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Introduction

Rhinosinusitis is manifested clinically by an inflammatory response involving the upper respiratory airway tract including the following: the mucous membranes (possibly including the neuroepithelium) of the nasal cavity and paranasal sinuses, fluids within these cavities, and/or underlying bone. Broadly speaking, rhinosinusitis is defined as an inflammation and/or infection involving the nasal mucosa and at least one of the adjacent sinus cavities. Traditionally this condition was called sinusitis but the Task Force on Rhinosinusitis believes that for issues of clarity the entity should be referred to as rhinosinusitis to reflect that the condition affects the nasal passages and the sinus mucosa simultaneously. Rhinosinusitis syndromes are discussed in temporal terms and the disease state is categorized by how long symptoms have been present. The incidence of rhinosinusitis in the United States has been estimated at 14% of the adult population as determined by surveys conducted.

Acute rhinosinusitis (AS) is defined as the persistence and worsening of upper respiratory symptoms for greater than a 7-day period but less than 4 weeks. Subacute rhinosinusitis (SAS) is defined as nasal symptoms lasting 4 weeks to 12 weeks. The infectious pathogens involved in SAS are similar to those found in AS. [11] Acute Bacterial Rhinosinusitis (ABS) is the fifth most common diagnosis, in the primary care setting, prompting antibiotic administration and accounts for 0.4% of ambulatory diagnoses. The economic burden of this disease is greater than $1.77 billion per year. Acute rhinosinusitis may lead to chronic rhinosinusitis (CRS).

CRS diagnosis is symptom based and requires persistence of patient complaints of mucosal inflammation for more than 3 consecutive months despite optimal medical therapy or episodes have occurred more than four times a year with persistent radiographic changes. Chronic Recurrent Rhinosinusitis (CRRS) consists of multiple episodes of sudden worsening of CRS with return to baseline between episodes. Typically the acute symptoms are alleviated but

the chronic symptoms persist. Rhinosinusitis is rarely life threatening, but the close proximity of the paranasal sinuses to the central nervous system, the multiple fascial planes of the neck, and the associated venous and lymphatic channels can lead to serious complications.

Incidence and Epidemiology

CRS ranks fifth compared to all diseases in frequency of antibiotic use associated with treatment. CRS affects approximately 32 million persons each year and accounts for 11.6 million visits to physicians' offices. Internationally, CRS is a common disease, particularly in places where atmospheric pollution levels are high. Damp, temperate climates along with higher concentrations of pollens are associated with a higher prevalence of this disease in the northern hemisphere. Epidemiological data for CRRS is scarce due to physician to physician variability in diagnosis and uncertainty in differentiation between CRS and CRRS.

Anatomy

Embryology

Classic anatomic treatises attribute initial paranasal sinus development to lateral nasal wall ridges called ethmoturbinals. A series of five to six ridges first appear during the eighth week of development; through regression and fusion, however, three to four ridges ultimately persist the first ethmoturbinal regresses during development; its ascending portion forms the agger nasi, while its descending portion forms the uncinate process. The second ethmoturbinal ultimately forms the middle turbinate, the third ethmoturbinal forms the superior turbinate, and the fourth and fifth ethmoturbinals fuse to form the supreme turbinate. These structures are all considered to be ethmoid in their origin. An additional ridge, the maxilloturbinal, arises inferior to these structures. This ridge ultimately forms the inferior turbinate but is not considered ethmoid in its embryologic origin.

In addition to the ridge and furrow development, a cartilaginous capsule surrounds the developing nasal cavity and has an important role in sinonasal development. Bighman et al. highlighted the role of the cartilage capsule through cross-sectional histologic analysis of fetal specimens. At 8 weeks, three soft-tissue elevations or preturbinates are seen that correlate to the future inferior, middle, and superior turbinates. At 9 to 10 weeks, two cartilaginous projections invade into the soft tissue preturbinates. An additional soft tissue elevation with an underlying cartilaginous bud emerges at this time, corresponding to the future uncinate process. This structure enlarges, and by 13 to 14 weeks, a space develops lateral to the structure that corresponds to the ethmoidal infundibulum. By 16 weeks, the future maxillary sinus begins to develop from the inferior aspect of the infundibulum. The cartilaginous structures resorb or ossify as development progresses. The cartilaginous capsule, therefore, plays an important role in sinonasal development

