these vessels onto the mucosal surface. This difference in permeability is a fundamental difference between the basement membrane found elsewhere. The lamina propria contains all the glandular, nervous, and vascular structures.

The third epithelium is the olfactory epithelium, which covers the superior turbinate and adjacent septum. It is a pseudostratified epithelium containing olfactory

cells (bipolar neurons acting like peripheral receptors and first-order ganglia), basal cells, and Bowman's glands (small serous tubulo-alveolar glands). Basal cells are small polygonal stem cells that give the olfactory epithelium the unique property for neural tissue regeneration after viral damage. The olfactory system is connected with the limbic system, reticular formation of the brain stem for odor-alerting response, hippocampus, thalamus, hypothalamus, and frontal lobe.

Lymphatic drainage of paranasal sinuses:

From skin over antero lateral wall of maxillary sinus, lymph drains to the submandibular nodes. From the antral cavity lymph drains to the retropharyngeal lymph nodes. From the retropharyngeal lymph nodes, lymph is drained to the upper deep cervical lymph nodes. Anterior and middle group of ethmoid cells drains to the submandibular nodes and those of posterior ethmoid cells drains into retropharyngeal lymph nodes and those of posterior ethmoid cells drains into retropharyngeal lymph nodes. From sphenoid sinus, lymph drains into retropharyngeal lymph nodes. [17,19]

CLINICAL ANATOMY OF ADJOINING AREAS:

Lateral wall of nose: Lateral wall of nasal cavity is formed by the contribution of several bones. They are: nasal surface of maxilla, inferior conchae, perpendicular plate of palatine bone, middle and superior conchae of ethmoid bone. The horizontally aligned conchae form a passage or meatus, between the lateral wall and scroll like edge of the medially projected conchae. Each meatus is named after the conchae that forms its roof. In addition a number of important landmarks are located in relation to meatus as well as the opening of the paranasa sinuses and naso-lacrimal duct. From anterior to posterior the important landmarks are: Nasal valve, nasal antrum, meatus and its openings. [19]

Nasal valve: This is the area where lower edge of the upper lateral cartilage

arises. It is a fold on the inside of the lateral nasal wall well within the view of the examiner. [14]

Nasal antrum: (atrium of nose) This is the smooth and symmetric area between valve and beginning of turbinate on the lateral nasal walls. [19]

Turbinates and meati: Turbinates consists of cavernous vascular tissue on very thin bony support. Postero superior conchae is the space known as sphenoethmoidal recess, which is the drainage site of sphenoid sinus. Inferior to superior conchae in the superior meatus, there are usually one or two openings for posterior ethmoid air cells.

Middle conchae hoods the meatus which is the recipient site of all sinus ostea except posterior ethmoid and sphenoid sinus. Posterior end of middle conchae points to the opening of the sphenopalatine foramen in the upper part of vertical plate of palatine bone. This foramen actually represents a gap in the fusion between sphenoid, palatine and ethmoid bones rather than an opening in one of the bones. It transmits neurovascular bundle to nasal mucosa.

Nasofrontal duct: Usually opens into the anterior superior aspect of the ethmoid infundibulum and is in close anatomic proximity to frontal sinus. Just anterior to the superior attachment of the middle turbinate and anterior to the frontal recess is the agger nasi. This prominence on the lateral nasal wall represents the most anterior of the anterior ethmoid cells.

Bulla ethmoidalis: Contain large middle ethmoid cells within delicate walls. These cells open into ethmoid infundibulum or on to the medial wall of the bulla. The maxillary sinus opens via its natural ostium into the posterior aspect of the ethmoid infundibulum.

No sinus empties into the inferior meatus. But this meatus is the site of the nasolacrimal duct opening. The opening of the nasolacrimal duct is located in the antero

superior portion of the meatus at the point that inferior concha contact the lateral wall of the nasal cavity. [6,14]

COMPUTED TOMOGRAPHY:

CT differs from conventional radiographic study in several ways. First, X-ray tube is aligned with a detector crystal or banks of detectors rather than X-ray film. A highly collimated (very thin) X-ray beam is projected through the part being examined so that only a thin layer of the patient is exposed for slice, in contrast to conventional tomography, in which the entire volume being studied is exposed even though only a small layer of volume is in focus on each section. Therefore exposure of the patient to X- rays is much smaller in a CT examination than for conventional tomography. Currently CT scanning parameters are being adjusted to further decrease the radiation exposure. By reducing the milliamperage(mA) and time for scanning, the radiation exposure can be reduced to 1 or 1.5 rads

The coronal plane is the plane closest to the view of the endoscopist. It is also the imaging plane that best displays the OMU. Thus it is the preferred plane for direct scanning. Each patient is positioned prone with head hyperextended on the scanner. For optimal visualization of the osteomeatal channels, the field of view should be focused on the paranasal sinuses. Scanner computation algorithms are selected to favor the demonstration of the soft tissue. Window widths are usually at 2000 and the window is centered to -200, these parameters are optimal. For the demonstration of adjacent pathological conditions (in the face) a narrower window range is necessary. Scanner "raw" data are transiently saved so that high-resolution bone-enhancing reconstruction can be applied when bone erosion was either visualized or suspected.

When patients are unable to assume the prone position, axial scans (from the palate through the frontal sinus) are obtained and indirect coronal reconstruction is then

generated from them. For special attention to the anterior ethmoid region coronal indirect reconstruction are performed to complement the initial scanning plane. The coronal plane remains the plane of choice.

CT ANATOMY:

Ethmoidal Labyrinth: [20]

As seen on the coronal view, air cells collectively form the ethmoidal labyrinth. They appear as a near vertically oriented, thinly septated honeycomb lined by mucosa. These vertically situated air cells are narrower anteriorly and wider posteriorly.

Boundaries:

Laterally -lamina papyracea

Superiorly - orbital plate of the frontal bone Medially - perpendicular plate of ethmoid Inferiorly- middle turbinate

OSTEOMEATAL UNIT (Fig 3): [21,22,23]

Complex anatomic region at crossroads of mucociliary drainage from frontal,anterior ethmoid and maxillary sinuses. It incorporates the maxillary sinus ostium, infundibulum, uncinate process, hiatus semilunaris, ethmoid bulla, middle turbinate and middle meatus.

Maxillary sinus ostium and infundibulum:

Maxillary sinus ostium and infundibulum serve as the predominant channels linking the maxillary sinus with the nasal cavity. They are best visualized in the coronal plane.

The maxillary ostium is located in the superior portion of the medial maxillary wall and drains into the posterior aspect of the ethmoid infundibulum. The infundibulum is a funnel shaped passage that connects the maxillary sinus to the middle meatus via the hiatus semilunaris.

Boundaries of infundibulum

Anteromedial and anteroinferior - uncinate process

Posterior - Bulla ethmoidalis

Medial - Communicates with middle meatus through the hiatus semilunaris

Lateral - Superiorly - lamina papyracea (Separating the Orbit)

Inferiorly - Maxillary fontanelle (Separating the maxillary sinus) The accessory orifice most frequently opens into the anterior fontanel1a of the nasal cavity and is best seen on modified axial views, assuming a mid position between "true" axial and coronal planes. The infundibulum represents the supero medial extension of the ostium. The posterior extent of the uncinate process and the relative position of the ostium determine whether the ostium may be visualized on endoscopy.

Hiatus semilunaris:

This complex space gains its name from its arched appearance in the sagittal plane. The hiatus semilunaris is bounded superiorly by the ethmoid bulla, laterally by bony orbit, inferiorly by the uncinate process and medially by the middle meatus. The hiatus semilunaris is the final segment for drainage from the maxillary sinus being preceded by the maxillary ostium and infundibulum. The hiatus semilunaris is best identified on parasagittal sections.

Middle turbinate:

The middle turbinate lies inferomedial to the anterior ethmoidal air cells. Its most consistent bony attachments are vertical to the cribriform plate superiorly and to the lamina papyracea laterally via a bony strut termed the basal (ground) lamella. Quite often the body of middle turbinate contains an air filled cavity, the concha bullosa, which communicates variably with superior meatus, the frontal recess, or the sinus lateralis.

Ethmoidal bulla:

The ethmoidal bulla usually consists of an air cell of variable size and shape. It is bordered inferomedially by the infundibulum and hiatus semilunaris, laterally by the lamina papyracea and superoposteriorly by the sinus lateralis. It communicates with nasal cavity via an ostium, the site of which appears to be variable.

Frontal recess:

The frontal recess affords mucocillary drainage of the frontal sinus. Drainage may occur directly into the middle meatus medial to uncinate process, into ethmoidal infundibulum more laterally or more posteriorly above ethmoidal bulla.

Nasolacrimal Duct:

The Nasolacrimal Duct is a straight coursing tube that extends upward from the lacrimal fossa to an area adjacent to the attachment of the inferior turbinate. In the coronal view the duct is nearly superoinferiorly oriented with its inferior portion lying about 3 to 5 degree medial to its superior portion.

Sphenoid ostium and sphenoethmoidal recess:

These are best evaluated on either axial or sagittal scans. The ostium is located at the anterosuperior portion of sphenoid sinus. The sphenoidal ostium and the posterior ethmoidal cells drain into the sphenoethmoidal recess.

VITAL RELATIONS OF PARANASAL SINUSES: [6,14,23]

1. **Orbt:** The ethmoid labyrinth is separated from the orbit by only a thin bone "lamina papyracea". The lamina may have natural dehiscences especially in the cranial quarters. This permits the infection to spread from ethmoid to orbit.
2. **Optic Nerve:** This lies in close apposition to the lateral aspect of posterior ethmoid and sphenoid sinuses. The optic canal varying in length from 5.5 - 11.5 mm (average 9.22mm) runs between the two roots of the lesser wings of the

sphenoid after coming in relation to posterior ethmoid. Its distal opening termed the optic ring borders on the most posterior ethmoid cells in about 50% of the cases and on the sphenoid sinus in 25% cases. In 25% of cases the nerve is almost completely surrounded by an air space. During its course, the optic nerve produces the "optic bulge" against the superolateral wall of sphenoid. It is more pronounced in over pneumatised sphenoid cells.

3. **Internal carotid artery (ICA):** ICA can bulge into the sphenoid producing a carotid eminence. Van Alyea found 65% of arteries bulging into the sinus. In 14% the whole serpentine course of the vessel could be tracked along the lateral sinus wall.

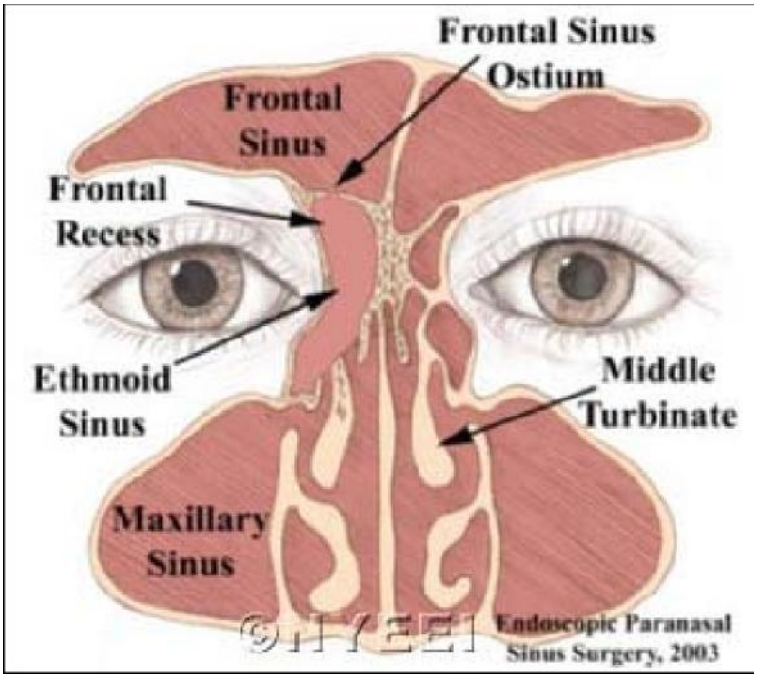


Fig 1 : Paranasal Sinuses

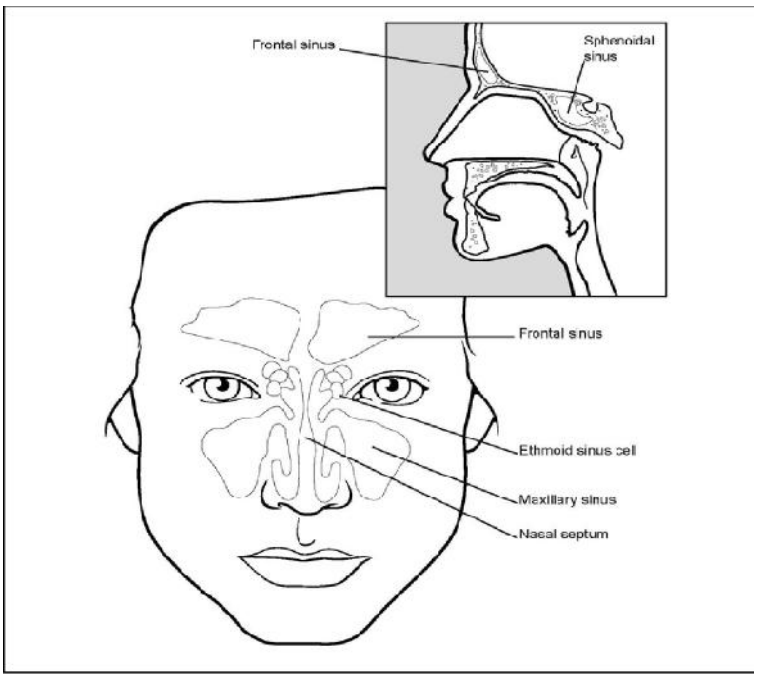


Fig 2 : Anterior and Lateral view of Paranasal sinuses

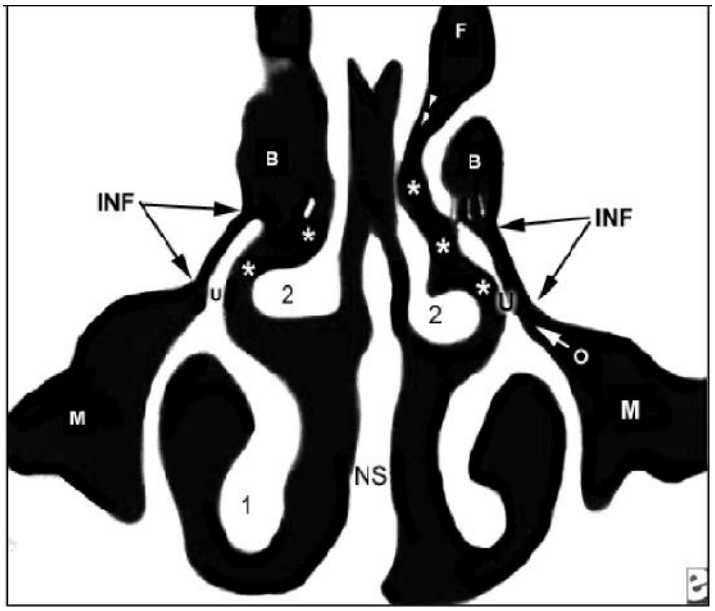


Fig 3 : Osteomeatal Unit : 1. Inferior turbinate, 2. Middle turbinate, INFInfundibulum, M-Maxillary Sinus, F-Frontal sinus, U-Unscinate process, B-Bulla ethmoidalis, O-Maxillary sinus ostium, * - Frontal recess.

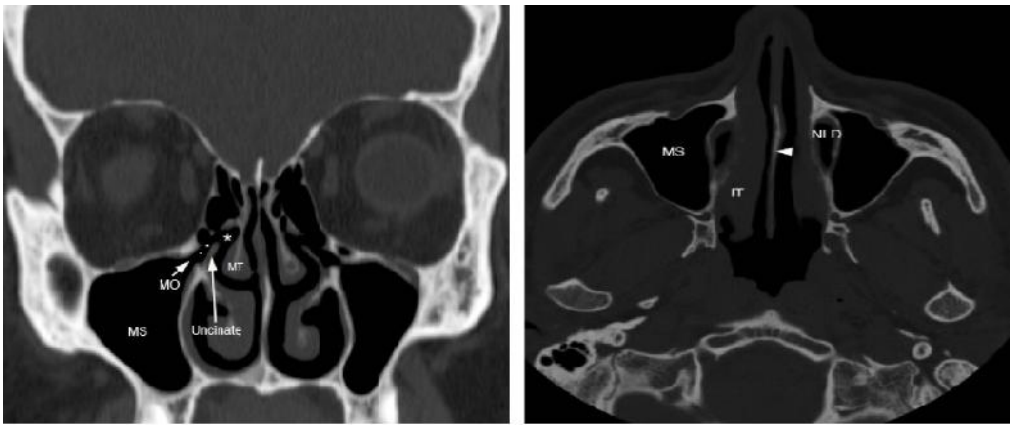


Fig 4 : Coronal and Axial CT images showing maxillary sinus.

