INTRODUCTION

Maxillary sinus is a paired structure located on either side of nose below the orbit contained within bone of maxilla. It is the largest of all four paranasal sinuses and has a complex anatomy. It is pyramidal in shape and has body and four processes namely zygomatic, palatine, frontal and alveolar processes. Pathology within the maxillary sinus can have either one or more sites of attachment. It can range from simple to complex and from benign to malignant lesions.

Endoscopic sinus surgeries are being widely used since it has the advantage of being less invasive, better magnification, minimal damage to adjacent structures thereby aim to restore the function. There are some areas within maxillary sinus which could not be accessed with basic procedures necessitating the need for alternative approaches. Also debulking and usage of powered instrumentation needs straight trajectory.

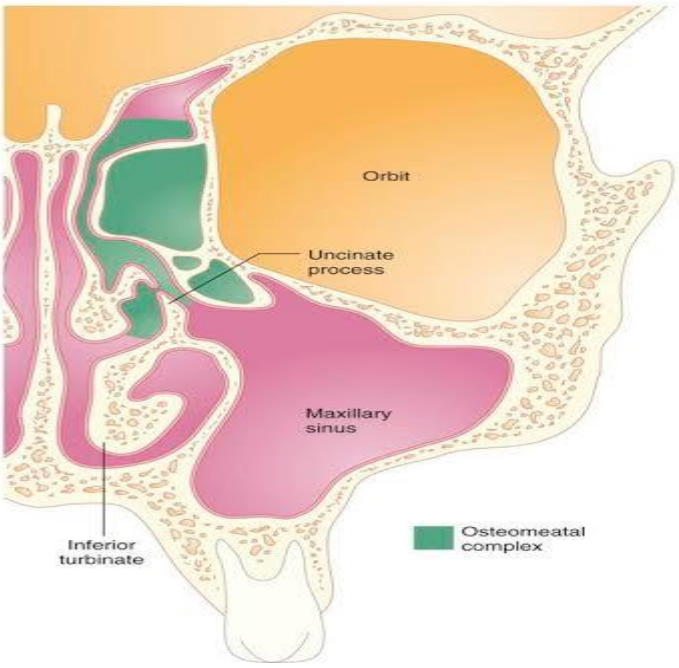
This study describes various approaches to maxillary sinus like middle meatal antrostomy, inferior meatal antrostomy, mega antrostomy, endoscopic medial maxillectomy and modified endoscopic medial maxillectomy by prelacrimal approach and Denker approach.

The basic step to address maxillary sinus pathology is middle meatal antrostomy. It is the widening of natural maxillary sinus ostium with the aim to re-establish the mucociliary drainage pathway.

Conditions where the clearance of attachment of disease is mandatory to prevent recurrence is to be considered of prime importance.

The aim of this study is to know the best possible approach for pathology in various walls of maxillary sinus and to describe the outcome in terms of recovery, complications and recurrence.

MAXILLARY SINUS



The maxillary sinus is a paired structure located on either side of nose below the orbit. It is the largest of all four paranasal sinuses and the adult volume is about fifteen millilitres. It is pyramidal in shape [1] with base directed towards nasal cavity and apex directed laterally. It consists of body and has four processes which articulate with neighbouring structures namely frontal process, zygomatic process, alveolar process and palatine process.

Maxillary sinus is bounded anteriorly by anterior surface of body of maxilla, posteriorly by anterior border of pterygomaxillary fossa, superiorly by bony orbital floor, inferiorly by alveolar and palatine processes of maxilla, laterally by zygomatic process of maxillary bone and medially by a bony plate which is thin and it includes the maxilla, inferior turbinate, uncinate process, perpendicular plate of palatine bone and lacrimal bone [2].

Dimension of sinus range from 38mm to 45mm in length, 36mm to 45mm in height and width range is from 25mm to 33mm.

DEVELOPMENT

Maxillary sinus develops from the outpouching of nasal capsule within the region of infundibulum and posterior to the uncinate process. This outpouching slowly enlarges because of the constriction of perichondrium of nasal capsule. The maxillary sinus enters the maxillary process when the nasal capsule is reabsorbed during the ossification process. The ossification of maxilla begins at 11 to 12 weeks of gestation. The air space becomes evident by 17 to 18 weeks of gestation.

At birth, the maxillary sinus measures approximately 10 mm long, 4 mm wide and 3 mm in height. The transverse diameter of the sinus expands between 1 to 8 years of age and the vertical height increases

between 1 and 5 years of age. By the age of 4, the maxillary sinus expands laterally to the level of infra orbital nerve and inferiorly up to the level of inferior turbinate.

By 8 years, the maxillary sinus grows laterally past the infra orbital canal and inferiorly to the middle of inferior meatus. By the age of 12, it extends laterally into zygomatic recess, medially to nasolacrimal duct and inferiorly to the floor of nasal cavity. With the growth of mid face and permanent teeth eruption, the sinus continues to aerate resulting in growth of floor of maxillary sinus to a level below the nasal floor [3].

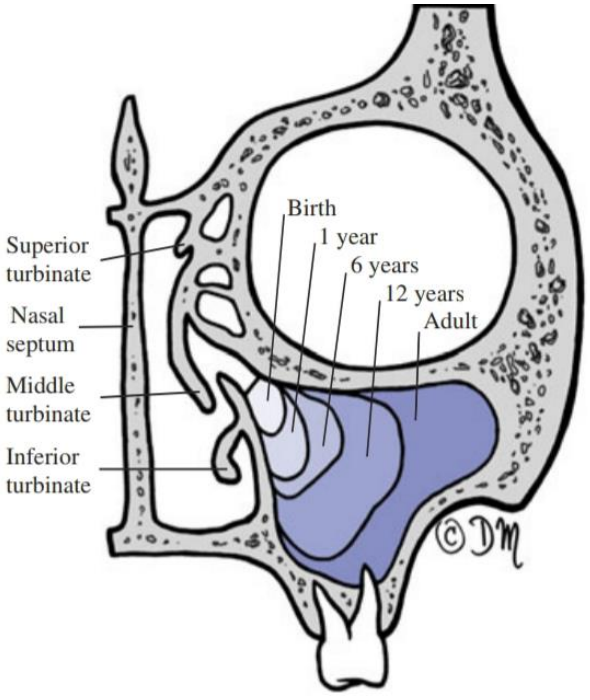


FIGURE- 2 The pattern of development of maxillary sinus

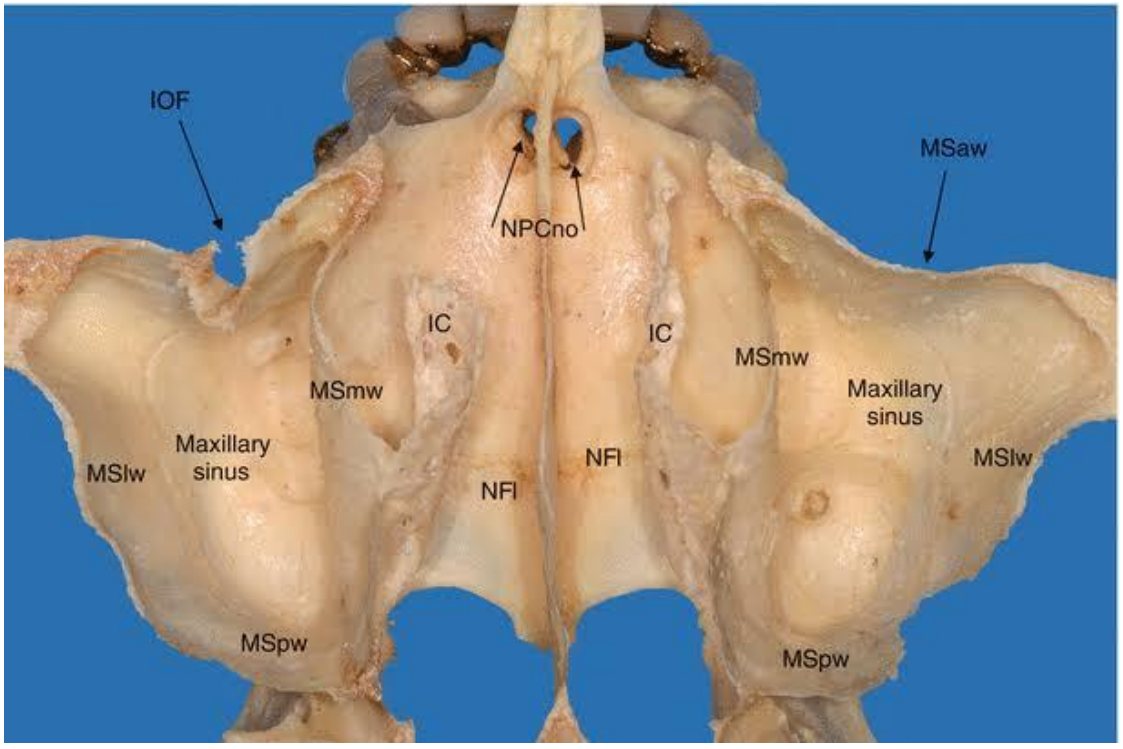


FIGURE-3 Boundaries of maxillary sinus

BOUNDARIES

Maxillary sinus has five walls namely superior, inferior, medial, posterolateral, anterior wall.

They are described as follows

Medial wall

The medial wall of maxilla lies against the lateral wall of nose at the level of middle meatus and inferior meatus. This can be divided into three portions for descriptive purposes [4].

Superior third of medial wall is composed of upper surface of body of maxilla and it has a large opening which communicates with maxillary sinus. This bony hiatus is bounded by bulla ethmoidalis above, maxillary process of inferior turbinate below, anterosuperiorly by inferomedial process of lacrimal bone, and posteriorly by perpendicular plate of palatine bone.

Uncinate process passes in the direction from anterosuperomedial to posteroinferolateral in the lateral wall of middle meatus. The upper anterior portion of hiatus is divided by inferolateral edge of uncinate process into posterosuperior and anteroinferior regions. The remaining area is closed by mucosa from both maxillary sinus and nasal cavity and forms anterior and posterior fontanelle.

The maxillary sinus ostium is contained within posterosuperior fontanelle. The ostium size ranges from 2 to 3mm. There may be one to three accessory maxillary sinus ostia found within the anteroinferior fontanelle.

Nasolacrimal duct runs within the bony canal and is located in the anterior bony portion of medial wall of maxilla just in front of maxillary hiatus. It courses from anterosuperomedial corner of maxillary sinus in downward and backward direction and opens into inferior meatus at the

junction of its anterior and middle third. This opening is guarded by Hasner valve. It is situated approximately 30 to 35 mm posterior to limen nasi.

The middle third of medial wall forms the lateral wall of inferior meatus. It is situated below the inferior turbinate and the inferior third of medial wall is formed by alveolar process of maxilla.

Prelacrimal recess is the space which extends anterior to nasolacrimal duct. It is present between pyriform aperture and nasolacrimal duct from nasal floor to orbital floor.

Anterior wall

Anterior wall of maxillary sinus is formed by anterior wall of maxilla. It extends from pyriform aperture medially to maxillozygomatic suture laterally. It is bounded superiorly by infraorbital rim and inferiorly by alveolus. The anterior wall is directed forward and laterally. Canine fossa is the thinnest portion over the anterior wall. It is located above the canine tooth and is bounded superiorly by infraorbital foramen, inferiorly by alveolar ridge and medially by canine eminence. The central and lateral incisiors are not related to maxilla. Infraorbital foramen is located above the canine fossa in mid superior position. Infraorbital vessels passes through this foramen.

Posterolateral wall

The posterolateral wall of maxillary sinus is formed by zygomatic bone and greater wing of sphenoid. It forms the anterior limit of pterygopalatine fossa and pterygomaxillary fissure. The fissure is located in the medial wall of infratemporal fossa through which traverses the maxillary vessels.

Superior wall

The superior wall of maxillary sinus is formed by floor of orbit, orbital process of palatine process posteromedially and anterolaterally by zygomatic bone. Roof of maxillary sinus is thin and slants inferiorly from medial to lateral direction .

Inferior wall

The floor of maxillary sinus is formed by alveolar and palatine processes of maxilla and is located 1 to 1.2cm below the level of floor of nasal cavity and is separated from premolar and molar teeth by layer of bone. Periapical or periodontal inflammation of upper premolars and molars can spread to maxillary sinus.

Pyriform aperture is a pear shaped structure which forms the bony inlet of the nose and is made of nasal and maxillary bones. It forms the boundary between anterior nasal vestibule and the posterior nasal cavity proper.

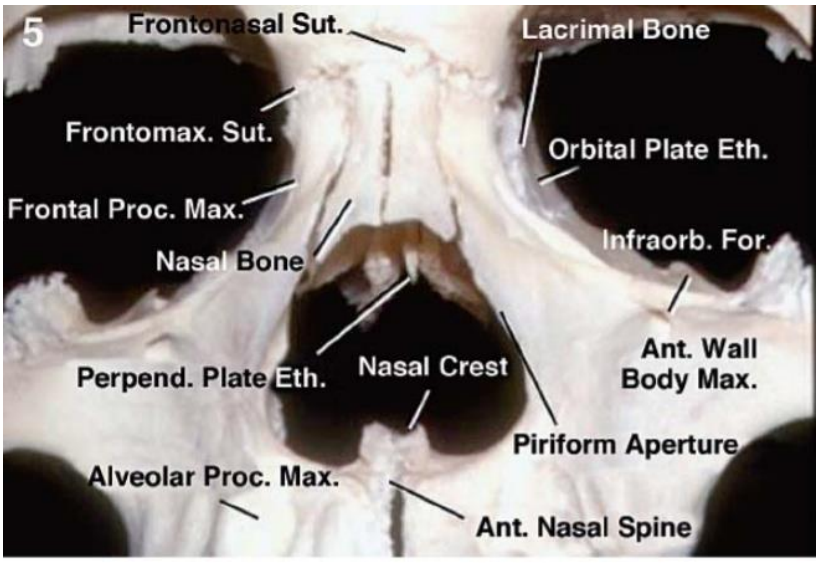


FIGURE-4 The above image shows the pyriform aperture

<u>Maxillary sinus ostium</u> is situated in the superior medial wall of maxillary sinus which measures approximately 3 to 4 mm in diameter. Posterior lateral nasal branches of sphenopalatine artery passes through ostium. The ostium should be widened in anteroinferior direction to prevent injury to nasolacrimal duct. Maxillary line is the curvilinear prominence along the lateral wall of nose. It runs from the anterior attachment of middle turbinate to root of inferior turbinate. It corresponds

externally with lacrimo maxillary suture. Natural ostium of maxillary sinus can be visualised at junction of lower one third and upper two third on maxillary line [1]

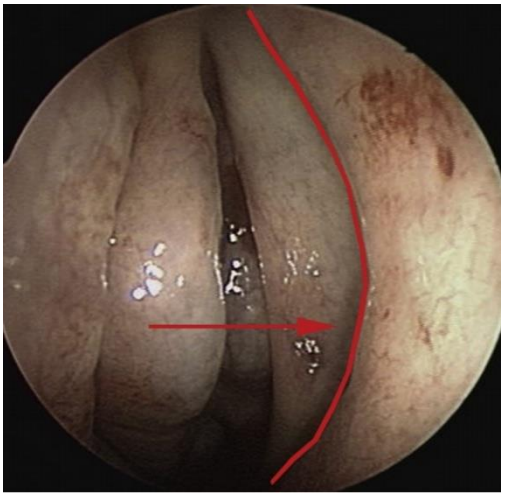


FIGURE-5 shows Maxillary line

BLOOD SUPPLY

1) Infraorbital artery

2) Lateral branches of sphenopalatine artery

3) Greater palatine artery

4) Alveolar arteries

SPHENOPALATINE ARTERY

It is the terminal part of maxillary artery given off in the pterygopalatine fossa. It enters nasal cavity after passing through sphenopalatine foramen just above the posterior end of middle turbinate. It ends by dividing into lateral nasal branches and medial branch. The lateral nasal branch supply the nasal concha, meatus and maxillary sinus. The medial branch crosses the anterior surface of sphenoid to supply the nasal septum

VENOUS DRAINAGE

It runs anteriorly into facial vein and posteriorly into maxillary vein, jugular and dural sinus system.

