F.E.S.S.
FUNCTIONAL ENDOSCOPIC SINUS SURGERY

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# Contents

1.0 Introduction to endoscopic surgery ........................................ 7
2.0 Surgical Anatomy of the Lateral Nasal Wall ............................ 9
3.0 Physiology of Sinus in Health and Disease Applied to Endoscopic Sinus surgery .................................................. 15
4.0 Nasal Endoscopy ............................................................. 17
5.0 Imaging of Paranasal Sinuses and Nose ................................. 21
6.0 Techniques of Functional Endoscopic Sinus Surgery ............... 31
7.0 Post Operative Care ......................................................... 39
8.0 Complication of F.E.S.S. .................................................... 41
9.0 Allergic Fungal Rhinosinusitis ........................................... 45
10. Trans Nasal Endoscopic Ligation of Sphenopalatine Artery ...... 55
11. Endoscopic Dacryocystorhinostomy (DCR) ............................ 59
Acknowledgement

This book is dedicated to my wife and children, Azra, Zishan, Mehreen, Sahrish, Qurratul-Anne for their dedication, support and contributions to make this book a reality. I am also thankful for the inspiration from my senior and junior colleagues from UK and Pakistan. My thanks to Dr. Farooqui and Joyce Cummings for proof reading and Qurratul-Anne for the design and help.
Introduction to endoscopic surgery

M. Yousaf Mian

Historically the management of nasal and sinus diseases have been carried out by a variety of methods by Otolaryngologists. The evaluation of the patient has involved careful history, examination with head mirror and nasal speculum and imaging with plain x-rays. Medical management involved nasal douches, fluid displacement, sinus washouts antibiotics and decongestants. The chronic rhino sinusitis, resistant to medical treatments has been managed by intranasal inferior meatal antrostomy, Caldwell-Luc procedure, sphenoethmoidectomy and frontoethmoidectomy and lateral rhinotomy.

In the last two decades there has been great exhilaration in the management of the diseases of the nose and sinuses by otolaryngologists. This owes to the better understanding of the pathophysiology of chronic sinus diseases and has been elucidated through the tireless work of Professor Messerklinger. He observed that chronic sinusitis is usually due to the blockage in the ostiomeatal complex, an area bounded by the middle turbinate medially, the lamina papyracea laterally and the basal lamella superiorly and posteriorly. The mucociliary transport system of the sinuses occur in a definite predetermined pattern. He stated that the mucous layers in the frontal sinus moves upwards along the interseptal wall to the roof of the sinus. Then it moves laterally along the roof and medially along the floor to reach the ostium. Recirculation within the frontal recess generates some back flow into the frontal sinuses while the remainder of the mucous exits. In the maxillary sinus mucociliary movements begin on the sinus floor, rise along the wall superiorly towards the natural ostium, thus creating a dependent opening such as inferior meatal antrostomy which does not result in adequate drainage of the sinuses.

The mucociliary clearance of the nose is towards the nasopharynx due to beating of the cilia which beats in one direction in the SOL layer. The GEL layer moves passively. Drainage of the anterior group of the sinus converge below the Eustachian tube and the posterior group above it. The mucociliary clearance is an important local factor in causing the sinus infection. This depends on ciliary function, secretory activity, resorption, the integrity and continuity of mucosa and the patency of the ostia. Disease usually spread from the nose to the paranasal sinuses due to the obstruction of the delicate and narrow chambers of the ethmoid sinuses as well as the anatomical variation causing the ostiomeatal complex obstruction. This resolves when normal ventilation and mucociliary clearance is restored. This knowledge has led to the acceptance of endoscopic sinus surgery as a valuable modality in the surgical management of the sinus disorders. Several other factors also point that ostiomeatal complex is the likely site for the development of the inflammatory changes. Proctor pointed out that anterior end of the middle turbinate bears the brunt of the inspiratory airflow. Wolfsdorf demonstrated that particles of the size of 6 m are deposited in this area. It is a common finding that during surgery anterior ethmoid cells are more often involved by inflammation.

The evaluation of the patients with Nasal or Sinus symptoms now includes nasal endoscopy. This has permitted the physician a more thorough examination with modern imaging techniques particularly Computerized Tomography (CT), these techniques provide diagnostic possibilities unimagined a few decades ago.
Functional Endoscopic Sinus Surgery (F.E.S.S.) was introduced in the 1960's by Messerklinger and Wigand and popularised by Stammberger in Europe and by Kennedy in North America. The Endoscopic techniques are now well established. This has changed the management of the Nasal Sinus disease by the Otolaryngologist. For instance the operation in the frontal sinus has changed into frontal recess surgery and an operation on the maxillary sinus into a procedure on the ethmoidal infundibulum and the cells of the clefts of the nasal lateral wall. Experience with endoscopic sinus surgery has further expanded the horizons and now encompasses not only the management of the infections of the sinuses but also the treatment of the nasal polyps, nasolacrimal duct obstruction, thyroid orbitopathy, CSF leaks, drainage of orbital abscess and haematoma, decompression of the optic nerve and globe, choanal atresia, meningoencephaloceles, and surgical management of circumscribed benign and well localised malignant neoplasms. Nasal endoscopic techniques have allowed a meticulous and delicate removal of the diseases while preserving normal mucosa and structure. In short the endoscope is an instrument that helps us to preserve the normal functioning of the nose, thus avoiding the surgery of the past era!

References
Surgical Anatomy of the Lateral Nasal Wall
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In order to understand the pertinent surgical anatomy for endoscopic sinus surgery, it is paramount to study the complex anatomy of the lateral nasal wall of the nose. The ethmoid sinuses and their relations to other paranasal sinuses, ostiomeatal complex as well as the relations to the vital structure, cribiform plate, dura and roof of the ethmoid above, orbit, lamina papyracea and optic nerve laterally.

The most prominent features of the lateral nasal wall in the sagittal view are the turbinates, usually three, occasionally four, in number i.e. superior, middle and inferior turbinates with their corresponding meati (Fig. 1). They are delicate scrolls of bone, covered by ciliated columnar epithelium. The inferior meatus houses the opening of the nasolacral duct in the anterior third. This duct courses from the lacrimal sac under the agger nasi cells to its opening under the anterior end of the inferior turbinate about 3-4 cm from the anterior nares.

The ostias of anterior sinuses e.g. frontal, anterior ethmoidal and maxillary lies in the middle third of the lateral nasal wall, under the middle turbinate, termed as ostiomeatal complex by Nauman, referring to the area bounded by the middle turbinate medially, lamina prapyracea laterally and the basal lamella superiorly and posteriorly, the inferior borders being open. This description denotes that OMC is more of a functional entity rather than an anatomical unit, representing the final common pathway for drainage and ventilation of the frontal, anterior ethmoid and maxillary sinuses. (Fig. 2).

Anteriorly there is a thin bony leaflet resembling a hook called uncinate process, a part of the ethmoid bone orientated sagittally and runs in anterosuperior to posteroinferior direction (Fig. 3).
Behind this lies semilunar groove called Hiatus Semilunaris. The uncinate process is one of the three downward vertical projections of ethmoid bone (The other two are the perpendicular plate and the middle turbinate) and articulate inferiorly with the ethmoid process of the inferior turbinates. Posteriorly and superiorly the uncinate process is free and is covered by the membranous area of the lateral wall called the posterior fontanelle. Similar membranous area is present anterior and inferior to the uncinate process called anterior fontanelle. The fontanelles may be sites of accessory maxillary ostia.

The ethmoid air cells system is classified on the basis of the anatomy of the ground lamella and various ostia of the ethmoid sinuses. The ethmoid bone lies in the midline bounded superiorly by the frontal bone, posteriorly by the sphenoid and orbits laterally. It contributes to the septum via perpendicular plate inferiorly and ends up superiorly as crista galli. The cribriform plate forms the horizontal part, terminating in the lamina papyracea, lies between the crista galli and the basal lamella of the middle turbinate (Figs. 4, 5).

The basal lamella are horizontal shelves of the bone attaching the middle turbinate to the lamina papyracea. The most prominent is named, the ground lamella separates the anterior ethmoidal sinus from the posterior ethmoid sinus. In adults the ethmoid sinus measures 4-5 cm anteroposterior, 2.5 cm in height and 0.5 cm wide anteriorly and 1.5 cm posteriorly. The ethmoid labyrinth usually contains 7-11 air cells, the largest and most non-variant air cells in the anterior ethmoid complex is the ethmoid bulla. It is formed by the pneumatization the bulla lamelle or second basal lamella and is like a blob on the lamina papyracea. Above the bulla lies the suprabullar recess (Sinus Lateralis) a potential space that may leads to a retrobullar recess. The space is bordered superiorly by the ethmoid roof, laterally by the lamina papyracea, inferiorly by the roof of ethmoid bulla and posteriorly by the basal lamella of middle turbinate (Figs. 4, 6).

Ethmoid sinuses. Diagrammatic illustrations.
There is a clear and distinct separation both embryologically and in the mucociliary transport-mechanism of the anterior and posterior ethmoid by the ground lamella of the middle turbinate. The most anterior superior insertion of the middle turbinate is adjacent to the crista ethmoidalis, which produces anterior bulge, known as agger nasi cells. The posterior end of the middle turbinate is attached to the perpendicular process of the palatine bone (lamina perpendicularis).

The anterior third of the middle turbinate inserts vertically into the skull base at the lateral edge of the cribriform plate. The middle third turns laterally to be attached to the lamina papyracea. The posterior third, generally becomes horizontal and is attached to the medial wall of the maxillary sinus and the lamina papyracea and forms the roof of the most posterior part of the middle meatus. Sometimes, the middle turbinate may also contain one or more air cells. This anomaly is called concha bullosa. This may drain into an ostia posteriorly in the middle meatus.

The Hiatus Semilunaris is a crescent shaped cleft that lies in the middle meatus and is bounded by the uncinate process anteriorly and by the anterior surface of the ethmoid bulla posteriorly. The suprabullar and retrobullar recess can be entered medially and inferiorly underneath the middle turbinate through the hiatus semilunaris (Fig. 6).

The ethmoid infundibulum is the anterior most part of the anterior ethmoid cells. It is bordered medially by the uncinate process and laterally by the lamina papyracea. Posteriorly the ethmoid infundibulum extends to the anterior face of the ethmoid bulla and opens into the middle meatus through the Hiatus Semilunaris inferiorly. It houses the maxillary sinus ostium usually found at the floor of lateral aspect of infundibulum and remains hidden under the middle turbinate in the middle meatus, lateral to the uncinate process. The drainage from this area is usually seen in the middle meatus.
The frontal recess usually opens at the apex of the Hiatus Semilunaris into the infundibulum. Superiorly the ethmoid infundibulum may end blindly in the terminal recess or the recess terminalis. The maxillary and frontal sinus infundibulums are within the respective sinuses. The frontal infundibulum is a funnel shaped narrowing of the inferior aspect of the frontal sinus towards the floor of the frontal sinus ostium. Similarly the maxillary infundibulum is a funnel shape narrowing of the lumen of the maxillary sinus towards the natural ostium, though it does not narrow significantly.