The ethmoid sinus is commonly referred to as “the labyrinth” due to its complexity and inter-subject variability. Fortunately, several rhinologists and surgeons have reduced the complex ethmoidal labyrinth of the adult into a series of lamellae on the basis of embryologic precursors. These lamellae are obliquely oriented and lie parallel. With experience, these structures are relatively easy to recognize during surgery and are invaluable in maintaining orientation in

ethmoid procedures. The first lamella is the uncinate process; the second lamella corresponds to the ethmoidal bulla; the third is the basal or ground lamella of the middle turbinate; and the fourth is the lamella of the superior turbinate. The basal lamella of the middle turbinate is especially important, as it divides the anterior and posterior ethmoids. The frontal, maxillary, and anterior ethmoids arise from, and therefore drain into, the middle meatus. The posterior ethmoid cells arise from, and therefore drain into, the superior and supreme meati, while the sphenoid sinus drains into the sphenoethmoid recess. The lamellae are relatively constant features between human subjects, making intra-operative recognition important.

Agger Nasi

On anterior rhinoscopy, a prominence can be easily appreciated at and just anterior to the middle turbinate's insertion into the lateral nasal wall. This region was designated the agger nasi, taken from the Latin agger, meaning mound or eminence, and nasi, meaning nose. This mound or eminence is a very consistent feature on nasal examination. In many but not all cases, the agger nasi region is pneumatized by an anterior ethmoid cell, referred to as the agger nasi cell. This cell usually takes its origin from the superior aspect of the infundibulum or the frontal recess region. The agger nasi cell is bordered anteriorly by the frontal process of the maxilla, superiorly by the frontal recess/sinus, anterolaterally by the nasal bones, inferomedially by the uncinate process of the ethmoid bone, and inferolaterally by the lacrimal bone. The intimate relationship of the cell to the lacrimal bone readily explains the finding of epiphora in select patients with sinus disease. The agger nasi can also be important in frontal sinusitis and its treatment. The superior aspect of the cell serves as the anteromedial floor of the frontal sinus and a significant portion of the anterior border of the frontal recess. This is relevant for understanding the pathophysiology of frontal sinusitis and the surgical treatment of the frontal sinus. The agger nasi can pneumatize inferomedially to pneumatize the uncinate process. In a small percentage of patients, the pneumatization can be significant, and bulla formation of the uncinate may occur.

Uncinate Process

The uncinate process is most easily appreciated by viewing a sagittal gross anatomic specimen after deflecting the middle turbinate superiorly. This ethmoid structure is nearly sagittally oriented, nearly paralleling the ethmoidal bulla. It is approximately 3 to 4 mm wide and 1.5 to 2 cm in length. Through most of its course, its posterior margin is free as it has no bony attachments. The hiatus semilunaris lies directly behind the posterior margin of the uncinate (Figure 1–3). Anteriorly and superiorly, it attaches to the ethmoidal crest of the maxillae, just inferior to the lateral attachment of the anterior aspect of the middle turbinate and agger nasi. Directly inferior to this, it fuses with the posterior aspect of the lacrimal bone. Its anterior inferior aspect does not have a bony attachment.

Posteriorly and inferiorly, the uncinate attaches to the ethmoidal process of the inferior turbinate bone. The attachment here is thick, and the uncinate often splits or widens in this region to fuse with the stouter inferior turbinate bone. At its posterior and superior limit, the uncinate also gives off a small bony projection to attach to the lamina perpendicularis of the palatine bone. The uncinate has no bony attachment anterior and posterior to its attachment to the inferior turbinate bone. Here, the lateral nasal wall is made not of bone but rather middle meatal mucosa, a small layer of intervening connective tissue, and sinus mucosa. These areas are referred to as

the anterior and posterior fontanelles. The posterior fontanelle is much larger and more distinct than its anterior counterpart. An opening into the maxillary sinus, the accessory ostium, can often be seen here and can be mistaken for the natural maxillary sinus ostia. Accessory ostia are frequently encountered in the posterior fontanelle region, occurring in approximately 20 to 25% of patients. Returning to its superior aspect, the uncinate projects posterior and superior to the middle turbinate attachment and most commonly bends laterally to insert on the lamina papyracea of the orbit. Inferior and lateral to this portion of the uncinate lies the superior aspect of the infundibular air space, the recessus terminalis. Superior and medial to this portion of the uncinate (most commonly) lies the floor of the frontal recess. Alternatively, the uncinate can attach centrally to the skull base or medially to the superior aspect of the vertical lamella of the middle turbinate near the turbinate's insertion to the cribriform plate. It can also fuse with an anterior ethmoid cell, such as the agger nasi. Stammberger highlights that the superior portion of the uncinate can divide to attach to the lamina papyracea, skull base, and middle turbinate. Each leaflet can develop variably to produce partial or complete septations with accompanying inlets. The inlets vary as well, from shallow, blind pouches to small cells and, of course, include the native frontal recess. These observations underscore the complexity and variability of this region.