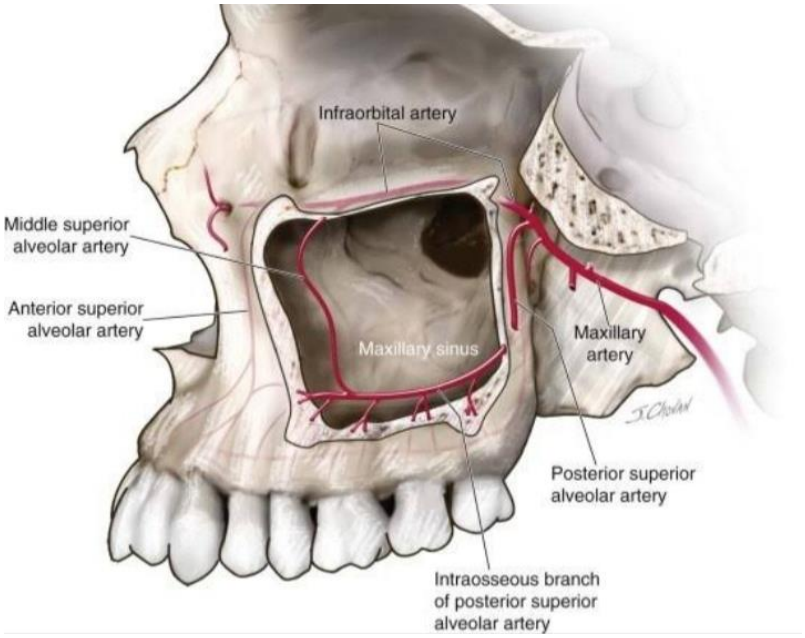


FIGURE-6 Blood supply of maxillary sinus

LYMPHATIC DRAINAGE

Maxillary sinus mucosa has superficial and deep longitudinal lymphatic capillary network oriented towards natural maxillary sinus ostium and then to nasopharynx through nasal vessels. It is mainly directed to submandibular nodes. It may travel by other route which is through pterygopalatine plexus to Eustachian tube and nasopharynx which drain into lateral cervical and retropharyngeal lymph nodes [5]

INNERVATION

1) Posterior superior alveolar nerve supplies most of maxillary sinus
2) Anterior superior alveolar nerve innervates anterior portion of maxillary sinus
3) Middle superior alveolar nerve has secondary mucosal innervation
4) Ostium by greater palatine nerve
5) Infundibulum by anterior ethmoidal branch of ophthalmic division of trigeminal nerve [6]

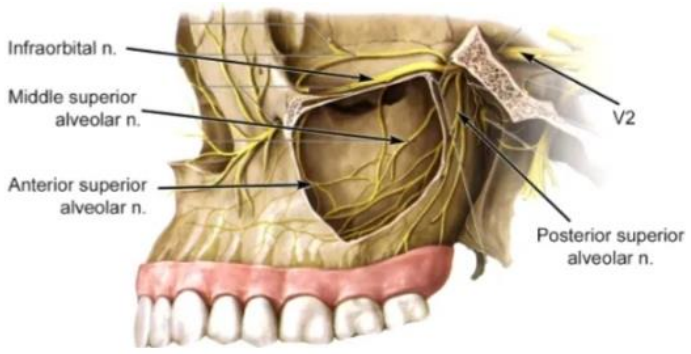


FIGURE-7 Nerve supply of maxillary sinus

LATERAL NASAL WALL

The anterior portion of lateral nasal wall is the vestibule which is lined by skin and hair. Behind the vestibule is called atrium. Agger nasi forms a bulge anterior to middle turbinate. Ridge of bone extends from agger nasi to superior border of inferior turbinate enclosed within is nasolacrimal duct.

There are three turbinates behind atrium namely inferior, middle and superior turbinate. The middle turbinate has three parts based on attachment and orientation. The anterior third has sagittal orientation and is attached to cribriform plate at the junction of lateral and medial lamella and anterior attachment to frontonasal process of maxilla. The medial surface of frontonasal process has two crests namely ethmoid and conchal crest.

Ethmoidal crest is the upper one to which the anterior part of middle turbinate is attached. Conchal crest is the lower one which gives attachment to inferior turbinate. The middle third of middle turbinate has coronal orientation and is attached to lamina papyracea. It is also called ground lamella of middle turbinate. The posterior third has horizontal orientation and is attached to lamina papyracea and perpendicular plate of palatine bone.

Below middle turbinate is the middle meatus. Within the middle meatus, most anteriorly present is a curved ridge of bone called Uncinate process. It is a sickle shaped structure and has vertical, horizontal limb with intermediate transition part. Deep inside the uncinate process is the maxillary sinus ostium.

The normal maxillary sinus ostium is ovoid in shape and is tunnel like. The accessory ostia are usually circular and has two dimensions only. Behind uncinate process is anterior ethmoidal cell called bulla ethmoidalis. It is the most constant and well pneumatised cell. The uncinate process and bulla ethmoidalis is separated by a groove called hiatus semilunaris. It is a two dimensional space which leads into three dimensional space called infundibulum.

The uncinate process, bulla ethmoidalis and hiatus semilunaris forms the key area called osteomeatal complex. It is the drainage site for frontal sinus, maxillary sinus and anterior ethmoidal sinus.

The Inferior turbinate overlies a smooth structureless area called inferior meatus. Nasolacrimal duct opens into inferior meatus at its apex and is guarded by Hasner valve. The duct lies 5mm anterior to maxillary sinus ostium.

NASOLACRIMAL DUCT

Tear collected from lacrimal puncta passes through canaliculi, valve of Rosenmuller and enter the lacrimal sac. Lacrimal sac is housed within bony lacrimal fossa which is bounded anteriorly by frontal process of maxilla and posteriorly by the lacrimal bone. From lacrimal sac, tears drain into nasolacrimal duct which opens into inferior meatus of nose. It is guarded by Hasner valve and it opens at approximately 1cm posterior to anterior end of inferior turbinate. The superior aspect of the nasolacrimal duct is housed in the bony nasolacrimal canal which is just medial and anterior to the maxillary sinus [2]

PTERYGOPALATINE FOSSA

Pterygopalatine fossa is a tear drop shaped space which is bounded medially by perpendicular plate of palatine bone, posteriorly by root of pterygoid process and anterior surface of the greater wing of sphenoid, anteriorly by posterior surface of maxilla, laterally it opens into infratemporal fossa through pterygomaxillary fissure.

It has communication with orbit through inferior orbital fissure which contains infraorbital artery, with middle cranial fossa through foramen rotundum which transmits maxillary division of trigeminal nerve, with nasal cavity via sphenopalatine foramen through which passes the sphenopalatine artery, with oral cavity through greater and lesser palatine canals traversed by greater palatine vessels and nerve. The contents of pterygopalatine fossa include maxillary nerve, terminal part of maxillary artery and pterygopalatine ganglion.

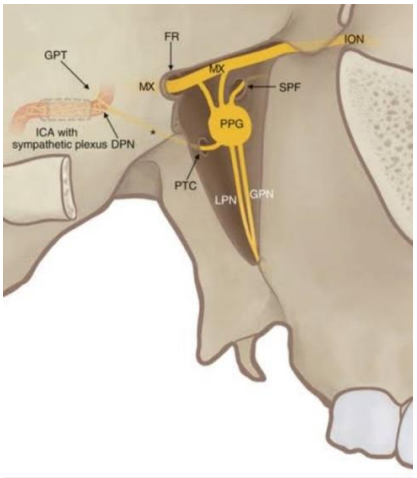


FIGURE-8 Contents of pterygopalatine fossa

INFRATEMPORAL FOSSA

It is a irregular shaped space found deep to ramus of mandible, posterior to maxilla, deep and inferior to zygomatic arch. It is bounded superiorly by horizontal part of greater wing of sphenoid, anteriorly by maxilla, medially by pterygoid plate and laterally by ramus of mandible. Contents of infratemporal fossa includes inferior part of temporalis muscle, medial and lateral pterygoid muscles, maxillary artery, pterygoid venous plexus, mandibular nerve, inferior alveolar nerve, lingual nerve, buccal nerve, chorda tympani nerve and otic ganglion.

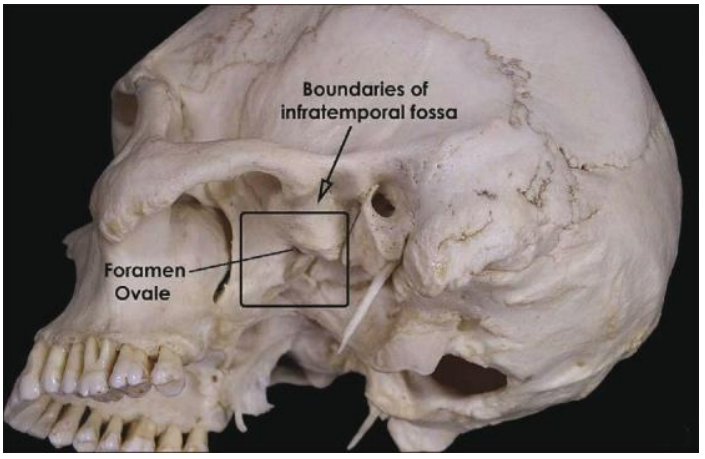


FIGURE-9 shows Infratemporal fossa

PHYSIOLOGY OF PARANASAL SINUS

The mucosa of paranasal sinus protects the upper airway and sinonasal cavities from inhaled toxins and pathogens by means of unique function called the Mucociliary clearance. It helps to clear the airway by removing both healthy and pathological debris

Other functions of paranasal sinuses include

1) Lightening of skull bones

2) Act as buffer against injury to face

3) Vocal resonance

4) Air conditioning effect

5) Humidification of inspired air

6) Heat insulation

MUCOCILIARY ACTION

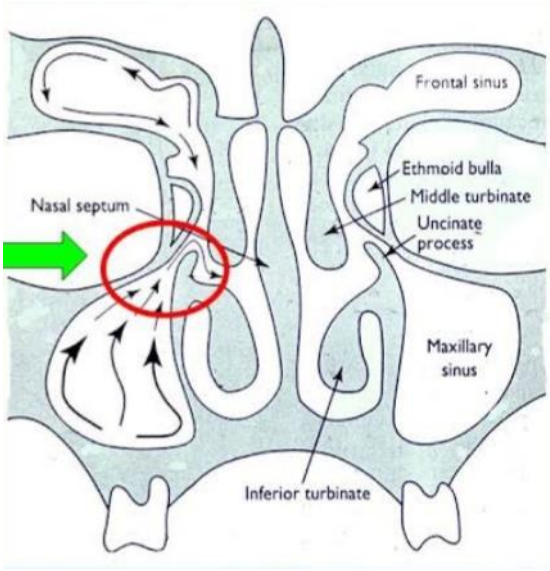


FIGURE-10 shows Mucociliary drainage pattern of maxillary sinus

The mucosa of paranasal sinus is lined by columnar epithelium and is made of simple ciliated columnar cells. Over the surface, it has tiny hair like projection called microvilli which helps to increase the surface area of columnar cells. The mucosa has two layers namely gel layer and the sol layer.

The gel layer is the outer layer which is highly viscous thereby helps to trap the inhaled pathogens and particulate matter. The sol layer is the inner layer of low viscosity made of water and electrolytes. The cilia beats in a rhythmic fashion.

Each cilium has rapid propulsive stroke and a slow recovery phase. Each cilium has nine outer paired microtubules which encloses single

inner paired microtubule. It have outer and inner dynein arms which is made of ATPase.

Activation of dynein arms generates a sliding motion of one microtubule doublet against the other. Metachronous ciliary movement propels the mucous blanket backwards towards the sinuses. Within the sinus, mucus flows superomedially from the most inferior portion of the cavity against gravity.

Propelled by cilia it courses along the walls of antrum and across the roof of sinus towards the natural ostium which is in the superior medial wall of maxillary sinus and drains into ethmoidal infundibulum. It then passes to the posterior nasopharynx around the Eustachian tube orifice and is swallowed.

The cilia beats at a frequency of 7 to 16 Hz. Frequency remains constant in the temperature of 32-40 degree Celsius [7]

PATHOPHYSIOLOGY

The important factor for sinus pathology is osteomeatal complex. Narrowing of osteomeatal complex along with inflammatory change contributes to sinus pathology. The contributory factors include

- ANATOMICAL VARIANTS

1) Concha bullosa
2) Everted uncinate process
3) Enlarged ethmoidal bulla
4) Paradoxical middle turbinate
5) Septal deviation
6) Agger nasi pneumatization
7) Haller cell

- MUCOCILIARY ABNORMALITIES

Primary-

1) Primary ciliary dyskinesia
2) Young syndrome
3) Cystic fibrosis

Secondary causes include infection and allergy

- Immune Deficiency
- Allergy

ETIOLOGY

Non neoplastic causes may include

1) Infection or Inflammation - Bacterial, Viral, Fungal disease, Antrochoanal polyp, Allergy

2) Cystic causes - Mucocele, Radicular cyst

3) Calcification - Antrolith

4) Traumatic - Foreign body

5) Dental causes - Periapical abscess, Periodontal disease, Sinus perforation during tooth extraction, Oroantral fistula, Odontogenic cyst, Infected dental cyst, secondary infection caused by intra antral foreign bodies

6) Benign lesions - Inverted papilloma, Oncocytic papilloma, Exophytic papilloma, Respiratory epithelial adenomatoid hamartoma, Salivary gland adenoma, Fibroma, Lipoma, Myxoma, Neuroectodermal tumours, Fibroosseous lesions

7) Others – Cholesterol granuloma, Eosinophilic angiocentric fibrosis, Sarcoidosis, Wegener granulomatosis, Mucociliary disorders.

NASAL POLYP

It is the inflammation of nose and paranasal sinuses associated with two or more symptoms, one of which should be nasal obstruction or nasal discharge with or without facial pain and reduction or loss of smell and either endoscopic evidence of polyp or mucopurulent discharge from middle meatus and/or CT shows mucosal changes within osteomeatal complex or sinuses.

Polyp usually occur as a result of previous inflammatory event which predisposes to sinus ostium obstruction, hypoxia followed by bacterial infection. It consists of loose connective tissue, inflammatory cells and fluid and is covered by pseudostratified, columnar, ciliated epithelium. Oedematous connective tissue stroma ruptures and herniates through the basement membrane forming polyp.

ANTROCHOANAL POLYP

Also called Killian polyp. It is more common in males and onset is usually before 40 years. It is a dumb bell shaped polyp arising in maxillary antrum and prolapse in the middle meatus through sinus ostium. It extends posteriorly into choana and may be seen in oropharynx pushing the soft palate forwards. Most commonly it arises from floor and lateral wall. Histology shows respiratory epithelium over normal

basement membrane with interstitium being grossly edematous and cellular. Caldwell luc antrostomy was the treatment of choice in adults where recurrence is uncommon. For children with incomplete dentition radical procedure is avoided instead simple intranasal polypectomy is preferred.

FIGURE-11 shows Endoscopic image of Antrochoanal polyp

MUCOCELE

It is a mucus filled sac which is lined by epithelium, found within paranasal sinuses. It causes expansion of the sinus cavity and remodeling of the sinus wall [8]. Formation of mucocele occurs secondary to obstruction of outflow tract of the involved sinus along with inflammatory process within the sinus. Most common cause of mucocele is following sinus surgery. Bony erosion may lead to expansion of sac beyond the sinus cavity into orbit or cranial cavity.

FUNGAL BALL

It is a dense accumulation of fungal hyphae within the sinus. Most commonly involved is maxillary sinus and the causative agent is Aspergillus. It is usually seen in immunocompetent, middle aged females. Diagnosis is based on radiological evidence of opacification with areas of hyperattenuation, no evidence of tissue invasion, nonspecific inflammation of sinus, absence of allergic mucin or eosinophil predominance.

INVERTED PAPILLOMA

It is one of the most common benign sinonasal tumors. Men are more commonly affected and is unilateral in most cases. Histological examination shows characteristic inverted epithelium into the underlying connective tissue. It is histologically benign but locally aggressive because of local destruction, intracranial extension, risk of recurrence and malignancy [9]

MUCORMYCOSIS

It is an invasive and rapidly progressive fungal infection affecting immunocompromised patients. Fungus causes colonization of nasal mucosa and then through the paranasal sinuses spread to other structures like orbit, palate, intracranial cavity. Infection spread to pterygopalatine

fossa through sphenopalatine foramen and also by angioinvasion. Pterygopalatine fossa is the main conduit for extension of infection to other areas like through inferior orbital fissure into the retrobulbar space, through pterygomaxillary fissure into masticator space and inferior temporal fossa, sphenopalatine foramen to nasal cavity, through foramen rotundum and vidian canal into middle cranial fossa and through greater palatine canal to palate [10]. It is treated by surgical debridement followed by antifungal therapy.

SURGICAL APPROACHES FOR MAXILLARY SINUS PATHOLOGY

HISTORICAL ASPECTS

Nathaniel Highmore in 1651 described maxillary sinus and associated suppuration and the sinus was referred by his eponym. He advocated decompression by thrusting silver bodkin through empty teeth socket.

Lamorier in 1743 and Desault in 1798 preferred canine fossa approach.

John Hunter in 1835 advocated intranasal approach and Zuckerkandl in 1893 advocated perforation of middle meatus but it is later abandoned due to potential risk of orbital damage.

Continued interest in middle meatal antrostomy predates the introduction of endoscopic visualization by Lavelle and Spencer Harrison in 1971.

First description of Inferior meatal antrostomy was by Gooch in 1770 but attempts at proof puncture and irrigation began in 1880s. In 1890, Lichtwitz invented cannula for proof puncture

Caldwell in 1893, Spicer in 1894, Luc in 1897 described the more radical canine fossa approach which differed from Lamorier and Desault in that nasal counter opening was included.

Endoscopic surgery traditionally divided into two, of which one is Messerklinger approach championed by Stammberger in 1985 where the pathology in osteomeatal complex is removed sufficient enough to achieve ventilation and drainage, addressing the pathophysiology by conservation technique, hence the term functional was used by Kennedy in 1985.

Radical extirpation of disease was proposed by Wigand in 1981 and Draf in 1983, particularly related to nasal polyposis in which an absence of surgical landmarks and profuse pathology determines a back to front approach.

CONVENTIONAL SURGICAL PROCEDURES

ANTRAL LAVAGE

Antral lavage has been used for the diagnosis and treatment for sinusitis. Antral puncture is performed through inferior meatus and was performed repeatedly before proceeding with inferior meatal fenestration. The alternative way for repeated puncture was placement of indwelling catheter through which regular irrigation was done till there is improvement in quality and quantity of secretions [11]. It is also known as antral proof puncture because the presence of infection can be proved by the procedure. It is contraindicated in children less than 3years of age and

in hypoplastic maxilla as the puncture may be technically difficult. It can lead to complications like vasovagal syncope, pain and swelling of cheek if anterior wall is breached and pain occurs if there is perforation of orbital floor. This procedure is performed less often since both osteomeatal complex obstruction with secondary sinusitis can be addressed by functional endoscopic sinus surgery at the same time

CANINE FOSSA PUNCTURE

Here maxillary sinus is entered through sublabial anterior approach. The site of location of puncture is just lateral to the canine fossa to minimize complications like damage to infraorbital nerve and anterior superior alveolar nerve. In Caldwell luc approach, this opening is enlarged with instruments thereby causing improved anterior access to maxillary sinus.