In the sagittal section the frontal sinus, frontal ostium and nasal frontal recess resemble an hourglass. The medial wall of the frontal recess is the most anterior and superior part of the middle turbinate; most of the lateral wall is made of lamina papyracea. The frontal recess is the most anterior and superior part of the anterior ethmoid complex. From here the frontal bone is pneumatized resulting in a frontal sinus. Frontal recess narrows towards the ostium but then widens in inferior and posterior direction (Figs. 7-9) Sometimes this communication is narrowed and resembles a duct on the CT Scan. This is due to enlarged size of the ethmoid bulla or bulla lamelle or by an excessive pneumatization of agger nasi cell. Furthermore the frontal recess may harbour the supraorbital cell of frontal recess as a result of pneumatization of supra orbital cells. This may vary from one to seven in numbers.

Posterior ethmoid cells are two to five in numbers and lie posterior to the ground lamella. Superiorly they are in relation to the dura, posteroinferiorly to the sphenoid sinus and laterally to the orbital apex and the optic nerve. The posterior ethmoidal cells drain into superior meatus at its anterior recess.

![Frontal sinus, frontal recess and ostium, probe in the recess, middle turbinate dissected.](image)
Posterior cells can be pneumatized laterally and superiorly to the sphenoid sinus, called sphenoethmoid cells or Onodi cells. The optic nerve and carotid artery may be exposed in an sphenoethmoid cell (Onodi cell) (Figs. 10, 11 and 12). The clinical significance of this should be born in mind while operating in the area more over one should always bear in mind that the posterior part of the lateral wall of the ethmoid sinus curves inwards, therefore one should turn the instruments inwards and medially to avoid accidental damage to the optic nerve.

The Sphenoid Sinus is usually an unequal pair of sinuses located posterior to the posterior ethmoidal sinus. The sphenoid sinus shows variation in size as well as the location of intersphenoidal septum. The anterior wall of the sphenoid sinus is about 7.15 cm from the columella or inferior nasal wall. The internal carotid artery and optic nerve impression on the lateral wall of the sphenoid sinus is visible in the well pneumatized sinuses. The roof of the sphenoid sinuses presents a convex bulge corresponding to the floor of the pituitary fossa (Figs. 13 and 14).
The anterior ethmoid artery lies in the roof the ethmoid sinus just posterior to the nasofrontal recess. The anterior ethmoidal artery, a branch of the ophthalmic artery leaves the orbit via anteroethmoidal foramen, crosses the roof of the anterior ethmoidal sinus and supplies the anterior ethmoidal cells and frontal sinuses. The artery then enters the anterior cranial fossa, gives off the meningeal branches and thereafter turns downwards into the nasal cavity through the slit by the side of christa galli and returns to the roof of the nose through the cribriform plate. The anterior ethmoidal artery supplies the anterior third of the lateral wall of the nose and the corresponding part of the septum. The sphenopalatine artery, a branch of internal maxillary artery enters the nose through the sphenopalatine foramen located in the posterior part of middle meatus between the ethmoid crest and lamina perpendicularis of the palatine bone.

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The sinuses and nasal mucosa are lined by pseudostratified columnar epithelium, serous and mucinous glands. Under this mucosal layer lies a rich blood supply characterised by venous sinuses, AV anastamoses and venules due to nasal erectile tissue. The abundant vascular supply facilitates breathing by warming and humidifying the inspired air. About 2 litres of mucous is produced daily, consisting of two layers. The deeper layer is Sol layer while the superficial layer is the "Gel" layer. Co-ordinated mucosal ciliary action of the nasal cavities and paranasal sinuses propel Sol layer while the Gel layer moves passively. The ciliary movement propels the mucus towards each sinus ostium at a rate of 1cm/min. In the maxillary and frontal sinus mucous moves in a spiral pattern towards and out of the natural ostium, in the ethmoid and sphenoid the flow is directly to the natural ostium (Figs. 1-3). Drainage of anterior group of sinuses converge below the Eustachian tubes while the posterior group above it.
Sinuses ostias vary in size due to 02 tension in sinuses, mucociliary clearance, susceptibility to infection and associated anatomical variations and abnormalities. About ¾ of the bacteria entering the nose are trapped by the mucous blanket, which is antibacterial and antiviral. Sinonasal mucous blanket is renewed every 10-15 minutes. Sinonasal secretions are in equilibrium with the interstitial fluids.

By weight 95% of these secretions are water and 5% are solid. The mucous blanket normally contains mast cells, polymorphs, eisonophils, lysozymes, IgA, IgG, and interferons. Solids are macromolecular proteins predominantly glycoprotein. When the sinuses are chronically obstructed, the number of goblet cells in the sinus are increased, resulting in the increased production of glycoprotein. Sinus mucosa absorbs the water. The sinus secretion changes to loose mucous collection and may change into a mucous plug. Intrinsic viscosity of sinonasal secretion increases with a 35% protein contents, making ciliary clearance difficult (Fig. 4).

In the diseased sinuses, the membrane show no changes other than of chronic inflammation. Microscopically they present every characteristics of being able to repair themselves. In due course, when favourable conditions are provided, the most potent of which is the establishing the functional drainage pathways of sinuses, the mucosal changes are reversed. Certainly there will be no return of functional sinuses with the removal sinus mucosa which is resisting the diseases when functioning normally. Instead it will be replaced with fibrosis.

Eradication of the diseases with the restoration of normal osteomeatal ventilation is the only way to reverse the irreversible. Alternative radical procedures offer little more, with it also goes the last hope of cure of the disease by restoration of sinus function. Ventilation and mucociliary clearance are the requisites for maintaining normal sinus physiology. Functional endoscopic sinus surgery ensures this.

Increased viscosity of mucus hampering the flow.

References
Nasal Endoscopy
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Examination of the nose with an endoscope is an important diagnostic modality that yields helpful information while evaluating the patients with sino-nasal diseases. The advent of HOPKINS® nasal endoscopes has enhanced the methods of nasal examination. It has significantly improved our understanding of nasal anatomy, physiology, and pathophysiology and revolutionized the management of sino-nasal diseases. Nasal endoscopy is routinely applied not only to examine the nose, photograph and document, the normal and variant anatomy and the gross pathology in today's otolaryngological clinics around the world but also used as an essential teaching and training tool.

The nasal endoscopic examination is performed in the clinic after the anterior rhinoscopy has been performed. The nasal cavity is sprayed with 5% Lidoicaine with Phenylephrine Hydrochloride 0.5% topical solution, a few minutes before examination is performed. The 0-degree and 30°-degree scopes are used. The 2.7 mm diameter scopes are preferred over 4 mm diameter as the former is better tolerated. The patient is sitting straight with head rested on the headrest in the sniffing position. The telescope is introduced under the direct vision without making contact with the walls. Endoscope is dipped in an antifog solution before its introduction into the nose. On the first pass the scope is introduced between the septum and the inferior turbinates and advanced till the posterior choana, inspecting the inferior meatus, eustachian tube orifice, fossa of Rosen Muller and nasopharynx. Through a longitudinal rotation this allows the overview of entire nasopharynx and the eustachian tube orifice on the other side.

The second pass is made along the middle turbinate and septum to the upper edge of the posterior choana and then rolled over the posterior end of the middle turbinate into the sphenoid-ethmoidal recess. The superior turbinate and in some cases, the supreme turbinates and corresponding meatus are visualised. The sphenoid sinus ostium may be seen in certain cases.

The third pass is in the middle meatus after retracting the middle turbinate medially. The uncinate process, the hiatus semilunaris, bulla ethmoid and ethmoid infundibulum and the frontal recess is inspected. Along with it the obvious pathology and anatomical variations are inspected. The natural maxillary ostium is normally hidden in ethmoidal infundibulum towards the back end of the hiatus semilunaris. The accessory ostium may be found in the anterior or posterior fontanelle.

Nasolacrimal duct may be identified in the inferior meatus by gently massaging the lacrimal sac of the patient and visualising the tears in the inferior meatus.

The goal of the nasal endoscopy is to identify the normal anatomy, normal variants, pathology and hidden malignancy. Precise documentation of the findings together with clinical photographs if possible should be documented (Figs. 1-23).
1. Normal.
3. Prominent agger nasi cells.
4. Ethmoidal mucocele.
6. Allergic fungal sinusitis.
7. Allergic rhinitis.
8. Small nasal polyp.
9. Conchum bullosa.


In the post operative period one can clean all the crustations in the operated area under the direct vision with the help of telescope, improve and augment healing (Fig. 24).

Endoscopic examination is a simple non invasive technique which helps to identify deviated nasal septum, hypertrophied turbinates, obstructed maxillary sinus ostia, high septal spur, polyps, synachiae, concha bullosa, accessory ostia, bulla ethmoidalis, antrochoanal polyps, mucocele, foreign bodies, congenital atresia, chronic and acute sinus infections, paradoexical and bifid middle turbinate, bent uncinate process CSF leaks, fungal sinus diseases and neoplasms. A comparative study of the diagnostic value of nasal endoscopy with conventional methods found it to be a superior method of examination, indeed most of its findings were comparable with CT findings¹.

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 Imaging of Paranasal Sinuses and Nose

Z.A. Yousef, M. Yousaf Mian, R. Kukreti

Radiographic imaging of the nasal cavity and paranasal sinuses is essential for evaluation and planning. Plain film studies have been used for more than five decades by the physicians; despite the most meticulous attention to technical detail, these have substantial limitations. They correlate well only in acute sinusitis, indicated by air fluid level with both soft tissue and bone disease consistently underestimated. Accurate assessment of the bony framework, soft tissue, anatomical variation, inflammatory and other pathological lesion of the paranasal sinuses and nasal cavity has been only possible with increased availability of CT scans. It has become a popular practice to perform limited, low cost, coronal CT studies as an alternative to the plain film examination. However in view of the increased net radiation risk to the population, a careful monitoring of the clinical setting is required, so that the patient dose and examination cost are balanced by the Radiologist’s choice of the best study to provide information needed for management. Depending on the clinical need, MR examination can be performed, which has no such risks and provides more information about soft tissue of the face, head and neck, skull base and central nervous system. However the lack of optimal display of cortical bone-air interface as both display signal void make it unreliable as an operative road map.