(Doted lines indicate maxillary sinus ostium)

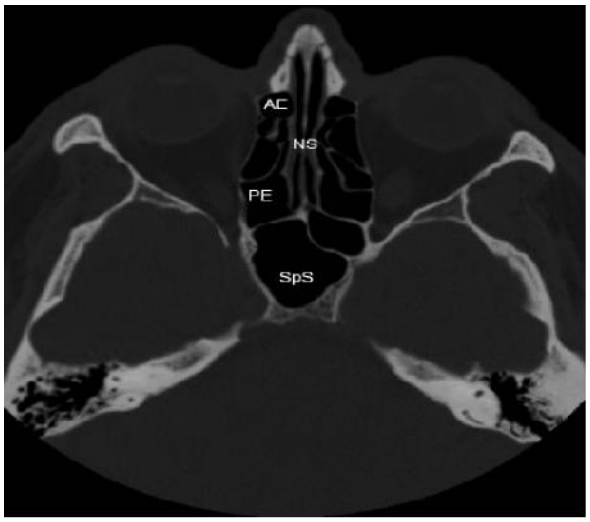
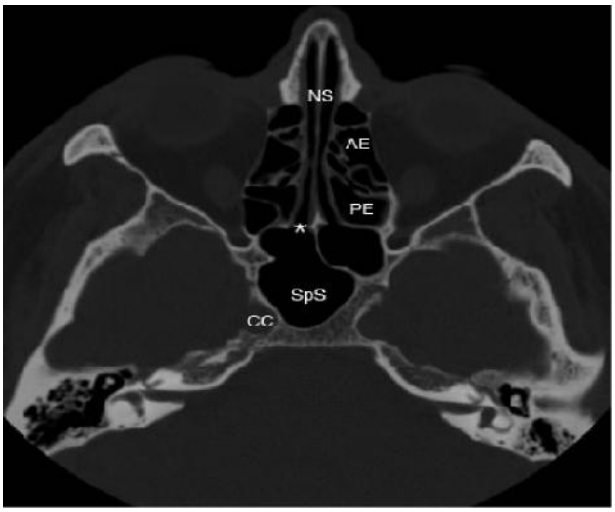


Fig 5 : Axial CT image showing normal ethmoid sinus anatomy. AE-Anterior ethmoid PE-Posterior ethmoid NS-Nasal septum SpS-Sphenoid sinus

Fig 6 : Axial CT image showing normal sphenoid sinus and sphenoidal ethmoidal recess (*) AE-Anterior ethmoid PE-Posterior ethmoid NS-Nasal septum SpS-Sphenoid sinus CC-Carotid canal



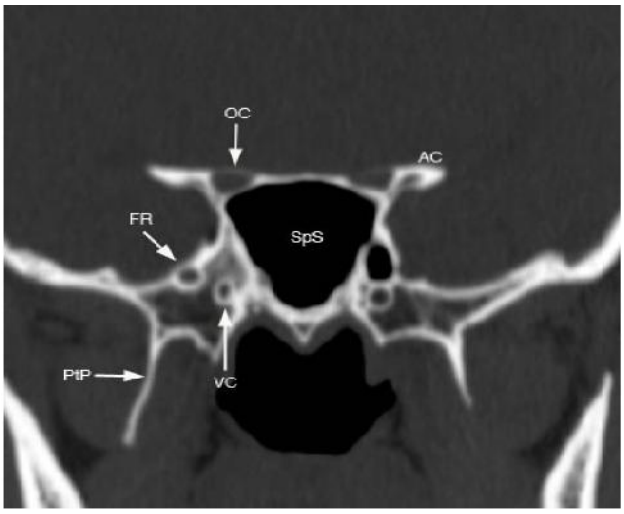
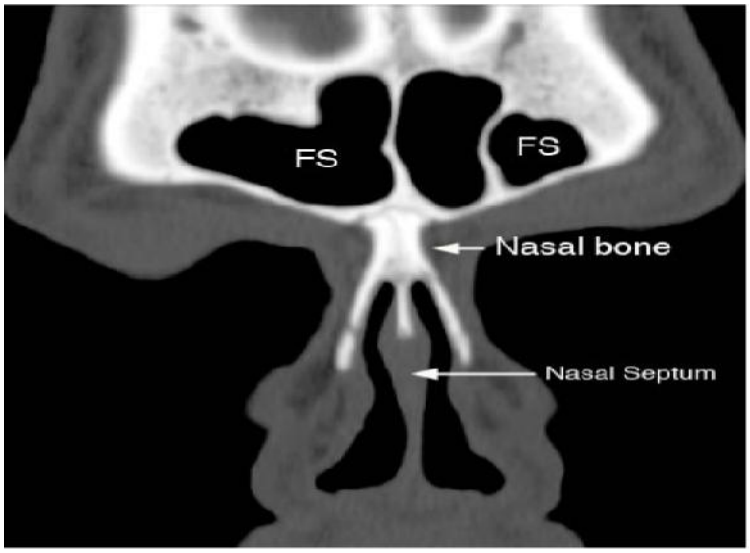


Fig 7 : Coronal image of the sphenoid sinus (SpS) and neighbouring structures, FR-Foramen rotundum VC-Vidian canal OC-Optic canal AC-Anterior clinoid PtP-Pterygoid plate



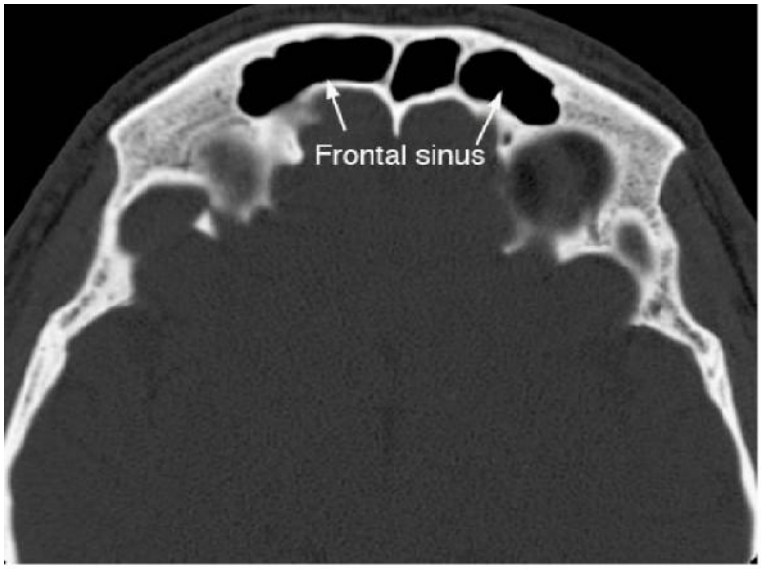


Fig 8 : Coronal and Axial CT images showing normal frontal sinus (FS) anatomy

CLINICALLY RELEVANT ANATOMIC VARIANTS OF PARANASAL SINUSES

Computed tomography (CT) is the modality of choice when assessing inflammatory sinus disease and is routinely performed prior to functional endoscopic sinus surgery, the aim of which is to restore the normal mucociliary drainage pathways.

It is important for the radiologist to understand the anatomy of the drainage pathways and the frequent anatomical variants in this region in order to guide the surgeon.

These variants may impair the functional drainage pathways, increase the risk of endoscopic surgery, and make access to sites of disease extremely difficult.

The aim of this review is to highlight the clinically relevant sinonasal anatomy and variants.

The Agger Nasi Air Cell : (ANC) (Fig 10)

The ANC is the most constant and anterior of the ethmoidal air cells, hence the Latin term meaning nasal mound, and is located anterior to the vertical (anterior) attachment of the middle turbinate to the skull base.

The degree of ANC pneumatization varies and has a significant effect on both the size of the frontal sinus ostium and the shape of the recess. If the ANC is small, then the thick bone or “beak” of the frontal process of the maxilla, lying anteriorly and superiorly, will be prominent and extend posteriorly into the frontal recess, resulting in a narrow ostium. Conversely, if the ANC is large, the beak will be small, resulting in a wider ostium but potentially causing obstruction more inferiorly.

The Frontoethmoidal (Kuhn) Cells : There are various accessory air cells in the frontoethmoidal region that may or may not be present. It is important to work out the drainage pathway of the frontal sinus around these cells.

Frontolethmoidal air cells, also known as Kuhn air cells, are categorized into four types depending on their number and degree of extension into the frontal sinus.6 They are all located superior to the ANC.

Type 1 (most common): Single cell superior to the ANC that does not extend into the frontal sinus (ie, remains below the “beak”)

Type 2: Two or more cells superior to the ANC that may or may not extend into the frontal sinus.

Type 3: Single frontal cell superior to the ANC that extends into the frontal sinus.

Type 4: Completely contained in the frontal sinus. This configuration is rare (if assessed in three planes, a connection with an ethmoidal air cell can usually be demonstrated).

Sphenoethmoid cell (Onodi cell) (Fig 12) :

This is formed by lateral and posterior pneumatization of the most posterior ethmoid cells over the sphenoid sinus. The presence of Onoid cells increases the chance that the optic nerve and / or carotid artery would be exposed (or nearly exposed) in the pneumatized cell.

OTHER ACCESSORY AIR CELLS IN THE FRONTAL SINUS REGION

Other anterior ethmoidal air cells that may form the boundary of the frontal recess have been described such as the supraorbital, suprabulla, and frontal bulla cells. The supraorbital cell, usually anterior ethmoidal in origin, extends into the orbital plate of the frontal bone often medial and superior to the frontal sinus and is usually bilateral. The frontal bulla cell is a superior extension of the ethmoidal bulla into the frontal recess region. The suprabulla air cell is an additional air cell just superior and anterior to the ethmoidal bulla. Finally there may be an air cell within the intersinus septum of the fontal sinus. All these cells may alter the shape and position of the frontal recess or frontal sinus ostium. However, radiologists should only use these terms in the context

of the frontoethmoidal drainage, if they are used and understood by their clinical colleagues. incomplete removal of air cells forming the boundaries of the recess is the most frequent cause of continued symptoms following surgery.

VARIATIONS IN UNCINATE PROCESS CONFIGURATION :

The atelectatic uncinate process opposes or may even be fused to the junction of floor and medial wall of the orbit. This is usually associated with a hypoplastic and opacified antrum, which may be associated with descent of the orbital floor, increasing the risk of trauma to the orbit

The horizontal or vertical orientation of the uncinate process is dictated by adjacent structures: the ethmoidal bulla, middle turbinate, and nasal septum, which affects the anterior OMU drainage. The horizontal uncinate process is almost always associated with an enlarged ethmoidal bulla. The uncinate process may also be hooked or pneumatized

THE ETHMOIDAL BULLA (Fig 14)

The ethmoidal bulla is an anterior ethmoidal air cell of variable size located just posterior to the free edge of the uncinate process. The opening between the anterior surface of the bulla and the free edge of the uncinate process is the hiatus semilunaris and the passageway between the two is the ethmoid infundibulum.

An enlarged ethmoidal bulla may compromise the outflow of both the maxillary antrum and the frontal sinus by distorting the ethmoid infundibulum/hiatus semilunaris and the frontal recess, respectively.

THE COMMON MIDDLE TURBINATE VARIANTS

Concha Bullosa (Fig 9)

Pneumatization of the inferior bulbous portion of the turbinate is called a concha bullosa, is usually bilateral, and occurs in 24-55% of the population. If the

pneumatization is above the level of the OMU complex, it is called a lamella cell or a conchal neck air cell. Although small, the bullosa is notclinically significant; a large concha bullosa, which is usually associated with septal deviation, may obstruct the drainage pathway of the antrum by distorting the uncinate process and narrowing the infundibulum.

Paradoxical Turn (Fig 13)

The middle turbinate may have a lateral convexity (a paradoxical turn) and is present in approximately 26% of people. Again small paradoxical turbinates are not clinical significant but, if large, are frequently associated with septal deviation and may impair access to the OMU.

INFRAORBITAL (HALLER) AIR CELLS (Fig 11)

They are centered inferior to the ethmoidal bulla and grow into the floor of the orbit. They may narrow the maxillary sinus ostium, especially if infected

MAXILLARY SINUS (ANATOMICAL VARIANTS)

The anatomical variants of the maxillary sinus are sinus septations, the accessory sinus ostium, and the sinus hypoplasia. The normal maxillary sinus (or recesses) may extend into the palate, infraorbital region, and maxillary alveolus

The maxillary sinus septum may be fibrous or bony and often extends from the infraorbital canal to the lateral wall and if not recognized may lead to inadequate drainage of the antrum. The accessory ostium or posterior fontanelle is located posterior to the natural ostium and is present in approximately 10% of the population. 15 It is important to identify as antrochoanal polyps may extend through the accessory sinus ostium rather than the natural ostium. In addition there is occasionally a circular flow of mucus from the natural ostium inferiorly into the accessory ostium, leading to recurrent sinusitis. If recognized, the accessory ostium should be surgically joined to the natural

ostium.

THE NASAL SEPTUM (Fig 16, Fig 17, Fig 18)

The components of the nasal septum are the septal cartilage anteriorly and the vomer and perpendicular plate of the ethmoid posteriorly. The anatomic variations of the nasal septum are septal deviation (which may be developmental or acquired), septal spur, and pneumatization.

The incidence of septal deviation is varied 20-79% and is often not clinically relevant. However septal deviation can displace the middle turbinate, narrowing the middle meatus, making surgical access difficult.

The septum may be focally deviated inferiorly at the chondrovomeral junction or have a more broad-based curvature often associated with a concha bullosa of the middle turbinate.

Septal spurs are frequently encountered in association with septal deviation and if prominent may also make surgical access difficult and narrow the middle meatus or ethmoidal infundibulum.

The pneumatized septum is usually due to extension of air from the sphenoid sinus or crista galli and is usually not significant but may narrow the sphenoethmoidal recess.

Fig 9 : Coronal CT image showing left Concha Bullosa (*) with DNS towards right (arrow)

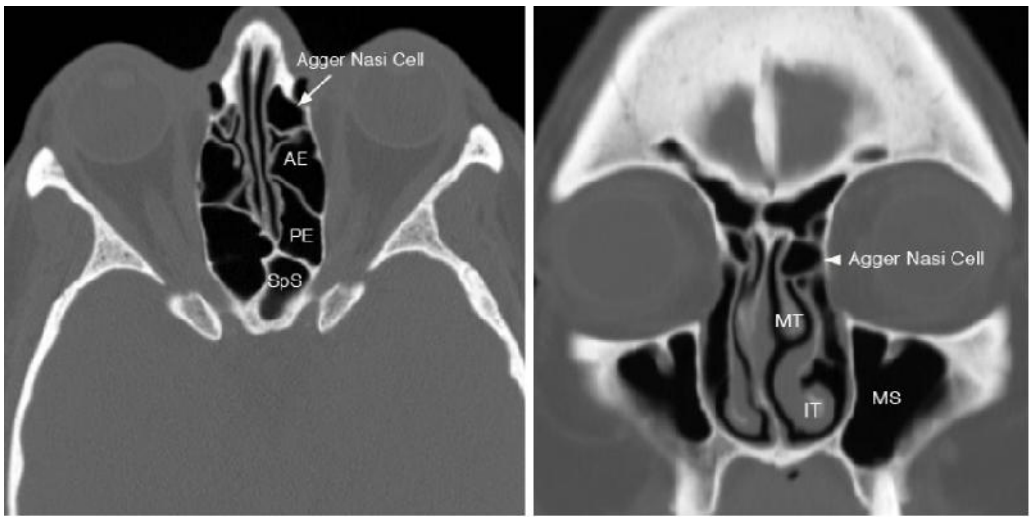


Fig 10 : Axial and Coronal CT images showing Agger Nasi Cell [AE-Anterior ethmoid, PE-Posterior ethmoid, SpS-Sphenoid sinus, MT-Middle turbinate, IT-Inferior turbinate, MS-Maxillary sinus,]

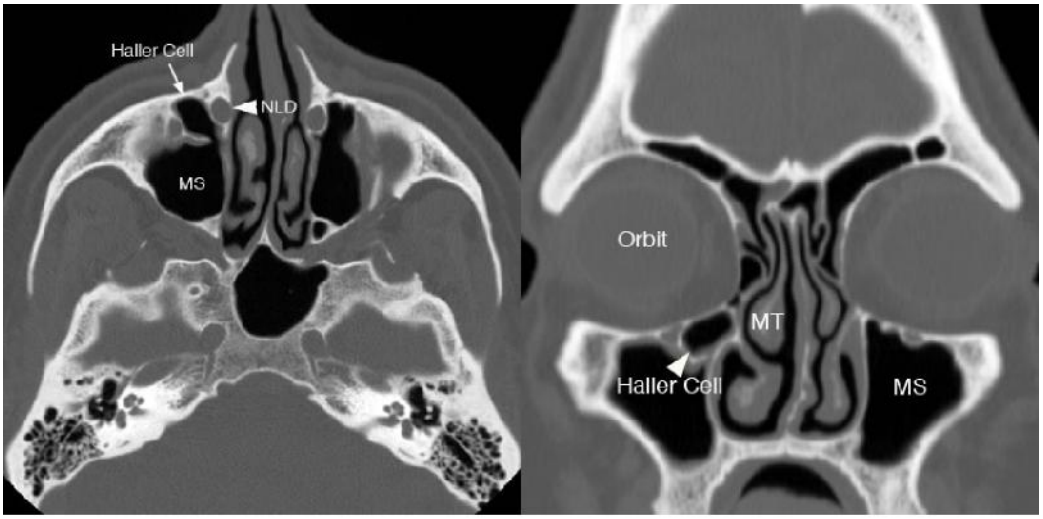


Fig 11 : Axial and Coronal CT images showing Haller Cell (Infraorbital air cells)

[MT-Middle turbinate, NLD-Nasolacrimal duct, MS-Maxillary sinus,]

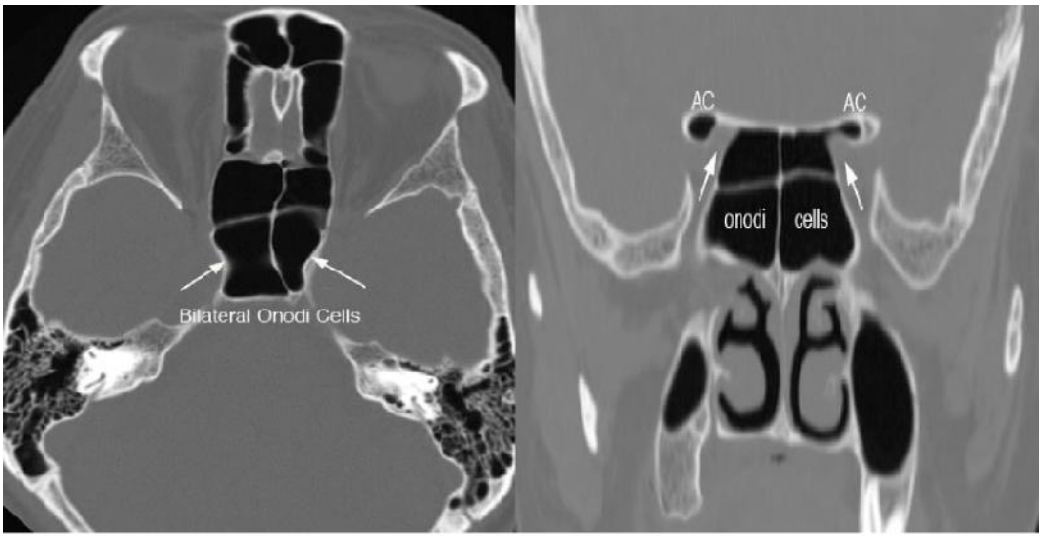


Fig 12 : Axial and Coronal CT images showing Onodi Cells

[Sphenoethmoidal air cells]

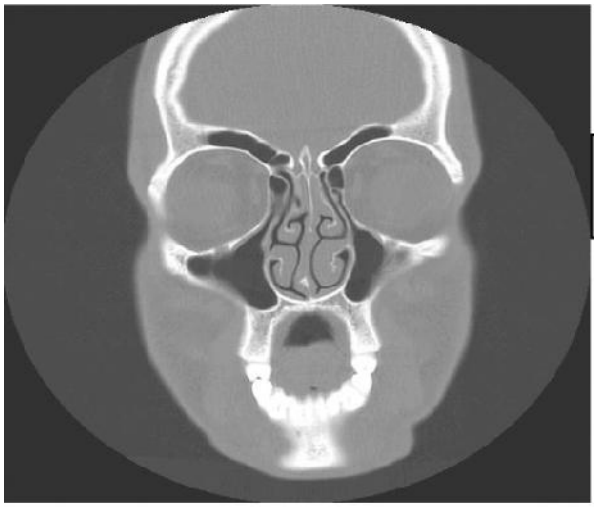
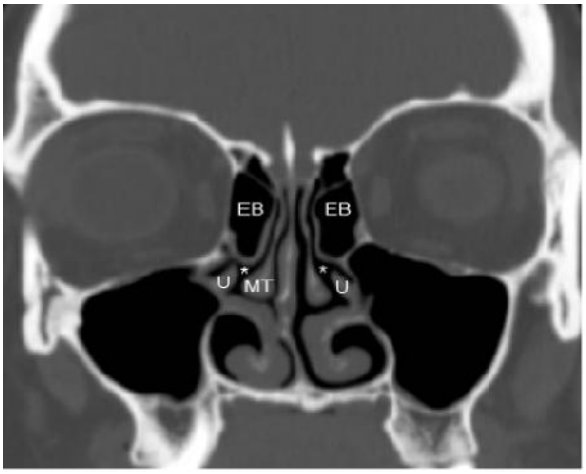


Fig 13 : Coronal CT image showing paradoxical turn of middle turbinates.