CALDWELL LUC PROCEDURE

It is also known as transbuccal radical antrostomy in which the diseased maxillary sinus mucosa is completely extirpated by Caldwell luc approach and gravitational drainage is established through inferior meatal antrostomy [12]

Indications include

1) Chronic maxillary sinusitis
2) Oroantral fistula closure
3) Dental cyst involving maxillary antrum
4) Removal of foreign body such as dental root or amalgam
5) Removal of recurrent Antrochoanal polyp
6) Access to pterygopalatine fossa
7) Stabilization of orbital floor fractures or for removal of orbital floor for decompression

It is contraindicated in children as it can cause damage to secondary dentition.

Complications of Caldwell luc procedure includes

- Hemorrhage
- Paresthesia due to damage of infraorbital nerve
- Alteration in dental sensation
- Oroantral fistula

TRANSANTRAL ETHMOIDECTOMY

Also called Jansen Horgan procedure. It combines Caldwell luc approach with access to ethmoids. Here Caldwell luc approach is done followed by opening of posterior ethmoid cells through antrum by pushing forceps in upward, medial and posterior direction. Conventional procedures has largely been replaced by Endoscopic sinus surgeries.

ENDOSCOPIC SINUS SURGERY

The following are the indications for endoscopic sinus surgery.

- Chronic sinusitis
- Acute recurrent sinusitis
- Allergic fungal sinusitis
- Nasal polyposis
- Frontoethmoid Mucocele
- Repair of cerebrospinal fluid leaks
- Orbital and optic nerve decompression
- Repair of orbital blow-out fractures
- Dacryocystorhinostomy
- Choanal atresia
- Septal surgeries
- Management of epistaxis
- Management of benign tumour

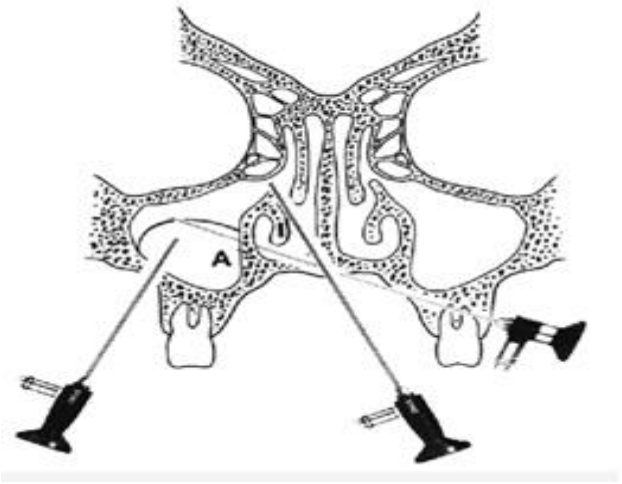


FIGURE-12 Schematic diagram showing endoscopic view of maxillary sinus through natural ostium, inferior meatus and canine fossa.

MIDDLE MEATAL ANTROSTOMY

Uncinectomy is the first step in endoscopic sinus surgery. This exposes the natural maxillary sinus ostium. Once ostium is identified, it should be enlarged inferiorly and anteriorly into the fontanelle but not posteriorly to prevent disruption in mucus clearance [1]. Care is taken to avoid injury to nasolacrimal duct. If accessory ostium is present, it should be joined with natural ostium to prevent abnormal mucus circulation.

FIGURE-13 shows Endoscopic image of Middle Meatal Antrostomy

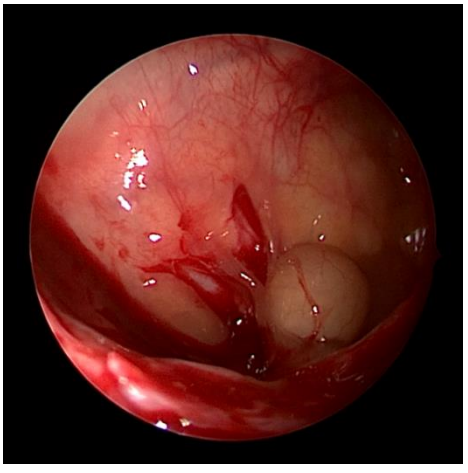


FIGURE-14 Endoscopic image of disease in posterior wall of maxillary sinus.

MEGA ANTROSTOMY:

This approach is used in conditions like antrochoanal polyp where surgical removal of complete pathology is important to prevent recurrence and in fungal pathologies where the anatomy is already disrupted. It is a partial medial maxillectomy where removal of part of inferior turbinate can happen so as to lower the ostium till the nasal floor[13].

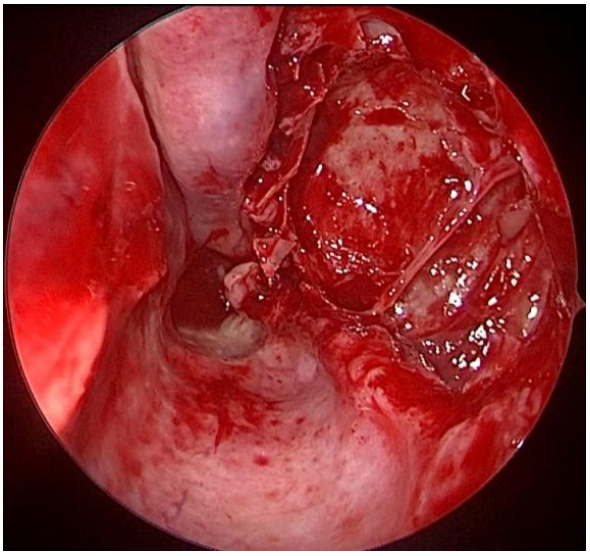


FIGURE-15 shows Endoscopic image of Mega Antrostomy

INFERIOR MEATAL ANTROSTOMY:

This approach has been used in treatment of acute, recurrent and chronic maxillary sinusitis which has failed to respond to conservative management. It relies upon gravitational drainage and aeration to effect improvement in sinus mucosa. Though it is a historical procedure, it is the relevant indication for today in case of primary mucociliary abnormality

such as cystic fibrosis and primary ciliary dyskinesia like kartagenar syndrome. In this approach, the inferior turbinate is incised parallel to the inferior margin in a way that a posteriorly pedicled flap is created.

The inferior portion of medial maxillary sinus wall is opened [14]. This primary window can be enlarged anteriorly. It aids removal of disease in the alveolar recess of the maxillary sinus. Complications include hemorrhage if antrostomy is extended posteriorly due to injury of inferior meatal branch of sphenopalatine artery. If antrostomy extended too anteriorly it may damage anterior superior alveolar nerve leading to altered dental sensation.

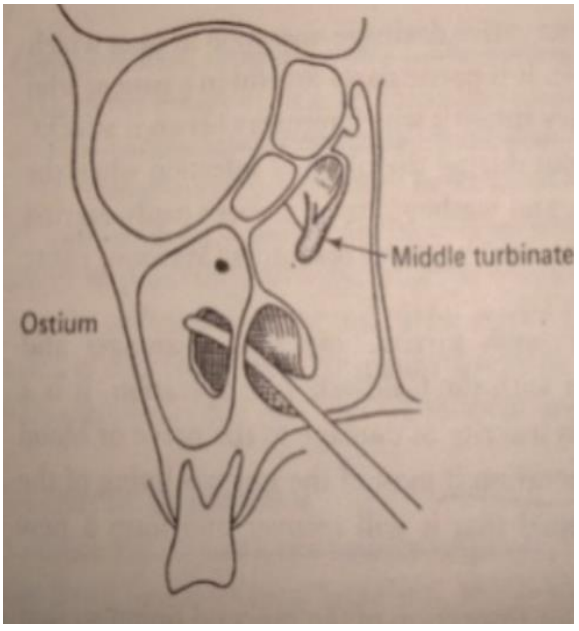


FIGURE-16 Schematic diagram showing Inferior meatal antrostomy

ENDOSCOPIC MEDIAL MAXILLECTOMY:

This approach is an extended middle meatal antrostomy with indications being inverted papilloma, sinonasal tumours and inflammatory disease of maxillary sinus [15]. The steps include debulking of polyp or tumour followed by wide middle meatal antrostomy.

Subtotal inferior turbinectomy is done by incising at the junction of anterior one third and posterior two third along the direction of middle meatal antrostomy. Nasal floor mucosal flap is elevated by making an incision in the posterior portion of lateral nasal wall and extended along the floor of nasal cavity. Another mucosal incision made in the anterior portion of lateral nasal wall behind Hasner valve. It is joined with previous incision superiorly and the flap is reflected towards septum. Medial wall of maxilla is removed using drill until the floor of maxillary sinus flushed to the nasal floor followed by removal of pathology from maxillary sinus and the mucosal flap is repositioned

MODIFIED ENDOSCOPIC MEDIAL MAXILLECTOMY BY PRELACRIMAL APPROACH

The following are the steps involved in prelacrimal recess approach.

With proper positioning and local infiltration,

STEP-1: Mucosal incision made at the anterior end of the inferior turbinate about 1 to 2mm posterior to mucocutaneous junction. Mucosa over lateral wall of the inferior meatus is elevated thereby exposing conchal crest

STEP-2: Bony wall around nasolacrimal duct is removed and the nasolacrimal duct is lifted along with inferior turbinate

STEP-3: Lateral wall of inferior meatus removed and the maxillary sinus mucosa is incised exposing maxillary sinus

STEP-4: Following removal of pathology, inferior turbinate along with nasolacrimal duct is repositioned and sutured.

Advantages of this procedure includes preservation of inferior turbinate and nasolacrimal duct thereby preventing complications like dry nose and epiphora [16]. It permits the usuage of straight endoscope and instrumentation.

Pathologies in difficult to reach areas with middle meatal antrostomy like anterior portion and floor of maxillary sinus can be addressed. It is also used as a second port to access structures beyond maxillary sinus like pterygopalatine fossa.

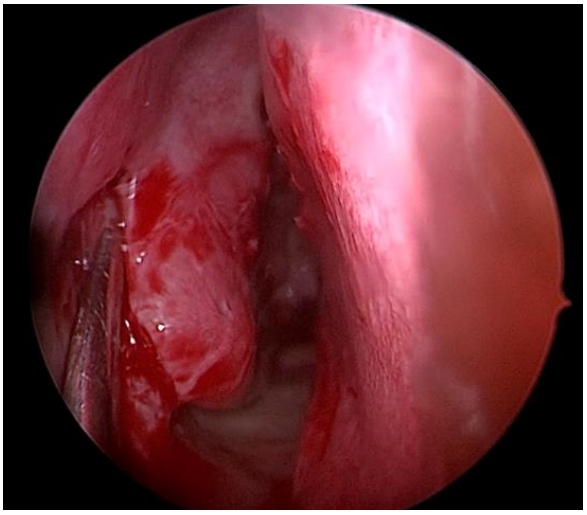


FIGURE-17 STEP 1 OF PRELACRIMAL APPROACH

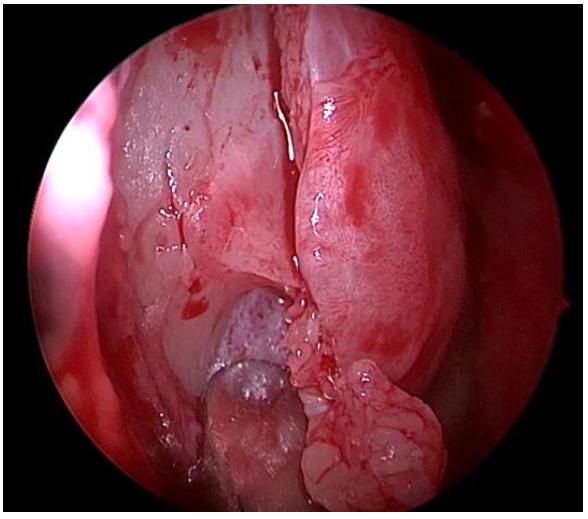


FIGURE-18 STEP 2 OF PRELACRIMAL APPROACH

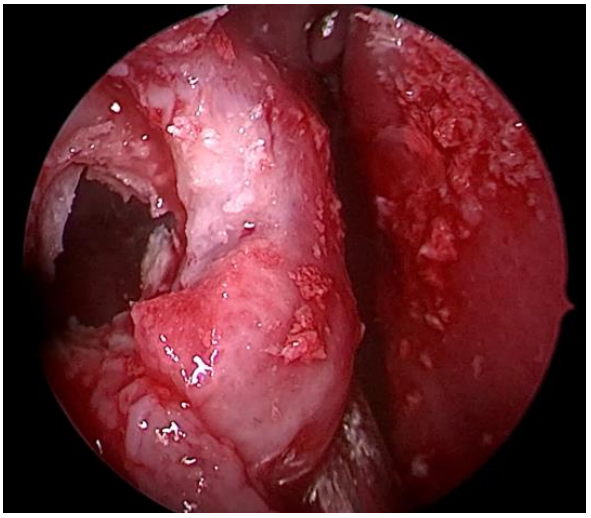


FIGURE-19 STEP 3 OF PRELACRIMAL APPROACH

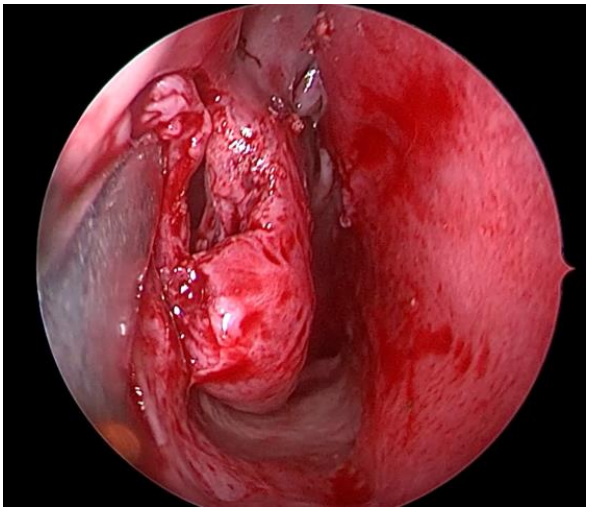


FIGURE-20 STEP 4 OF PRELACRMAL APPROACH

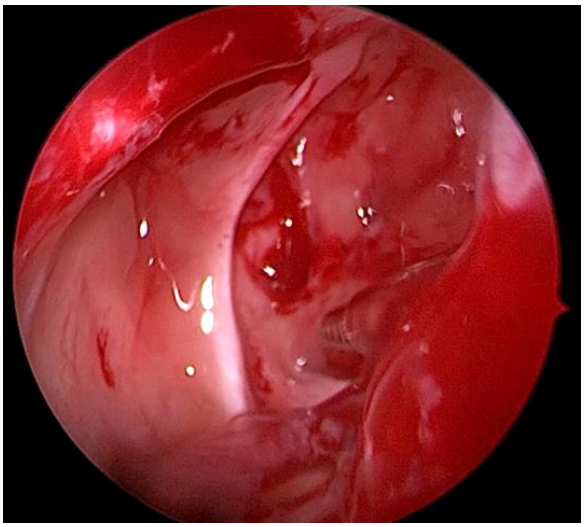


FIGURE-21 The above image shows maxillary sinus visualised by prelacrimal approach. It demonstrates angled instrumentation in middle meatal antrostomy site can reach only till the posterior wall but the attachment of disease is in anterolateral wall which is accessible with straight instrumentation by prelacrimal recess approach without damage to adjacent structures

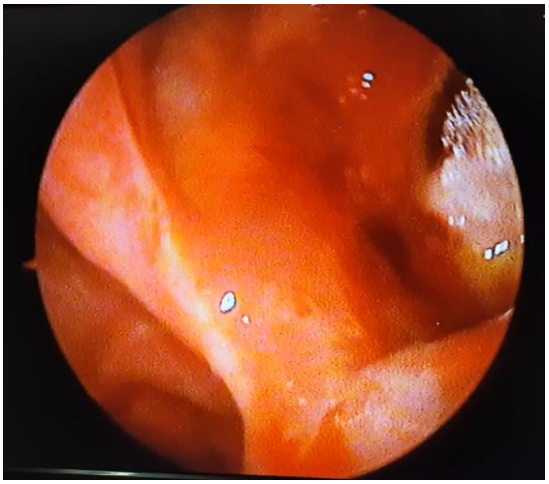


FIGURE-22 Endoscopic image of followup at 1month after prelacrimal approach

MODIFIED ENDOSCOPIC DENKER APPROACH

This procedure is also called Endoscopic Anterior Medial Maxillectomy [17] The steps are as follows,

With proper positioning and infiltration

STEP-1: Nasal mucosa is incised at junction of floor and lateral wall of nose and is incised through periosteum. Second incision made superiorly along lateral nasal wall and is extended to lie at anterior end of inferior turbinate over the edge of pyriform aperture.

STEP-2: Anterior maxilla is exposed by subperiosteal dissection

STEP-3: Inferior to infraorbital foramen, bone window is created in anterior maxilla.

STEP-4: This bony window is connected with medial maxillectomy using osteotome or burr thereby exposing maxillary sinus. Lesion in maxillary sinus is removed.