Though nasal endoscopy reveals considerable anatomical and pathological information, the extent of the disease together with the surrounding anatomy, can only be evaluated by CT scan. The primary object being to provide a road map for endoscopic sinus surgeon by identifying the normal anatomical landmarks and variant anatomy as well as to aid the diagnosis of pathological conditions. The work of Hilding, Proctor and Messerklinger on the mucociliary clearance and air flow in the nose and sinuses point out the importance of ostiomeatal complex in the pathogenesis of the sinus disease. The successful outcome of the endoscopic sinus surgery depends upon the evaluation of pathological changes, an anatomical definition of the ostiomeatal complex by CT and the re-establishing of the mucociliary clearance and ventilation of the sinuses with functional endoscopic sinus surgery by limited resection and preserving the sinus mucosa which will become normal hence afterwards.

The coronal plane best shows the ostiomeatal complex, shows the relationship of the brain to the ethmoid roof, and correlates with the surgical orientation. The ethmoid sinuses, maxillary sinuses and its ostia, sphenoid sinuses, frontal recess and agar nasi cells, middle turbinate, uncinate process, and the basal lamella are also best visualised in this plane (Figs. 1-3). This can be accomplished by direct coronal scanning or by reformatting data acquired in the axial plane into coronal images. The axial images compliment the coronal study, particularly in visualizing the posterior walls of the sinuses, frontoethmoid junction and the sphenoeethmoid recess.

Frontal sinuses.

Middle turbinate and basal lamella.

Sphenoid sinuses.
The axial images are excellent to show the vital structures such as carotid artery, optic nerve and the relation of posterior ethmoidal cell such as Onodi cell to the optic nerve and Sphenoid Sinus (Fig. 4).

The Ostiomeatal complex is defined as the physiological unit providing airflow and mucociliary clearance to the maxillary, ethmoid, frontal and sphenoid sinuses. Anatomically the otolaryngologist refers this area bounded medially by the middle turbinate, laterally by the lamina papyracea and uncinate process, the basal lamella superiorly and posteriorly. The inferior and anterior borders are open (Figs. 5, 6).

Examination Protocol

For direct coronal scanning, the patient is placed prone on the scanning table with the chin hyper extended. The scanner gantry is angled perpendicular to the hard palate. This is important as Melhem et al. noted that variation in scan angulation greater than 10° from the plane perpendicular to the hard palate result in significant loss of anatomic detail of the structures of the OMC.

Scanning is performed as contiguous 3 mm thick images from the anterior wall of frontal sinus to the posterior wall of sphenoid sinus. The field of view is adjusted to only include area of interest. This not only reduces artefact from teeth and associated metallic restorations but magnifies the small anatomic structures of the nose and sinuses. The recommended exposure settings are 125 kVp and 80-160 mAs.
**Image Display**

Windows are chosen to highlight the air passages, the bony detail and the soft tissues. The CT scan images should be photographed on "bone" (window width of +2000 HU and a level of -200 HU) setting as well as soft tissue (window width of +250 HU and level of 45 HU) settings. The bone windows settings are best to define the detailed anatomy as well as pathology of the OMC, ethmoid sinus, uncinate process, the frontal recess, the frontal and the sphenoid sinus. However the soft tissues setting will help the physician to evaluate the pathological changes in the orbit, intracranial as well as in the nose and sinuses.

Sagittal reconstructions can be obtained for a morphological orientation. The frontal sinus appears at the age of 8 years on the X-ray. On CT scanning, the first coronal images display the outline of the frontal sinuses. They are the most variable in size, and are asymmetrical. They are aplastic in 17% of various European races, in 12% of Continental European races, in 35% of other races and 52% Eskimos. The frontal sinus drains via the frontal infundibulum to the frontal sinus ostium and then into the frontal recess, thus making an hourglass appearance (Figs. 7, 8).

The CT scan appearance of a diseased frontal sinus may vary from membrane thickening to complete opacification (Figs. 9a, b).

In acute cases an air fluid level may be visible. Mucocele appears as an opacification and expansion of the frontal sinus with the loss of haustrations septas. The osteomyelitis of the frontal sinuses will appear as Pots puffy tumours (Fig. 10).
The nasolacrimal duct appears as a vertically oriented tubular structure with well defined cortical margins filled by soft tissue, extending from lacrimal fossa to the level of the inferior turbinate (Fig. 11).

Recognition of the importance of OMC has increased the role of the radiologist to evaluate and identify different anatomical anomalies as well as pathological process in this key area. The ethmoid is a delicate bone which articulates with thirteen bones, the frontal, the sphenoid, the nasal bone, the maxilla, the palatine, the vomer and the inferior nasal conchae. The ethmoid bone consists of four parts e.g. a perpendicular plate, two labyrinths and a horizontal plate, called the cribriform plate. Each ethmoid labyrinth comprised of vertically oriented air cells up to eighteen in number that are separated so that they form honey comb of mucosa lined spaces that drain into each other. The most prominent air cell is bulla ethmoidalis, bordered anteroinferiorly by the hiatus semilunaris and infundibulum from back to front respectively. The lamina papyracea forms the lateral wall of the ethmoid sinus. The supra bullar recess may lead to a space superio-posteriorly, between the posterior wall of the bulla ethmoidalis and basal lamella called sinus lateralis (Figs. 12, 13).
The ostia of ethmoid sinus cannot be visualised by CT scan. The anterior, most intramural, ethmoidal cells are the frontal recess cells. The infundibular cells are the next most anterior ethmoidal cells, from here arise the agger nasi cells, located immediately anterior to the anterior end of the middle turbinate. Just inferior and posterior to the agger nasi cells lies the uncinate process, a boomerang shaped bone subjected to considerable variation. It is about 1-4 mm wide and 14-22 mm long, forms the medial boundary of the hiatus semilunaris. As it progresses posteroinferiorly it forms the inferior border of the hiatus semilunaris and the medial wall of the infundibulum. The infundibulum is a trough shaped cavity below the bullae, above and lateral to the uncinate process (Figs. 14-17). The variations of the uncinate process in terms of deviation, attachment and pneumatisation can contribute to impaired sinus ventilation especially in the infundibular, anterior ethmoid and frontal recess regions.
Within the nasal cavity three scrolls of bone on the lateral of the nose, covered with ciliated respiratory mucosa are the inferior, middle and superior conchae (turbinates), divide the nasal passage into the corresponding meati. The inferior concha is usually the largest and separate bone while the middle and superior conchae are the parts of ethmoid bone. The nasolacrimal ducts open in the inferior meatus.

The superior turbinate is the smallest and anchored superiorly to the cribriform plate. The middle turbinate attaches to ethmoid roof at the lateral lamella of the cribriform plate anteriorly via ground lamella. The middle turbinate inserts laterally to the lamina papyracea via the basal lamella posteriorly. The fovea ethmoidalis is separated from the cribriform plate by the ground lamella of the middle turbinate. The fovea ethmoidalis, normally is situated at a higher level, occasionally this may be reversed and worthy of notice to avoid the potential complications during surgery. The most common anatomical variation is the pneumatization of the middle turbinate called concha bullosa and is present in about 30% of the patients (Figs. 18, 19).
Concha bullosa are classified according to the degree and portion of turbinate pneumatisation. When it involves the bulbous segment it is termed bullosa, and if only the attachment portion is pneumatised it is known as lamellar concha. This may occur on one side or both sides.

The other uncommon variants are Onodi cell and Haller cells (Fig. 20).

The ethmoid sinuses are the commonest site for inflammation manifested as thickening of the mucosa. Mucocele of the ethmoid sinuses may present as proptosis or lateral displacement of the eye and most often involves the anterior ethmoid air cells (Figs. 21-27), presumably because the ostia here are the smallest.

Haller cells narrowing the OMC.

Mucocele of ethmoid sinus.
Sometimes the mucoceles may appear as hyperdense, expansile masses on CT and may extend along orbital roofs or extend cranially to thin or erode the bone and may be difficult to differentiate from tumours. In such cases MR examination may be useful as in the above case (Figs. 23a-e).

Polyps appear as expansile masses with the opacification of sinuses and without the destruction of the bony walls. The malignancies will destroy the bony walls without remodelling and will enhance with contrast (Figs. 24, 25).

Mucocele of ethmoid sinus and frontal sinuses.

Polyps involving OMC and ethmoid sinuses.
Allergic fungal Sinusitis is manifested by the involvement of sinuses with area of high attenuation between 180-320 HU surrounded by an area of hypointensity, thus creating double density due to the concretion surrounded by allergic mucin (Figs. 26-30). Fungal sinusitis is also suspected if the soft tissue changes in the sinus are also associated with thickened, reactive bone and localized areas of osteomyelitis, or if the inflammatory sinus disease is associated with involvement of the adjacent nasal fossa and the soft tissues of the cheek\textsuperscript{9,10}.

Allergic fungal sinusitis involving ethmoid and maxillary sinuses.

Nasal polyps in the ethmoid and maxillary sinuses.

Allergic fungal sinusitis.

Allergic fungal sinusitis.
The sphenoid sinus is the most posterior sinus with a variable pneumatisation and septation. They start pneumatization after the age of three years and grow to an average adult size of 2 cm high and 2.3 cm deep and 1-7 cm wide. The internal carotid artery and optic nerve are adjacent to the posterolateral aspect of the sphenoid sinus and may produce two corresponding bulges, on occasions the bony wall may be deficient. Acute sinusitis may be represented by the fluid level and the polyps in allergic fungal sinusitis may also involve the sphenoid sinuses and may erode through the walls into the surrounding structures (Figs. 31, 32).

Allergic fungal sinusitis. Sphenoid sinusitis.

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Techniques of Functional Endoscopic Sinus Surgery
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Function endoscopic sinus surgery is a conservative type of surgery aiming to restore the normal mucociliary flow of the paranasal sinuses. It is based on the findings that anterior ethmoid sinus diseases predisposes to the ethmoid infection leading to the development of maxillary and frontal sinusitis, as the complex anatomical compartment (ostiomeatal complex, OMC) contains the drainage sites of maxillary ethmoid and frontal sinuses.

If adequate drainage and ventilation can be restored sinusitis will be alleviated and the normal function of the sinuses is restored. On the basis of this Kennedy and Stammberger advocate a conservative type of surgery termed “functional endoscopic sinus surgery” popularly known as “F.E.S.S.”. Surgical correction of the ostiomeatal complex obstruction, provides sinus ventilation adequate drainage by restoring the normal mucociliary flow and access to the sinuses for topical intranasal sinus therapy.

Anaesthetic Consideration
F.E.S.S. can be performed under general and local anaesthetic. Kennedy, Stammberger, and other endoscopic surgeons prefer local anaesthetic as there is less bleeding and any undue pain indicates that one is touching dura or orbital perios- tum. In UK the general anaesthesia is preferred due to the efficiency, reduced pain, controlled ventilation, avoidance of aspiration and freedom to use the powered equipment, as well as suction irrigation. More over it is more acceptable to people who are very apprehensive of surgery and are present with advance disease.