Fig 14 : Coronal CT image showing bilateral large ethmoidal bullae compromising the outflow of both the maxillary antrum and the forntal sinus by distrorting the ethmoid infundibulum and the frontal recess, respectively.



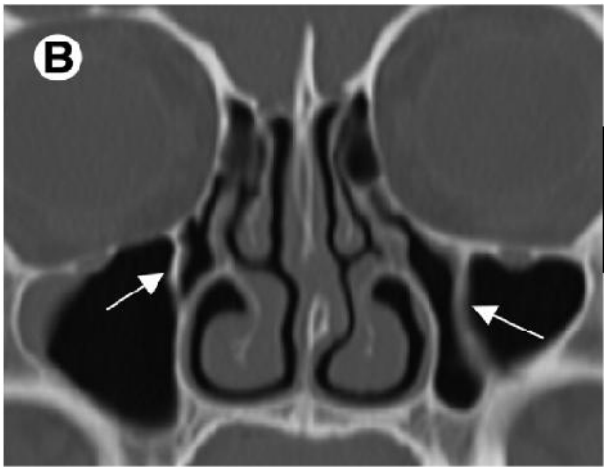


Fig 15 : Coronal CT image demonstrating a bony septation within the maxillary antrum

DISEASES OF PARANASAL SINUSES

The nose with its paranasal sinuses constitute the common portal entry to human body, respiratory system, the gateway and check post of the whole respiratory system. Hence they are also prone for frequent infections. They also get affected with the neoplastic conditions like other parts of the body.

[24,25]

Inflammatory conditions:

Acute sinusitis

Chronic sinusitis

Mucoceles

Fungal diseases.

Granulomatous diseases

Retention cysts

Polyps Tumors:

Benign tumors

Malignant tumors.

[25,26,27,28]

INFLAMMATORY CONDITIONS

Acute inflammatory conditions:

A. ACUTE SINUSITIS:

Sinusitis is classified on the basis of duration. In acute sinusitis the symptoms last as long as 4 weeks with acute inflammation of mucosa of any or all walls of the paranasal sinuses. Inflammation may be suppurative or non-suppurative.

Aetiology:

Bacterial infection from the nose may spread to the sinuses through the ostium or submucosal lymphatics. There were very few healthy noses that were sterile, and

most common bacteria cultured were Aerobes - Streptococcus viridans - 27%, Streptococcus Pneumoniae- 11.7%, Staphylococcus Aureus -9.4%, H influenzae- 4.5%. Anaerobes: Actinomyces -14.9%.

Acute sinusitis of dental origin:

This particular form of maxillary sinusitis occurs following dental problems seen more commonly in maxillary sinuses. The most common cause is the extraction of a molar tooth, usually the first molar, during which a small piece of bone is lying between the apex of tooth and the maxillary sinus. It was Nathaniel who described that there is a thin membrane of bone that separates the teeth from the sinuses. Other dental infections such as apical abscess or periodontal disease may cause similar condition.

Traumatic:

In fracture of sinus, infection may spread directly or by infected blood clots.

Swimming and diving in infected water:

While swimming in infected pond, water may enter into sinuses through the ostium and may cause acute infection.

Baro-trauma:

As a result of rapid pressure changes, volume and pressure of air decreases in the sinus, leading to suction effect on the lining mucosa which in turn leads to the osteal block. If the person is suffering from acute rhinitis at the same time, chances of getting sinus infection are high.

Predisposing factors:

Local- DNS, nasal allergy, foreign body, enlarged adenoids.

General:

Low general health, chilling, prolonged exposure to cold, and associated chest infection.

Iatrogenic factors:

Mechanical ventilation, nasogastric tube.

B. CHRONIC SINUSITIS:

This is a chronic inflammatory process affecting the mucosa of various groups of paranasal sinuses.

Aetiology: On time initial evaluation of the patient with chronic sinusitis, it may be difficult to determine the exact cause of persistence of the infection. It may be merely a matter of incomplete treatment with inappropriate antibiotics. There may be physical obstruction to the sinus outflow, making the resolution difficult or impossible. Physical obstruction may vary from edematous mucosa obstructing a sinus ostium, chronic scar tissue obstructing a sinus, sinus ostea of inadequate size, obstruction by septal deflection or turbinate abnormalities such a concha bullosa or a paradoxically bent middle turbinate to less frequent causes of obstruction leading to chronic sinusitis following mucocele, osteoma, cystic fibrosis, other anatomical variations like tonsillar adenoid hypertrophy, DNS, nasal polyps & cleft palate.

Clinical features of acute and chronic sinusitis:

Symptoms: Headache: Headache is one of the most common and significant symptom of sinusitis. Wolff states that head pain arising in the nose has its origin in congestion and edema in and around the sinus ostea. Headache due to sinus disease is more often unilateral, more pronounced on one side. The headache, which originates in the sinus is increased on stooping forward and on closing the eyes.

Pain: Pain is vaguely deep seated in the head. Pain is usually referred to region involved in the deep sinuses, such as ethmoidal and sphenoid sinuses.

SIGNS:

Smell:

Swelling and edema:

If the sinuses are acutely involved, some slight swelling of the skin due to a periostitis with edema may occur. On palpation with finger gives the sensation of slight thickness. Nasal discharge: Pus within the nasal chambers may indicate the empyema of the sinuses. The nasal mucosa is rarely the focal center of suppurative inflammation, where as the sinuses are commonly the focal centers of such inflammation.

Tenderness upon pressure: Tenderness upon pressure may be present in diseases of those sinuses contiguous to the surface of the face, namely the frontal, anterior ethmoidal and maxillary sinuses.

Radiological findings in acute and chronic sinusitis:

Radiographically we cannot differentiate acute and chronic sinusitis. Views to be taken are:

1. Caldwell's view
2. Water’s view
3. Lateral view
4. Submento vertical view

X-ray findings in sinuses:

1. **Thickening of the lining membranes :** The thickened mucosa is very dense and is almost as opaque as the surrounding bone. The inner outline of the sinus wall is hazy and ill defined. The thickening of the mucosal membrane is variable.
2. **Opacity of entire sinus :** The entire sinus may become opaque because of

gross thickening of mucosa, the overlapping of polyps or cysts, the filling of the central part of sinus with the fluid.

3. **Fluid level :** Fluid level may be present.
4. **Changes in the bony wall :** Disappearance of the mucoperiosteal line indicate extension of the infection from the mucosal membrane in to the bony margin of the sinus. When the infection extends beyond the mucoperiosteal line, there will be changes in the bony walls which may become sclerotic.

Computerized tomographic findings:

With reference to sinus secretions, watery and more acute secretions have a CT attenuation that is less than that of muscle but higher than that of fat. The Hounsfield units (HU) are usually in the range of 10-25, and this appearance is often referred to as water or mucoid attenuation. Once the secretions have become chronically thickened and concentrated, the CT attenuation rises to be equal to or slightly greater than that of muscle (30-60HU).

As per Glicklich et al graded the severity of sinus disease. As per this validated grading system it is classified as

Grade: 0: Less than 2 mm. mucosal thickening on any sinus wall.

Grade 1 : All unilateral disease or anatomic abnormalities.

Grade 2 : Bilateral disease limited to the ethmoid or Maxillary sinuses.

Grade 3 : Bilateral disease with involvement of at least one sphenoid or frontal sinus.

Grade: 4 : Pansinus disease.

Tasks force on Rhino sinusitis sanctioned by the American Academic of Otolaryngology used Lund - Mackay CT staging system by scoring method.

Five Major Recurring Patterns of inflammatory disease identified on CT [28]

1. Infundibular pattern (Fig 25) : This is the most limited of the obstructive Pattern

and is diagnosed when there is disease limited to maxillary sinus with obstruction visualized within the ipsilateral maxillary ostium and infundibulum. The osteomeatal unit is patent and there is no disease in the ipsilateral anterior ethmoid air cells and ipsilateral frontal sinus. The incidence being 26%. The causes are due to (a) Mucosal swelling at the infundibulum. (b) Polyps (c) anatomical variant such as Haller's cells (d) abnormally big uncinate process that encroach on infundibulum.

2. **The Osteo meatal unit (OMU) pattern (Fig 21, Fig 22):** It is mainly caused by occlusion of the middle meatus. Ipsilateral frontal, anterior ethmoid, middle ethmoid and maxillary sinuses which drain through middle meatus will be involved. They all show inflammatory involvement. The OMU pattern may be full blown or partial. Any combination of involvement of frontal, maxillary, anterior and middle ethmoid sinuses is designated as OMU pattern. The lesion pre-disposed to obstruction are mucosal swelling, hypertrophied turbinates, polyps, adhesions, nasal tumors and anatomic variants like – concha bullosa, septal deviations, paradoxically curved middle turbinate. The incidence being 25%.

3. **The Spheno- Ethmoidal Recess Pattern (Fig 23, Fig 24):** Inflammatory nasal Pathology will lead to obstruction of the sinus ostia in the spheno ethmoidal recess (SER) with variable involvement of ipsilateral posterior ethmoidal and sphenoid sinuses. The incidence being 6%. It is mainly due to obstruction of the superior meatus anterior to Spheno – Ethmoidal Recess.

4. **Sino nasal polyposis (SNP) (Fig 27, Fig 28, Fig 29) :** It is an inflammatory condition leading to polypoid mucosa of the nose and para nasal sinuses. The SNP pattern of CT combines features of the 4 other pattern with additional features unique to SNP. At times it is aggressive and tendency to recur. Pathologically edematous hyperplastic heaped up in polypoid shape of mucosa observed. There are two major

and number of minor findings on CT - Polypoid masses in the nasal cavity in 90% of patients with soft issue density, usually hypodense in the region of middle turbinate and frequently bilateral. Second major criteria - Infundibular enlargement. Bony remodeling or attenuation rather than erosion. In aggressive form - diffuse naso ethmoidal soft tissue component, absence of normal number and size of ethmoidal trabeculae, a Deossified nasal septum.

The presence of thin hypodense mucosal rim differentiate it from malignancy. Secondary fungal infection in SNP is usually has no evidence of bony destruction, necrosis, vascular thrombosis and anatomical extension.

5. **Sporadic or unclassified pattern:** This includes retention cysts, mucoceles and mild mucoperiastial thickening.

[25,28]

C. MUCOCELES

These are the most common expansile lesions of paranasal sinuses. Radiographically the definition being an airless mucoid filled, expanded paranasal sinuses.

Causes are:

- Inflammatory
- Allergic
- Trauma
- Osteoma
- Complications of previous surgery

Obstruction of paranasal sinus causes the secretions to accumulate and to fill the sinus. Increased pressure results in expansion of the sinus and erosion or remodeling of its walls. There is a period preceding the remodeling/erosion when there is just accumulation of the secretions. These are most often found in the frontal

sinuses (60%), due to vulnerability of the long fronto nasal duct to obstruction by mucosal swelling.

Ethmoidal mucoceles are also common (25%).

Maxillary mucoceles (10%) and sphenoidal mucoceles (1.2%) are less common. A mucocele can be thought of as the end stage of a chronically obstructed paranasal sinus.

Clinical Features:

Presenting symptoms are those of swelling and mass effect in the concerned sinus. There may be diplopia and proptosis. Pain is rare unless it is infected.

CT findings:

On CT scan, a mucocele appears as an expanded sinus filled with homogenous material of fairly low (15 HU) attenuation contents with a few having higher attenuation due to concentrated secretions within. Along with this, other features pertinent to the sinus involved may also be seen. The surrounding sinus bone is remodeled around the sinus content and this bone may be focally thinned or eroded. The overall CT appearance is that of bone preservation and remodeling.

The critical points to be noted in describing the paranasal sinus mucoceles are the presence of intracranial extension (extra axial) mass and intra orbital extension. The preservation of fat planes outside the areas of bone destruction was seen whereas in carcinoma this is lost.

D. INFLAMMATORY POLYPS

These are pedunculated out growths of edematous mucosa, which is cellular, and covered by normal epithelium, arising either from the paranasal sinus and nasal fossa. They are believed, in most cases, to be related to hypersensitivity states, but are also seen in non-allergic asthma, vasomotor rhinitis and in cystic fibrosis. They are

most common in the ethmoidal air cell complex and nasal cavity, which may be completely filled with soft tissue.

CT Findings:

Shows expansion of nasal fossa filled with soft tissue density polypoid masses with central high density and peripheral rim of low attenuation. Sinuses also opacified with extension into orbits may be seen. Characteristically, bilateral involvement usually distinguishes it from malignancy.

E. RETENTION CYST

A cyst is a localized dome shaped swelling arising from the wall of a paranasal sinus. Pathologically cyst may be of the secretory variety (mucus retention cysts) or the non- secreting type (degenerative cysts). Majority of the cysts are small and are not sequelae to the previous episodes of infection.

CT findings:

On CT, they appear as a smooth, round or convex or dome shaped soft tissue attenuation. One study shows that these cysts are present in about 10% of the population.

[29,31]

F. FUNGAL INFECTIONS:

Various fungal diseases involve the paranasal sinuses and nasal cavity. The most common and most important of these include mucormycosis, histoplasmosis, candidiasis, aspergillosis. Mucormycosis occurs almost exclusively in immunocompromised hosts. 50-75% of the patients have poorly controlled or uncontrolled diabetes mellitus. The causative organisms are invasive and tend to spread rapidly from the nasal cavity to the paranasal sinuses. They have propensity for involving blood vessels. Invasion of the orbits, cavernous sinuses and ophthalmic veins are common. Progression may also occur in immunocompromised patients with

haematological malignancies with acquired immunodeficiency syndrome, because fungi tend to bind calcium, manganese, and other heavy metals.

CT findings:

May vary from those of non-specific mucosal inflammation, with or without bone involvement, to an opacified sinus with a central mycetoma (mass), and areas of reactive thickening and focal bone erosion in the surrounding sinus walls and classification. On CT, the presence of a sinus mycetoma is suggested when there is a central high attenuation intra sinus mass that is separated from the sinus walls by a zone of mucoid attenuation secretions. However, similar findings may be seen in sinuses filled with very dried proteinaceous secretions, or in case of hemorrhage in the sinus.

G. GRANULOMATOUS DISEASES[21,24,25,]

A variety of granuloma forming diseases involve the paranasal sinuses. Clinically all are chronic diseases. In addition, all of them first involve the nasal fossa and then extend into the paranasal sinus. These include Wegner's granulomatosis, tuberculosis, syphilis, actinomycosis, leprosy, yaws and sarcoidosis.

CT findings:

Group of these diseases cause non-specific nasal fossa soft tissue masses preceded by a chronic, non-specific pansinusitis. There is usually a focal mass or septal erosion in granulomatous diseases. The two most common causes of nasal septal masses are granulomatous disease and cartilage tumors. Occasionally, paranasal sinuses filled with mucosal thickening that appear to be routine inflammatory mucosal disease. The sinus walls, however, are thickened and hypertrophic, and have areas of local bone erosion as well. Such appearance is suggestive of an aggressive infection such as fungal disease or granulomatous disease.

NEOPLASMS OF PARANASAL SINUSES[31,32,33]

Incidence: The incidence of tumors of paranasal sinuses is around 0.2%. They constitute 3% of cancers of upper respiratory tract. Among 5050 tumors of the upper respiratory tract reported by Asch et al from Armed Forces Institute of Pathology (U.S.A.), 530 cases occurred in paranasal sinuses and nasal cavity. John G. Batakis observed that the incidence of carcinomas of paranasal sinuses is around 1 % of all human malignancies.