The uncinate process forms the anteromedial boundary of the ethmoidal infundibulum. For most of its course, the uncinate is a three-layer structure, comprising nasal or middle meatal mucosa on its anteromedial aspect, ethmoid bone, and infundibular mucosa on its more posterolateral aspect. The most common orientation of the uncinate to the lateral wall and lamina papyracea is approximately 140°; however, there is a significant amount of variability. The uncinate can be displaced laterally against the orbit, as commonly occurs in maxillary sinus hypoplasia, or it can be displaced medially, as commonly occurs in cases with extensive polypoid disease within the infundibulum. In select cases, the uncinate is displaced medially to such an extent that it recurves on itself and has been misinterpreted is a duplication of the middle turbinate. Additionally, in a small percentage of cases, the uncinate process can be pneumatized. An appreciation of uncinate variability is important. If lateral displacement of the uncinate with accompanying atelectasis of the infundibulum is not appreciated during infundibulotomy incision, inadvertent orbital injury can occur.

Ethmoid Bulla

The ethmoid bulla is one of the most constant and largest of the anterior ethmoid air cells. It is located within the middle meatus directly posterior to the uncinate process and anterior to the basal lamella of the middle turbinate. The cell is based on the lamina papyracea and projects medially into the middle meatus. The cell has the appearance of a bulla, that is, a hollow, thin-walled, rounded, bony prominence. Superiorly, the anterior wall of the ethmoid bulla can extend to the skull base and form the posterior limit of the frontal recess. Posteriorly, the bulla can blend with the ground lamella. Anatomic variations can occur in the ethmoid bulla. When highly pneumatized, the ethmoid bulla can be one of the largest ethmoid air cells and can lie in the lower aspect of the middle meatus. In select cases, a low-lying bulla can potentially narrow the ethmoidal infundibulum and impair mucociliary transport and ventilation. The ethmoid bulla is formed by pneumatization of, and behind, the second basal lamella or bulla lamella. When unpneumatized, a bony projection from the lamina papyracea results and is referred to as the torus lateralis.3 It is estimated that this occurs in approximately 8% of subjects.

Hiatus Semilunaris

The hiatus semilunaris can be more easily understood by translating the Latin roots directly into English: hiatus, a gap, cleft or passageway, and semilunaris, crescent-shaped. Indeed, the hiatus semilunaris is a crescent-shaped gap between the posterior-free margin of the uncinate process.

Ostiomeatal Unit

The ostiomeatal unit is not a discrete anatomic structure but refers collectively to several middle meatal structures: the uncinate process, the ethmoid infundibulum, anterior ethmoid cells, and ostia of the anterior ethmoid, maxillary, and frontal sinuses. The ostiomeatal unit is a functional rather than an anatomic designation, coined by Naumann in discussing the pathophysiology of sinusitis. He emphasized that a small amount of obstruction in this critical region could lead to significant disease in the larger frontal and maxillary sinuses.