No single approach may be suitable for every case. There are two techniques of F.E.S.S. one described by Messerklinger and other by Wigand. Modification of Messerklinger technique had been adapted in several centres of Europe and North America. For the patient with extensive nasal polyps and Sampler's Syndrome (triad of nasal polyps, aspirin sensitivity and asthma) are put on oral steroids prior to surgery, during surgery and after surgery to avoid the side effects of sudden surge of histamine, prostaglandin E1, E2 and slow reacting substances SRS.

The steroids also help to reduce the bleeding during surgery. For the patient with recurrent sinusitis we advocate to add the appropriate antibiotics 3 days before surgery. For the patients to be operated under local anaesthetic care (MAC) the nose is sprayed with 4% Cocaine or 2% Xylocaine with 1:200.000 adrenaline. Further the cotton soaked in the above solution, are applied to the nasal mucosa and middle meatus, covering the nose from the floor to the roof and extending to the nasopharynx. After 5 minutes the medial infundibular wall, uncinate process, and anterior part of the middle turbinate and ethmoidal bulla are injected with 2% Xylocaine and 1:200.000 adrenaline under endoscopic visualisation.

For the patients who are undergoing F.E.S.S. under general anaesthetic 0.5% oxymetazoline spray is applied to the nose about 30 minutes before surgery. The CT Scans are reviewed and are hung on the view box in the operating room so that the surgeon may refer to them intermittently. May I remind all the readers that no F.E.S.S. is contemplated without a coronal CT of the paranasal sinuses. The routine general anaesthesia by LMA or endotracheal is established. 4% cocaine solution or 2% lidocaine with phenyl epherine is sprayed after intubation. The patient is placed in supine position with head up and face is tilted to the surgeon who stands on the right side.

A septoplasty is performed if the septum is deviated enough to interfere with the approach to the ostiomeatal complex and if a 4 mm endoscope cannot be passed between the septum and the middle turbinate before the F.E.S.S.
Before starting the surgery a thorough nasal endoscopic examination is carried out with 30-degree scope. The endoscope is dipped in an antifog solution. On the 1st pass the scope is introduced between the septum and inferior turbinate and advanced inspecting the inferior meatus and septum, till the posterior choana is reached. Eustachian tube orifice, fossa of Rosenmüller and nasopharynx is inspected, while retracting the scope the orifice of nasolacrimal duct is visualised in the inferior meatus. The 2nd pass is made along the middle turbinate and septum and rolled over to the posterior end of the middle turbinate and into the sphenoethmoidal recess. The superior turbinate and superior meatus and sphenoid sinus ostium are visualised. The 3rd pass is in the middle meatus after retracting the middle turbinate medially, the uncinate process, the hiatus semilunaris, bulla ethmoidalis and the frontal recess is inspected. Along with it any obvious pathology like paradoxical middle turbinate, conchal bullosa, polyps or pus in the ostiomeatal complex is noticed.

The lateral wall of the nose is infiltrated with 2% Xylocaine with 1:200,000 adrenaline. The infiltration is done at various parts on the medial infundibular wall, uncinate process, anterior part of the middle turbinate and bulla ethmoidalis. Blanching of the mucosa will occur. Sublabial infiltration may be done if one plan to perform canine fossa puncture for maxillary sinus sinuscopy.

Using 0-degree telescope the uncinate process and bulla ethmoidalis are exposed by retracting the middle turbinate medially. An incision is made on the uncinate process, starting at the level of middle turbinate and going downwards following the curve of the uncinate process till just above the inferior turbinate (Figs. 1-4).
The uncinate process is fractured medially and then grasped with *Blakesley-Wilde* forceps and removed with medial twisting movement, uncapping the infundibulum. This exposes the base of the infundibulum, anterior ethmoid sinus, bullae ethmoidalis and maxillary sinus ostium. If the maxillary sinus ostium is not visible it is palpated with double ended maxillary sinus ostium seeker or olive tipped curved *Eicken* cannula (*Fig. 5*).

We prefer to identify the maxillary sinus ostium after uncinectomy due to its close relation to the orbit. This serves as a window for the visualisation and identification of the lamina papyracea and the floor of the orbit. Thus reducing the likelihood of entering the orbit. More over establishing the maxillary sinus patency is essential to the success of ostiomeatal complex surgery. Once the ostium is identical it is widened by punching out its bony walls by reverse cutting Ostrum's forceps (*Figs. 6, 7*).

It is better to enlarge the ostium in the anterior direction but one should stop short of nasolacrimal duct. The presence of dense bone anteriorly in the area of lacrimal duct is the anterior limit of the dissection in the area of maxillary sinus ostium. If further enlargement of the maxillary sinus ostium is necessary the posterior edge should be enlarged to the posterior fontanelle. A 10-15 mm diameter opening is adequate. If the uncinate process consists of very hard bone, retrograde uncino-tomy may be performed with a reverse cutting Ostrum punch forcep.
The ethmoid infundibulum is opened and the anterior ethmoid cells are removed anterior and superior to the bullae ethmoidalis. I keep the anterosuperior wall of the bullae ethmoidalis intact as it marks the junction between the roof of anterior ethmoid cells and nasofrontal recess. A 30-degree scope and upward biting forceps are necessary to remove the agar nasi cells which may be seen as making a bulge in the lateral nasal wall just anterior to the anterior attachment of the middle turbinate. These cells are opened and frontonasal recess is exposed and unblocked by removing the disease mucosa. In a sagittal section the transition from the infundibulum of the frontal sinus to the frontal recess has an hour-glass shape, the narrowest portion representing the frontal sinus ostium. The size and shape of the frontal recess may be significantly influenced by the agar nasi cells, ethmoidal bulla, uncinate process and infundibular cells (Figs. 8-12).

To avoid injury to the lacrimal sac, the orbit and anterior cranial fossa during the exenteration of agar nasi cells the surgeon must keep the tip of 45 degree upward cutting Blakesley-Wild forceps in vertical position rather than directing medially or laterally, keeping in mind the various relations the uncinate process makes to this area. The uncinate process insertion is used as a guide to enter the frontal recess and should be carefully studied by CT. After removing the polypoidal tissue the frontal sinus and infundibulum can be enlarged by circular cutting Stammberger punch forcep. The frontal sinus may be entered with 3 mm long olive tipped curved Eicken antrum cannula or with the curved curtte.
The safest way to enter the bulla ethmoidalis is to penetrate the inferomedial wall with straight Blakesley-Wild ethmoid forceps using the 0-degree scope. The contents of the bulla ethmoidalis and the middle ethmoid cells are removed, the basal lamella may be identified as a bluish grey thin sloping bony septum between the bulla ethmoidalis and posterior ethmoid cells that lie superior and posterior to bulla ethmoidalis (Figs. 13-17).

Superiorly the dissection must stop on reaching the ethmoid roof where sometimes the anterior ethmoid artery can be identified and mark the superior limits of the dissection. The roof of the ethmoid is formed by the frontal bone that curves upward as it goes laterally. Medially it is thin and dips down sharply to join the cribriform plate. While removing the diseased cell in this area, the tip of the Blakesley-Wild forceps should be directed laterally to avoid accidental perforation of the cribriform plate. The middle turbinate attachment to the skull base is useful landmark to remember and one should not violate this. The lamina papyracea forms the lateral limits of the dissection and can be recognised by slightly yellowish tinge because of orbital fat. The cells in this area are removed by the cutting edge of the forceps. The basal lamella makes the posterior limit of the dissection if the CT shows no disease in the posterior ethmoid sinus or sphenoid sinus.
For the extensive disease involving the posterior ethmoid and sphenoid sinuses, the posterior ethmoid sinus is entered by gently penetrating the basal lamella by straight Blakesley-Wild forceps (Figs. 18, 19). The posterior ethmoid cells are carefully removed until the anterior wall of the sphenoid sinus. Kerrison forceps are safer to remove the posterior ethmoidal cells. It should be noted that lateral wall of ethmoid sinus curves inward and the posterior ethmoid cells are intricately related to the orbital apex and optic nerve laterally. Also the effort is made to stay away from the superior attachment of the middle turbinate, as the bone is paper thin and vulnerable to penetration, resulting in the CSF leak. The surgeon must be on his guard by continually checking of the depth of his surgical field (Fig. 20).

Posterior ethmoidectomy.  Opening and enlarging the sphenoid ostium.

Checking the depth of the surgical field.
The sphenoid sinus is entered inferiomedially by perforating the posterior wall of posterior ethmoid with straight Blakesley-Wild forceps using 0 degree scope. The anterior wall of sphenoid sinus is identified by locating the posterior attachment of the middle turbinate and the arch of the posterior choana. It is about 1.5 cm above the posterior choana and 7.1 cm from the anterior nasal spine on average. Sphenoid sinus wall and ostium should be palpated and identified in this area before entering the sinus. Sphenoid has postero-inferior and medial relation to posterior ethmoid sinus, therefore the forceps should point inferiomedially while entering the sphenoid sinus via the posterior ethmoid.

Extreme caution is necessary while removing the disease like polyps and fungus from the sphenoidal sinus. They should always be removed under direct vision. Fungal concretion can be extracted by irrigation and mobilisation with Eicken antrum cannula. The superior portion of the lateral wall of the sphenoid sinus is dealt with extreme caution due to the close proximity of the optic nerve and internal carotid artery. The optic canal may be dehiscent in about 4% of the cases in the superolateral wall of the sphenoid sinus.

For the extensive disease of maxillary sinus, which cannot be dealt with enlarged natural ostium, an inferior meatus antrostomy can be performed. 30 degree scope is introduced to inspect various part of the maxillary sinus through the natural ostium and the disease can be removed from the various parts of the maxillary sinus through the inferior meatal antrostomy.

Direct visualisation of maxillary sinus can also be achieved by canine fossa puncture with a Trocar and Canula. The sublabial sulcus is injected with 2% Xylocaine and 1:200,000 adrenaline. The upper lip is lifted with Hijeck retractor and the infraorbital notch is palpated to avoid injury to the infraorbital nerve. The tip of the Trocar is placed in the suprolateral part of the canine fossa and with a screwing movement the sinus is entered. Care must be taken not to injure the posterior sinus wall with a forceful entry. A 30-degree scope can be introduced to inspect various parts of the maxillary sinus. To deal with extensive disease the scope is held in through the Trocar and the instruments are introduced through the middle meatus antrostomy.