Nasolacrimal duct is sharply cut in an oblique plane to avoid stenosis. This procedure facilitates the visualisation of anterior and posterior portion of maxillary sinus and also permits four handed technique so as to remove pathologies from pterygopalatine fossa and infratemporal fossa

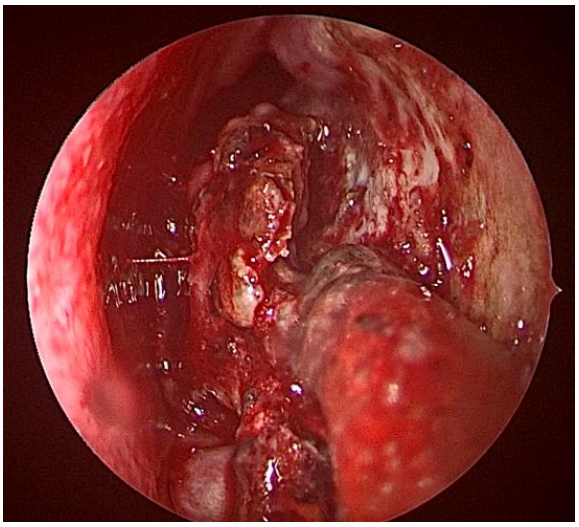


FIGURE-23 STEP-1 OF DENKER APPROACH

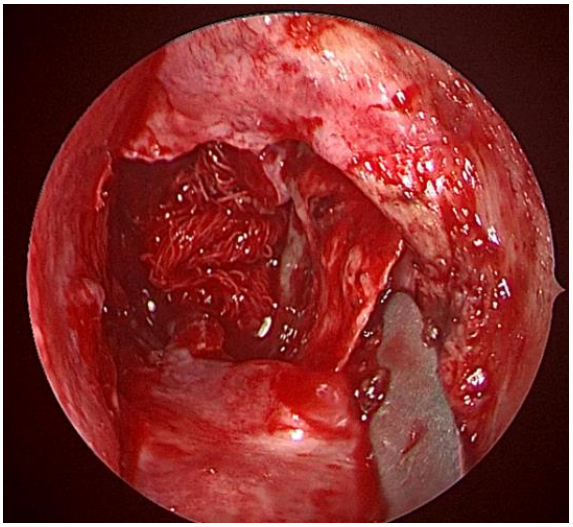


FIGURE-24 STEP-2 OF DENKER APPROACH

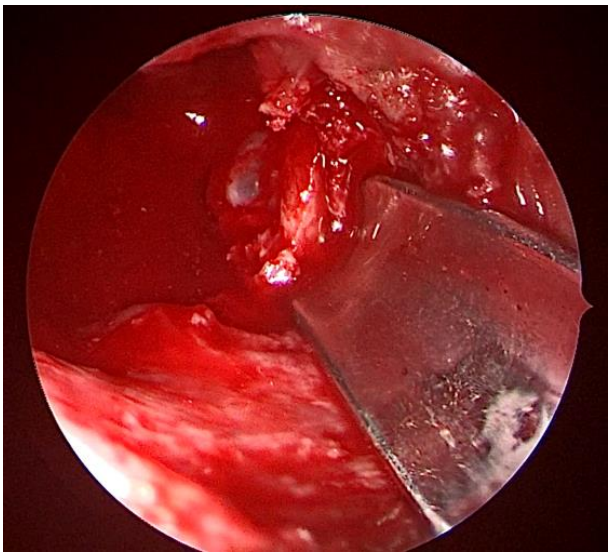


FIGURE-25 STEP-3 OF DENKER APPROACH

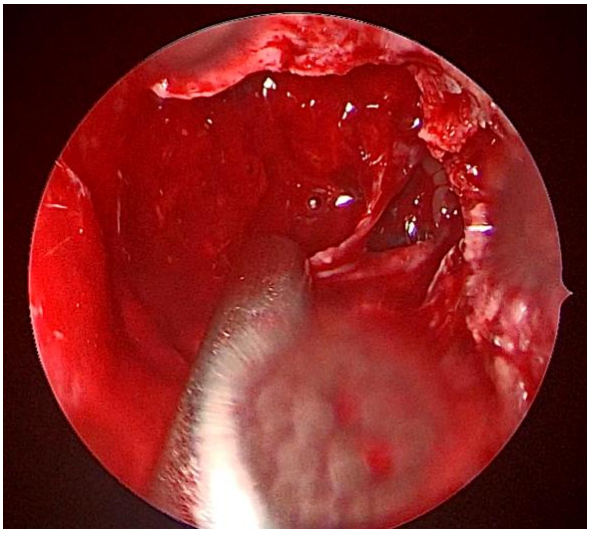


FIGURE-26 DENKER APPROACH

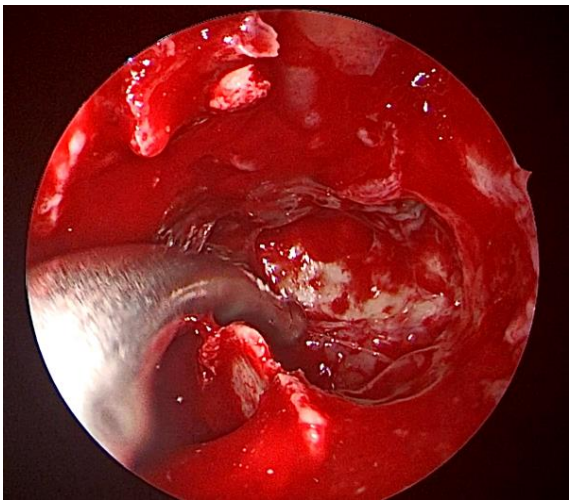


FIGURE-27 STEP-4 OF DENKER APPROACH

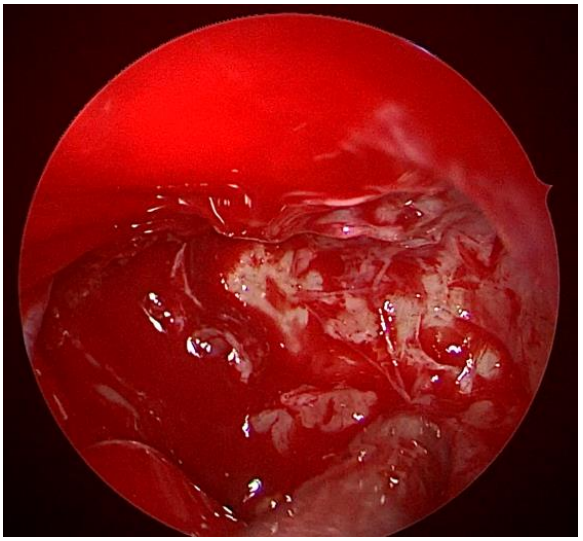


FIGURE-28 The above image shows visualised maxillary sinus by Denker approach

TRANSEPTAL APPROACH

This is also called cross-court approach. It provides additional access to reach anterolateral wall of maxillary sinus. Here septal flap is elevated on the ipsilateral side and cartilaginous window is created. The instruments are passed from contralateral nose. Compared to procedure through ipsilateral nasal cavity, the transeptal approach increase the access by approximately 14.7 degrees [18]. Disadvantages include previous history of septal surgeries does not include under candidacy criteria and this requires instruments with appropriate size and angulation which are difficult to handle or may not be available.

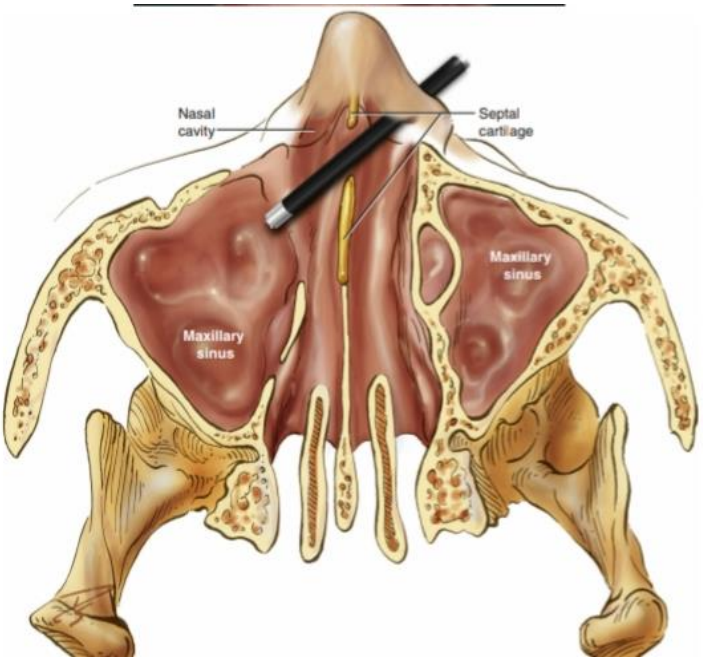


FIGURE-29 Schematic diagram showing Transeptal approach

SEPTAL DISLOCATION APPROACH

This approach increases the exposure of anterolateral wall of maxillary sinus by 20 degrees when compared with total endoscopic medial maxillectomy. In this procedure, the cartilaginous septum is separated form maxillary crest and the septum is mobilised to the other side. Straight instrumentation passed through ipsilateral nostril to reach maxillary sinus and infratemporal fossa [19]

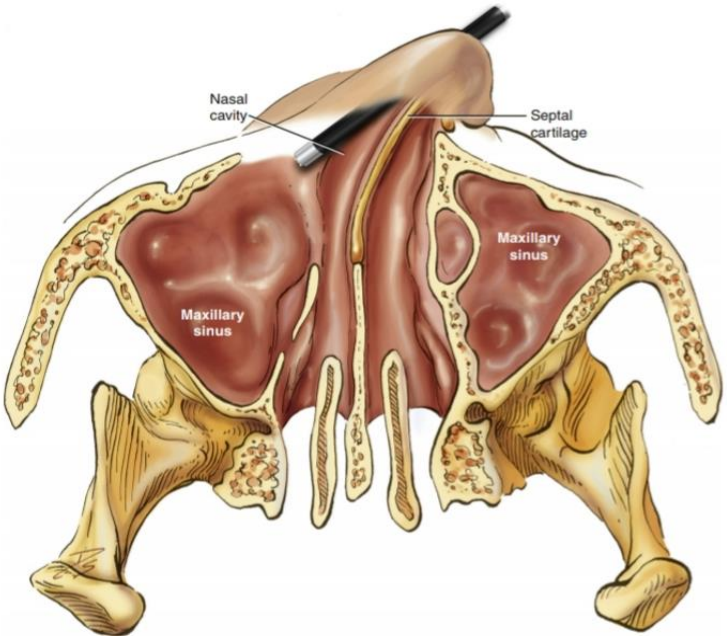


FIGURE-30 Schematic diagram showing Septal dislocation approach

REVIEW OF LITERATURE

In 1903, Endoscopic surgery was first performed by Hirschmann using Modified Nitze cystoscope which he used in nasal cavity and in maxillary sinus through teeth socket.

Reichert in 1902, Sargon in 1908 and Imhofer in 1910 all have used similar instruments and attempted removal of foreign bodies.

In 1922, Speilberg was the first to introduce endoscope into maxillary sinus through inferior meatus.

In 1925, Maltz commissioned Wolf to make endoscope and introduced the term “Sinuscopy”. These endoscopes used a series of small lenses.

Hopkins, professor of optics at Reading, invented a far superior system in 1950s, based on solid glass rod which is universally being used now.

A study was conducted on Endoscopic versus Caldwell Luc approach in chronic maxillary sinusitis: comparison of symptoms at one year follow up by M A Penttila, Finland in 150 patients with chronic maxillary sinusitis between 1987 and 1989. Of which 75 patients underwent Caldwell luc approach and 75 patients underwent Functional endoscopic sinus surgery and concluded that patients who underwent FESS reported marked overall improvement [20]

A study on endoscopic Denker Approach for resection of lesions involving anteroinferior portion of maxillary sinus and infratemporal fossa by Jivianne T lee between 1993 and 2001 included 17 patients with inverted papilloma and concluded that lesions involving anterior, inferior, posterior and lateral recess can be completely removed by Denker approach without the need for sublabial incision and angled instrumentation [17]

A study named 'endoscopic removal of sinonasal inverted papilloma including Endoscopic Medial Maxillectomy' by Peter John Wormald in 2002 performed on 17 patients with inverted papilloma concluded that tumours involving floor, lateral, medial and anterior walls of maxillary sinus are accessible by Endoscopic Medial Maxillectomy with recurrence rate of about 5% [21]

A study named Intranasal Endoscopic Prelacrimal recess approach to maxillary sinus by Zhou Bing in Beijing between 2003 and 2008 enrolled 19 patients and concluded that to preserve the function of nasal cavity and lacrimal apparatus, prelacrimal recess approach is preferred and further added that all areas of maxillary antrum can be reached with zero degree endoscope [22] .

A study named "Endoscopic Medial Maxillectomy Breaking New Frontiers" by Sanjeev Mohanty, M. Gopinath in July 2013 where 9 patients underwent endoscopic medial maxillectomy over a period of 2

years with involvement of disease in maxillary sinus and superior ethmoid sinus. Of which one patient had bony erosion on imaging with tumour involving pterygopalatine fossa. All were managed with endoscopic medial maxillectomy with complete excision of pathology. No patients showed recurrence when followed for 2 years except one who had recurrence of Invasive fungal sinusitis. The study stated that endoscopic surgeries provide good visualization of difficult to reach areas like anterior and lateral walls of maxillary sinus with angled endoscopes[23]

In a study named Modification of endoscopic medial maxillectomy- A novel approach for Inverted papilloma of maxillary sinus conducted by A Ghosh, S Pal in a semi urban location between 2010 to 2014, they performed Endoscopic medial maxillectomy in 10 patients for tumours of anterior wall, roof and floor of maxillary sinus and concluded that modified Endoscopic Medial Maxillectomy allows removal of disease from anterolateral wall of maxillary sinus without the need for septal window [24]

A study on endoscopic endonasal Anterior Maxillotomy was conducted in the year 2015 by Smitha Upadhyay, Ricardo in 10 fresh cadaveric heads concluded that by this approach, anteroinferior corner of maxillary sinus, junction of anterior and lateral wall could be accessed in

all specimens and it also provides good exposure of Infratemporal fossa and added that loss of pyriform aperture may lead to alar collapse [25]

A study named Modified Endoscopic Inferior Meatal Fenestration with mucosal flap for maxillary sinus diseases by Yi Zhao, in China between 2011 to 2016, included 23 patients with Maxillary sinus mucocele and 9 patients with Antrochoanal polyp. All patients underwent Inferior meatal fenestration and concluded that by this approach, the medial and inferior aspect of maxillary sinus can be accessible and the blind spot is anterior wall of maxillary sinus [14]

In a study named Intranasal Endoscopic Prelacrimal recess approach for maxillary sinus-Inverted papilloma by Qian-Qian Yu, Ge Guan, they performed Endoscopic sinus surgery in 71patients between 2005 to 2018 in patients with histopathologically confirmed maxillary sinus Inverted papilloma and were followed for 3years. Of which 20patients underwent prelacrimal recess approach, 14patients underwent middle meatal antrostomy, 3 patients with endoscopic medial maxillectomy and 7 patients underwent endoscopic middle meatal antrostomy combined with Caldwell luc procedure. Prelacrimal recess approach were applied for inverted papilloma which involve alveolar crypts, prelacrimal recess and anteromedial inferior walls of maxillary sinus or with two or more pedicles and multiple areas of bone destruction in each walls of themaxillary sinus. Among 20 patients managed with prelacrimal recess

approach, only one patient had recurrence in 8months after surgery and stated that complications like vision disturbances, epiphora, facial numbness, dry nose were not encountered following prelacrimal recess approach [16]

A study on Endoscopic endonasal Prelacrimal Recess approach for antrochoanal polyp by Wael F Ismaeil, conducted between 2013 and 2018 which included 32 patients of which 16 patients underwent endoscopic Middle Meatal Antrostomy and 16 patients underwent Endoscopic transnasal Prelacrimal recess approach and concluded that prelacrimal approach allows complete visualization of anterior, lateral and posterior walls of antrum and better instrumentation [26]

During the early part of 2021, India saw a surge in the number of COVID-19cases, creating a second wave amidst an ongoing pandemic due to SARS-CoV2 virus which started in 2020. This was also accompanied by a sudden increase of rhino-orbital mucormycosis in patients diagnosed with COVID-19. Diabetes mellitus (DM) was found to be an independent risk factor for both severe COVID-19 and mucormycosis as described by Singh AK et al [27].

According to a study by Parul Goyal et al, invasive fungal sinusitis disease with infratemporal fossa extension can be debrided safely through transnasal endoscopic techniques, as these provide good visualization of the pathology with safe debridement and low morbidity [28].

METHODOLOGY

STUDY PLACE : Upgraded Institute of Otorhinolaryngology

Rajiv Gandhi Government General Hospital

Chennai-600003

TYPE OF STUDY : Prospective observational study

STUDY PERIOD : September 2019 to August 2021

SAMPLE SIZE : 28

ETHICAL CLEARANCE: Obtained clearance from Institutional Ethics Committee

INCLUSION CRITERIA:

1) Age 15 to 60 years

2) Both sexes- Male and Female

3) Chronic rhinosinusitis with sinonasal polyposis refractory to medical management

4) Benign and low grade pathology of maxillary sinus like Antrochoanal polyp, Mucocele, Inverted papilloma

5) Patient with Mucormycosis or other pathologies who warranted improved exposure of pterygopalatine fossa and infratemporal fossa for disease clearance

6) Understands the protocol and is able to give informed consent

EXCLUSION CRITERIA:

1. Age < 15yrs and > 60yrs

2. Intracranial extension

3. Malignancy

4. Immunocompromised status

5. Patient not willing for surgery or not fit for surgery

MATERIALS

Patients who attend UIORL OPD fulfilling inclusion criteria and exclusion criteria were subjected to detailed clinical ENT and Head and Neck Examination followed by diagnostic nasal endoscopy and radiological imaging and proceeded with surgical intervention for maxillary sinus. The findings are documented in proforma which includes other details like approach preferred, histopathological evaluation and follow up details. The patients were followed up periodically with clinical examination and diagnostic nasal endoscopy and if needed radiological imaging was done.