Frontal Recess and Sinus

The frontal sinus drains into the middle meatus and nasal cavity through a complex passage. Review of the anatomic nomenclature of this region has produced much discussion. Several authors describe a “nasofrontal duct” that forms the nasofrontal connection. Anatomic dissection reveals that a true duct, that is, “a tubular structure conducting any fluid,” does not exist. In an attempt to refine the nomenclature and more accurately characterize the anatomy, the term frontal recess has been recommended. The frontal recess is the most anterosuperior aspect of the anterior ethmoid sinus that forms the connection with the frontal sinus. The boundaries of the frontal recess are the lamina papyracea laterally, the middle turbinate medially, the posterosuperior wall of the agger nasi cell (when present) anteriorly, and the anterior wall of the ethmoid bulla posteriorly. If the anterior wall of the ethmoid bulla does not reach the skull base and form a complete posterior wall, the frontal recess may communicate with the suprabullar recess. The frontal recess tapers as it approaches the superiorly located internal os of the frontal sinus; above the os, it again widens, as the anterior and posterior tables diverge to their respective positions. An hourglass-like appearance is evident, with the narrowest portion being the frontal ostium. There is tremendous variation with respect to the pattern of the nasofrontal connection. The anatomic complexity of this region is better understood when the effect of the surrounding ethmoid cells, such as the agger nasi cell, frontal cells, and supraorbital ethmoid cells, are considered. An intimate relationship therefore exists between the agger nasi cell and the frontal recess. Secretions from the frontal sinus destined for the nasal cavity usually follow a path through the frontal recess and over the posterior and medial surface of the agger nasi cell. If the agger nasi cell is extensively pneumatized, the frontal recess can be relatively narrowed, and hence the patient may be predisposed to frontal sinusitis. In surgery, an extensively pneumatized agger nasi can be mistaken for the frontal recess or sinus. If a large agger nasi cell is opened and mistaken for a frontal sinus, the residual superoposterior wall of the agger nasi cell can scar posteriorly to the ethmoid roof, and iatrogenic stenosis or obstruction of the nasofrontal connection can occur. In addition to the agger nasi cell, there are other ethmoid cells that have an intimate relationship with the frontal recess. Van Alyea reported that approximately 50% of anatomic specimens had anterior ethmoid cells that encroached into the frontal sinus, and that one-third of these encroached into the area of the frontal ostium. He termed these cells “frontal cells.” Schaeffer pointed out that anterior ethmoid cells could pneumatize sufficiently into the

frontal sinus to give the appearance of duplication of the sinus. Stammberger points out that "from the frontal recess, anterior ethmoid cells can develop into the frontal bone along side the frontal sinus." These were called "the bulla frontalis" by Zuckerkandl.

Ethmoid Roof

An area that deserves special attention is the ethmoid roof. From its orbital plate, the frontal bone sends an extension across the ethmoids, which are open superiorly, to join with the lateral lamella of the cribriform plate. The extension of frontal bone forms the ethmoid roof, which is indented by various ethmoid air cells and clefts to form indentations or foveolae: specifically, the foveolae ethmoidales ossis frontalis. The ethmoid roof may vary in its orientation from being nearly horizontal to nearly vertical; however, in most patients, the ethmoid roof lies above the level of the cribriform plate, and therefore, the roof has a superomedial aspect. The medial aspect of the ethmoid roof is formed by the lateral lamellae of the cribriform plate, also known as the lamina lateralis of the lamina cribrosa because it projects superiorly or superomedially from the cribriform plate. Keros has described three types of skull-base conformations that have clinical relevance in sinus surgery. In type one, the olfactory sulcus is 1 to 3 mm deep, the corresponding lateral lamella is short, and there is a significant portion of frontal bone that backs the ethmoid roof, making the roof thick and the sinus less hazardous to operate in. In type two, the olfactory sulcus is 3 to 7 mm deep, and the corresponding lateral lamella forms a considerable portion of the medial ethmoid roof. In type three, the olfactory sulcus is 7 to 16 mm deep, and the ethmoid roof lies at a significant level above the cribriform plate. The thin lateral lamella is a much larger component of the roof, and a significant portion of the ethmoid roof is not backed by thick frontal bone, making this the most hazardous sinus to operate in. Extreme caution must be exercised when operating along the skull base, especially medially in the region of the thin lateral lamellae of the cribriform plate. In an anatomic study using microscopic techniques, the extension of frontal bone that backs the ethmoid roof measured 0.5 mm, while the lateral lamella was noted to be only 0.2 mm thick. At the ethmoidal sulcus, a groove in the lateral lamella for the anterior ethmoidal artery, the bone measured only 0.05 mm, a 10-fold reduction in the thickness of the roof.

Patient Evaluation

When evaluating a patient for complaints related to sinus symptoms it is important to pay close attention to the following aspects (in addition to a complete history and physical), a detailed chief complaint, history of allergies, asthma, aspirin sensitivity and polyps. In patients with a history of with CRS, it is important to note facial pain, congestion, nasal obstruction, drainage and hyposmia. Of note a review of the medical care a patient has received prior to evaluation is also important.

A complete head and neck exam should be completed with particular attention to basic ocular examination such as visual fields, extraocular eye movement and a basic visual acuity. Anterior rhinoscopy should be performed to evaluate septal deviations, character of mucosa, and the presence of polyps. Nasal endoscopy (typically 30° or 45°) should be used to evaluate the nasal floor, nasopharynx, middle meatus, and sphenoethmoidal recess.

Pre-operative evaluation includes a review of CT imaging. A technique used at UTMB is the CLOSE Technique.