Mass and Nectous (1 986) reviewing the descriptive epidemiology of neoplasms of paranasal sinuses and nose noted that the highest occurrence is in Japanese population in whom unexplained excess risk is confined to maxillary sinus. Up to 80% of all paranasal sinus cancers arise in the maxillary sinus. Ethmoid sinus is uncommon. But osteoma occurs in this sinus more frequently than in any other sinuses. Sphenoid sinus has the least incidence of tumors.

Sex ratio: Average female to male ratio revealed by various reportsis 1:2 (F:M).

Age[31,32] : Malignant lesions are rare before the age of 35 years, although a greater incidence of sarcoma and adenocarcinoma are seen in younger age group. In Maeheths series (1905) maximum incidence of malignant tumors were in the 6th decade of life.

Predisposing factors:

Many theories have been suggested to explain the aetiology of tumors of paranasal sinus. Regarding the origin of osteoma, many theories are existing. Embryogenic, infectious, traumatic factors all account for its origin. A higher incidence among males favour a traumatic cause. Thus persistence of embryonal periosteum in areas where endochondrial and membrane bone meets would explain the frequency with which Osteomas occurring at the junction of ethmoid and frontal

bones. Regarding the origin of inverted papilloma, viral aetiology was suggested by Jarvi (1994). Some extrinsic factors also suggested are atmospheric pollution, textile industries, steel factories etc. B. Majumdar (1984) reported high incidence (22%) of inverted papilloma among steel factory workers. The. carcinogens suggested by James, Suen, and Cugen include.

Carcinogens[34]

- Wood dust (furniture industry)
- Shoe industry (shoe making)
- Textile workers.
- Radio chemicals
- Radium dial (painters)
- Mustard gas
- Nickel refining

Other factors: Chronic sinusitis Cigarette smoking Alcoholism. **Pathological Classification Of Tumors In Paranasal Sinuses**[35,36] **Benign tumors:**

I Epithelial tumors:

1. Papilloma.

   Squamous papilloma Inverted papilloma.

2. Adenoma.

II. Connective tissue tumors: y Fibroma. Osteoma.

- Localized compact osteoma
- Localized cancellous osteoma
- Fibrous dysplasia. Angioma. Chondroma
- Schwannoma, Neurofibroma

- Myxoma
- Gaint cell reparative granuloma
- Acinic cell tumor
- Odontogenic tumors.

B. Malignant tumors:

1. Epithelial tumors:

- Squamous cell carcinoma y Basal cell carcinoma y Lymphoepithelioma
- Adenocarcinoma
- Spindle cell and clear cell carcinoma
- Olfactory neuroblastoma
- Malignant melanoma
- Minor salivary gland tumors (Malignant)
- Adamantinoma

II. **Connective tissue tumours:** y Sarcoma.

- Fibrosarcoma y Osteosarcoma
- Lymphosarcoma y Myxosarcoma
- Haemangio endotheliosarcoma
- Hemangio pericytoma
- Chondrosarcoma
- Malignant lymphoma
- Plasmacytoma

III. Teratomas and terato carcinosarcoma

IV. Metastatic tumors to sinonasal tract.

V. **Tumors involving the sinuses by contiguity.** [21,37,38,39,40]

- Angiofibroma
- Chondroma
- Meningioma
- Pituitary tumors
- Nasopharyngeal carcinomas
- Olfactory neuroblastomas

[33,34]

BENIGN TUMORS:

Epithelial tumors:

Papilloma : The commonest epithelial (Benign) tumors in the paranasal sinus and lateral wall of nasal cavity is the papilloma arising from scheneiderian membrane, which is lining respiratory epithelium of nose and paranasal sinuses. Often behaving as a neoplasm, the scheneiderian papillomas probably arise from a proliferation of reserve or replacement of cells located at the basement membrane of mucosa. This proliferation leads on to inverting, fungifrom or combination of both growth patterns. Papilloma in the lateral wall may involve multiple sites, sinuses, floor and roof of nasal cavity and nasolacrimal duct and their association with squamous cell carcinoma is well documented. Other terminologies used for this papilloma are:

1. Ringertz tumor.
2. Inverted papilloma.
3. Scheneiderian papilloma.

Generally, they are bulkier and firmer than nasal polyps, but lack its

translucency. They grow into architectural patterns. 1. Papillary and exophytic 2. Inverted, with an inwardly invaginating epithelial growth into underlying stroma. The later type is more often seen in lateral wall and sinuses. The predominant epithelial growth of the inverted form of papilloma is directed into underlying stroma instead of being a surface proliferation. The common sites of occurrence are: Lateral wall of nose - 68%. Ethmoidal and maxillary sinuses - 27% Sphenoid and ethmoidal- 5%.

Computed Tomography (CT):

They appear as soft tissue attenuation masses. Fungiform type nearly always arise from the nasal septum and are usually solitary and unilateral, and may have the typical irregular veracious surface. Unlike the inverted, fungiform papillomas are not considered premalignant.

Inverted papillomas characteristically arise from the lateral nasal wall in the region of the root of the middle turbinate and may extend laterally into the paranasal sinuses, especially the maxillary sinuses and less commonly the ethmoid sinuses. Calcification may be seen in some cases.

Adenoma :

Occurs in sinuses, but are rare. It remains capsulated, usually symptomless, but if they arise from the lateral wall of the nose it produces nasal obstruction.

CT:

These are soft tissue masses of around 20-40 HU associated rarely with bone expansion, and on contrast enhancement these tumors show well defined capsule, and no evidence of bone destruction seen.

Connective tissue tumors:

Fibroma :

These are relatively benign lesions of connective tissue covered by hypoplastic

epithelium. This tumor has no infiltrative or destructive capability and does not metastasize.

Imaging: Soft tissue mass which does not enhance with contrast, and walls of the sinuses are normal. No evidence of bone destruction is seen. No evidence of calcification or necrotic areas are seen.

2. Osteoma :

70% of the osteomas are in the frontal sinuses, 25% in ethmoid sinuses, and 5% in maxillary and sphenoid sinuses. Handuosa (1952) reported in 35 patients, and recorded the site of origin in relation to various skull bones as determined by the histological appearance of the tumor after removal. They may be:

Ivory: Composed of hard compact bone.

Spongy: Where a cortical plate surrounds mature cancellous bone with a lamellar structure of a mixture of two osteomas, usually found as asymptomatic lesion in adults (15-35 years average) as an incidental radiological findings. Larger lesion may produce pain, and critically placed tumors may be associated with mucoceles. Local bone destruction from pressure can result in pneumocele, meningitis or brain abscess. These are very slow growing and benign. Theories of origin include embryonal, infection and traumatic factors. Higher incidence is in males. Dive and Bussy (1962) recognized a triad symptoms consisting of soft tissue masses, bone lesions, and colonic polyps called Gardener's syndrome.

CT: These are obvious on plain film and CT examination. Small tumors may even obstruct the sinus and lead to C.S.F. rhinorrhoea. On CT these tumors appear equal to bone density.

CT reveals an osteomas to be smoothly demarcated, frequently lobulated, homogenously hyperdense, and often lying within expanded paranasal sinus. CT is

the procedure of choice for the evaluation of osteoma.

Ossifying fibroma or fibrous osteoma or osteofibroma:

Ossifying fibroma is a benign, gradually expansile and fairly encapsulated tumor. This tumor was reported as early as in 1865 in British literature. More commonly occurs between 3 0-40 years of age with women more often than men are affected. The lesions usually arise in close proximity to the root of the teeth. The most commonly involved bone appears to be the mandible, with high affinity to the molar teeth.

Tumor is well vascularized stroma containing various amounts of calcified materials. Calcification may appear as irregular bony structures and spicules. These are slow growing and non invasive, and do not metastasize.

Chondroma and chondrosarcoma:

Chondromas arise from primordial cell nests. They may develop at any site. But ethmoidal sinus is the most common location. Often asymptomatic and found incidentally, they may cause obstruction and disfigurement. A chondroma is seen well demarcated from surrounding tissue.

They are slow growing, and do not metastasize. But expansion with loss of bone, and malignant degeneration into chondrosarcoma may occur. Gross total excision is required.

Imaging:

Ossifying fibroma in its early stage appears to be solitary, cyst like and osteolytic, without a prominent periosteal reaction. At a later stage of maturation, lesions are radiopaque and surrounded by a uniform radiolucent rimming. Occasionally sclerotic border may separate the lesion from the adjacent normal bone. On CT scan non-homogeneity is due to regions of sclerotic bone alternating with less

dense matrix.

Chondroma/chondrosarcomas are slow growing, but form destructive soft tissue mass lesions with radiologically characteristic amorphous calcification even on plain films. Sharply marginated lytic bone change with stippled calcification can mimic that of meningioma. On CT, chondromas have values that are similar to muscle, and shows densely calcified mass, often showing a whorled pattern (with central hypodensity) and capped by soft tissue mass that is not calcified.

D. Inflammatory Polyps:

CT shows expansion of nasal fossa filled with soft tissue density polypoid masses. With central high density and peripheral rim of low attention. Sinuses also opacified with extension into orbits may be seen. Characteristically, bilateral involvement usually distinguishes it from malignancy.

Angiofibroma (Jwamk nasopharyngeal angiofibroma)

It is a benign vascular tumor occurring almost exclusively in pre-pubescent or pubescent males. It accounts for less than 0.05% head and neck tumor (waliman et al 1981). Its incidence being 1 in 50,000 (chandler et al, pharyngeal angiofibromas, staging and management, Anals of otology Rhinology Laryngology 93:323-320) Intracranial extension has been observed in 20-30% patients. These tumors are highly vascular and non encapsulated polypoid mass that is histologically benign but highly aggressive. The triad of epistaxis, nasal obstruction and presence of a nasopharyngeal mass strongly indicates an angiofibroma.

Imaging:

The site of origin of the tumor is thought to be the nasopharyngeal region at the pterygopalatine fossa or sphenopalatine foramen. Involvement of pterygopalatine fossa is seen in approximately 90% of patients as asymmetry in the size or widening

of this structure, and an obliteration of the fat plane between the pterygoid plates and the back of the maxillary sinus. The tumor may extend anteriorly and superiorly into the maxillary sinus, nasal cavity, sphenoid and ethmoid sinuses, or superiorly into the cranial fossa through foramen rotundom and pterygoid canal through superior orbital fissure. Contrast enhanced CT examination reveals a polypoid and infiltrating, markedly enhancing mass that involves the nasopharynx without extension. On dynamic scanning they reveal intense early enhancement characteristic of highly vascular lesions. Ideally angiography should be performed to demonstrate the major feeding vessels which are more often the internal maxillary artery and ascending pharyngeal artery.

MALIGNANT TUMORS OF PARANASAL SINUSES:

Malignant tumors of Paranasal sinuses are rare, comprising about 3% of all head and neck tumors. Approximately 50-65% of sino- nasal malignancies arise within the maxillary sinuses, 10-25% in ethmoid sinuses and 15-30% in the nasal cavity of all Paranasal sinuses cancers about 80% arise in maxillary antrum with an annual incidence of about 1 in 1 lakh in USA and Europe.[37,38,41,43,44]

Squamous cell carcinoma accounts for 80% of all malignancies . Other neoplasms in this region include lymphoma, melanoma, plasmacytoma and others. The lethality and poor prognosis of carcinoma of the sinuses are directly related to early silence or misleading signs and symptoms of these cancers, which allow extension before discovery. In that respect it may be said that carcinomas of sinus do not show significant evidence of their pressure until they have broken out of sinus of origin. More than 90% of paranasal sinus carcinomas will manifest with invasion through at least one wall of the involved sinus.

SQUAMOUS CELL CARCINOMA IMAGING

The primary pathological and therefore imaging features of these lesion is propensity to destroy bone even in the presence of a relatively small demonstrable mass. Because of the similarity in the density of squamous cell carcinoma and other carcinomas to adjacent secretions within obstructed sinuses, a small region of bony abnormality and apparent destruction is important. Maxillary sinus carcinomas have a propensity for extension into the orbit, ethmoid sinus, pterygopalatine and infratemporal fossa and rarely cranial cavity. Radiologically it is important to note the extent of invasion, especially orbital/cranial, as the extent of surgery and whether orbit exenteration is required depends on this extent.

CT in axial and coronal planes resolve not only the boundaries of the soft tissue density mass and bone destruction but reveal the extension of the tumor into the adjacent sinuses and surrounding compartments. The use of contrast is useful for differentiating tumor from inflammatory conditions or other masses with in the sinuses. After contrast these tumors tend to enhance very little. IV contrast enhancement is however useful, particularly in suspected intracranial and orbital invasion. Rescans are useful for assessing the results of chemo and radiotherapy. MRI is however more useful in this respect.

Malignant melanoma:

Between 0.5 to 1.5% of malignant melanomas arise from nasal cavity and Para nasal sinuses. At these sites the highest incidence is in fifth decade. Presentation of patients who are younger than 30 years is unusual. There is no significant sex predilection. These tumors arise from melanocytes, which are usually present in the mucosa and submucosa. The maxillary antrum is the common extra nasal site.

Signs and symptoms of sinonasal melanomas are non-diagnostic. Epistaxis is

frequent (over 80% patients), pain and swelling are less frequent complaints. The typical malignant melanoma of Para nasal sinuses appear as freshly polypoid mass, solitary or multicentric" These tumors may be heavily pigmented (appearing black or achromatic appearing pink tan). Over 2/3 of the melanomas will manifest readily identifiable melanin. The remainder is amelanotic. When melanin is sparse errors in diagnosis is possible. These include anaplastic carcinoma, angiosarcoma, lymphoma, rhabdomyosarcoma and metastases.

CT:

CT appearance of malignant melanoma is variable, and nonspecific. The tumor has no characteristic density or pattern of enhancement. These tumors consist of a soft tissue mass or mucosal infiltration within it (20-40 HU). Often associated with bone expansion and less frequently with aggressive bone destruction.

Ameloblastoma:

It is less than 0.1 % of sinus tumor. 20% of these occur in the maxilla and the remaining major part of mandible. They are found in the molar area, adjacent to the antrum and at other sites. The tumor commonly extends into the pterygomaxillary fossa, ethmoidal sinuses and orbit.

IMAGING:

Radiographically:

The ameloblastoma may be a unilocular or multilocular radiolucent lesion. The unilocular variety reveals a round to oval configuration with distinct borders and occasional slight marginal sclerosis, but no new periosteal bone formation. Bony expansion of various degrees, sometimes with a scalloped margin is also observed. Loss of lamina dura, erosion of the tooth apex, and displacement of the teeth are also encountered. The CT findings of ameloblastoma consists of low attenuation cystic

areas inter mixed with isodense areas, reflecting the solid components of this lesion. The size of the low attenuation cysts varies from small to large.

Extramedullary plasmacytoma:

This tumor usually appears in elderly adults as a single polypoid mass. Occasionally plasmacytoma involves bone as an isolated radiolucent lesion. Histology reveals sheets of plasma cells of variable maturity in a capillary network. Amelanotic melanoma, lymphoma, lymphosarcoma and anaplastic carcinoma must be differentiated. The clinical course of primary extramedullary plasmacytoma is highly variable and not predictable. The most favourable group is aggressive with repeated local recurrence and develop into multiple myeloma or plasma cell leukopenia. In addition to local recurrence bone invasion is a poor prognostic sign. Plasmacytoma is highly radiosensitive.

Imaging:

On CT, plasmacytoma of sinonasal tract appears as a fairly well defined mass which often has expansible characteristics and is associated with bone remodeling as well as erosion with moderate to marked enhancement after IV contrast administration.

On CT, they appear as moderate to markedly enhancing masses, which may show calcification and may enlarge and associated with bone erosion. It is extremely difficult to distinguish a benign from a malignant hemangioma.

Sarcomas:

Osteogenic sarcoma and chondrosarcomas of facial skeleton are encountered more commonly in the mandible than in the maxilla. Osteogenic sarcomas account for 2% of all primary malignant neoplasms.

On CT, sarcomas have similar values of muscle and shows densely calcified

mass often showing a whorled pattern (with central hypodensity) and capped by soft tissue mass that is not calcified.

Lymphoma:

The actual involvement of the nose and Para nasal sinuses are rare. Lymphomas arising in the nose and Para nasal sinuses are of the Non-Hodgkins type and frequently observed in patients who have disseminated lymphoma common among African people. Epstein barr virus is supposed to cause it. It is commonly seen in children between 4-8 years of age. Maxilla is the commonest site.

Imaging:

On CT, lymphoma of the nose and Para nasal sinuses may mimic the much more common entities of sinusitis, polyposis, and benign and malignant neoplasms. They are often seen as bulky masses and there may be changes to indicate expansion, erosion or infiltration.

Metastatic lesions:

Metastasis of primary tumor to sinonasal cavities is rare. Most common primary tumor is renal cell carcinoma followed by tumors of the lung, breast, prostate, testes and gastrointestinal tract. The metastatic tumors to the Paranasal sinuses have a tendency to enter their expansion about the margins of the sinus rather than a mucosal thickening. The majority of metastases to the Para nasal sinuses are to the bone and are mainly hematogenic, and clinical features are almost similar to that of a primary malignant tumor of the affected sinus or nose.

On CT scans, metastases from renal cell carcinoma and melanomas appear as markedly enhancing, soft tissue masses that may remodel or destroy the walls of the sinonasal cavities. Prostatic lesions, like elsewhere, often result in sclerotic bone with abnormal irregular margins associated with small or large soft tissue components.

Metastases from the lung, breast, bladder, distal GU tract and gastrointestinal tract are usually aggressive and bone destroying.

Harrisions classification of sinus malignancies: Category Description

T1 - Limited to antral mucosa without evidence of erosion of bone.

T2 - Bony erosion but without involvement of facial skin, orbit, ethmoid or pterygopalatine fossa.

T3 - Involvement of orbit, ethmoids or facial skin.

T 4 - Extension to nasopharynx, sphenoid sinus, cribriform plate or pterygopalatine fossa.