DATA COLLECTION:

1. Complete history
2. Clinical ENT and Head and Neck examination
3. Diagnostic nasal endoscopy
4. CT/MRI Paranasal sinuses with or without contrast
5. Surgical procedure done- approach preferred
6. Disease involvement of maxillary sinus
7. Histopathological examination
8. Postoperative Follow up by diagnostic nasal endoscopy

Approach preferred is based on the involved walls of maxillary sinus

- Posterior wall- Middle meatal antrostomy
- Anterior wall and Infratemporal fossa- Modified endoscopic medial maxillectomy by prelacrimal approach
- Lateral and medial wall- Endoscopic medial maxillectomy
- Floor – Inferior meatal antrostomy
- Medial and posterior wall- Mega antrostomy
- Posterior wall, Pterygopalatine fossa and Infratemporal fossa- Endoscopic denker approach

OBSERVATION AND RESULTS

DISEASES INCLUDED UNDER STUDY

DISEASE	NO.OF CASES
Sinonasal pathology including polyposis, mucocele, inverted papilloma, dental abscess	13
Mucormycosis	10
Nasopharyngeal angiofibroma	5

AGE DISTRIBUTION

AGE	SNP	NA	Mucor	Total
15-25	4	5	0	10
26-35	2	0	2	3
36-45	3	0	4	7
46-55	1	1	3	5
56-65	1	0	1	2
66-75	1	0	0	1

SNP- Sinonasal pathology including polyposis, mucocele, inverted papilloma NA-Nasopharyngeal Angiofibroma

TABLE-1 shows Age distribution

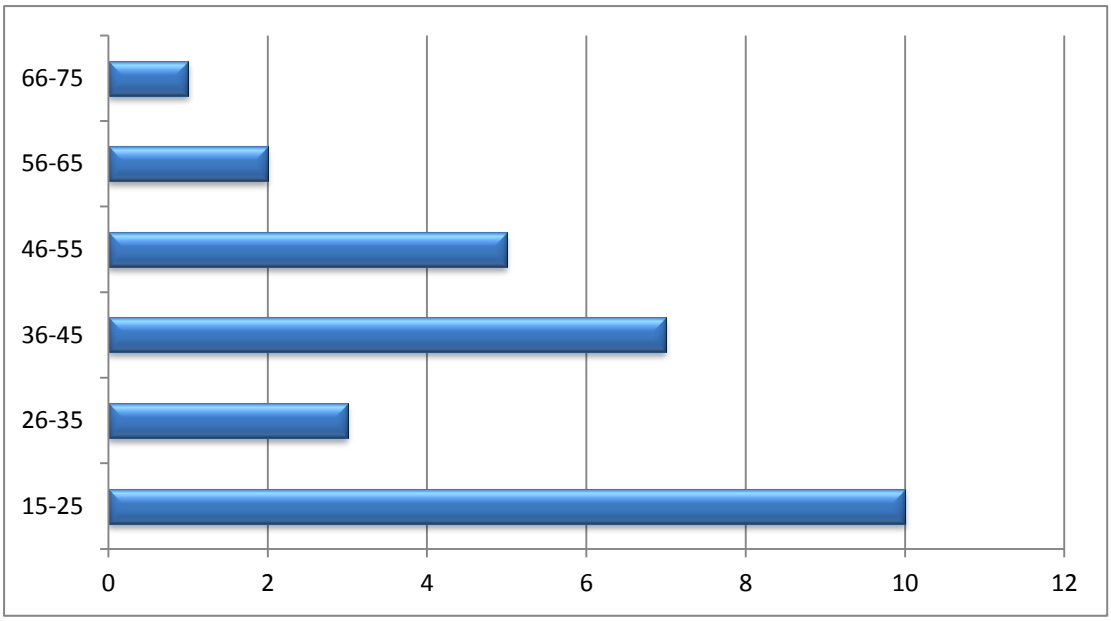


FIGURE-31 The above bar diagram shows Age distribution

Average age at presentation is 15 to 25yrs. Of 13 patients with sinonasal pathologies, majority of patients were in age group of 15-25 years, the lowest age of presentation was 19 years and highest is 66years. Of 5 patients with nasopharyngeal angiofibroma, all were within age group of 15-25 years with lower limit being 15yrs and upper limit was 20years. Out of 10 patients with mucormycosis, most of the patients were in age group of 36-45 years with lower limit was 35yrs and higher limit was 65 years

GENDER DISTRIBUTION

	SNP	NA	Mucor	Total
Male	6	5	6	17
Female	7	0	4	11

TABLE-2 shows Gender distribution

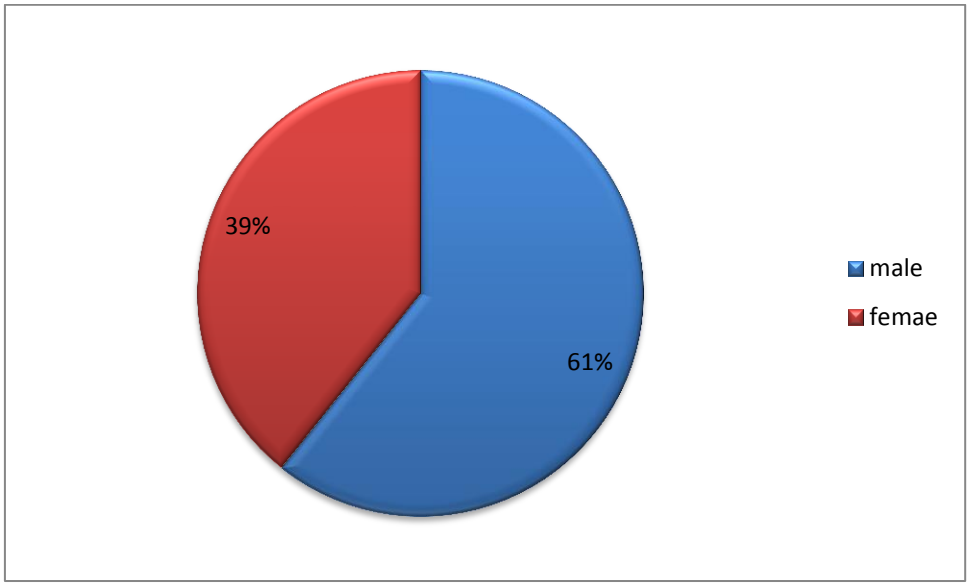


FIGURE-32 The above pie chart shows gender distribution

Out of all 28 patients included in study, 61% were males and 39% females. Of 13 patients with sinonasal pathologies, 7 patients were female showing female preponderance. All nasopharyngeal angiofibroma patients were males. Of 10 patients with mucormycosis, males were more common.

Therefore male: female ratio is 1.5:1

COMORBID ILLNESS

	SNP	NA	Mucor	Total
DM	5	0	10	15
HTN	1	0	0	1
Nil	8	5	0	13

DM- Diabetes Mellitus HTN- Hypertension

TABLE-3 shows Comorbid illness

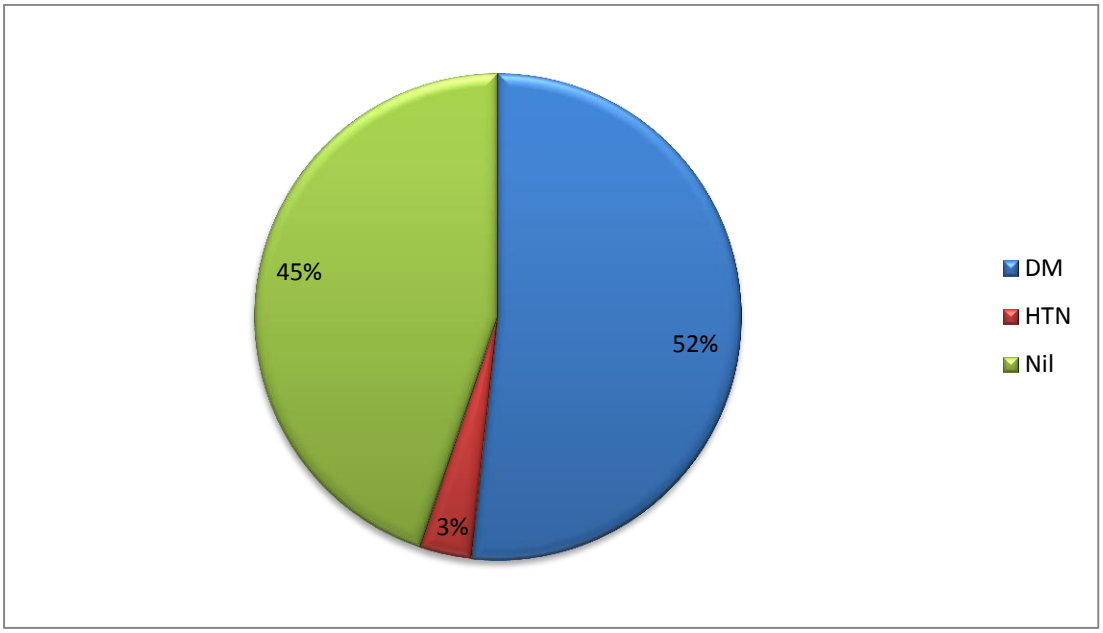


FIGURE-33 The above pie chart shows comorbid illness

Majority of the patients had diabetes mellitus as comorbid illness (52%), Of 13 patients with sinonasal pathologies, 8 of them have no comorbidities and 5 patients had diabetes mellitus and 1 had hypertension. No comorbid illness present for any patient with nasopharyngeal angiofibroma. All patients with mucormycosis had diabetes mellitus

BENIGN SINONASAL PATHOLOGIES LIKE

Sinonasal polyposis	61%	8
Inverted papilloma	15%	2
Mucocele	8%	1
Dental abscess	8%	1
Pterygopalatine fossa mass for evaluation	8%	1

TABLE-4 shows various pathologies addressed

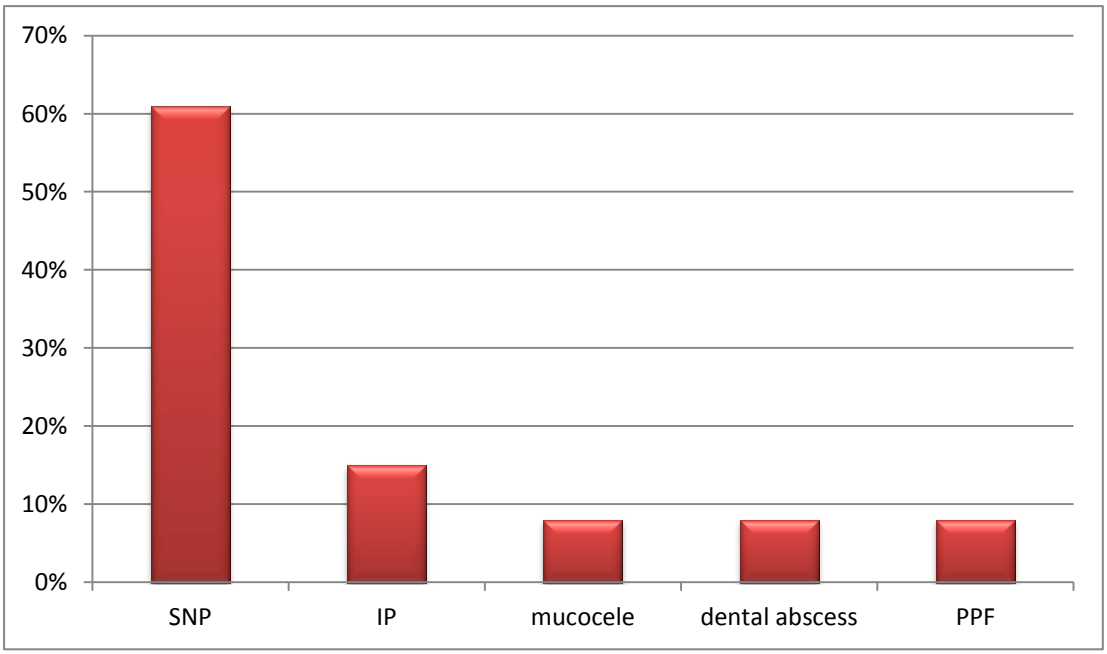


FIGURE-34 shows percentage distribution of various pathologies addressed

Of 13 patients, 8 patients with sinonasal polyposis, 2 patients with inverted papilloma, 1 with maxillary sinus mucocele,1 with Periapical abscess and 1 with pterygopalatine fossa mass for evaluation were included in the study.

SYMPTOMS

NASAL OBSTRUCTION	83%
NASAL DISCHARGE	75%
POSTNASAL DRIP	42%
EPISTAXIS	16%
SMELL DISTURBANCE	8%
FACIAL PAIN	66%
FREQUENT URI	50%
MOUTH BREATHING	41%

TABLE-5 shows percentage distribution of symptoms in sinonasal pathologies

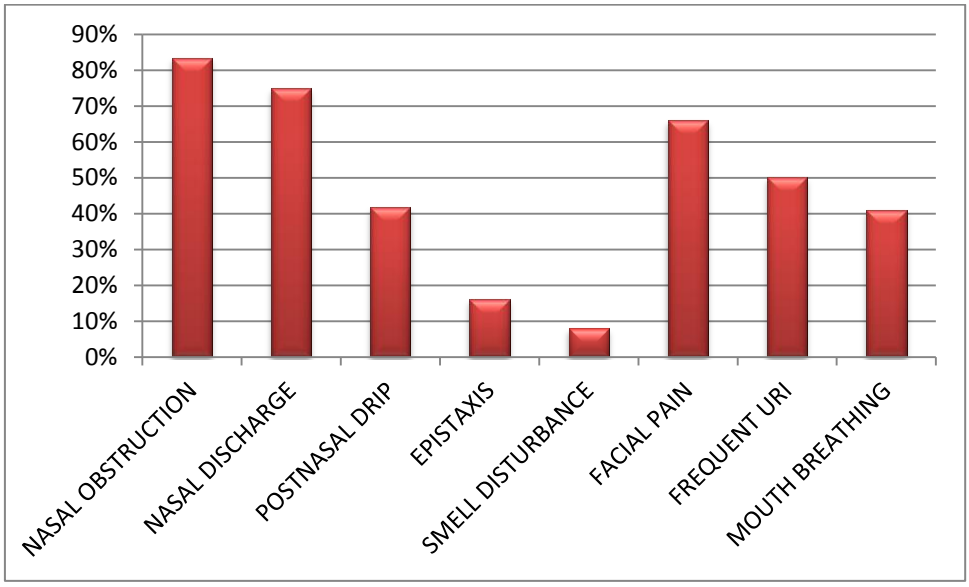


FIGURE-35 The above bar graph shows symptom presentation in sinonasal pathologies

The most common presenting complaint is nasal obstruction which is present in approximately 83% of patients followed by nasal discharge (75%), facial pain (66%), frequent upper respiratory tract infections (50%), postnasal drip (42%), mouth breathing (41%) and epistaxis (16%). The least common was smell disturbance seen in 8% of patients.

SIDE OF PATHOLOGY

Left	6	46%
Right	6	46%
Bilateral	1	8%

TABLE -6 shows percentage distribution of side of pathology

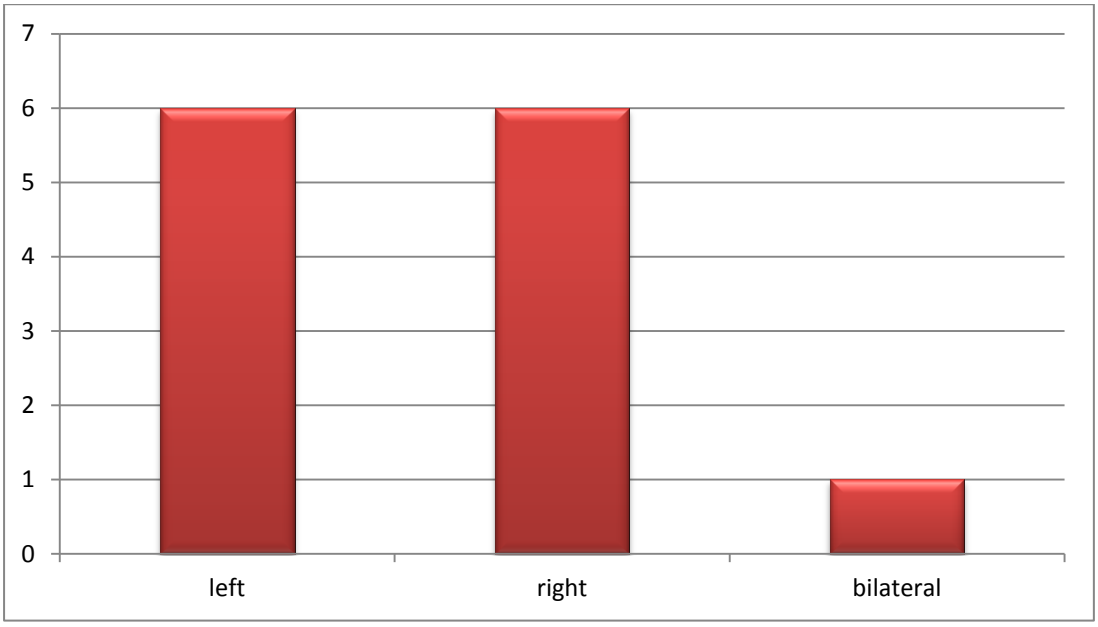


FIGURE-36 Bar chart showing side predominance of pathology

There was equal involvement of either right side or left side showing no side predilection for pathology. Bilateral presentation in 8% of patients.