- **C** – Cribriform – Asses for Keros type, asses asymmetry
- **L** – Lamina Papyracea - Check for dehiscence or pathologic fractures to avoid injuring vital structures.
- **O** – Orbits, Onodi cell, Optic Nerve – Check for dehiscence of the optic nerve in the sphenoid sinus, asses the presence of Onodi cells (superior-lateral to sphenoid) and determine the angle of the orbital slope
- **S** – Sphenoid, Skull Base - Assess for Carotid dehiscence and aeration patterns such as Conchal, Pre-sellar, & Sellar (thickness of clivus).
- **E** – Ethmoid Arteries – evaluate the location of the artery and the presence of a mesentery around the artery.

Functional Endoscopic Sinus Surgery – Concepts of Surgery

Significant controversy reigned throughout the 20th century with regard to the extent of surgery that should be performed in chronic sinusitis. Debate is sure to continue until the pathogenesis of chronic sinusitis is better understood. The concept of “irreversibly diseased” mucosa that needs to be surgically removed has now largely been eliminated. Indeed, the problems associated with exposure of bone from mucosal stripping during surgery have been increasingly appreciated. Moriyama and colleagues have shown that denuded bone results in extremely delayed healing. The bone may remain exposed for 6 months or more, and ciliary density may never return to normal at these sites. Greater emphasis thus should be placed on mucosal preservation within the ethmoid sinus during surgery. The initial understanding of functional endoscopic sinus surgery (FESS), namely, that drainage of the involved sinuses is sufficient to induce disease resolution, currently has been modified somewhat, based on continued improvement of the understanding of the disease process.

Controversy in Sinus Surgery

ANTROSTOMY

Several theoretic considerations need to be kept in mind when considering the most appropriate size of antrostomy opening. Experimental evidence clearly demonstrates that, in rabbits, exposure of the maxillary sinus to airflow results in dramatic slowing or cessation of mucosal clearance. Theoretically, therefore, the maxillary sinus ostium and the maxillary sinus mucosa should ideally remain protected from airflow. Additionally, it has been demonstrated that nitric oxide is actively liberated from the sinus mucosa at levels that may reach bacteriostatic concentrations.8 Theoretic advantages would appear to exist for keeping the surgically created ostium small. On the other hand, a significant part of the medial wall of the maxillary sinus is composed of the uncinate process, and this bone frequently displays osteitic changes. When the uncinate process is diseased and not completely resected, persistence of disease and scarring are typically seen at this site. Therefore, when disease is very mild, a minimal opening of the ostium, if necessary at all, is preferable. However, in the presence of long-standing diffuse chronic sinusitis, when there is evidence of osteitis on CT or at the time of surgery, or when there is a strong likelihood that significant local care may be required to the maxillary sinus following surgery, a wide middle meatal antrostomy, with careful and complete removal of the uncinate process anteriorly and inferiorly, is preferable. In addition, if the maxillary sinus extends medially so that the medial wall posterior to the antrostomy is displaced into the nasal air- flow,

this medially displaced wall should be removed posteriorly to the pterygoid plate, to avoid air being directed into the sinus cavity during inspiration.

FRONTAL SINUSOTOMY

The frontal sinus continues to present the surgeon with the most challenge, both in terms of the surgical procedure and in terms of the potential for persistent and recurrent disease. At minimum, exploration of the frontal recess commits both the patient and the surgeon to a prolonged period of postoperative care and endoscopic observation. At worst, unnecessary exploration of the frontal sinus or inadvertent stripping of mucosa in this area can result in prolonged morbidity and multiple surgical procedures. Therefore, the most difficult decision in FESS is whether the frontal recess should be explored. In some cases of frontal sinus involvement, it is clearly better to perform just an ethmoid dissection and then monitor the patient to see if the frontal recess disease resolves. The decision should, in part, depend on the surgeon's experience, the regional anatomy as seen on CT, and the availability of through-cutting mucosal-sparing instrumentation, as well as on the pathology present. Preoperative evaluation of the frontal sinus and frontal recess anatomy requires careful evaluation of the coronal and axial CT. A reconstructed sagittal view, as provided in computer assisted stereotactic navigation, is also of benefit, particularly in cases of complicated frontal recess pneumatization. In evaluating the frontal recess for potential surgical intervention, attention is paid to its size in the anteroposterior and lateral diameters, the presence of neo-osteogenesis, and an evaluation of the underlying disease process. Additionally, attention should be paid to the extent of the pneumatization of the frontal sinus itself, as a hypoplastic frontal sinus appears to be significantly more likely to result in frontal recess stenosis than one that is well pneumatized, irrespective of the anatomy of the frontal recess. One possible explanation for this phenomenon is that mucociliary clearance from a well pneumatized sinus is greater than from a hypoplastic sinus, and mucociliary flow may aid in maintaining patency.