American joint committee classification (1983): [44]

This is the most widely accepted classification. This is based on TNM classification. The T portion of TNM describes the tumor in terms of position in relation to extent of invasion. The N designation is for other lymph nodal description for tumor of upper aero digestive tract. M stands for distant metastasis.

Diagnosis of tumors of Para nasal sinuses: Clinical features

Although most of the tumors of the sinonasal tract are symptomatic. Most of these symptoms are non-specific such as swelling and pressure effects of the concerned area and other associated features like nasal obstruction, headache, visual disturbance or proptosis, epistaxis and nasal discharge etc., and some of these lesions may be incidental findings on plain radiographs or CT scan done for other reasons. Hence while evaluating any mass lesion of the sinonasal tract, the imaging physician should keep in mind the various entities that are possible like age, clinical presentation, duration, while focusing attention on the imaging features itself. By careful assessment and elimination, he will then be in a position to aid the concerned clinician regarding the diagnosis and further management.

MATERIAL AND METHODS

Source of data:

The source of data for this study is patients referred from the DEPARTMENT OF OTORHINOLARYNGOLOGY to the DEPARTMENT OF RADIOLOGY AND IMAGING at Shri B.M. Patil Medical College Hospital and research center, Vijayapur. Patients who were found to have history of headache, nasal obstruction, nasal discharge, anosmia, postnasal discharge, epistaxis. Their CT examination were studied.

Period Of Study: October 2014 - June 2016

Study Design: Descriptive study

Inclusion criteria:

1. Patients presenting with history of headache, nasal obstruction, nasal discharge, anosmia, postnasal discharge, epistaxis.
2. Clinically diagnosed / suspected sinusitis, benign / malignant neoplasms.
3. Patients undergoing functional endoscopic sinus surgery (FESS).

Exclusion criteria:

1. Pregnant women.
2. Patients with maxillo facial trauma.

INVESTIGATION DONE IN THE STUDY

Both axial and coronal CT scan study (Done with GE, spiral CT machine) was done for 84 patients referred from Department of Otorhynolaryngology and Department of Head and Neck Surgery, Shri B.M. Patil Medical College Hospital and research center, with clinically suspected PNS diseases.

TECHNIQUE

Patient position

- Supine for axial sections
- Supine with neck extended for coronal sections y Angulation
- Parallel to hard palate for axial sections
- Perpendicular to hard palate for coronal sections y Thickness
- 5 mm for both coronal & axial sections.
- 3 mm were taken at osteomeatal unit on coronal sections.
- Coronal – posterior margin of sphenoid sinus to anterior margin of frontal sinus
- Axial – hard palate to upper margin of frontal sinus

  [If necessary extended beyond above mentioned extent as required]

  Exposure : 120 kVp , 130 mAs, 1.5seconds scan time.

Bone window :

- Window width- 2000 HU
- Window level – 350HU

Soft tissue window :

- Window width – 90 HU
- Window level – 40HU

Contrast agent : Omnipaque 350 was used if indicated, at a calculated dose of 300 mg/kg weight as a single intravenous bolus injection after serum creatinine level was estimated.

Informed consent obtained from the patient if i.v contrast was administered (Annexure C)

CT findings were entered in the proforma (Annexure A)

Lund Mackay scoring was done in case of inflammatory lesions (Annexure B)

After the CT PNS patients consent was taken for endoscopic sinus surgery (Annexure C)

Diagnostic nasal endoscopy was carried out in most of the cases under general anaesthesia. Endoscopic sinus surgery : tailored according to the CT scan was carried out mainly concentrating on sinus drainage, collection of mucopus, destruction of bones. Any polypoidal or mass lesions were debrided or biopsy taken for histopathological examination and fungal culture in selected cases.

CT PNS findings were compared with endoscopic/ endoscopic sinus surgery findings.Statistical analysis was done using statistical software, Microsoft Word and Excel have been used to generate graphs, tables etc.

Sensitivity and specificity of CT findings were calculated using endoscopic/ endoscopic sinus surgery findings as standard with reference to mucosal thickening, polypoidal/mass lesions, involvement of adjacent bones and soft tissue.Finally clinical diagnosis was correlated with CT diagnosis using Chi-square test.

RESULTS

A prospective corelational descriptive clinical study of 84 patients who underwent CT PNS was done and correlated with the final diagnosis after FESS .

Table 1: Age-wise distribution of patients studied

Age in years	Number (n=84)			Percentage
	Females	Males	Total	
5-10	1	2	3	3.5
11-20	5	7	12	14.2
21-30	14	17	31	36.9
31-40	8	10	18	21.4
41-50	5	6	11	13.09
51-60	2	3	5	5.9
> 60	2	2	4	4.7

Highest number of patients were in the range of 2 1-30 years (36.9%) followed by 3 1-40 years (21.4%). Youngest patient was 4 year old and eldest patient was 79 year old.

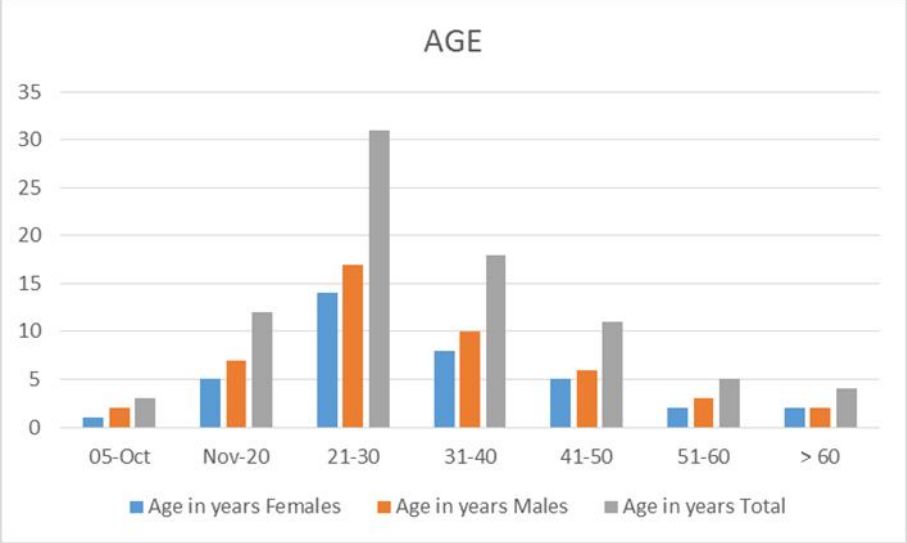
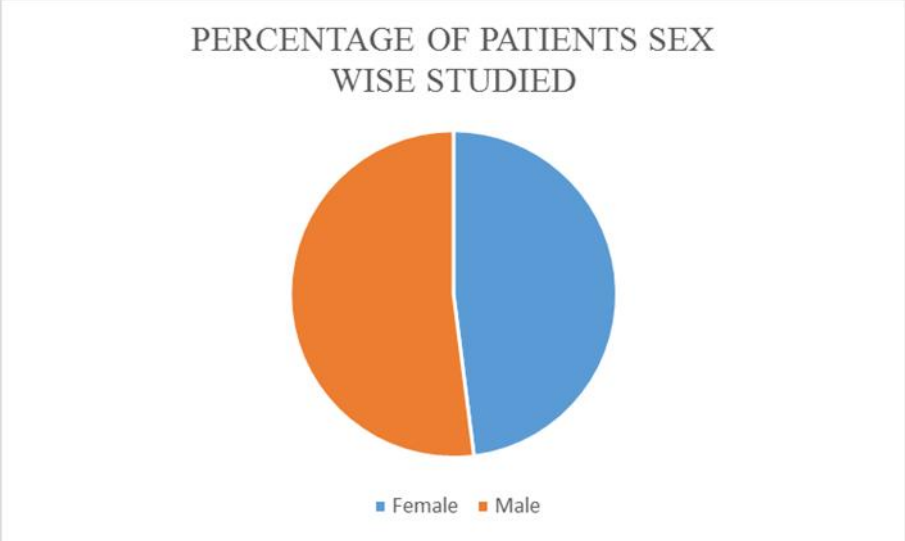


Table 2: Sex-wise distribution of patients studied

Sex	Number of Patients	Percentage
Female	40	48
Male	44	52
Total	84	100.0



In this study, it is observed that, highest number of patients were males forming 52 % patients and females accounted for 48% (40). The male : female ratio is 1.12

Table 3 : Chief Complaints

Chief Complaints	Number of Patients (n=84)	Percentage
Headache	43	55.9
Nasal discharge	48	53.7
Nasal obstruction	37	44.2
Epistaxis	3	3.5
Swelling	4	4.7

Most of the patients had headache (55.9%) followed in decreasing order by nasal discharge (53.79%) and nasal obstruction (44.2%). The least complaint was epistaxis and swelling in the facial region (4.7 %).

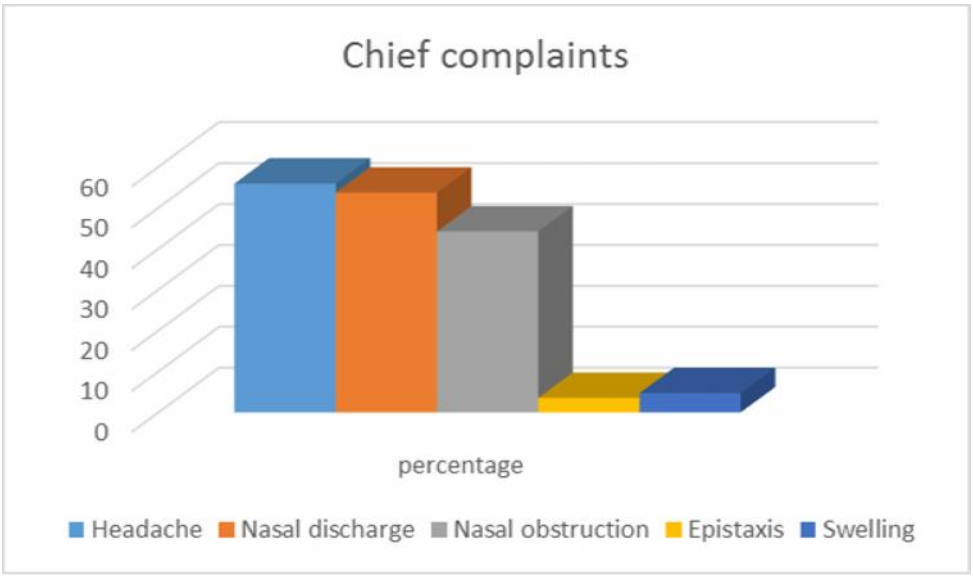
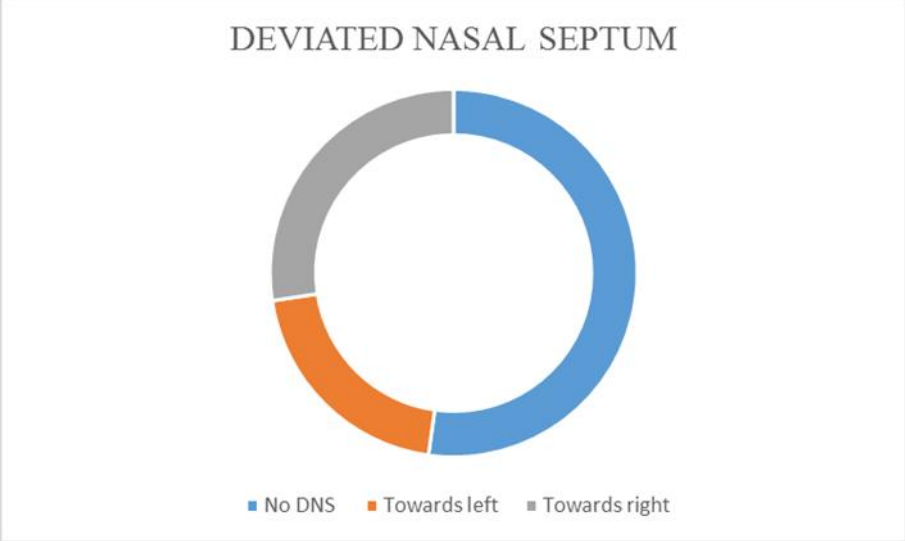


Table No 4 : Deviated nasal septum

DNS	Number (n=84)	Percentage
No DNS	44	52.2
Towards left	17	20.4
Towards right	23	27.4
Total	40	47.8



DNS was seen in 44 patients (52.3%) with more common towards right side. DNS towards right side is seen in 26 patients (30.9%), DNS towards left side seen in 21 patients

Table No 5 : Concha Bullosa

Concha Bullosa	Number (n=84)	Percentage
No	57	67.8
Left	11	13.09
Right	13	15.4
Bilateral	3	3.7
Total	27	32.2

Concha Bullosa is noted in 27 patients (32.2%) with more common on right side. Left side Concha Bullosa is seen in 11 patients (13.9%) and right side Concha Bullosa is seen in 13 (15.4%). Bilateral Concha Bullosa is seen in 3 patients (3.7%).

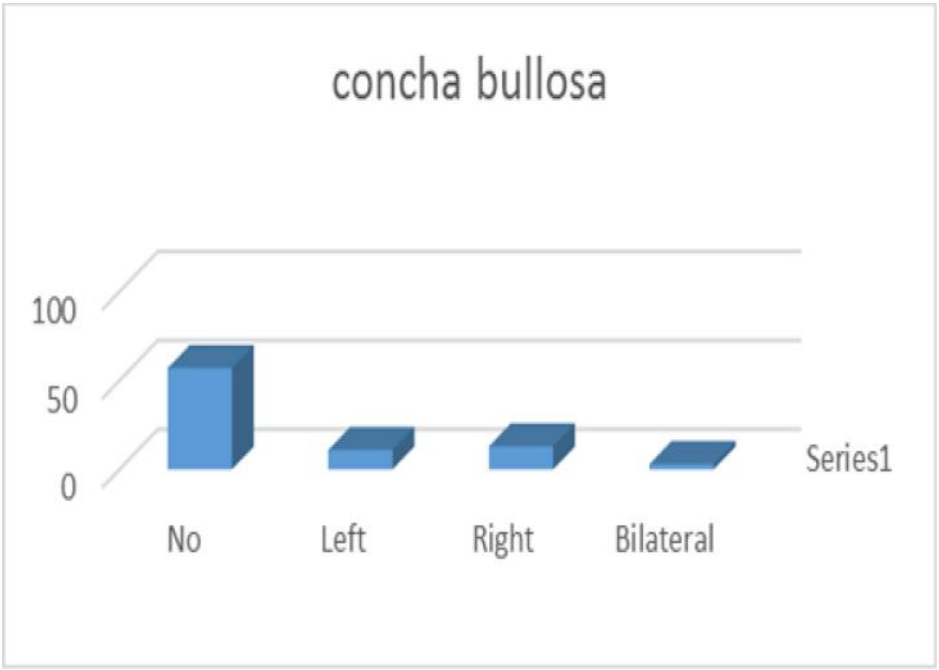
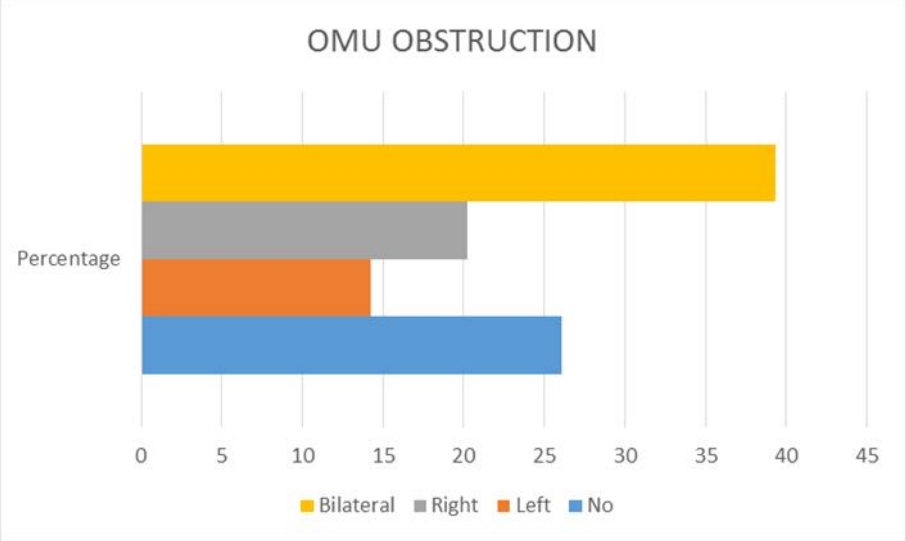


Table No 6 : Osteomeatal Unit Obstruction

OMU Obstruction	Number (n=84)	Percentage
No	22	26.1
Left	12	14.2
Right	17	20.2
Bilateral	33	39.3
Total	62	73.9



OMU obstruction is observed in 62 patients (73.9%) with bilateral involvement seen in 33 patients (39.3%).

Table 7 : CT Severity Grading

CT Severity	Number (n=84)	Percentage
Grade 0	1	1.0
Grade 1	24	28.0
Grade 2	12	14.2
Grade 3	27	32
Grade 4	21	25

CT severity was assessed in 84 patients who had inflammatory sinus diseases. Maximum number of patients had grade 3 severity (32.0%) and grade 0 severity was found in least number of patients (1.0%).