We pack the nose with merocel soaked in naseptin ointment after checking the allergy to pea nuts. The rapid rhino packs are useful alternate. In the post operative period the patient is given a course of broad spectrum antibiotic if necessary, saline nasal or sinus rinse douching, decongestant drops and steam inhalation with regular visit to the clinic for the nasal toilets are helpful tools for speedy healing.

**Indication for external approaches to frontal sinus**

1. The case in which annoying symptoms are present which have resisted all the available conservative measures.
2. The release of pus under pressure in severe cases with threatening complication.
3. The removal of cells and growths within the sinus which are encroaching in the ostium.
4. The treatment of malignant growths, osteomas and inflammatory conditions with bone involvement.
5. The endonasal approach to the frontal sinus surgery under the telescope may be difficult.

Two reasons may exist:

a) Frontal sinusitis is not as frequent as ethmoid and maxillary sinuses, hence lack of operative experience.

b) Frontoethmoidal transition varies greatly in anatomy.
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Post Operative Care

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Planning for postoperative care starts during the surgery. The common problem leading to obstruction of the outflow at the ostiomeatal complex is usually the tendency of adhesion formation between the middle turbinate and lateral nasal wall. At the termination of procedures, middle meatus should be left as wide as possible. An attempt is made to restore the normal anatomy by minimising the trauma to the turbinates. For the concha bullosa or an enlarged and oedematous middle turbinate I use diathermy needle on the incision line before reducing the middle turbinate to minimise the bleeding as the instrumentation of this narrowed part is difficult with the crushing forceps and may lead to the development of adhesions.

I invariably pack the nose with mercels dressing soaked with Naseptin ointment for three to four hours or with rapid rhino absorbable dressing, while others believe not to pack the nose. As most of the cases are done under GA in the UK we tend to extubate the patients when they are still in deep sleep as the bleeding may start if the patient is coughing and bucking. For GA most of us prefer LMA over the traditional endotracheal tube. Patients may be discharged on the same day if there is no bleeding after removing the pack. The patients with medical problems need to stay overnight to stabilise their condition.

There is considerable diversity in the postoperative treatment. I like to use broad-spectrum antibiotics if pus is found at the time of surgery. For simple nasal polyps I tend not to use antibiotics except when the surgery time has increased and is complicated by prolonged bleeding. For allergic fungal sinusitis I start the steroids and anti-histamine as soon as the diagnosis is made. I also like to start the nasal douching with alkaline saline nasal douches two to three days post operatively accompanied by the steam inhalation. Decongestants drops may be used for one to two weeks to minimise the discomfort. The patient may be able to make his own irrigation by adding one teaspoon of soda bicarb in one litre of water or alternately already made sinus rinse douching can be used. The mixture should not irritate or sting when being used. Following irrigation he should use the steam inhalation with menthol crystal or other similar product. This may be continued for three to four weeks to discourage the crustations and until the healing has occurred.

The patient should be seen at the end of the second week. The nose is then sprayed with 5% Lidocaine with Phenylephrine Hydrochloride 0.5% and a thirty-degree scope with a 2.7 mm diameter is passed to visualise the healing process. The examination is performed while the patient is in a sitting position and the standard three passes are made to visualise the nose, lateral wall and ostiomeatal complex. All the crustations are clears by suction (Figs. 1-3).

Crustation in the maxillary ostium.

Maxillary ostium after healing.
The nasal douching continues afterwards if required. Our routine follow up spans a period of six weeks in view of the fact that after surgery the mucociliary functions at the ostiomeatal complex are impaired for six weeks. During this period, fibrin, mucous secretions and blood clots tend to stick within the nasal cavity and ostiomeatal complex area, causing patients discomfort and predisposing to post operative infection and scarring.

Apart from synechia in the ostiomeatal complex, other factor which may result in poor healing are post operative infection, stenosis of maxillary sinus ostium, frontonasal recess and sphenoid sinus ostium as well as recurrence of polyps. Due to frequent complications of synechia or lateralization of middle turbinate some surgeons have used barriers or splints within the ostiomeatal complex to prevent these complications. We believe that such barriers are potentially capable of causing retention of clots, increase risk of infection and delay healing. However if adhesions are already present, after breaking them there is a case for such barriers insertion to prevent recurrence. For early recurrence of nasal polyps we recommend early application of steroid nasal spray.

References
Complication of F.E.S.S.

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Several key structures are closely related to operative field of endoscopic sinus surgery and hence carry the risk of potential complications by damaging these structures. To minimize the risk the surgeon must familiarise himself with surgical anatomy by cadaver dissection and studying the CT scan prior to surgery. There is a learning curve as evident from Stankiewicz reports, who stated 6% major complications and 13 minor complications in the first ninety cases. He compared the rate of complications with his next ninety cases. This dropped to 1% major and 1% minor complications. In our series we have one CSF leak in the first one hundred cases and 7% minor complication rate and the next three hundred and fifty cases, we have one orbital emphysema and twelve other minor complications. Several studies have demonstrated further decline in the incidence of complications. Dessi noted 1.2% overall complication rate.

There are several aspects that may impact regarding the risk of F.E.S.S. Several studies have cited massive polyposis prior to surgical interventions, anti-coagulants therapy, use of non-steroid anti-inflammatory drugs and long-standing disease. Familiarity with endoscopic anatomy and its variation together with the skill and experience of the surgeon plays a large part in determining the risk and adverse outcome. The close proximity of the ethmoid sinuses to the skull base, dura, brain, optic nerve and orbit, mandate continuous monitoring of one’s position during surgery. Ohniski identified five high-risk areas during F.E.S.S. The lamina papyracea, its fragility and relation to the uncinate process is the area frequently violated. Injury may predispose to the medial rectus entrapment and transection. The roof of ethmoid and anterior ethmoid artery is also susceptible. The fracture of attenuated ethmoid roof is a common cause of the CSF leak. The lateral lamella of the cribriform plate is an area in which one has to take great care, when dealing with superior ethmoid air cells. When working with an upward biting forceps it is important to remember that the ethmoid roof slopes rather steeply towards the cribriform plate which is at a lower level. The surgeon must not dissect medial to the superior attachment of the middle turbinate, the preservation of which is a landmark of critical importance. In addition, the area between the posterior ethmoid and the sphenoid sinus is of critical significance. The dura may be breached just superior to the anterior wall of the sphenoid sinus. There may also be anatomical variations predisposing the inadvertent injury to the optic nerve or carotid artery. The thick buttresses should not be taken down as fracture planes may run into the carotid artery bony canal with possible pseudoaneurysm formation or fistulisation to the cavernous sinus.

If CSF leak does occur, the area should be packed with adrenaline soaked patties to achieve haemostasis. The site of the dura tear should be identified accurately. The area should then be covered with temporalis fascia, or septal mucoperichondrium graft. The fibrinogen glue should be applied and the middle turbinate rotated into the defect. This should be kept in place by gel foam, morcel packing and BIPP packing.

The anterior ethmoid artery is also in the susceptible location and injuring the artery laterally can predispose to either significant haemorrhage into the field or the orbital haematoma if the vessel retracts in its bony canal. The posterior ethmoid artery and roof is usually not problematic but may present with dehiscent artery lying inferior to the roof.

Orbital complications, ecchymosis around the orbit, orbital emphysema, retro orbital haematomata, diplopia, injury to the extra ocular muscles and blindness may occur due to injury to the optic nerve. Injury to either anterior or posterior ethmoid artery or penetration of the lamina papyraceae can lead to peri-orbital or lid ecchymosis and proptosis (Fig. 1).
This needs to be addressed immediately otherwise it may result in persistent elevation of the intra-ocular pressure with compromise venous outflow leading to retinal ischaemia and blindness.

Under general anaesthesia, during surgery the eyes must be exposed and checked regularly. The middle meatal antrostomy is useful adjunct to visualise the floor of the orbital and the beginning of lamina papyracea, which is superior and lateral to the natural maxillary ostium. Several studies have cited the greater evidence of orbital complications in the left side by the right-handed surgeon. This is due to how the right-handed surgeon perceives the location of the ethmoid sinuses. On the right, they lie directly posterior to the 0° degree visualisation. On the left the scope orientation alters the view, giving the surgeon the impression that the lamina papyracea is more lateral when in actuality it is more medial. Gentle palpation of the eyeball while dissecting in this area will point out the lamina papyracea or the breech if it has occurred (Figs. 2a, b).

If the signs of orbital haematoma are present (Fig. 3), the nasal packs should be removed and immediate ophthalmic consultation should be requested and steps taken to reduce the intraorbital pressure. Acetazolamide 500mg IV can reduce intraorbital pressure by decreasing aqueous humour production. However its onset of action is slow. A dose of 1-2 grams per Kg of Mannitol over 20-30 minutes is usually effective and aids osmotically by drawing fluid out of the orbital spaces. If the medial management fails, lateral canthotomy has proven effective or orbital decompression should be considered.

Nasolacrimal duct stenosis due to F.E.S.S. is uncommon. It is believed that the nasolacrimal duct is injured more frequently, but few cases result in epiphora. The nasolacrimal duct lies about 4-6 mm anterior to the maxillary sinus ostium and is marked by the advent of hard bone. While using the backward biting forceps the surgeon should stop at this juncture.

The synechia may develop between the middle turbinates and the lateral nasal wall due to the large raw area as a result of surgery. This may lead to the obliteration of middle meatus and reoccurrence of the disease, and should be prevented by careful cleaning of the nasal cavity in the post-operative period. If the synechia are present, a revision of the surgery should be done and the expander be kept in situ until the healing has occurred.
References

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Allergic Fungal Rhinosinusitis

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Allergic Fungal Sinusitis (AFS) resembles allergic bronchopulmonary aspergillosis, resulting from hypersensitivity reaction to fungi mediated by IgE and IgG. A study of 20 patients from 1990 to 1998 suffering from AFS revealed that all presented with nasal polyps. Most had atopic with raised serum IgE and high eosinophil count. Sandwiched between polyps are dark greenish brown concretions with high metal contents. A high concentration of glycoproteins and macromolecular protein was found in the contents. The lesion showed high attenuation on CT and void signal on MRI due to the presence of metals. Aspergillus was the most frequently found fungus followed by Bipolaris, Helminthosporium and Curvularia. Polyps are surrounded by allergic mucin and Charcot-Leyden crystals interspersed with fungal hyphae. The eosinophilic host response to the fungi in the susceptible individuals leads to cascade of inflammatory reactions initiating IgE mediated hypersensitivity, specific T-cells HLA receptor expression and aberration of local mucosal defense mechanism resulting in AFS.