TYPE OF SURGERY PERFORMED

Primary	10
Revision	3

TABLE-7 shows type of surgery performed

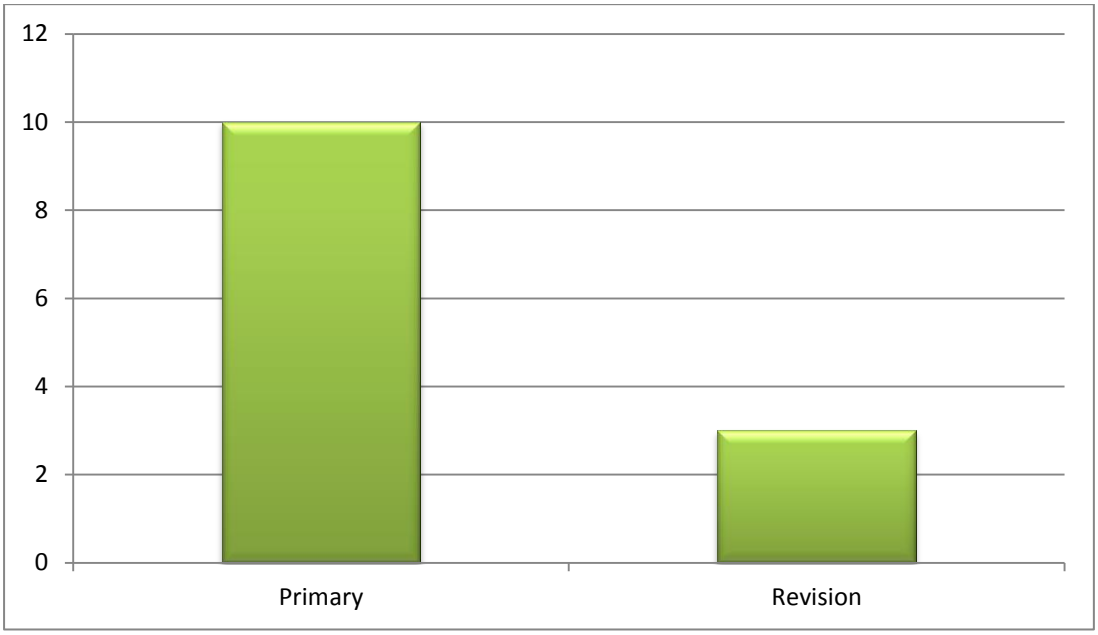
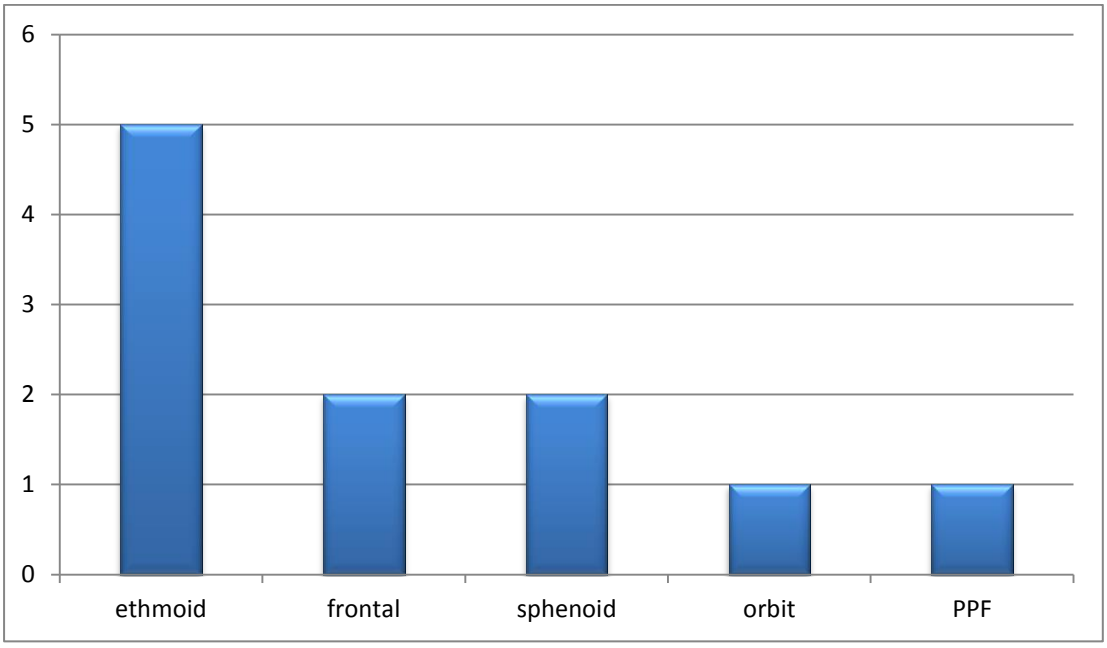


FIGURE-37 Bar diagram showing distribution of type of surgery performed

Of 13 patients with sinonasal pathology, 10 underwent primary surgery and 3 underwent revision surgery.

INVOLVEMENT OF OTHER STRUCTURES



PPF-pterygopalatine fossa

FIGURE-38 shows other structures involved

There were evidence of sinusitis secondary to occlusion of osteomeatal complex. Of which 5 patients had ethmoid sinus involvement followed by sphenoid sinus and frontal sinus. Orbit was involved in one patient with inverted papilloma and pterygopalatine fossa is involved in one patient.

SITE OF DISEASE ATTACHMENT

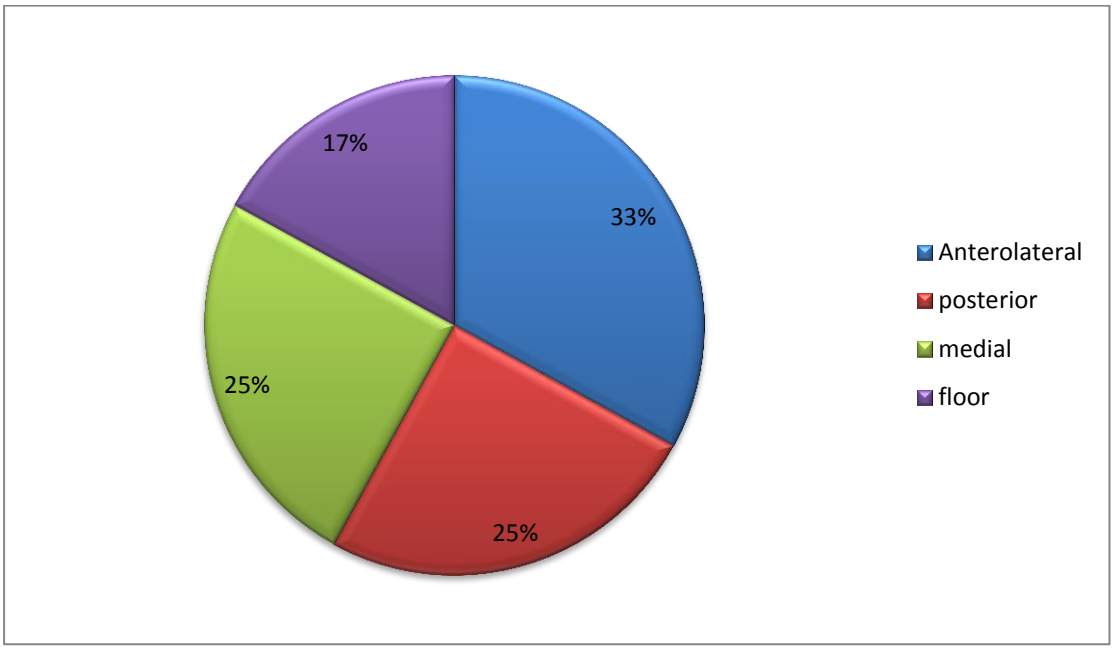


FIGURE-39 Pie chart showing Distribution of site of attachment of disease

Within maxillary sinus, the site of disease attachment was anterolateral wall in 33%, posterior wall in 25% of patients,25% in medial wall and 17% in floor of maxillary sinus.

ENDOSCOPIC APPROACH

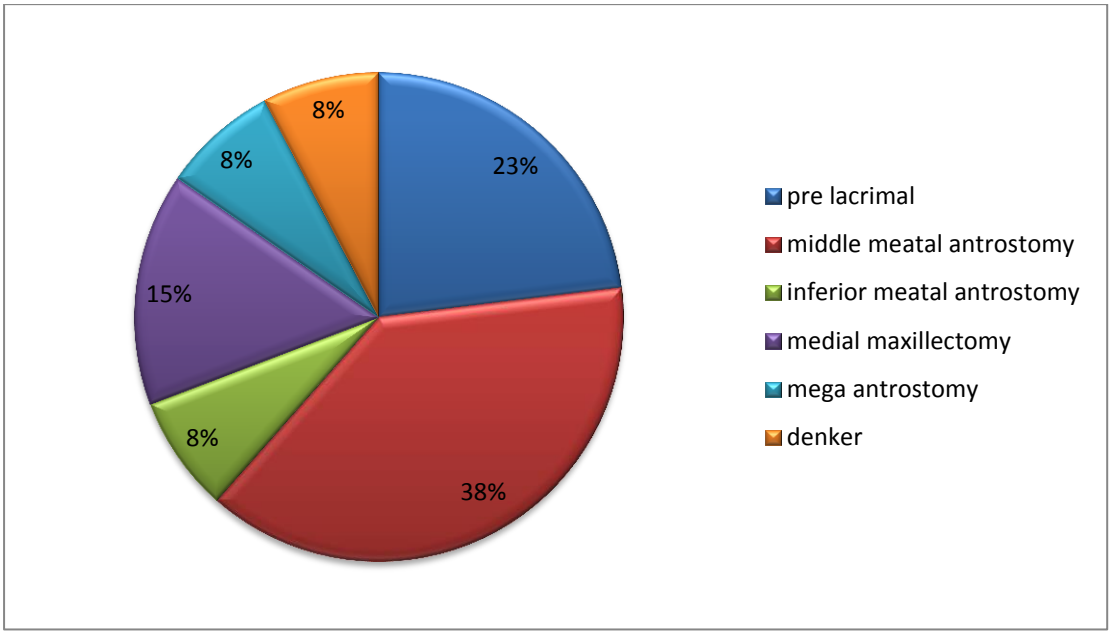


FIGURE-40 Pie chart showing surgical procedures done

6 patients were proceeded with endoscopic sinus surgery with middle meatal antrostomy, 3 underwent endoscopic sinus surgery by prelacrimal approach, 2 patients underwent endoscopic medial maxillectomy,1 patient with mega antrostomy, 1 with inferior meatal antrostomy and 1 underwent modified denker approach

INVOLVED WALLS AND APPROACH PREFERRED

1	Anterolateral	Prelacrimal
2	Anterolateral	Prelacrimal
3	Anterolateral	Prelacrimal
4	lateral	EMM
5	medial	EMM
6	Floor	IMA
7	Medial	MA
8	Medial	MMA
9	Floor	MMA
10	Posterior	MMA
11	Posterior	MMA
12	Posterior	MMA
13	Pterygopalatine fossa involvement	Denker

TABLE-8 shows site of disease attachment with approaches preferred

EMM- Endoscopic Medial Maxillectomy

IMA- Inferior Meatal Antrostomy

MMA-Middle Meatal Antrostomy MA-Mega Antrostomy

For 3 patients with disease attachment in anterolateral wall of maxillary sinus , prelacrimal approach was done, 5 patients with disease in posterior, medial wall and floor were removed by middle meatal antrostomy. 1 patient with disease in medial wall were removed by mega antrostomy. Disease in floor of maxillary sinus secondary to dental infection was removed by endoscopic sinus surgery with inferior meatal antrostomy.

Two patients diagnosed with inverted papilloma underwent endoscopic medial maxillectomy with disease attachment in lateral wall of nose and medial wall of maxillary sinus.

One patient with nasal cavity mass extending into pterygopalatine fossa with no attachment in maxillary sinus was removed by Denker approach which permitted complete removal from pterygopalatine fossa.

DURATION OF HOSPITAL STAY

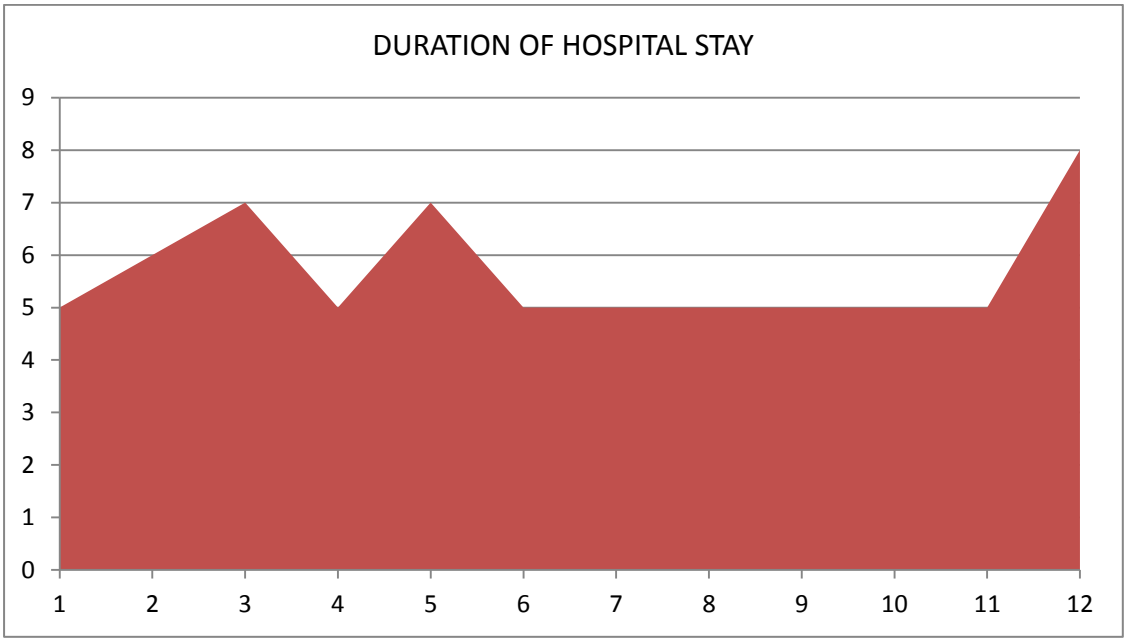


FIGURE-41 Graph showing duration of hospital stay

The average duration of hospital stay following endoscopic sinus surgery is 5 days, ranging from 5 to 7days. All patients were mobilized the next day of surgery.

No blood transfusion was needed intraoperatively.

HISTOPATHOLOGY

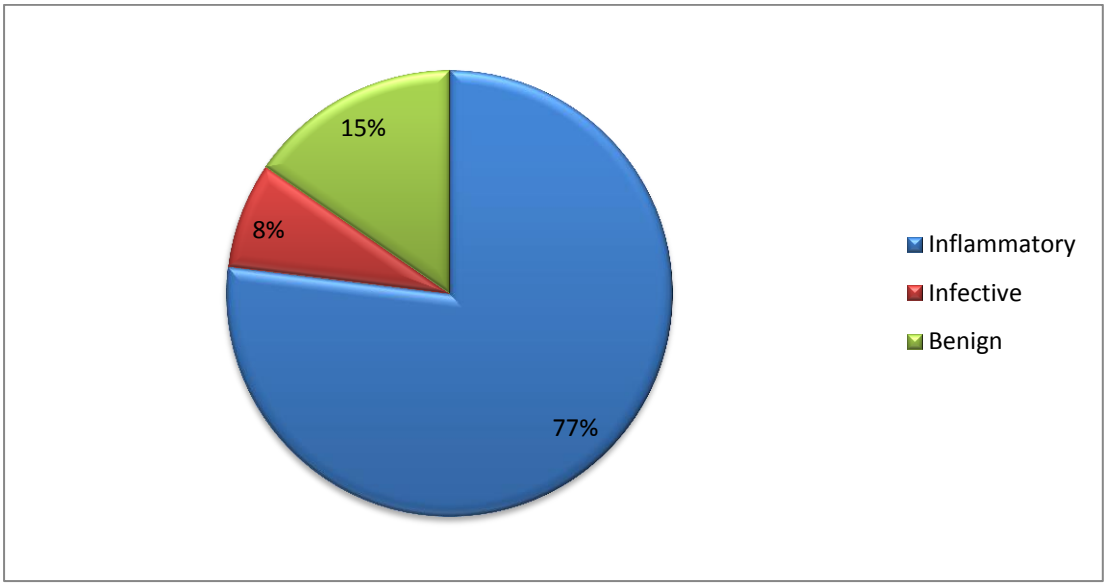


FIGURE-42 Pie chart showing Histopathological findings

Histopathological examination revealed inflammatory pathology in (10) 77% of patients, 2 (15%) patients proven to have inverted papilloma and 1 (8%) patient reported with Aspergillosis

FOLLOWUP

All patients were followed for a period of 1year with follow up at 1week, 1month, 3months, 6months and 1 year.