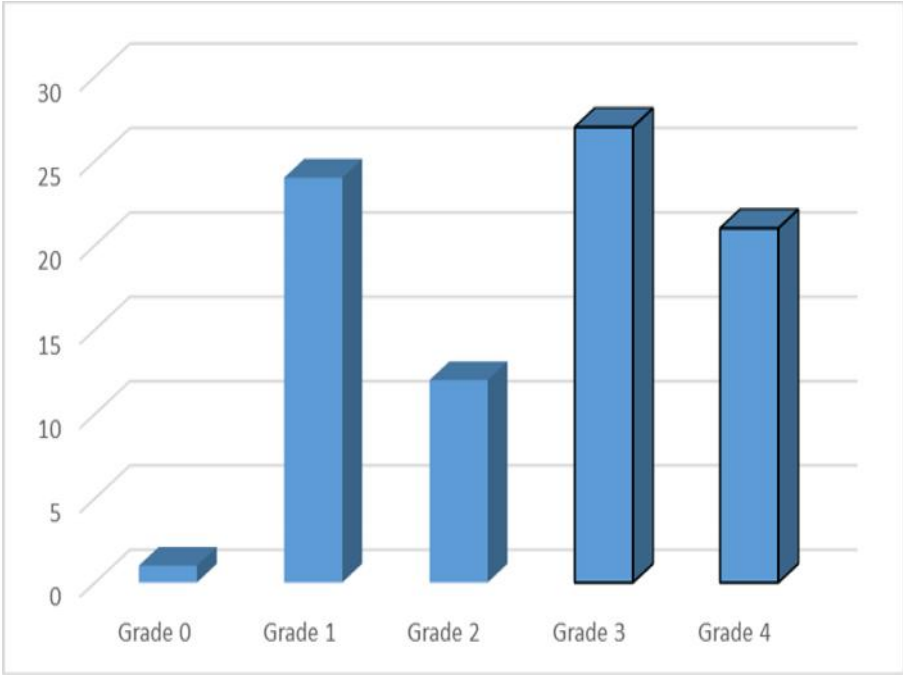


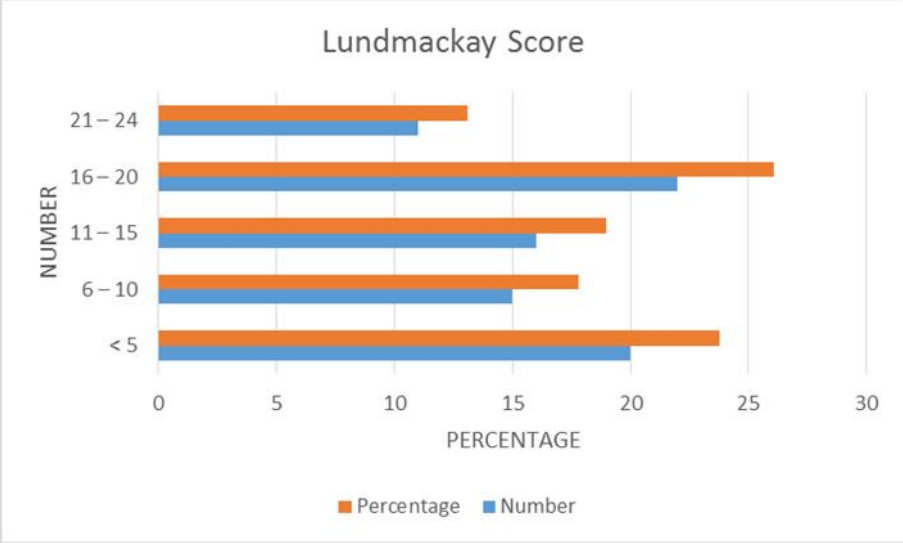
Table 8 : Endoscopy / FESS findings

Endoscopy	Number (n=84)	Percentage
Same as CT	79	94.4
Different from CT	5	5.6

Endoscopic / FESS findings were similar to CT findings in 79 (94.4%) patients and different from CT findings in 5 (5.6%) patients. These different findings were related to either fungal disease or inspissated secretions.

Table 9 : Lundmackay Score

Lundmackay Score	Number	Percentage
< 5	20	23.8
6 – 10	15	17.8
11 – 15	16	19.0
16 – 20	22	26.1
21 – 24	11	13.1
Total	84	100.0



Of 84 patients, Lund Mackey scores was assessed in 84 patients. Maximum number (26.1%) of patients had Lund Mackey scores between 16-20 and minimum number (13.1%) of patients had scores between 2 1-24.

Table 10 : Histopathological Reports

HPR	Number (n=84)	Percentage
Inflammatory polyp	24	28.6
Fungal sinusitis	10	11.9
Mucocele	2	2.3
Angiofibroma	2	2.3
Squamous cell carcinoma	2	2.3

Table 11 : Bone Involvement

Bone Involvement	Number (n=84)	Percent	Sensitivity	Specificity
In clinical diagnosis	1	1.2	12.3	100
CT diagnosis	9	7.00	100	100
Final Diagnosis	10	7.00	-	-

Out of the 7 patients found to have bone involvement in the form of erosion or destruction on endoscopy / FESS, CT detected in all the 7 patients but on clinical examination found only in 1 patient. CT had higher sensitivity and specificity whereas clinically sensitivity was very low.

Table 12 : Comparison of findings of Clinical, CT and final diagnosis

Findings	Clinical		CT		Final diagnosis (n = 84)	
	No	%	No	%	No	%
Sinusitis	70	83.3	44	51.2	43	51,2
Polyp	7	7.1	24	28.6	23	27.3
Fungal sinusitis	2	2.3	9	8.3	11	13.1
Others	5	8.3	7	11.9	7	8.3

Best comparison observed between CT and final diagnosis but poor comparison between clinical and final diagnosis.

Table 12a : Correlation of Clinical with Final Diagnosis - an Observation

Parameters	True Positive	False positive	False negative	True Negative
Chronic Sinusitis	43	27	0	14
Polyp	5	1	18	60
Fungal sinusitis	2	7	1	74
Others	2	2	1	77

Table 12b : Correlation of Clinical with Final Diagnosis -an evaluation

Parameters	Sen	SPp	PPV	NPV	Accuracy	P value
Chronic Sinusitis	100.0	30.0	60.7	100.0	66.4	<0.001
Polyp	46.0	98.3	88.9	74.7	75.9	<0.001
Fungal sinusitis	22.2	100.0	100.0	93.2	93.3	<0.001
Others	50.0	100.0	100.0	94.9	95.2	<0.001

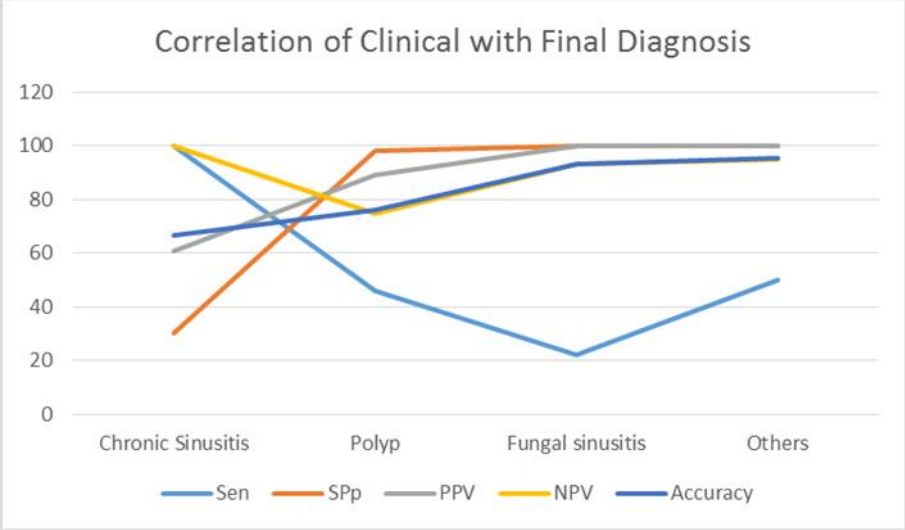
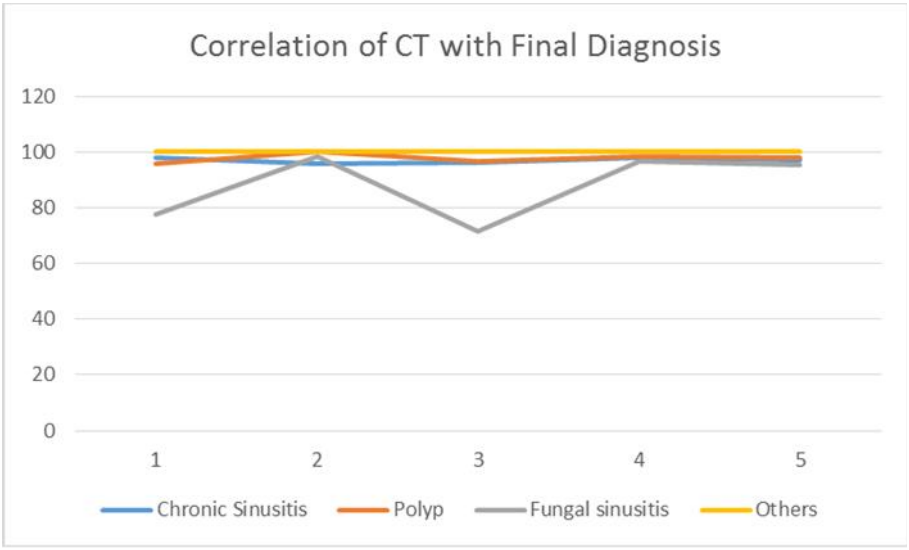


Table 13a : Correlation of CT with Final Diagnosis – an observation

Parameters	True Positive	False positive	False Negative	True negative
Chronic Sinusitis	47	0	0	41
Polyp	23	0	1	61
Fungal sinusitis	7	1	2	74
Others	5	0	0	79

Table 13b : Correlation of CT with Final Diagnosis - an evaluation

Parameters	Sen	SPp	PPV	NPV	Accuracy	P value
Chronic Sinusitis	98.2	96.0	96.4	97.9	97.1	<0.001
Polyp	95.9	100.0	96.9	98.6	98.1	<0.001
Fungal sinusitis	77.8	98.6	71.4	96.9	95.2	<0.001
Others	100.0	100.0	100.0	100.0	100.0	<0.001



DISCUSSION

In the recent past, it is accepted that CT is the best imaging method of demonstrating simple inflammatory disease to neoplasms in the paranasal sinuses. Previous studies have shown poor correlation of plain X-ray with CT. Plain films are unreliable and no longer routinely indicated for the evaluation of paranasal sinus disease. Clinical assessment be used to evaluate acute sinus infection and CT used for the investigation of persistent and chronic sinus disease. CT evaluates the osteomeatal complex anatomy, which is not possible with plain radiographs. Removal of disease in osteomeatal complex region is the basic principle of FESS, which is best appreciated on CT scan.

This study was carried out to evaluate the correlation of the CT findingswith pathological findings of the paranasal sinuses by CT. 84 patients were evaluated with CT which were referred after clinical examination and then correlated with histopathology.

Age of incidence (years):

In present study the patients age ranged between 8-76 yrs with maximum number of patients in the age group of 21 – 30 years in 31 out of 84 cases.

Our study is correlating with an indian study by vekatachalan et al (2000) who studied 210 consecutive cases of sinusitis with computerized tomography. The age of the patient ranged from 7 to 66 years with maximum patients in the age group of 21 to 30 years similar to my study. Similarly gliklich et al (2004) studied 104 consecutive cases of panasal pathologies, the mean age was 41.2 years with a range of 15 – 73 years [44] .

Sex distribution (%):

In our study about 52% of the patients were males and 48 % were fe males. Similary in a study by Sanjeev M et al(2016) in which the study comprising of 100 patients there was a female predominance with 49 % and slightly higher predominance of males 51%t. in a study by Venkatachalan et al (2000) on sinusitis there was a slight male predominance of 58% and females 42%.

Symptoms:

In our study, symptoms with which patients presented were recorded during clinical examination. The most common symptom was headache in 43 patients consisting of 53.2%, followed in by nasal discharge (50.0%) and nasal obstruction (42.3%). The least common symptom was epistaxis and swelling in facial region seen in 3 patients each (3.6%). The other symptoms with which the patients presented were facial pain, sneezing and dyspnoea. Patients presenting with history of maxillofacial / head trauma were not considered in our study.

Similarly in a study by nair s et al (2015) in which 100 patients with sinusitis were subjected to CT. the most common symptoms nasal discharge which was seen in 49% of patients [48] .

It is also correlating with a study by venkatachalan (2000)et al the most common symptom were nasal discharge and nasal obstruction , seen in 147 and 183 cases respectively.

Deviated nasal septum, Concha Bullosa and osteomeatal unit (OMU):

In my study, deviated nasal septum was seen in 40 of 84 patients constituting 47.8% Right DNS was more commonly seen than the left. The osteomeatal unit involvement of causing nasal obstruction and mucosal thickening

OMU were involved in 62 (73.9%) patients of which bilateral was seen more

commonly involving 33 (39.3%) cases. Concha bullosa was seen in 30 out of 84 patients (32.2%).

Similar results were seen in study by Dua k et al (2006) [46] which conducted a study for CT scan variations in chronic sinusitis in 50 patients in Dayanand medical college, Ludhiana the incidence of the deviated nasal septum was 44% which was consistent with the present study of 47.8% patients.

Similar findings were observed in study by Maru YK, et al (1999) in MGM college indore in which concha bullosa was seen in 62 of the 150 patients (41%).

The incidence of concha bullosa was similar in a study conducted by shalini et al (2015) in king George medical college, lucknow on 100 sino-nasal tomograms. The incidence of concha bullosa was seen in 24% of patients.

In a study by Dua k et al osteomeatal unit was involved in 44 out of 50 cases (88%), unilaterally in 22 cases (46%) and bilateral in 21 cases (42%) which was similar to my study [59] .

Sinuses opacified

Most common sinus involved was maxillary sinus in 76 patients (90.5%), followed by anterior ethmoid (78.8%), posterior ethmoid (69.2%), frontal (52.9%) and sphenoid sinuses (42.3%) in decreasing order

Similar findings are observed in the study Jagan v et al (2016) which conducted study computed tomograpgy for early diagnosis for paranasal sinus pathologies in this study, Maxillary sinuses are most commonly involved in the study (82 cases), followed by the ethmoid sinuses (ant. group 77% cases, post group 40% case) and frontal sinus 55 cases [52] .

Similarly,In a study by zojaji et al (2008) on chronic rhinosinusitis[61], the most commonly involved sinus The maxillary sinuses were most commonly affected, with

changes seen in 42 (82%) patients, followed by the ethmoidal sinuses with changes seen in 28 (54%) patients; the least affected sinuses were the frontal and sphenoid sinuses with 10 (20%) and 13 (25%) patients, respectively.

In all above studies maxillary sinus was most commonly involved because of higher positioning of the maxillary ostia which makes it difficult for drainage.

In a study by dua k et al (2006) on sinusitis, the most commonly involved sinus was anterior ethmoid sinus seen in 44 cases (88%), followed by posterior ethmoid sinus in 33 (66%), maxillary sinus in 25 (50%), frontal in 16 (32%) and sphenoid in 9 cases (18%) [59] .

The incidence of involvement of anterior and posterior ethmoid sinuses is similar to our study. However the incidence of involvement of maxillary sinus was 50% whereas in our study the involvement was 90.5%. the limitation in Dua k et al (2006) [46] study is that the finding were not confirmed by FESS and study sample was only 50 cases in contrast to our study.

CT severity index:

As per Glicklich et al (1988) graded the severity of sinus disease. As per this validated grading system it is classified as

Grade: 0: Less than 2 mm. mucosal thickening on any sinus wall.

Grade 1 : All unilateral disease or anatomic abnormalities.

Grade 2 : Bilateral disease limited to the ethmoid or Maxillary sinuses.

Grade 3 : Bilateral disease with involvement of at least one sphenoid or frontal sinus.

Grade: 4 : Pansinus disease.

In our study, the CT severity assessed for 84 patients with inflammatory diseases showed highest no of patients of grade 4- 33 (33%) patients and lowest of grade I- 1 (1%) patient. Lund MacKay scoring between 16-20 was observed in more number of

patients 25 (24.1%). The mean score observed was 12.37 ± 6.92.

Fungal sinusitis:

In our study the total number cases of fungal sinusitis was 10 out of 84 cases (11.9 %).

R.N. Samal et al (2014) studied on 120 suspected cases of chronic sinusitis at M.K.C.G. Medical College, Berhampur .

The prevalence of the fungal sinusitis in the same study was 14 out of 120 cases (11.66%) which is consisitent with my study.

In an another study carried out by S J zinerich et al (2004) [53] 28 out of 293 patients had fungal sinusitis (9.5 %) which is similar to my study.

The findings of fungal sinusitis such as bone erosions, bone thickening, increased opacity in sinuses (bone hazy opacity) and mucosal thickening were consistent to the study conducted by The prevalence of the fungal sinusitis in the same study was 14 out of 120 cases (11.66%) which is consisitent with my study.

In our study ,The most common involvement of the sinuses was of maxillary (6 cases) , followed by ethmoid (3 cases) and frontal (2 cases) sinuses.

The presence of calcification was common in fungal sinusitis was seen in the 30 % cases respectively which as consistent with study by Jagan v et al (2016)[52] which and calcification in (30%) and (50 %) of diagnosed cases of fungal sinusitis.

Greatest pitfall in diagnosis of PNS diseases by CT is the fungal sinusitis. In my study 10 patients had were studied among which 7 (70.0%) were diagnosed correctly and others were diagnosed on CT not. The sensitivity was 77.8% and specificity was 97.9% for CT to diagnose fungal sinusitis. The sensitivity described in literature was 76% by Zenreich SJ et al (2006) in fungal sinusitis [52] CT imaging which was a retrospective study. False positives are observed as the density increase is also seen in

inspissated secretion, calcification in bacterial infections etc. False negatives are observed, as there will be no increase in density in some cases. But CT plays important role in diagnosing invasiveness of fungal sinusitis like spread to adjacent structures, bone erosion or destruction.

Polyp:

In our study, the number of cases of with polyp are 24 of 84 cases (28%) has been reported of which the most common pathology encountered after sinusitis

The most common polyp was antrachoanal polyp which was found in 11 cases in the younger age group (15- 39 yrs) while ethmoidal polyp was found in 5 patients in older age group

Similar findings were observersed R N. das et al (2014)[50] which repoterd polyp in 35 cases Out of which antarchonal polyp was found in 15 patients most of them in younger age group. However ethmoidal polyp were most commonly found in this study probably due to more number of elder age group selected in the study

Bone destruction in fungal sinusitis:

In our study ,The most common involvement of the sinuses was of maxillary (5 cases) , followed by and frontal (2 cases) sinuses.