The first description of allergic fungal sinusitis (AFS) as a new entity appeared in the literature in the early 1980s. Katzenstein et al. were the first to describe in detail the entity of AFS in immune competent young adults. He described allergic Aspergillus sinusitis (AAS) that had histopathological similarities to allergic bronchopulmonary aspergillosis (ABPA), a well-known entity first described by Hinsen et al. The diagnostic criteria were nasal polyps, chronic sinusitis involving multiple sinuses with histological findings of "allergic mucin" including sheets of degenerated eosinophils, Charcot-Leyden crystals and interspersed segmented branching fungal elements which were most probably Aspergillus. The initial terminology and description of allergic Aspergillus sinusitis by Katzenstein and then by Waxman et al. is now universally used for AFS. Macmillan was the first to note that fungus Culvularia lunata can also cause a similar clinical syndrome of AFS as with Aspergillus. Since then a number of fungi causing AFS have been reported. These include Helminthosporium, Bipolaris specifera, Exserohilum rostratum, Alternaria alternata, Cladosporium and Bipolaris australiensis. As the clinical evidences started mounting, pointing to an allergic pathogenesis a number of question were raised about the fungi involved, role of IgE and cell mediated inflammatory responses different regional patterns of the disease and the treatment modalities and their outcomes.

Twenty patients were evaluated suffering from nasal polyps and a possible diagnosis of AFS from March 1990 to March 1998. There were 15 male and 5 female patients with an average age of 24 years. All the patients were immunocompetent. Blood and sera of each patient were tested for eosinophilia, serum specific IgE, total IgE and radio-allergo-sorbent test (RAST). The radiological assessment was done by CT and MRI with intravenous iodinated contrast media. MRI was later discontinued. CT scans were done initially without contrast. Tissue and inspissated debris and concretion from the nose and involved sinuses were sent for biochemical assays, histological and mycological studies. Histological studies of the polyps were done with formalin fixed, paraffin embedded, haematoxylin eosin stained sections. Representative sections were also stained with Gomori methenamine silver (GMS) stain. Material from all the patients was collected in a sterile container and sent for culture in mold inhibitory agar and Sabouraud's dextrose agar. Concretions from the sinuses were sent for chemical assays. The Dimension Clinical Chemistry System was used for analysis and quantitative determination of the suspected elements (9 cases were assayed). Black charred concretions were washed with water before analysing.
The histological diagnosis was based on the findings of branching segments of fungal hyphae interspersed throughout "allergic mucin", consisting of thick often inspissated mucus containing numerous eosinophils as well as Charcot-Leyden crystals (degradation products of eosinophilic granules) and absence of tissue invasion.

The clinical features and radiological findings of 20 patients are summarised in Table 1.

The duration of the symptoms ranged from 5 months to 3 years before presenting in the clinic. The mean age at the time of presentation was 24 years (range from 12-47). The male to female ratio was 15 to 5. The presenting feature in all patients was intranasal polyps causing nasal obstruction, headache and chronic sinusitis.

### Table 1: Clinical features and radiological findings

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<td>Aspergillus</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>37</td>
<td>M</td>
<td>Aspergillus</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>
None of the patients were immune compromised: 60% had a history of atopy and 20% had asthma. The CT scan revealed high attenuation material filling the sinuses and nose (HU 180-320). There was also a thin surrounding zone of lower attenuation separating it from the bone. Furthermore, there was expansion and erosion of the sinus walls and nasal cavity (Figs. 1, 2).

The most commonly involved sinuses were maxillary and ethmoid (Tab. 2) with a tendency towards pansinusitis. There was also erosion of the skull base in four cases but no evidence of intracranial spread (Fig. 3).

On the other hand the MRI sequence of events was entirely different showing mixed intensity lesions on T1 weighted images and an even lower signal or void signal intensity lesions on the T2 weighted images (Figs. 4a, b) making it impossible to differentiate from the aerated sinuses. Therefore the CT scan of the sinuses was used as a primary modality as the assessment of the disease was more accurate. During surgery the polyps were found to be immersed in allergic mucin and inter-spersed with dark greenish brown concretion in the nose, osteomeatal complex and the involved sinuses.
Histopathologically, the polyps were characterised by distended, dilated mucous glands, with myxoid stroma, thick inflammatory exudates and more sulphated mucin than ordinary polyps. The polyps were surrounded by thick allergic mucin, containing eosinophils with abundant Charcot-Leyden crystals. Fungal hyphae were identified within the allergic mucin by both hematoxylin-eosin and GMS stains. The hyphae were widely scattered, septated and interspersed with Charcot-Leyden crystals (Figs. 5-13).
Sulphated mucin.

Fungal hyphae.

Thick inflammatory exudates.

Distended Mucus glands.

Charcot-Leyden crystals.
The serological test showed that 17 patients (85%) had raised serum IgE (range between 150 IU/ml to 832 IU/ml). Specific IgE antibodies were raised to Aspergillus in nine cases. All nine patients demonstrated positive IgE RAST for Aspergillus (only available for this fungus in our hospital). Fourteen patients (70%) showed a high eosinophil count.

Intraoperative fungal cultures were positive in 17 patients (85%). Cultures from the involved sinuses failed to yield any fungal organism in three patients. These showed allergic mucin with Charcot-Leyden crystals only. Aspergillus fumigatus was the most common organism cultured (9 patients), followed by Bipolaris (4 patients), Helminthosporium (2 patients) and Culvularia (2 patients) (see Tab. 1). Fungi were identified by the use of a microslide culture technique. A chemical assay of concretion from the sinuses showed a higher concentration of iron, calcium, copper, magnesium and zinc (Tab. 2). These elements were chosen for analysis because they are known to be essential in fungal amino acid metabolism.

Although fungal infection of the paranasal sinuses has been recognized for a long time AFS has only recently been described. Stammberger et al.\textsuperscript{12} reported that Aspergillus couldn't actively penetrate undamaged and intact mucous membranes and skin as they lack keratolytic enzymes. On the basis of these findings the Fungal Rhino sinusitis has been classified into (A) invasive and (B) non invasive types. The non-invasive type, covers the whole spectrum of saprophytic fungal ball and allergic fungal sinusitis. The invasive type compassing (a) chronic indolent affecting both immune competent or immune compromised individuals (b) acute fulminating type, affecting immune compromised individuals and (c) sclerosing type. This classification covers considerable spectrum of the disease. At one end is extra mucosal fungal ball due to Aspergillus and is readily cured by the removal of fungal material. On the other hand, acute fulminating invasive fungal disease is due to Mucor in immune compromised individuals, resulting in massive soft tissue and bone necrosis as result of rapid angioinvasion and gangrenous necrosis and is often associated with fatal outcome\textsuperscript{13}.

---

**Tab. 2: Nasal Polyps in Allergic Fungal Sinusitis**

<table>
<thead>
<tr>
<th>Elements</th>
<th>Average Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium</td>
<td>1.30 µmol/gm</td>
</tr>
<tr>
<td>Iron</td>
<td>4.56 µmol/gm</td>
</tr>
<tr>
<td>Copper</td>
<td>0.24 µmol/gm</td>
</tr>
<tr>
<td>Magnesium</td>
<td>0.02 µmol/gm</td>
</tr>
<tr>
<td>Zinc</td>
<td>0.86 µmol/gm</td>
</tr>
</tbody>
</table>
AFS is being increasingly recognised as a distinct clinical entity since its description from the early 1980s. The disease typically occurs in immune competent individuals with histological features identical to ABPA. Clinical, immunological and histological findings leave one to believe that a combination of Gell and Coomb Type I (immunoglobulin E) and Type III (immune complex) hypersensitivity to fungal antigen provides the basis for the pathophysiology of AFS on the model of ABPA. Manning reported that patients suffering from AFS with positive Bipolaris culture demonstrated a positive skin reaction to Bipolaris and in addition, all tested positive by RAST and ELISA for IgE and IgG Bipolaris antibodies. Furthermore the sinus mucosa of AFS patients was analysed by immunohistochemistry for the eosinophilic inflammatory mediator major basic protein (MBP) and eosinophil derived neurotoxin (EDN) and neutrophil elastase. All AFS cases demonstrated evidence of eosinophilic mediator release, MBP and EDN predominance over neutrophil elastase, suggesting that AFS is an antigen triggered, IgE and IgG mediated hypersensitivity response.

The prevalence of AFS is unknown. The diagnosis of AFS should be suspected in young individuals who are immunocompetent with a strong history of atopy, and asthma (60% and 20% respectively in our series). Goldstein et al. reported a history of atopy in one third of the patients and a history of asthma in another third. All our patients presented with nasal polyps, a mucoid discharge and occasional blowing out of greenish brown concretions. There were raised serum IgE levels in 85% of the individuals with another 70% having a raised eosinophil count.

The non-contrast axial and coronal CT of paranasal sinuses reveals multi sinus involvement with areas of attenuation up to 180-320 Hounsfield units surrounded by an area of hypointensity, thus creating “double density” in all our cases. This is postulated on the basis of metal contents in the concretion (Tab. 2), e.g. calcium, iron, zinc, manganese. The surrounding hypo-intense area is due to allergic mucin and polyps as these concretions are found sandwiched between the polyps and allergic mucin in the involved sinuses, osteomeatal complex and nose. Normally the sinonasal secretion consists of a complex solution of 95% water and 5% macromolecular protein, predominantly mucous glycoprotein. Therefore in health the predominant water will have a long T1 and T2 relaxation time on MRI imaging, corresponding to low T1 weighted and high T2 weighted signal intensities. When the sinuses are chronically obstructed the concentration of mucous, glycoproteins and allergic mucin leads to desiccated stone like plugs. Iron contents of the concretion found in AFS magnetize the local field under MRI. The mixture of semi-solid and solid proteins with iron in the concretion have an ultra short T2 relaxation time expressed as low signal intensities and signal voids on both T1 weighted and T2 weighted MRI images (Figs. 4a, b). Thus a distinction may not be possible from an aerated sinus. On the other hand the CT shows characteristic double density images predicting the contents of the sinuses while the air appears black. Moreover the chronic bone changes can be identified more accurately on CT. It is suggested that CT should be used as the first modality of imaging. The diagnosis of AFS has been based on histological criteria: (i) thick inspissated mucous containing numerous eosinophilis as well as Charcot-Leyden crystals, (ii) branching segments of fungal hyphae interspersed throughout the allergic mucin, (iii) absence of tissue invasion. Although the erosion of the bone by the polyps allowed the disease to escape the confines of the sinuses and compress the adjacent structures e.g. dura, orbital contents, but no true invasion occurred. Affected individuals may develop compression symptoms e.g. proptosis, epiphora, diplopia and even permanent loss of vision.
The prevalence of a species of cultured fungus in AFS has varied in the reported series. We identified 17 fungal organisms (Tab. 1). In three specimens no organism could be identified either by culture or histopathologically. The diagnosis was based on criteria discussed above. The lack of fungal hyphae has most likely resulted from inadequate sampling due to the presence of degenerated or sparse fungal hyphae. Another possibility is that histologically unrecognisable agents may be responsible for the production of allergic mucin without fungus. Among the cultured fungi 45% were Aspergillus and 30% from the Dematiaceous family (Tab. 1). While reviewing the literature Torres reported 81% of the cultured fungal species were members of the Dematiaceous family and 16.6% the Aspergillus family. This variation reflects local prevailing environments but also confirms the belief that AFS is most often the consequence of allergic reaction to fungus genera. The pathogenesis of AFS is not known and has been largely extrapolated on the module of ABPA. Manning et al. reported that all of their 20 cases with a histological diagnosis of AFS reacted positively to at least one fungal antigen. Moreover 15 of these patients tested positive to two fungal antigens, indicating either a higher degree of shared antigenic epitopes among these fungi or multiple sensitivity among the patients. The complex immunological reaction results in increased oedema and inflammation of the osteomeatal complex causing obstruction of the sinuses. Inhalation and trapping of the spores then allows the mold antigen to react with IgE-sensitized mast cells. Impacted mucin adds to the stasis of sinus and mucosal reactions; thus the disease probably starts in the osteomeatal complex.