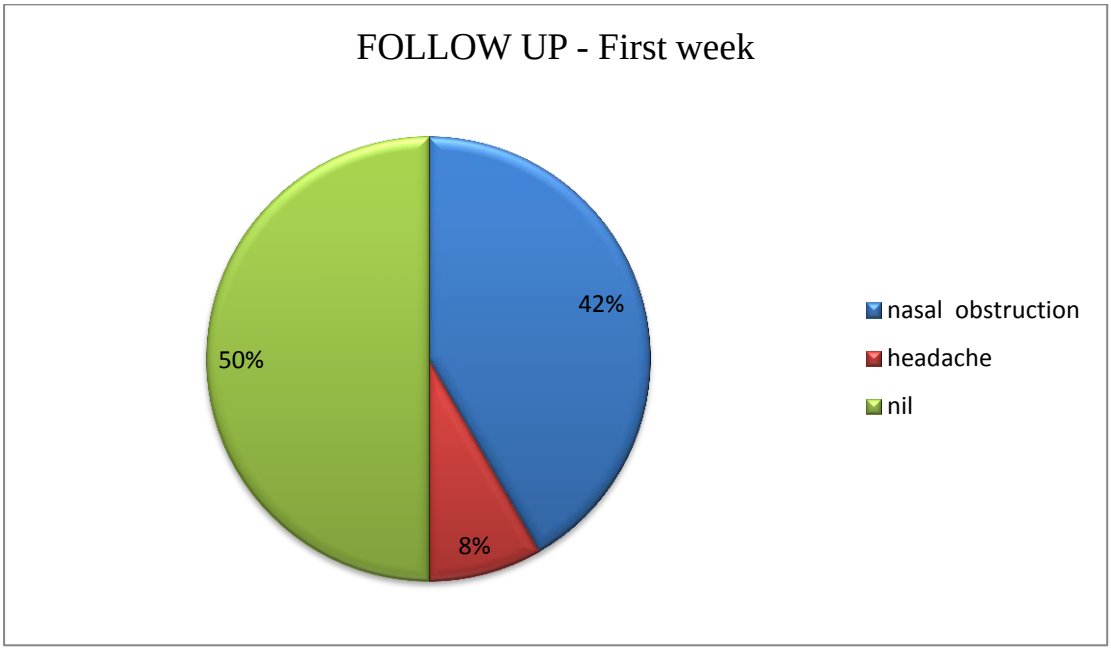


FIGURE-43 Pie chart showing symptoms at first week of follow up

Postoperatively after one week of procedure, majority of patients had no complaints, 42% had nasal obstruction and 8% had headache. Diagnostic nasal endoscopy showed postoperative changes with crusts. Suction clearance was done.

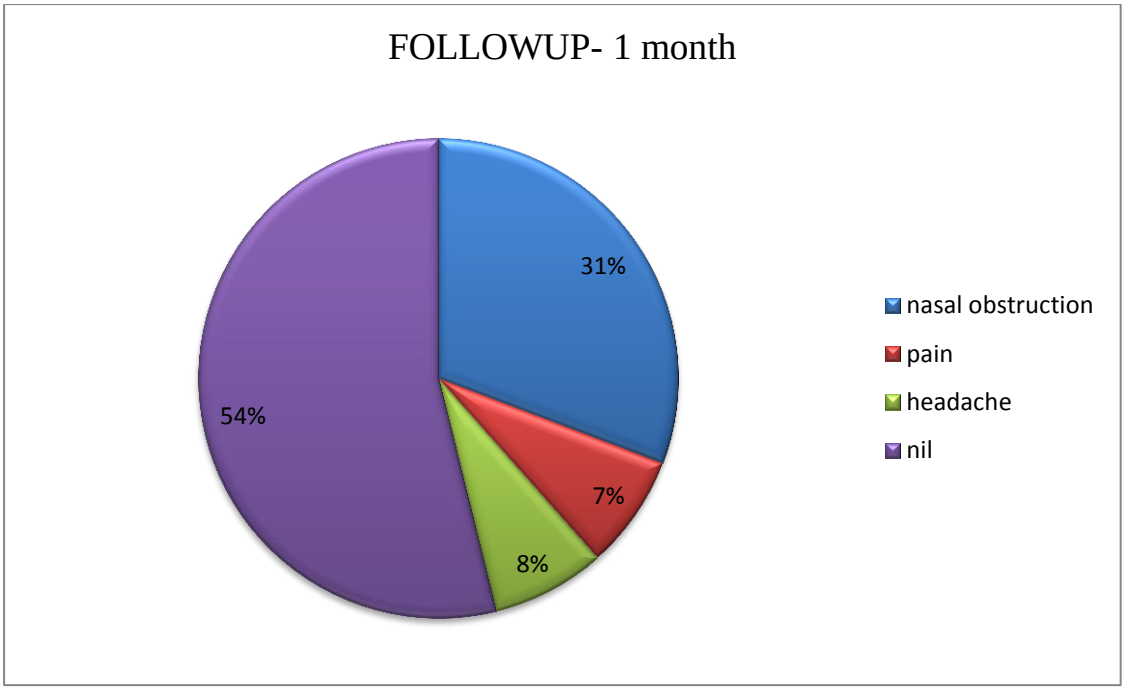


FIGURE-44 Pie chart showing symptoms at first month of follow up

By one month, 54% patients had no complaints and 31% with nasal obstruction and 7% with pain over nose. Nasal endoscopy done with no evidence of recurrence.

By the end of 3, 6months and 1 year, there were no complaints and on nasal endoscopy the mucosa is well epithelized with no evidence of recurrence

MUCORMYCOSIS

SYMPTOM PRESENTATION

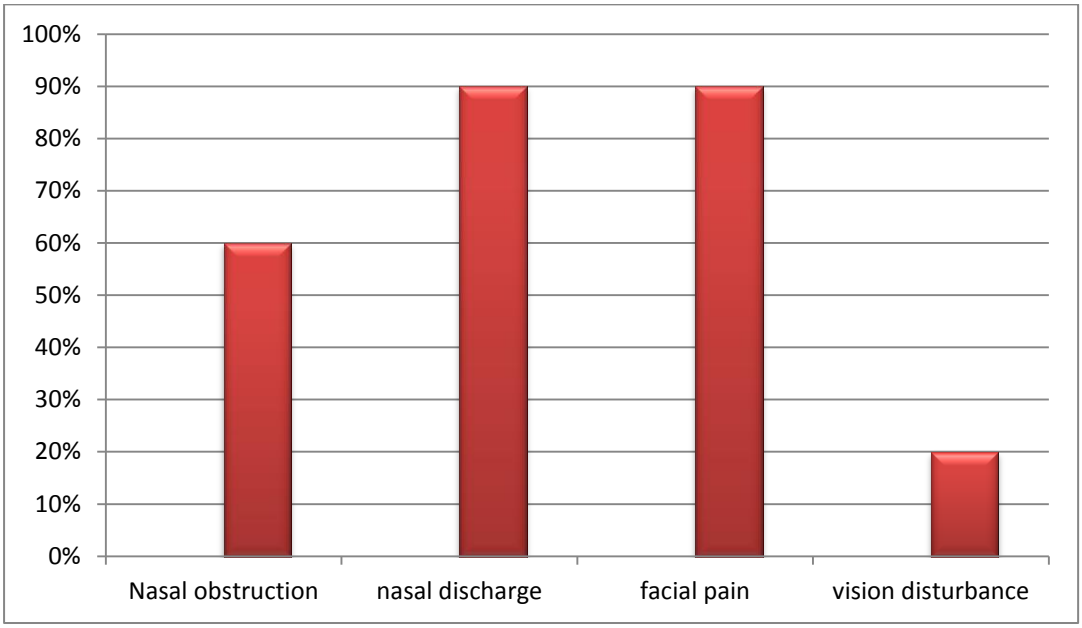


FIGURE-45 Bar diagram showing symptom presentation of mucormycosis

Of 10 patients with mucormycosis, the most common presenting complaint was nasal discharge (90%) and facial pain (90%) followed by nasal obstruction (60%) and vision disturbance (20%).

STRUCTURES INVOLVED

S.No	MS	ES	FS	SS	PPF	ITF	PM	ORBIT	P/D
1	1	1	0	0	1	0	0	0	Prelacrimal
2	1	0	1	0	1	0	0	1	Denker
3	1	0	0	0	1	0	0	0	Prelacrimal
4	1	1	0	1	1	0	0	1	Denker
5	1	1	1	0	1	0	0	1	Prelacrimal
6	1	0	0	0	1	0	0	0	Denker
7	1	0	0	0	1	0	1	0	Denker
8	1	1	0	0	1	0	1	0	Denker
9	1	0	0	0	1	0	0	0	Denker
10	1	1	0	0	1	1	0	0	Denker

MS- Maxillary sinus

ES- Ethmoid sinus

FS- Frontal sinus

SS-sphenoid sinus

PPF-pterygopalatine fossa

ITF- Infratemporal fossa

PM- Premaxilla O- Orbit

TABLE-9 shows structures involved in mucormycosis and surgery done

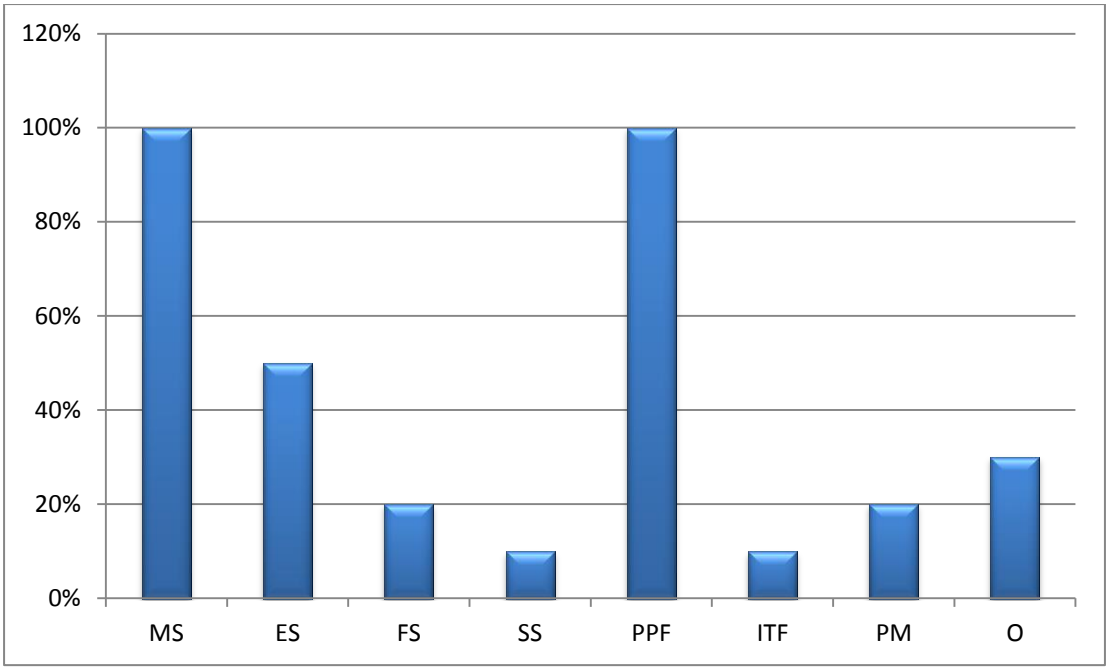


FIGURE-46 shows percentage distribution of structures involved in mucormycosis

Maxillary sinus and pterygopalatine fossa were involved in all patients. Ethmoid sinus involved in 50% of patients, orbit involved in 30% of patients followed by frontal sinus (20%), premaxillary region (20%) and sphenoid sinus (10%).

APPROACH

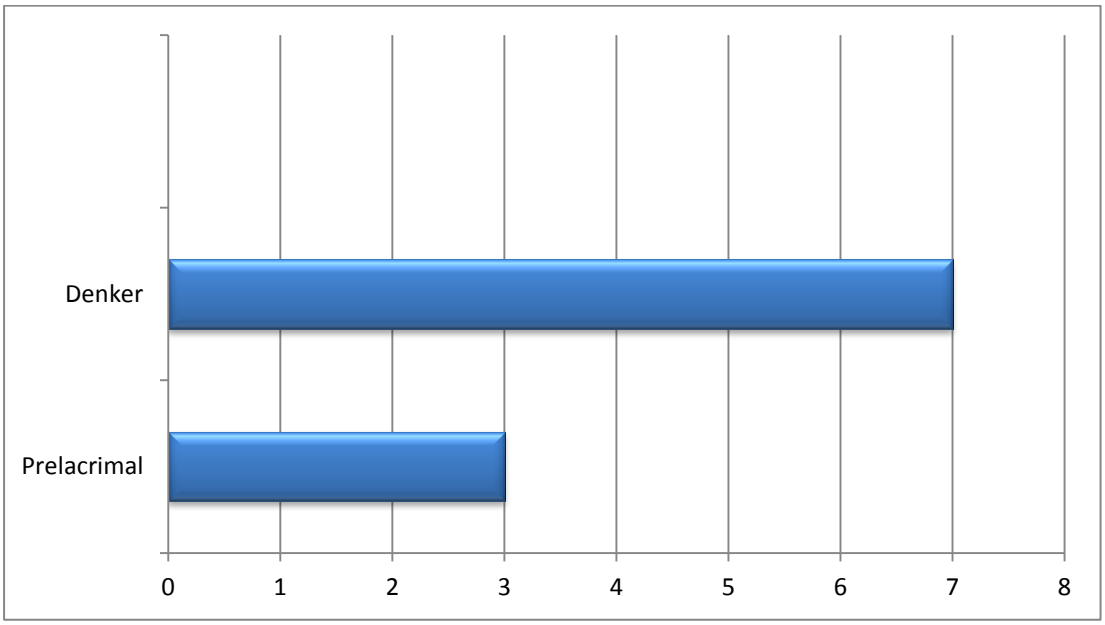


FIGURE-47 Bar chart showing surgery done in mucormycosis

Of all 10 patients, 3 patients underwent endoscopic sinus surgery by prelacrimal approach and 7 patients underwent endoscopic modified denker approach.

NASOPHARYNGEAL ANGIOFIBROMA

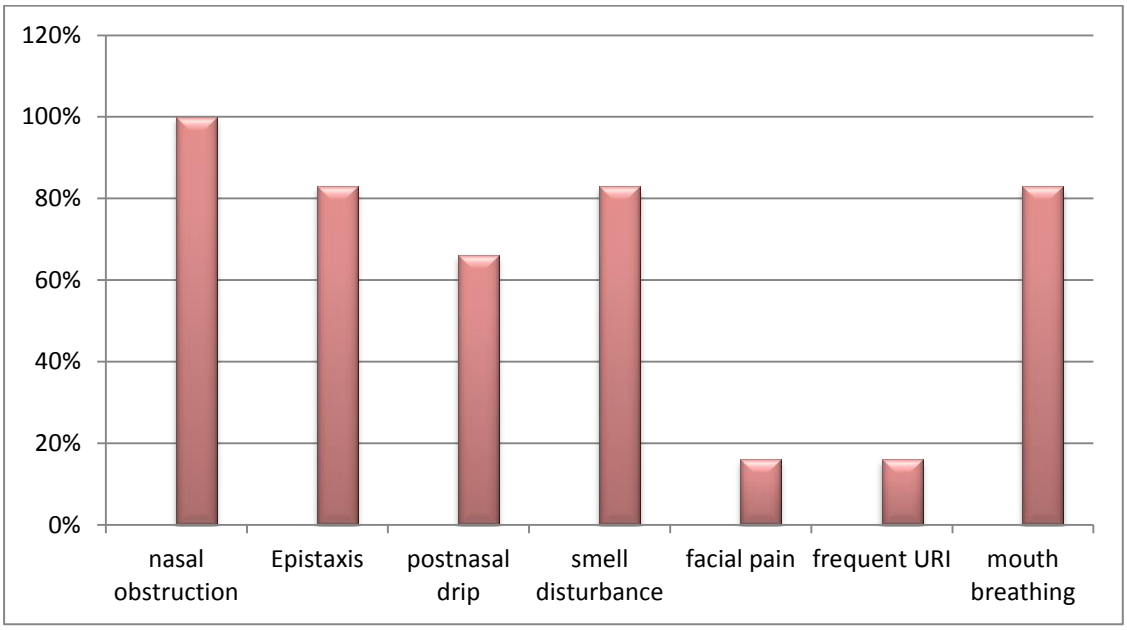


FIGURE-48 Bar chart showing percentage of symptom presentation in Nasopharyngeal angiofibroma

Of 5 patients with nasopharyngeal angiofibroma, all patients had nasal obstruction which is the common presenting complaint followed by epistaxis (83%), smell ditsurbance (83%), mouth breathing (83%), postnasal drip (66%) and frequent upper respiratory tract infections in 16%.