CT has the capability to delineate the bone erosion or destruction with the highest accuracy in the imaging modalities. In this study CT detected the bone erosion or destruction in all the 7 patients, which was confirmed on HPR. The sensitivity and specificity of CT to detect bone erosion or destruction was 100% where as clinical detection had 14.3% sensitivity and 100% specificity.

Neoplasms:

In our study the no of neoplasm were 5 of which 2 were epithelial tumors and 1 was non-epithelial tumor

In our study, the most commonly sinus involved in the tumors was maxillary sinus 3 followed by ethmoid sinus 2 cases.

A similar study by Chandan G et al (2015)[56] conducted a study of occurrence of paranasal sinuses tumors in karanataka. Correlates well with our study. The most commonly involved sinus was maxillary sinus in the (70%) of cases followed by ethmoid sinus (20%)which correlates well with my study.

In our study, squamous cell carcinoma is diagnosed malignant tumour in 2 cases.

Similarly the squamous cell carcinoma was the most diagnosed for the most common malignancy in the study by Khan et al (2006) reported that Squamous cell carcinoma was the most common malignancy observed in the study and it constituted 37.5% (13) of all the malignancies studied [53] .

Lango mn et al (2010)[55] reported that 60 % of all the malignancies occur in the maxillary sinus.

In our study, 1 case of fibrous dysplasia of maxillary sinus were diagnosed. The diagnostic accuracy being 100% in our study. J Philips et al (2015)[57] reported that fibrous dysplasia is the most common fibro-ossous lesions..

In our study ,2 cases of juvenile nasal angiofibroma were diagnosed both were males the cases presented with nasal obstruction and epsistaxis.

Similar findings were observed in the study by K Narayana S et al (2004)[57] in the study of benign tumors of paranasal sinuses concluded that juvenile nasal angiofibroma was the most common benign tumors (26.66%) in the nose and paranasal sinuses in 30 patients which is similar to our study.

Clinical, CT and Final diagnosis:

When the comparision table is viewed there is a best correlation between the CT diagnosis and final diagnosis but poor correlation between the clinical diagnosis and

final diagnosis.

On correlating clinical diagnosis with final diagnosis, sinusitis has 100% sensitivity but only 30% specificity with accuracy of 66.4%. Polyps has sensitivity of 25% and specificity of 98.6%. For fungal sinusitis the sensitivity was only 22.5%, which was very poor. In diagnosing benign and malignant lesions of PNS was also difficult which had sensitivity of only 50%.

On correlating CT diagnosis with final diagnosis, chronic sinusitis has 98.2% sensitivity and 96% specificity. Polyps have sensitivity of 96.9% and specificity of 100 %. Again for fungal sinusitis CT has lower sensitivity of 77.8% and specificity of 98.6%. For diagnosing benign and malignant lesions CT has 100% sensitivity, specificity, positive predictive value and negative predictive value with 100% accuracy. P value in all instances was < 0.05 i.e. <0.01, indicating the significance of the findings. This high sensitivity and specificity for benign and malignant masses could be due to small number of masses evaluated.

Thus, CT plays an important role in diagnosing and also adding important findings for the better management of the patients with paranasal sinus diseases.

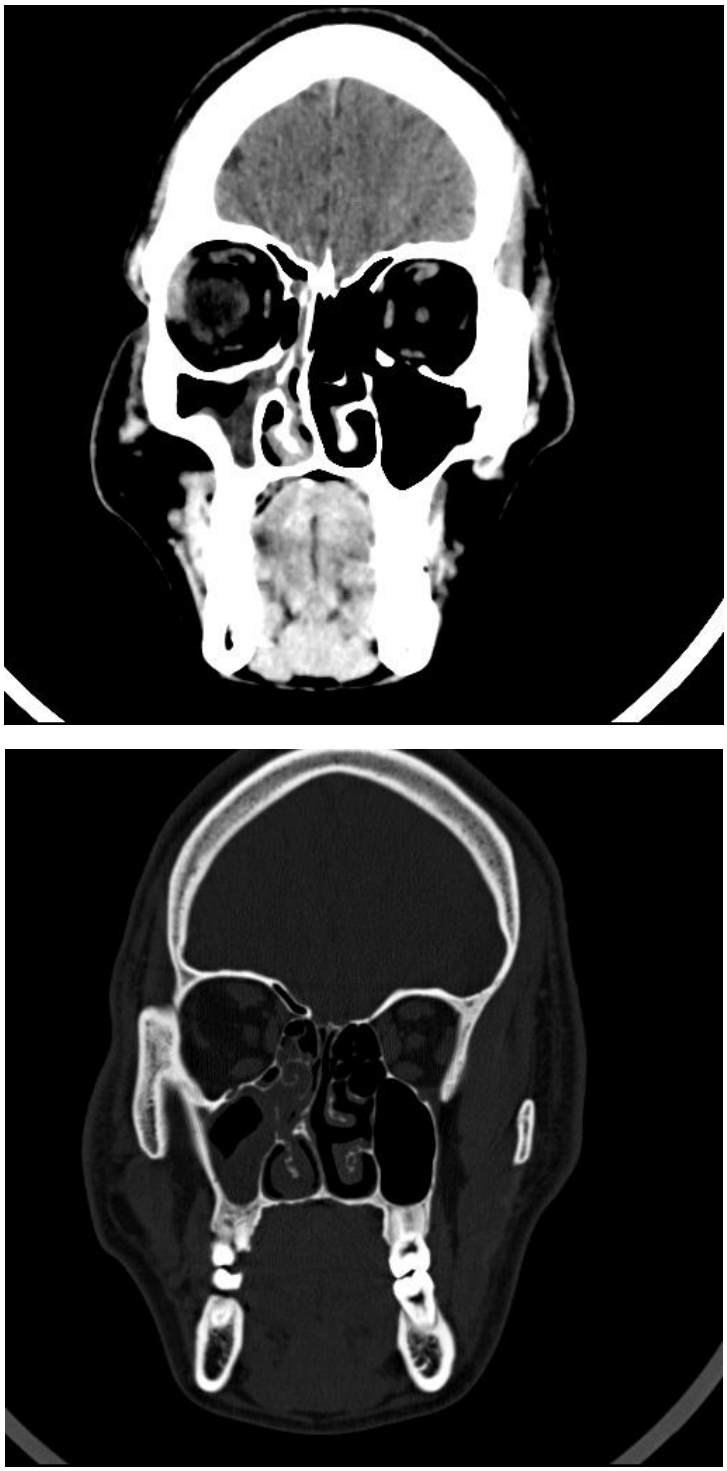


Fig :16 Soft tissue density causing near complete obliteration of right maxillary, right frontal, right anterior ethmoid and sphenoid sinuses

Case : Right maxillary, frontal and sphenid sinusitis

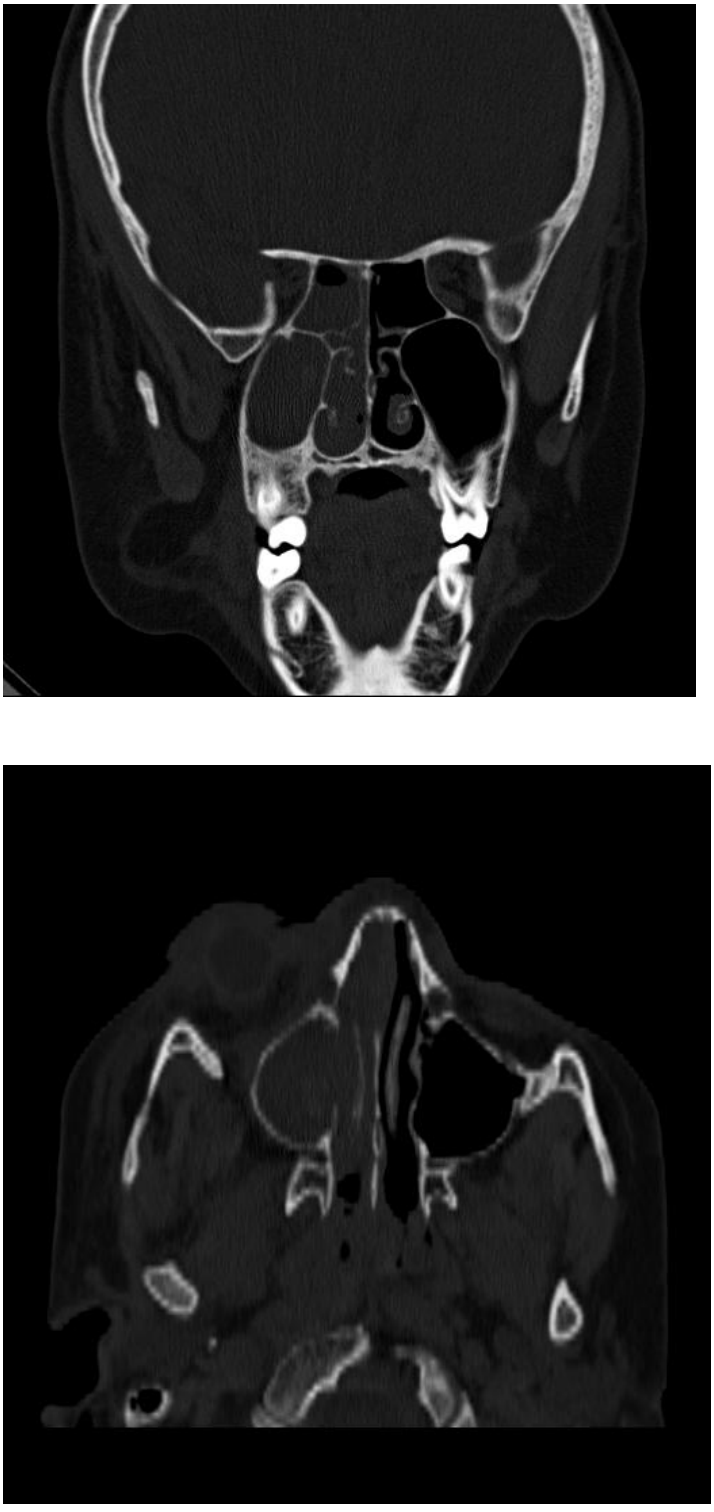


Fig : 17 Soft tissue density lesion in the right maxillary sinus causing its complete obliteration with the lesion extending to the right maxillary ostium

Case : Right antrachoanal polyp.

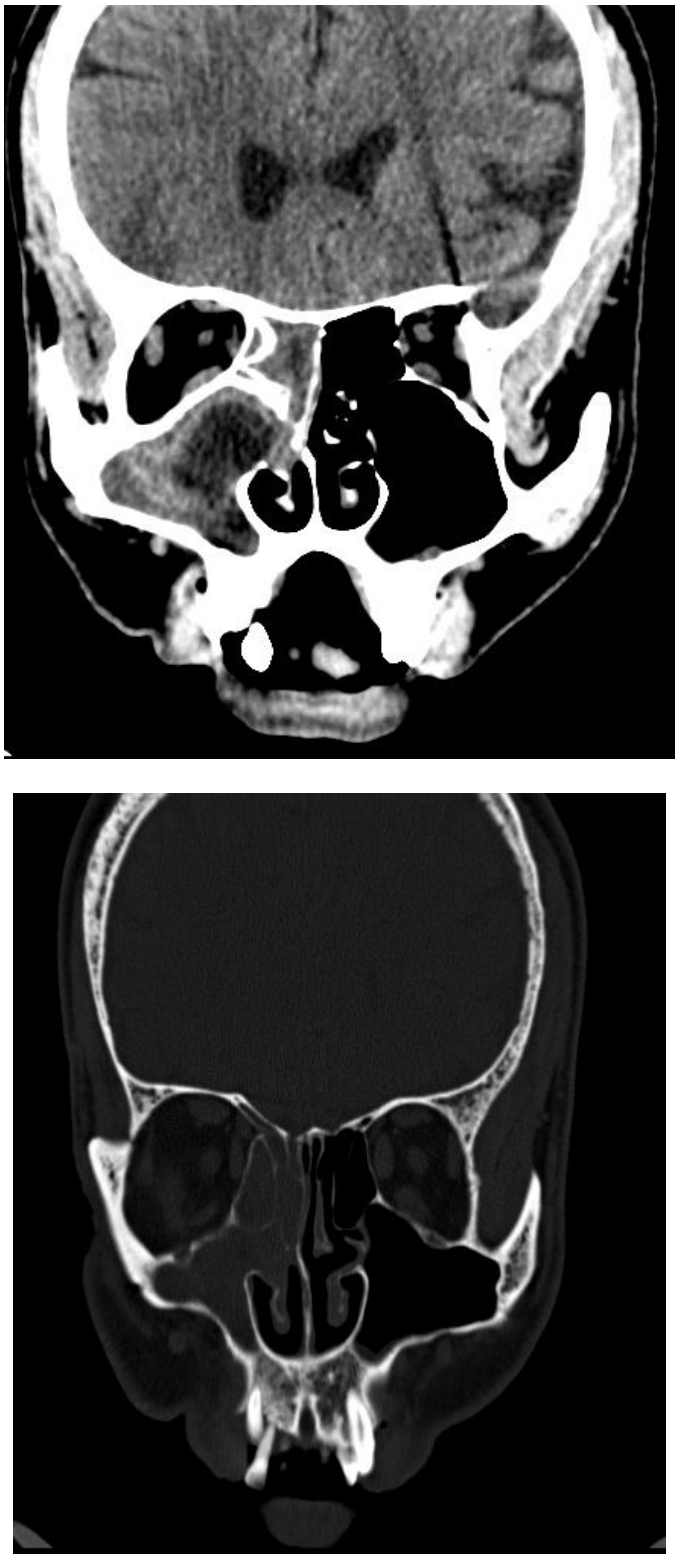


Fig : 18 Soft tissue density lesion with areas of hyperdensites and calcifiction in the right maxillary sinus
Case : Chronic Sinusitis

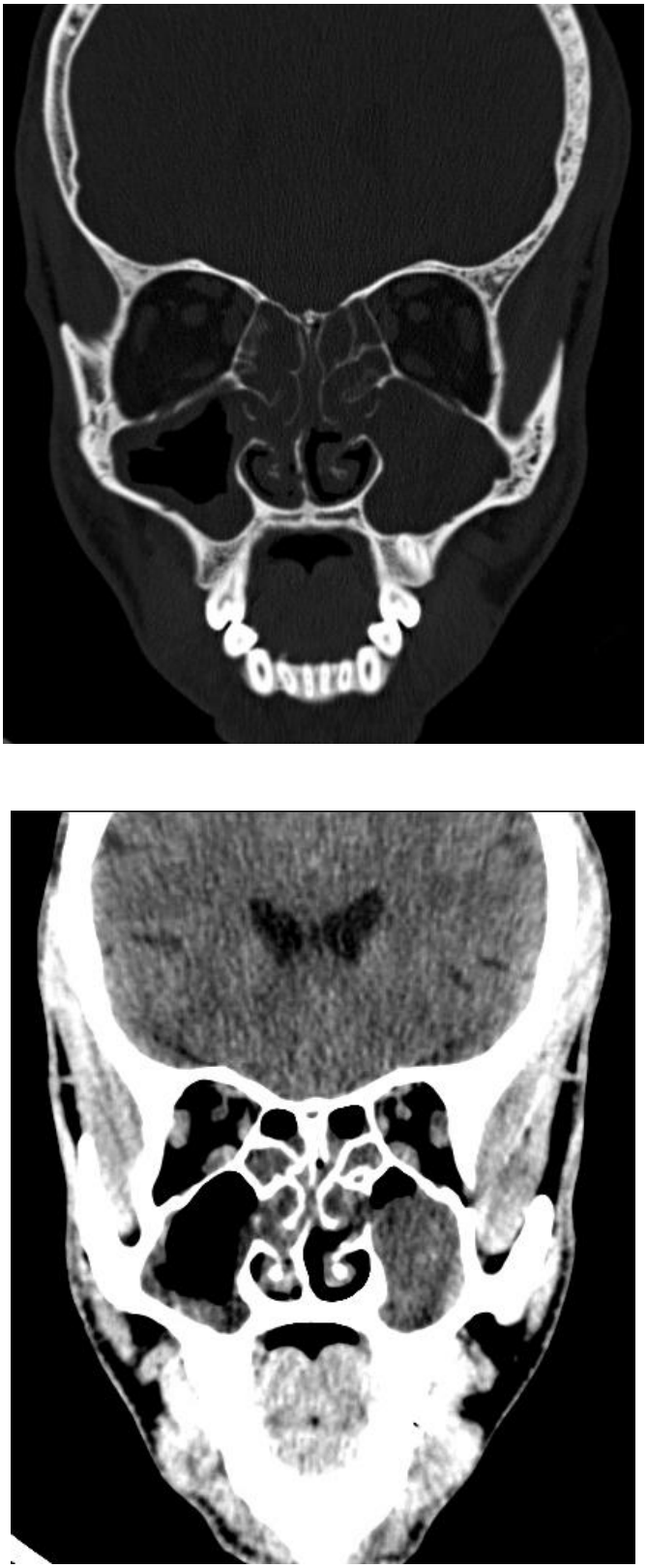


Fig 19 :Mucosal thickening of bilateral maxillary, ethmoid , sphenoid and frontalsinuses