A review of our cases suggests that clinical manifestation of the disease exhibits on a wide spectrum ranging from scant allergic mucin to an extreme atopic state, a massive polypoidal non-invasive expansile disease with a dark greenish brown discharge, which has no clinical or histological evidence of invasion of the surrounding tissue. The polyps may erode into the bone extending to the skull base and orbit causing an ophthalmic symptoms and facial deformity (Fig. 3). Our pathologists have not witnessed vascular invasion, granulomatous reaction or subsequent evidence of invasion but have observed bone erosion and tissue necrosis. Moreover there has been strong evidence of IgE mediated fungal hypersensitivity in immunocompetent atopic patients and the presence of allergic mucin with a few scattered fungal hyphae. We concur with those authors who postulated an immunological mediated hypersensitivity in the pathogenesis of AFS.

Although evidence is mounting to support a true allergic pathophysiology in AFS, many authors are reluctant to discount entirely an infectious component in the aetiology of AFS, therefore treating AFS with surgery, steroids and systemic anti-fungal medication. Zieske et al. reported six cases with Dematiaceous fungal sinusitis that were treated with amphotericin B in addition to surgery. All patients had allergic mucin but four showed submucosal erosion of the fungus within mucosa or bone perhaps representing the change of spectrum from AFS to chronic indolent sinusitis. We have never encountered a vascular invasion granulomatous reaction, metastatic spread of infection or change of the spectrum with a histological diagnosis of AFS even if it recurs. Recurrence may be related to the severity of an atopy extension of the disease or incomplete eradication. Surgical approaches should be tailored to individual need e.g. a functional endoscopic sinus surgery, or microscopic endonasal surgery may be used alone or combined with the traditional external approaches if the frontal sinuses are also involved to achieve eradication of the disease and establish a drainage system, essential to reduce the recurrences.
In spite of adequate surgical clearance, drainage and aeration of sinuses and treatment with steroids the recurrence of disease is common. Follow up of our cases from 6 months to 8 years showed that all except two had recurrence disease (Tab. 3). This can be attributed to short course of steroid therapy and inadequate aeration of the sinuses and extensive disease. Indeed two cases that did not recoccur had the multiple sinuses involved only on one side and had prolonged treatment with systemic steroids and non-sedative antihistamine followed by the topical steroid and non-sedative antihistamine. Recurrences are common perhaps due to the remaining fungal spores reproduced within the inspissated sinus mucin, inciting an antibody host response. This leads to increased inflammation and swelling of sinus mucosa with decreased drainage and stasis. The respiratory epithelial lining which already suffered from the disregulation of ionic transportation processes and an increased sub-epithelial accumulation of electrolytes and water succumbs to the insults, resulting in the recurrence of the whole disease process. Therefore we strongly recommend long-term treatment with low dose systemic steroids and non-sedative antihistamine for 3 months followed by topical steroids and non-sedative antihistamine for another 2-3 years guided by the mucosal response and endoscopic findings at the follow-up. In our opinion, an early detection, an appropriate surgery and a vigilant follow up is a key to control the disease.

The allergic fungal sinusitis (AFS), have great propensity to reoccur. The disease involves multiple sinuses and nose and often results in severe expansile sinusitis with raised IgE, allergic mucus and eosinophilia. A high index of suspicion occurs in an atopic individual presenting with nasal polyps, a double density on CT and void signals on MRI. This may be due to metal contents in concretions with surrounding mucin and polyps. The present study of 20 patients strongly advocates an allergic pathogenesis. Defining effective treatment strategies is not easy due to common recurrences. Surgical drainage and removal is essential from the diagnostic and therapeutic standpoint followed by system steroids and a non-sedative antihista mine administration. To prevent the recurrence, topical steroids and non-sedative antihistamine should be administered for a long time, perhaps indefinitely.

Tab. 3: Involved sinuses and recurrences

<table>
<thead>
<tr>
<th>Sinus involved</th>
<th>No. of procedures</th>
<th>Recurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pan sinusitis</td>
<td>3</td>
<td>No recurrence</td>
</tr>
<tr>
<td>Maxillary, ethmoid and frontal</td>
<td>2</td>
<td>Recurrence</td>
</tr>
<tr>
<td>Maxillary and ethmoid</td>
<td>1</td>
<td>No recurrence</td>
</tr>
<tr>
<td>Pan sinusitis</td>
<td>3</td>
<td>Not available Not</td>
</tr>
<tr>
<td>Maxillary, ethmoid and frontal</td>
<td>2</td>
<td>available</td>
</tr>
<tr>
<td>Maxillary, ethmoid and sphenoid</td>
<td>2</td>
<td>Recurrence</td>
</tr>
<tr>
<td>Magnesium</td>
<td>2</td>
<td>Not available Not</td>
</tr>
<tr>
<td>Maxillary, ethmoid and frontal</td>
<td>2</td>
<td>available</td>
</tr>
</tbody>
</table>
References


Trans Nasal Endoscopic Ligation of Sphenopalatine Artery

Epistaxis is a common ailment experienced by humans from the earliest of time. Hippocrates described the remedy as "application pressure on the nose". Its prevalence in the population is about 10-12%, however only 10% of these seek medical attention.

There are two areas often implicated in the epistaxis, Kesselback plexus giving rise to anterior nasal bleed and Woodruff's plexus, causing posterior bleed. The maxillary sinus ostium being the dividing line between anterior and posterior nose bleeds. Severe and intractable epistaxis is usually posterior in origin, requiring more intensive care and hospitalization. Patients whose bleeding cannot be controlled by conservative methods are treated by surgical intervention that includes embolization, endoscopic coagulation and arterial ligation.

The transmaxillary sinus arterial ligation of the internal maxillary artery has been the gold standard and most commonly used procedure for the management of intractable epistaxis with a success rate of 80-95%. Although most authors have described the risk to be low, others have stated small, but significant risk of sinusitis, oro-antral fistula, paraesthesia, dental injury and neuralgia of the intra orbital nerve. Recurrent epistaxis after this procedure has been due to extensive collateral bleed flow of the sphenopalatine artery and multiple branches of the internal maxillary artery in the Pterygomaxillary fossa, making it difficult to recognise the sphenopalatine artery. Moreover, this procedure requires general anaesthetic, which can be a significant risk to an elderly and anaemic patient. Microsurgical ligation of sphenopalatine artery was introduced by Parades. With the advent of endoscopic sinus surgery, the ligation of the sphenopalatine artery has become very popular, initially reported by Budrovich and Sactti 1992.

The sphenopalatine artery is the largest and terminal branch of the internal maxillary artery that transverses the sphenopalatine foramen, that is located most commonly at the posterior end of the middle meatus, just below the most posterior attachment of the middle turbinate. The distribution of the sphenopalatine artery parallels that of the maxillary nerve and contributes the major blood supply to the nose and sinuses. The 1st branch of the sphenopalatine artery passes from the foramen posteriorly supplying the sphenoid sinus and associated nasopharynx. The main artery divides into medial and lateral division providing the vascular supply to the posterior two thirds of the nose and para nasal sinuses. There is rich anastomosis between the ethmoid arteries (internal carotid system) and the lateral branches of the sphenopalatine artery, contributing to the vascularization of the lateral nasal structure i.e. ethmoid, maxillary and frontal sinuses, as well as turbinates and meati. The medial branch of sphenopalatine artery crosses anteriorly on the inferior surface of sphenoid sinus and over the posterior part of the roof of nose and enters the nasal septum where it divides into the anterior and posterior branches. Anteriorly it also anastomoses with the ethmoid arteries, as well as, branches from the palatine artery which gain access through incisive canal i.e. Kesselback plexus. Thus the sphenopalatine artery is the main vascular supply of the nose and para nasal sinuses, and is often named as the 'artery of epistaxes'.


**Technique**

In our experience, the endoscopic ligation of the sphenopalatine artery can be performed under local as well as general anaesthetic, we prefer general anaesthetic as it increases patient comfort and decreases the risk of aspiration of blood. After induction of general anaesthesia, the nasal packings are removed and the nose is packed preferably with ribbon gauze soaked in 10% cocaine solution diluted in 10 ml of water. Alternatively 5% lidocain with phenyepiphrine (0.5%) can be used. The packing is directed in to the middle meatus, particularly the posterior most position. The packs are removed and the middle meatus lining is injected with 1% xylocaine with 1:200,000 adrenaline posterior to the maxillary antrum. The '0' degree endoscope is introduced, uncinotomy is performed and maxillary sinus ostium is recognised and widened (middle meatal antrostomy), creating an additional window for inspection as well as a referral point. The bulla ethmoid may have to be resected for additional exposure. The incision is then made vertically up in the middle meatus, starting from the upper border of the inferior turbinate behind the middle meatal antrostomy and about 1 cm anterior to the posterior attachment of the middle turbinate (Figs. 1, 2)

Using an elevator (*Freer or Cottle*) the mucosa of the lateral nasal wall is elevated. It is easier to start inferiorly. The designed mucoperiosteal flap is elevated towards the posterior end of the middle turbinate (Fig. 3), exposing the underlying vertical plate of the palatine bone. The sphenopalatine neurovascular bundle can be readily exposed and identified as it transverses the sphenopalatine foramen (Fig. 4) which lies just posterior to the upper and posterior end of the vertical plate (perpendicular) of the palatine bone. We prefer a barrel shaped flap.