STRUCTURES INVOLVED

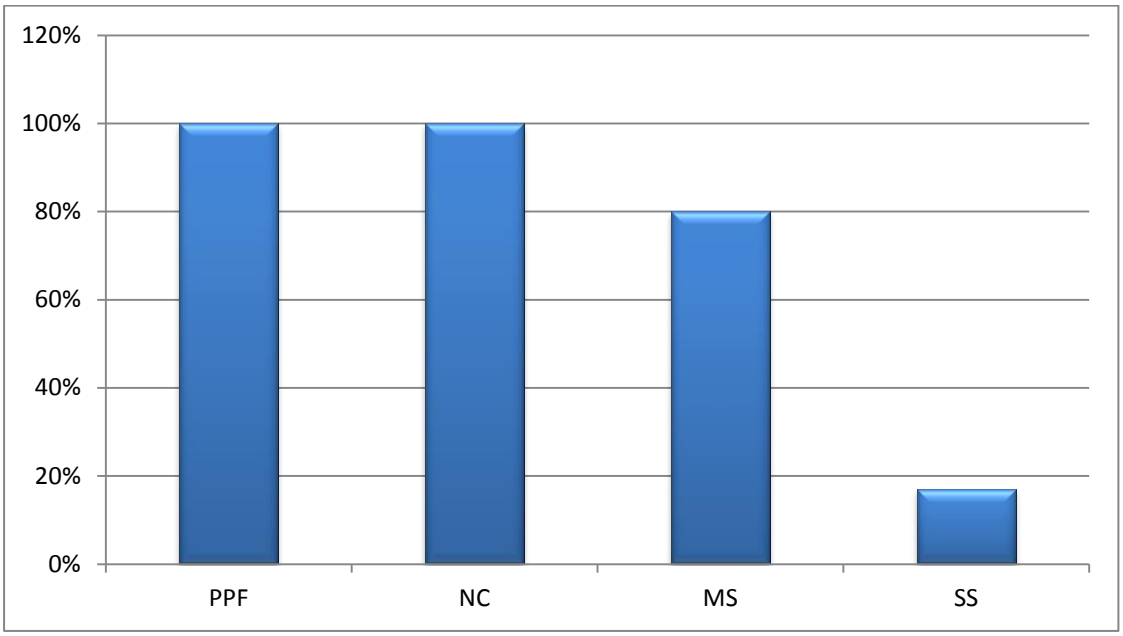


FIGURE-49 Bar chart showing structures involved in nasopharyngeal angiofibroma

Nasal cavity and pterygopalatine fossa were involved in all patients followed by maxillary sinus in 80% and sphenoid sinus in 17% of patients. Endoscopic modified Denker approach were done for all patients. It allows complete visualization of the tumor and facilitates removal of mass in toto.

DISCUSSION

Maxillary sinus is a pyramidal shaped space contained within maxilla. It has hidden areas like alveolar recess, zygomatic recess and prelacrimal recess. Pathology in the crevices of maxillary sinus must be addressed in order to prevent recurrence. The aim of surgery is to re-establish the ventilatory and mucociliary drainage pathway of paranasal sinuses by removal of pathology and preserving the healthy mucosa.

External approach like radical Caldwell luc approach is associated with significant complications like bleeding, anaesthesia of infraorbital nerve, numbness of canine and premolar teeth, Oroantral fistula, injury to nasolacrimal duct and osteomyelitis of maxilla [29]. Hence endoscopic approaches is being preferred. It provides superior magnification, excellent illumination, high resolution, allows access to difficult to reach areas like anterior and lateral walls of maxillary sinus, facilitates the use of powered instrumentation and also preserves the adjacent normal healthy mucosa.

Our study excludes malignant pathology as it may need external approach if bone invasion present. Some areas in maxillary sinus are difficult to visualize and handle with middle meatal antrostomy alone

even with angled endoscopes and instrumentation [30]. In such cases alternative endoscopic approaches are needed to address the pathology.

Pathologies like Antrochoanal polyp, Mucocele, Periapical dental abscess, benign tumour like inverted papilloma were included. In this study we preferred certain endoscopic approaches to improve visualisation of structures like pterygopalatine fossa, infratemporal fossa thereby aiding complete disease clearance in patients with Nasopharyngeal angiofibroma and Mucormycosis.

Preoperative mapping of the pathology is important to facilitate complete removal of disease. This was achieved by radiological evaluation. At the site of origin of pathology there may be focal hyperostosis as evidenced by Lee et al [31].

Qian yu et al [16] in their study preferred maxillary antrostomy before prelacrimal recess approach for all patients. In our study, middle meatal antrostomy was done as the basic step in all of the approaches as it helps in mucociliary clearance , for topical drugs to act and to look for recurrence during periodic followup.

The lesion in anterior wall, floor, alveolar recess and prelacrimal recess were difficult to access by middle meatal antrostomy alone, hence

preferred other approaches. This correlates with the study done by hoseman et al [30]

Modified endoscopic Denker approach is the endoscopic anterior maxillotomy. It has the same entry route as Caldwell luc procedure but avoids the need for sublabial incision thereby preventing complications like damage to anterosuperior alveolar nerve and oroantral fistula . Upadhyay et al [25] and Lee et al [17] described in their study that by this approach, the anterior, lateral and inferior walls of maxillary sinus can be reached and also pathologies in anterior aspect of infratemporal fossa can be addressed without the need for angled instrumentation and allows four handed surgery due to straight trajectory.

In our study endoscopic denker approach was performed for all patients of Nasopharyngeal angiofibroma with mass occupying pterygopalatine fossa and infratemporal fossa. It was removed enmasse in all 5 cases. Since the study by Upadhyay et al [25] were performed on ten fresh cadavers, no complications were reported. Lee et al [17] performed this procedure in 2 patients with no reported side effects and no evidence of recurrence in a followup of 4 and half years.

Our study also faced no significant complications except crust formation. We employed this approach in 7 patients of mucormycosis

with involvement of maxillary sinus, premaxillary region and pterygopalatine fossa. We were able to provide adequate disease clearance for all patients.

Endoscopic medial maxillectomy allows visualisation of posterior portion of maxillary sinus but it involves removal of inferior turbinate and nasolacrimal duct. Removal of inferior turbinate affects the humdification of inspired air and causes persistent crust formation and injury to nasolacrimal duct can lead to epiphora.

Mohanty et al [23] in their study reported extensive nasal crusting and persistent epiphora as a complication following endoscopic medial maxillectomy. Wormald et al [21] reported epiphora following endoscopic medial maxillectomy in 30% of study population.

To overcome this, Pagella et al [31] in their study conducted on 181 patients with sinonasal inverted papilloma, have performed modification of endoscopic medial maxillectomy in 29 patients where inferior turbinate is removed partially with preservation of head of inferior turbinate and nasolacrimal duct. By this technique, they addressed disease in anteroinferior and posterolateral portions of maxillary sinus with no evidence of complication and recurrence in a follow up of 2years.

Ghosh et al [24] in their study reported recurrence in 10% of patients who underwent modified endoscopic medial maxillectomy with crusting of nose as complication.

Our study correlates with study of Pagella et al [31] where we performed. Endoscopic Medial Maxillectomy in two patients of inverted papilloma with pedicle in lateral and medial walls of maxillary sinus facilitating complete removal with no recurrence. We faced nasal crusting as complication in first 2 postoperative visits requiring endoscopic suction clearance

Inferior meatal antrostomy indicated in conditions where gravity dependent drainage is needed like in cystic fibrosis, Kartagener syndrome, mucociliary dysfunction secondary to chronic sinusitis and also in conditions where visualization of floor and anterior walls of maxillary sinus is needed [33]. Zhao et al [14] in their study on Inferior meatal fenestration conducted on 32 patients concluded that lesions in inferior and medial wall of maxillary sinus can be accessed with no reported recurrence or complication. In our study Inferior meatal antrostomy was done to address the floor of maxillary sinus in a patient with periapical dental abscess with no complication.

Mega antrostomy involves widening of natural maxillary sinus ostium and connected to inferior meatal antrostomy with the removal of inferior turbinate posterior to the valve of Hasner [13]

Prelacrimal recess approach provides the advantage of using zero degree endoscopes as stated by Zhou et al [22] . Our study agrees with the above study in use of straight endoscopes and instrumentation on using Prelacrimal recess approach. Al ayadi et al [34] reported one case of epiphora following prelacrimal recess approach. Whereas our study showed no complication.

Comoglu et al [35] stated that disease in lateral or anterior wall of maxillary sinus can be removed by prelacrimal recess approach with preservation of nasolacrimal duct. Our study agrees with the above study and we removed disease from anterolateral wall by prelacrimal approach. It facilitated complete removal of pathology in all 3 patients with no complications or recurrence.

Since December 2019, sudden emergence of pneumonia cases of unknown etiology started in Wuhan, China and went on to become a global pandemic causing severe morbidity and mortality, later found to be caused by a novel coronavirus , named as Severe Acute Respiratory Syndrome-coronavirus-2, causing a disease called COVID-19.

In early half of 2021, India saw a second wave of surge of COVID -19 cases, also resulting in numerous complications. One of them was a severe lethal opportunistic fungal infection - Rhinocerebral mucormycosis, usually seen in Diabetic or immunocompromised individuals. Involvement of nasal cavity, maxillary sinus and orbital inflammatory lesions create high degree of suspicion of mucormycosis [10].The mean duration between diagnosis of COVID-19 disease and mucormycosis was 15.6 ± 9.6 (3-42) days, noted Sen M et al, in their study [36].

Though fatal in many cases, it was found that early diagnosis and appropriate management can improve survival. Surgical debridement by endoscopic techniques help in both diagnosis and management [37]. Hence, mucormycosis was included as a part of our on going study.

In our study, endoscopic sinus surgery helped in better visualization and clearance of the disease as seen with many studies done previously.

COLOR PLATES

FIGURE-50 shows axial CT image of maxillary sinus shows focal hyperostosis in right posterolateral wall which signify disease attachment

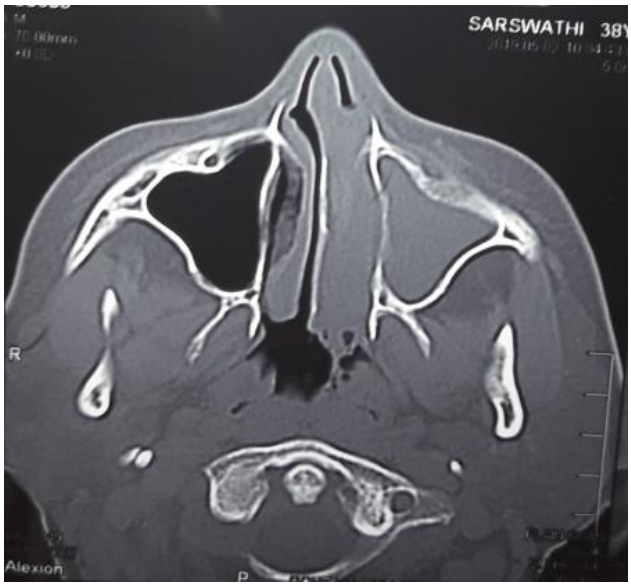


FIGURE-51 The above axial CT image of maxillary sinus shows focal bony hyperostosis in left anterolateral wall which signify disease attachment

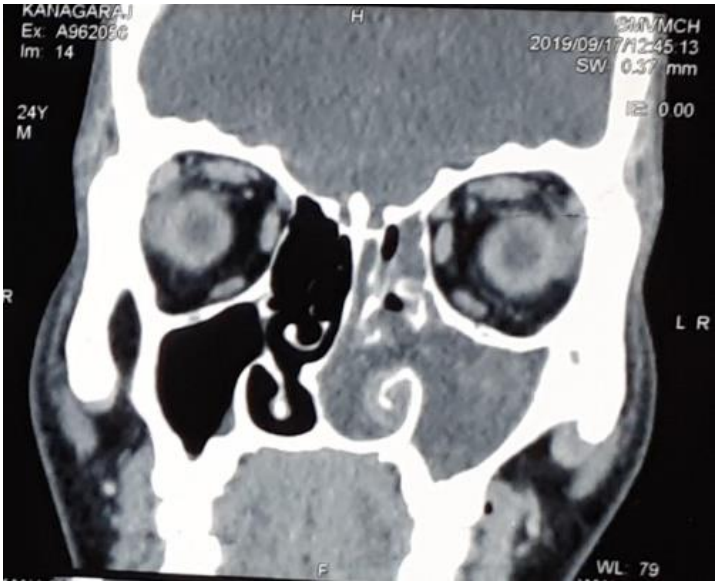


FIGURE-52 shows coronal CT image of Inverted papilloma

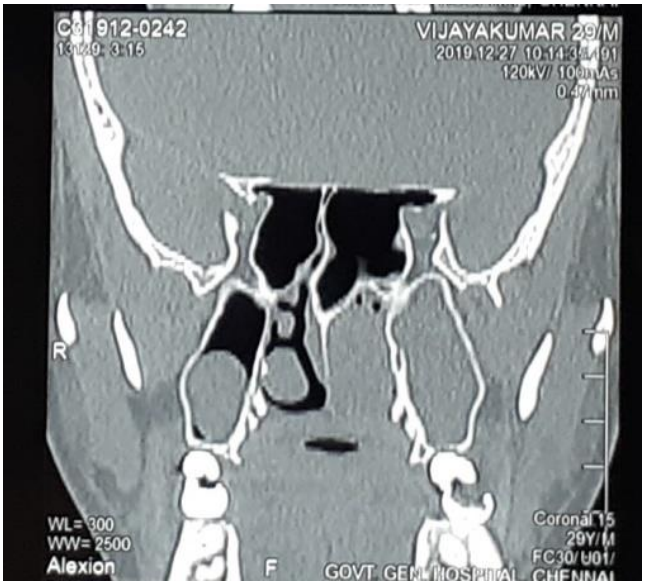


FIGURE-53 shows CT PNS coronal section showing Antrochoanal polyp

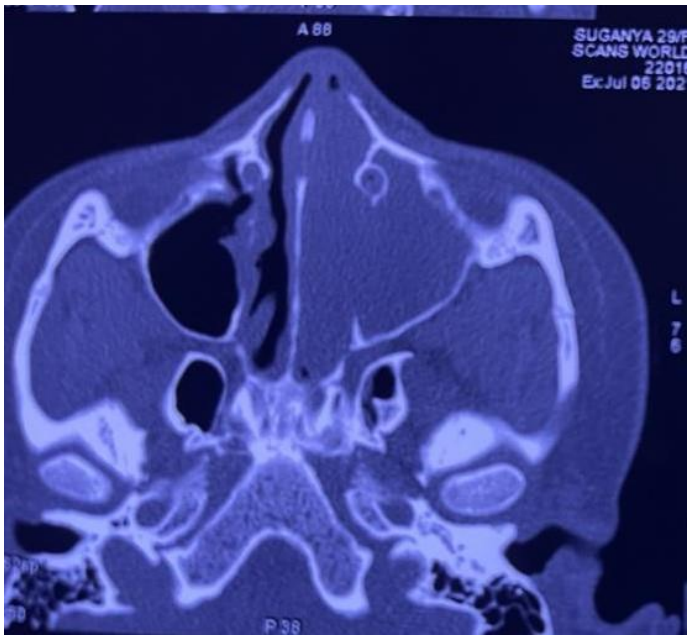


FIGURE-54 Axial CT image showing Antrochoanal polyp, with focal bony hyperostosis in anterior wall of left maxillary sinus with wide prelacrimal recess.

FIGURE-55 Axial CT PNS image showing Dental abscess with maxillary sinusitis

FIGURE-56 MRI PNS showing Dental abscess with secondary sinusitis

FIGURE-57 Axial MRI PNS image showing disease in retromaxillary area

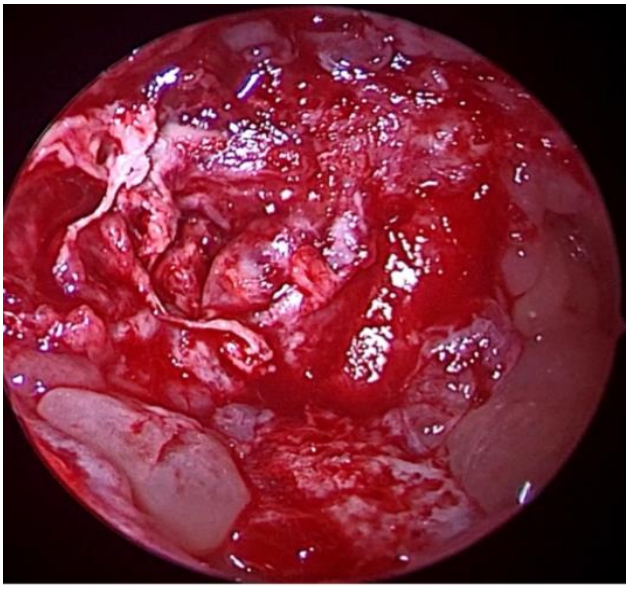


FIGURE-58 Endoscopic picture of pterygopalatine fossa following Denker approach

CONCLUSION

- Endoscopic sinus surgery is the preferred modality of treatment and it has replaced conventional surgeries for sinonasal pathologies since it aims to restore the physiology of nose and paranasal sinus.

- Preoperative radiological imaging helps to determine the attachment site of lesion based on focal hyperostosis.

- The approach preferred is predetermined based on the involvement of walls of maxillary sinus.

- Middle meatal antrostomy is the basic step in all surgeries as the mucociliary clearance is directed towards the natural ostium and for periodic follow up after surgery for suction clearance and also to look for recurrence. It permits visualization of posterior wall of maxillary sinus. It needs angled endoscopes and instrumentation for addressing the pathology.

- Benign and low grade pathology in anterior and lateral walls are addressed by modified endoscopic medial maxillectomy by prelacrimal approach and endoscopic anterior maxillotomy by modified Denker approach. These approaches facilitates the passage of straight endoscopes and instrumentation with access to

all walls of maxillary sinus particularly improved access to anterolateral wall.

- Modified Denker approach provides additional access to antero inferior portion of maxillary sinus and also used in mucormycosis and other sinonasal pathologies as a second port to access structures behind maxillary sinus like pterygopalatine fossa and infratemporal fossa.

- Endoscopic medial maxillectomy is preferred for inverted papilloma as it helps in complete removal of tumour pedicle with removal of newly formed bone thereby preventing recurrence.

- Inferior meatal antrostomy is preferred where pathology in floor and medial wall of maxillary sinus need to be addressed.

- We faced difficulties in followup due to COVID pandemic.

- Nasal crusting was present in most of the cases but with periodic suction clearance the mucosa turned healthy.

- No major complications and recurrence were evident in our short follow up period.