Case : Pansinusitis

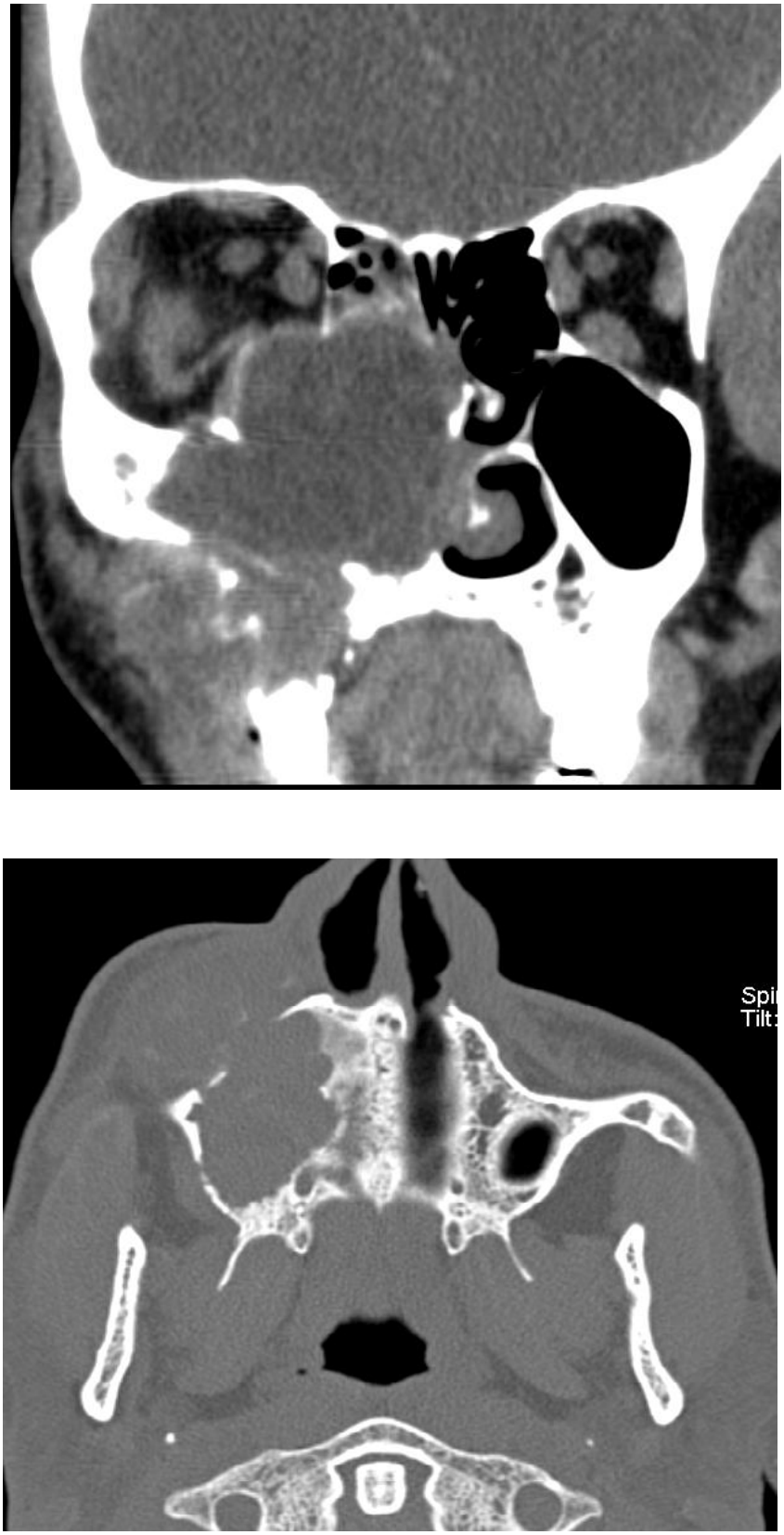


fig :20 carcinoma of maxillary causing erosion of bony wall of rt. Max sinus

Fig 21: Large expansile mixed lytic, ground glass lesion involving the alveolus of maxilla on the left side, walls of maxillary sinus, both the wings of sphenoid Case : Fibrous Dysplasia.

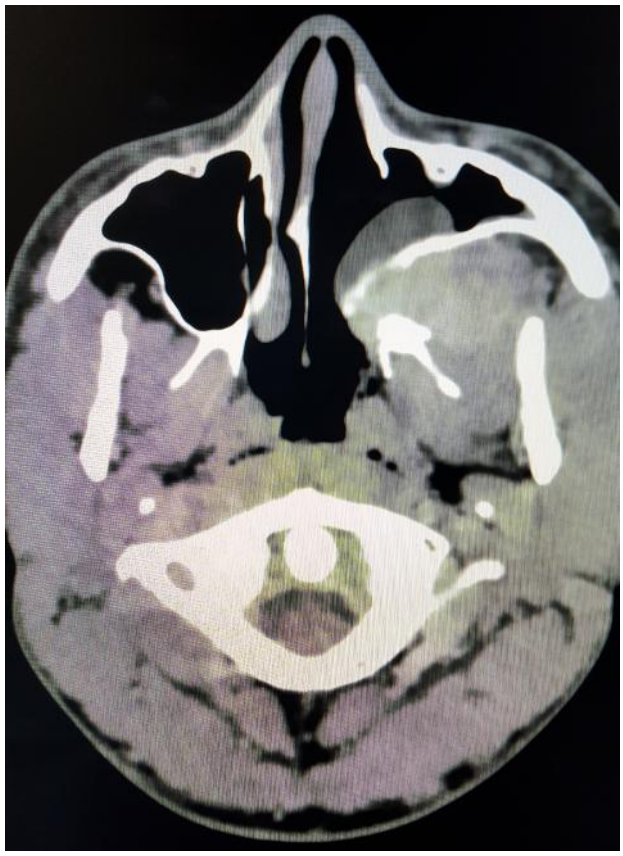


Fig 22 :Case of post contrast enhanced soft tissue density lesion in the left maxilry sinus causing dislascement of the anterior wall of maxilla and orbit.

Case: Nasopharyngeal Angiofibroma

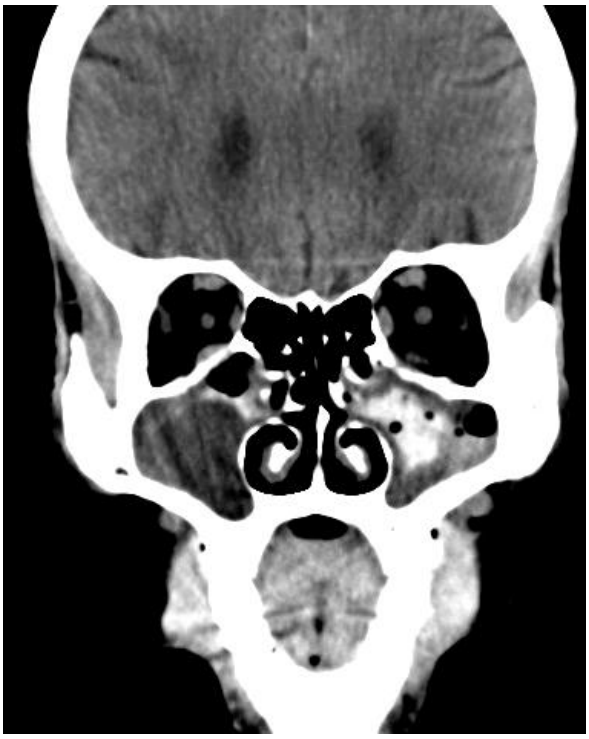


Fig 23:Heterogeneous soft tissue density mass with calcification and near complete filling of bilateral maxillary sinuses with widening & block of ostium.

Case : Fungal Sinusitis

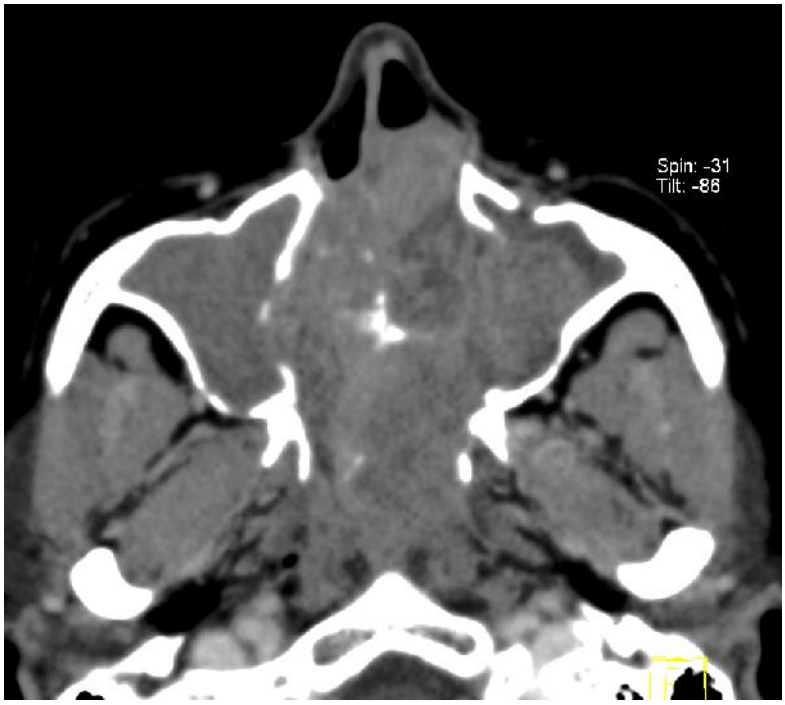


Fig 24 Heterogeneous soft tissue density mass with calcification and near complete filling of bilateral maxillary sinuses with destruction of both medial walls of Maxillary sinuses.

Case - FUNGAL SINUSITIS

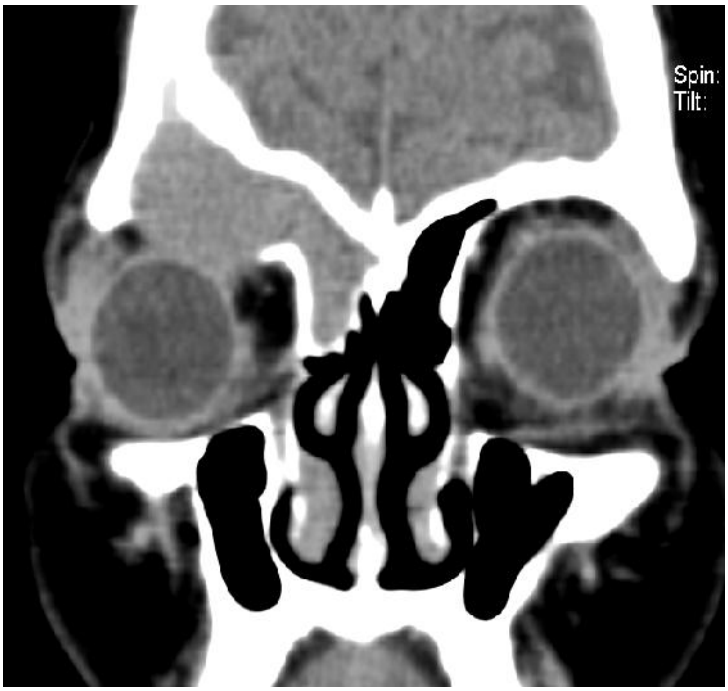


Fig 25: Mucocele in Rt frontal sinus with extension into Rt orbit.

SUMMARY

1. CT is the modality of choice in imaging the paranasal sinuses for evaluating the chronic diseases and associated complications.
2. Fungal sinusitis and dense secretions are potential pitfall on CT to differentiate them. But CT may suggest fungal sinusitis in whom it is not suspected.
3. CT is the modality of choice in evaluating the bone erosion or destruction.
4. CT evaluation of PNS in symptomatic patients helps in planning the further management of the patient.
5. CT helps in staging the PNS disease and its extension and involvement of surrounding structures.

However, CT has certain potential drawbacks and disadvantages like complex projections, artifacts induced by very high density structures in and around PNS, by the patient movement, limited soft tissue resolution. Even radiation exposure in CT examination limits frequent usage, test repeatability and its use in children and pregnant women.

For these reasons, MRI is taking an increasingly important role in many of these areas. The soft tissue contrast discrimination is greater than with CT images, with an equivalent spatial resolution. Further advantages of MRI include the ability to image in any plane without loss of spatial resolution, the ability to demonstrate vessels without the need for contrast medium, no ionizing radiation, and the relative freedom from artifacts compared with CT.

Both CT and MRI with their unique features for better depiction bone details and soft tissue details respectively, carry their own importance and play a complimentary role to each other in identifying the pathological conditions of paranasal sinuses.

CONCLUSION

This was the prospective correlational descriptive clinical study carried out on 84 symptomatic sinus diseased patients who underwent CT imaging of paranasal sinuses in both coronal and axial sections.

Most patients were in the 2nd and 3rd decades of their life with male: female ratio of 1.12:1.

The common complaint with which they presented was headache followed by nasal discharge and nasal obstruction.

On evaluating patients with CT PNS, the most common sinus involved was maxillary sinus and sphenoid sinus was the least involved. Commonest pattern of inflammation was sinonasal polyposis followed by osteomeatal unit pattern.

Sensitivity and specificity of CT in diagnosing fungal sinusitis was 77.8% and 97.9% respectively. But sensitivity and specificity for detection of mucosal abnormality was very good.

CT had best statistical results in evaluating benign and aggressive lesions, which was 100% in this study attributable to the less number of aggressive or malignant lesions studied. On the other hand clinical assessment of these lesions was poor, indicates that CT is mandatory in assessment of paranasal sinus diseases and also to look for any bone erosion or destruction with adjacent structure involvement. The real value of CT lies in defining the exact location, extent of lesion and involvement of adjacent structures.

To conclude, this study proved superiority of CT evaluation over the clinical evaluation of symptomatic patients for the diagnosis and also the planning of management in paranasal sinus diseases.

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ANNEXURE

Institutional Ethical Committee
BIJAPUR-586 103.
OUTWARD
No. 5411
Date 24/11/14
BLDE U's Shri B.M. Patil Medical College.

B.L.D.E. UNIVERSITY'S
SHRI.B.M.PATIL MEDICAL COLLEGE, BIJAPUR-586 103
INSTITUTIONAL ETHICAL COMMITTEE

INSTITUTIONAL ETHICAL CLEARANCE CERTIFICATE

The Ethical Committee of this college met on 22-11-2014 *at* 3-30pm *to scrutinize the Synopsis of Postgraduate Students of this college from Ethical Clearance point of view. After scrutiny the following original/corrected & revised version synopsis of the Thesis has been accorded Ethical Clearance.*

Title "Role of computed tomography in the evaluation of diseases of paranasal sinuses"

— x — x — x —

Name of P.G. student Dr. Saurabh. S. Rathi
Dept of Radiology.

Name of Guide/Co-investigator Dr R. C. Pattanshetti, Prof & HOD.
Dept of Radiology.

for
DR.TEJASWINI. VALLABHA
CHAIRMAN
INSTITUTIONAL ETHICAL COMMITTEE
BLDEU'S, SHRI.B.M.PATIL
MEDICAL COLLEGE, BIJAPUR.

Following documents were placed before E.C. for Scrutinization
1) Copy of Synopsis/Research project.
2) Copy of informed consent form
3) Any other relevant documents.

ANNEXURE-A

CASE PROFORMA

Name: Age: Sex: MRD

No: Chief complaints:

History of present illness:

1. Headache
2. Nasal obstruction
3. Nasal discharge
4. Sneezing
5. Epistaxis
6. Facial pain
7. swelling
8. dyspnoea
9. Others

PAST HISTORY:

FAMILY HISTORY: PERSONAL HISTORY:

GENERAL PHYSICAL EXAMINATION:

1. Pulse rate:
2. Blood pressure:
3. Temperature:
4. Respiratory rate:

RELEVANT E.N.T EXAMINATION FINDINGS:

CLINICAL DIAGNOSIS:

INVESTIGATIONS: Blood:,Hb%, TC, DC, ESR

Urine: Albumin, Sugar, Microscopy

CT FINDINGS:

DNS:

STRUCTURES	RIGHT	LEFT
Nasal bone Turbinates Superior Middle Inferior Lamina papyracea Cribriform plate Fovea ethmoidalis Infundibula Uncinate process Hiatus semilunaris Brain parenchymal lesions		

Structures	Frontal			Maxillary	Ant. ethmoi		Post. ethmoidal		Sphenoid	
	R	L	R	L	R	L	R	L	R	L
Mass										
Mucosal thickening										
Fluid level										
Soft tissue extension										
Walls of sinus										

CT diagnosis :

Endoscopic/ FESS findings : HPR :

Final diagnosis: Treatment :

ANNEXURE - B

PARANASAL SINUSES – CHECKLIST

Frontal Sinuses

- Anatomy
- Wall contours (smooth)
- Pneumatization

Ethmoid Cells

- Anatomy
- Pneumatization
- Bony structures (especially bordering the orbit : boundaries are smooth, sharp, and intact)
- No wall erosions
- No mucosal thickening

Sphenoid Sinus

- Anatomy (coarse honeycomb structure)
- Clear and pneumatized
- No fluid collection
- No mucosal swelling
- Bony structures (smooth, intact walls, no erosion)
- No extrinsic wall indentations

Maxillary Sinuses

- Anatomy
- Size (bilaterally symmetrical)
- Bony structures (smooth, intact contours, walls of normal width, no bone erosion or destruction)

- Pneumatization
- No tooth roots projecting through maxillary sinus floor.

Nasal Cavity

- Anatomy (symmetry)
- Size
- Aeration (clear)
- Nasal septum on the midline
- Nasal turbinates (three on each side: superior, middle, inferior) are normally developed

Pharynx and Parapharyngeal structures

- Anatomy (symmetry)
- Size
- Wall thickness
- No foreign bodies, calcifications or masses

Important Measurements and Data

Frontal sinus

- Height Ca. 1.5 – 2 cm

Sphenoid sinus

- Width 0.9 – 1.4 cm

Maxillary sinuses

- Width Ca. 2 cm
- Height Ca. 2 cm

Lund -MacKay CT Scoring system

NAME : MRD NO:

AGE : SEX :

Maxillary:

Frontal:

		No abnormality	Partial opacification	Total opacification
Ant. Ethmoid:		0	1	2
	R	0	1	
	L			
Post. Ethmoid:		0		2
	R	0		2
	L			
		0		2
	R	0		2
	L			
		0		2
	R	0		2
		0		2
Sphenoid:	R	0		2
	L		Not-Obstructed	Obstructed
		R	0	2
Ostiomeatal Complex:		L	0	2

Total Score:

Lund-Mackay staging system for chronic rhinosinusitis

0 Points	No abnormality
1 Point	Partial opacification
2 Points	Total opacification