![Middle meatus and maxillary ostium.](image1)

![Incision.](image2)

![Mucoperiosteal flap.](image3)

![Sphenopalatine artery transversing the foramen.](image4)
The sphenopalatine artery can be ligated with titanium endoclips or may be coagulated. In case the main artery has already branched, the different branches can be identified and coagulated. At the same time, one should look for other bleeding sites and deal accordingly. The nose is packed with surgicell and rapid rhino nasal packs (Figs. 5, 6).

In our experience, the routine anterior packing is not always necessary. Moreover, the sphenopalatine foramen and its neuromuscular bundle may vary. The foramen may open into the superior meatus or may be divided by the bony ethmoid crest. This may need to be removed before the ligation of sphenopalatine artery.

Nasal endoscopic ligation of the sphenopalatine artery is a simple reasonable and effective procedure for intractable severe posterior epistaxis and should be considered first among the options for definite management of posterior epistaxis. Our experience shows a high success rate and shortening of hospital stay with low morbidity (Tab. 1).

Coagulation of the sphenopalatine artery.

Packing of the operated area.

### Tab. 1: Patients with Recurrent Epistaxis

<table>
<thead>
<tr>
<th>Age</th>
<th>Sex</th>
<th>Possible cause</th>
<th>Treatment</th>
<th>Anaesthesia</th>
<th>Morbidity/ complication</th>
<th>Hospital stay</th>
</tr>
</thead>
<tbody>
<tr>
<td>38</td>
<td>M</td>
<td>Idiopathic</td>
<td>SPA ligation and selective coagulation and ant packing</td>
<td>GA</td>
<td>Nil</td>
<td>7 days</td>
</tr>
<tr>
<td>65</td>
<td>M</td>
<td>Aspirin and hypertension</td>
<td>SPA ligation</td>
<td>GA</td>
<td>Nil</td>
<td>4 days</td>
</tr>
<tr>
<td>77</td>
<td>M</td>
<td>Warfarin</td>
<td>SPA ligation</td>
<td>LA</td>
<td>Nil</td>
<td>2 days</td>
</tr>
<tr>
<td>63</td>
<td>F</td>
<td>Idiopathic</td>
<td>SPA ligation and septoplasty and ant packing</td>
<td>GA</td>
<td>Nil</td>
<td>4 days</td>
</tr>
<tr>
<td>67</td>
<td>F</td>
<td>Aspirin</td>
<td>SPA ligation, selective coagulation and ant packing</td>
<td>GA</td>
<td>Synechiea</td>
<td>3 days</td>
</tr>
<tr>
<td>47</td>
<td>M</td>
<td>Idiopathic</td>
<td>SPA ligation septoplasty and ant packing</td>
<td>GA</td>
<td>Nil</td>
<td>2 days</td>
</tr>
<tr>
<td>69</td>
<td>F</td>
<td>Warfarin</td>
<td>SPA ligation</td>
<td>LA</td>
<td>Nil</td>
<td>5 days 73</td>
</tr>
<tr>
<td>38</td>
<td>F</td>
<td>Aspirin and hypertension</td>
<td>SPA ligation and selective coagulation</td>
<td>GA</td>
<td>Crustation</td>
<td>4 days</td>
</tr>
</tbody>
</table>

M = male; F = female; SPA = sphenopalatine artery, ant packing; anterior packing; GA = general anaesthesia; LA = local anaesthesia
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Endoscopic Dacryocystorhinostomy (DCR)
M. Yousaf Mian, P. Stoney, E. Khadem, M. K. Yousef

Over the past decade, with the advent of the endoscopic sinus surgery there has been renewed interest in the endoscopic DCR. Endoscopic DCR was first described by McDonogh. Since then the techniques have improved as the understanding of the anatomy and the ability to achieve reliable and consistent results have improved.

The endoscopic DCR is indicated in the management of epiphora that is associated with primary acquired nasolacrimal duct (NLD) obstruction or NLD obstructions secondary to infiltrate or inflammatory mechanisms and as a complication of previous nasal surgery or facial trauma. The contraindications for endoscopic DCR are neoplasm obstructing the lacrimal flow, entropion, ectropion, punctal abnormalities and blepharitis.

Anatomy
The lacrimal excretory system consists of the main lacrimal glands, 10-12 secretory ducts, puncta, canaliculi, lacrimal sac and nasolacrimal duct. Tears are collected in the medial canthus, where they drain into the upper and lower puncta, 0.3 mm opening situated about 5-6 mm from the canthal angle, on the summit of small papillae of the upper and lower eyelids. From each punctum the canaliculus passes vertically about 2 mm to a receptacle called ampula. From ampula the canaliculus extends about 6-8 mm medially travelling through the orbicularis muscle before joining the lacrimal sac. The inferior and superior canaliculus formed together to form common canaliculus in 90-94% of the people before joining the lacrimal sac. During any probing procedure, the eyelid should be pulled laterally to straighten these channels to prevent injury. The common canaliculus and lacrimal sac are located between the anterior and posterior limbs of the medial canthal ligament. Prior to entry to the lacrimal sac the common canaliculus dilates slightly to form the sinus of Maier. It then enters the posterolateral wall of the lacrimal sac at the common internal punctum, creating an angle to form the valve of Rosenmuller. This prevents retrograde reflux of the tears from the sac (Fig. 1).
Surgical Technique

Endoscopic DCR can be performed under local or general anaesthesia. Adequate local anaesthesia is achieved by installation of topical proparacaine or tetracaine in the conjunctival sac. Intravenous short-acting sedatives and hypnotics may enhance patient comfort. 2% xylocaine with 1:200000 adrenaline or 0.75% bupivacaine is administered to provide an intraorbital nerve block. Local anaesthesia is also administered in the medial canthal region and medial eyelids. The nose is sprayed with 5% lidocaine with 0.5% phenylephrine solution. A ribbon gauze or 2 cm neuroplagets soaked in 10% cocaine solution is applied anterior to the point of insertion of the middle turbinate, the axilla of the middle turbinate and 1 cm area above it. If general anaesthesia is used, decongestion of the nasal mucosa is achieved by spraying 5% lidocaine with 0.5% phenylephrine solution and applying the cocaine soaked ribbon gauze or neuroplagets.

The lacrimal sac is a membranous conduit lined by modified respiratory epithelium. On average it is 12-15 mm in height and extends 3-5 mm superior to the medial canthal ligament to form the fundus. It lies in the depression, the lacrimal sac fossa, formed by the frontal process of the maxillary bone anteriorly and a thin lacrimal bone posteriorly. Intranasally the lacrimal sac lies an average of 8.8 mm above the insertion of the middle turbinate. The middle turbinate and lacrimal sac (dotted line).
Surgery begins by assessing the nasal septum particularly for any significant deflection in the region of the axilla of middle turbinates, which may need to be corrected by septoplasty for adequate exposure. The point of insertion of the middle turbinates and the lateral nasal wall and maxillary line are important landmarks for identifying the lacrimal sac (Fig. 3).

This area is identified and infiltrated with 2% xylocaine and 1:20000 adrenaline. We prefer a 0 degree scope but a 30 degree scope may be used. A flap is raised 5 mm posterior and 8-10 mm above the axilla of the middle turbinate, the incision is brought 10 mm anterior to the axilla on to the frontal process of the maxilla. The incision is then turned vertically downwards and backwards towards the insertion of the uncinate under the middle turbinate (Fig. 4).

While raising the flap one should be careful over the junction of the frontal process of the maxilla with the thin lacrimal bone. To expose the lacrimal sac the bony lacrimal fossa needs to be uncovered. The identification of lacrimal fossa can be enhanced by transillumination (Fig. 5). The Rosen knife (from ear instuments) is used to fracture the thin lacrimal bone (Fig. 6).

The free frontal process of the maxilla is removed by the Higek punch. The rest of the thick bone us removed by powered endoscopic microdebrider with a rough diamond 2.5 mm DCR bur (Fig. 7). Care should be taken not to damage the sac. As the posterior superior bone is removed the mucosa from the agger nasi cell is encountered. The inferior or superior punctum is dilated as the Bowmans lacrimal probe is passed and the tip of the probe is visualised with the endoscope, tenting the lateral wall of the lacrimal sac.
The lacrimal sac is then incised vertically for the whole length by using the lacrimal spear knife (Fig. 8). The marsupialisation of the lacrimal sac is achieved by reflecting the mucosa of the lacrimal sac on the lateral nasal wall. The silastic O'Donaghue tubes are passed through the upper and lower canaliculus (Figs. 9, 10).
We use the Diode laser to open the canaliculi if required, before inserting the O'Donaghue Tubes. The tubes are then tied in the nasal vestibule in such away to allow the appropriate length and tension of the silicon tubing to loop on the puncta and the medial canthus (Fig. 11). A neuroplaget soaked in mitomycin C is applied to the operated area in the nose. The flap is then incised to allow it to wrap around the O'Donaghue tube (Fig. 12) and held in place by rapid rhino packing (Fig. 13). O'Donaghue tubing are removed after 8-10 weeks.
Results

A successful outcome is defined as a patient who is asymptomatic and has a healed patent lacrimal ostium with a free flow of fluorescence from conjunctiva to the nose. The success is influenced by the anatomical versus the functional block. Wormald and Tsirbas noted a success of 97% in patients who has anatomical obstruction but only 84% in patients who had functional outflow impairment. The reported outcome of endoscopic DCR is summarised. Our results are comparable with an overall success of 84% with one year follow up (Tab. 1).

Our recent data shows that result have improved over previous years due to 'the learning curve' and gained experiences.

Tab. 1: Result of endoscopic DCR

<table>
<thead>
<tr>
<th>Author</th>
<th>Number</th>
<th>Success Rate</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tripathi et al.</td>
<td>46</td>
<td>89%</td>
<td>Laser assisted</td>
</tr>
<tr>
<td>Tsirbas Wormald</td>
<td>44</td>
<td>89%</td>
<td>Lacrimal and nasal mucosal flap</td>
</tr>
<tr>
<td>Massegar et al.</td>
<td>96</td>
<td>93%</td>
<td>Hammer, chisel, mucosal flap</td>
</tr>
<tr>
<td>Javate, Pamintuan</td>
<td>117</td>
<td>98%</td>
<td>Radiofrequency, double stent, motomycin C</td>
</tr>
<tr>
<td>Mian et al.</td>
<td>62</td>
<td>84%</td>
<td>Mucosal flaps, mitomycin C</td>
</tr>
</tbody>
</table>

Complication

In our series the most common complications we have encountered are infection (17%), followed by displaced tube (7%) (due to internal migration), granuloma and nose bleed.
References


7. TRIPATHI A, LESSER TH, O’DONWELL NP et al.: Local anaesthetic endonasal endoscopic laser dacrocystorhinostomy: analysis of patients acceptability and various factors affecting the success of this procedure. Eye 2002; 16 (2): 146-9


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