Balloon Sinuplasty

Balloon sinuplasty was developed in 2006 and this new iteration of it is considered different from prior french biliary catether in that the new technique can fracture bones. Kennedy concluded in a recent study that this technique may lead to bacterial introduction and subsequent osteitis, mucositis, and mucoceles.

Bolger et. al. published results in 2007 in which he demonstrated the usefulness of balloon sinuplasty. The trial involved a 24 week follow up and they enrolled 115 patients. Exclusion criteria for the study was patients with extensive sinonasal polyps, prior surgery, or cystic fibrosis. At 24 weeks the patency of the frontal sinus was noted to be 80%, 17.9 % of the sinuses could not be assess secondary to normal anatomy of the area and only 1.6% of patients were non-patent. Revision surgery was required in three sinuses (1%) and three patients (2.75%), in addition SNOT-20 scores were shown to improve with balloon sinuplasty alone. Of note, they only reported 9 cases of bacterial sinusitis, which were all managed with oral antibiotics. No other adverse events reported.

Extended Maxillary Antrostomy

The extended maxillary antrostomy has been advocated by some R. Casiano in cases where maxillary sinus disease is refractory to medical and prior surgical treatment. His group has published a small series with impressive results. In their description of the procedure they state the middle meatal sinusotomy is opened widely anteriorly (up to NLD), posteriorly to post wall of max sinus, superiorly to roof of max sinus and inferiorly to inferior turbinate. The inferior maxillary antrostomy performed inferiorly into the inferior meatus, post to Hasner's valve (lacrimal punctum). They noted 60% of patients had a complete symptomatic response and 50% of the patients had no evidence of disease upon nasal endoscopy.

Conclusions

Functional endoscopic surgery is a complex and constantly evolving field with new techniques, instruments and approaches continually described. The most important aspect to remember when performing sinus surgery is that one must be safe and the best way to assure one is safe is to have an excellent understanding of the anatomy of the paranasal sinuses. Even in the advent of image guidance, it is paramount to have a good understanding of the proximity of structures to avoid damage to them. The second most important aspect of sinus surgery, as in all other surgery, is understanding the indications and knowing what type of surgery is best fitted for each individual patient.

DISSCUSSANT- Remarks by Patricia Maeso, MD 2009-05-29:

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

It's important to define what the agger nasi cell is. The agger nasi is a bony prominence that is often pneumatized in the ascending process of the maxilla. Its location below the frontal sinus also defines the anterior limit of the frontal recess. Approximately 75-80% of patients have agger nasi cells.

You mentioned hyposmia in your discussion. To prevent this when we do sphenoid surgery we remove the inferior 1/3 of the superior turbinate, but leave the rest of it to preserve the olfactory neuroepithelium.

Further, we avoid producing any senechiae or any trauma to the area between the middle turbinate and the septum (olfactory cleft) so that it doesn't scar down and cause anosmia.

The other important thing about the sphenoid and the skull base is the sphenoid intersinus septum. In 25% of patients it may insert directly on the carotid, so don't crack it so that you don't open directly into the carotid.

You mentioned a Haller cell. This is really an infraorbital ethnoidal cell. The Haller cell (infraorbital cell) is usually situated below the orbit in the roof of the maxillary sinus. It is a pneumatized ethmoid cell that projects along the medial roof of the maxillary sinus. Enlarged Haller cells may contribute to narrowing of the ethmoidal infundibulum and recurrent sinus disease, despite previous (perhaps incomplete) surgery.

There are patients who can't properly get rid of their secretions- for example – CF patients or patients with immotile cilia. We help them to get rid of their secretions by extending the antrostomy to the floor of the maxillary sinus. Otherwise I like to stay with my normal middle meatus antrostomy. This gives the mucosa a chance to regenerate and the mucosa will regenerate usually if you get rid of the disease.

There are several theories in sinus surgery and one is the Kennedy theory of operating.

He's done multiple studies and the Kennedy theory of operating says that the bone itself may be osteitic and houses osteomyelitis so that apart from removing the mucosa, the "billiard ball" sinus, you have to remove the infected/inflamed bone as well.

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