Section: Miscellaneous

Original Research Article

# FRONTAL SINUS AND ANATOMICAL VARIATION IN OUTFLOW TRACT- DECISION MAKING AND SURGICAL OUTCOME A SYSTEMATIC REVIEW

**Sangram Kishore Sabat[1], Bibhujit Padhy S[2], Bhagirathi Pradhan[3]**

[1]Assistant Professor, Department of Orthopedics, MKCG Medical College & Hospital, Berhampur, India.
[2]Assistant Professor, Department of Emergency Medicine, MKCG Medical College & Hospital, Berhampur, India.
[3]Assistant Professor, Department of Anaesthesiology, FM Medical College & Hospital, Balasore, India.

*Received* : *08/01/2023*
*Received in revised form* : *19/02/2023*
*Accepted* : *04/03/2023*

*Keywords:*
*Frontal sinus, frontal recess, frontal sinus outflow tract, Agar nasi cell, and Draf classification.*

Corresponding Author:
**Dr. Sibasis Acharya**
Email: drsibasisacharya@gmail.com

DOI: 10.47009/jamp.2023.5.2.159

Source of Support: Nil,
Conflict of Interest: None declared

*Int J Acad Med Pharm*
2023; 5 (2); 754-758

## Abstract

**Background:** Because to its complicated location, varied architecture, and disease processes that modify its pathophysiology, the frontal sinus and its outflow tract are of particular interest to aspiring otorhinolaryngologists. The surgical care is difficult, and in order to predict the optimum surgical result, a surgeon must be well-versed on its anatomical variety and radiological findings. **Objectives**:-Reviewing the anatomy, imaging, and several surgical techniques of the frontal sinus and its drainage channel. **Data Analysis:** The FS has a wide range of anatomical diversity, and different clinical circumstances can necessitate different surgical techniques to address them. Beginners need to understand the limits of safe work in order to achieve the best results because the FR is the area of "surgery bottleneck" with maximal endoscopic narrowing. The frontal sinus is frequently affected by frontoethmoidal mucocele, osteomas, chronic rhinosinusitis, and a wide variety of malignant tumours, all of which present unique surgical challenges. **Conclusion:** Various surgical diseases impact the frontal sinuses and its outflow tract, but they can be successfully addressed provided the surgeon has a thorough understanding of the relevant anatomy, uses the right surgical instruments, and adopts a customised approach.

## INTRODUCTION

Given how close the frontal sinus is to the skull base and the orbit, surgery on it is thought to be the most difficult procedure in sinus surgery. This could cause the surgeon to mistakenly damage the normal anatomy, which would encourage complications, or insufficiently treat the condition. When the patient reaches the operating room, proper surgical planning is crucial, such as a preoperative radiography to determine the disease process and pertinent frontal sinus anatomy. Our study offers a thorough understanding of the pertinent theory and frontal surgery methods.

**Anatomy and Radiology**

FS is an air space in the anterior cerebral vault that is surrounded by two cortical bones. The craniofacial growth is synchronised with the frontal sinus and reaches its maximum size by the time a person is 18 years old. It is radiographically apparent by the time they are 4 years old. The anatomical specifics of the region are crucial to the outcome of any surgery, just like with any other procedure. Due to its proximity to the orbit and skull base, the frontal sinus must be treated with extreme caution during endoscopic sinus surgery to prevent damage to this vital structure. Because of its near physical proximity to the ethmoidal cell and same embryological origin, the frontal sinus was once thought to be one.[1,2] The development of FS is thought to be either a direct extension of the infundibulum or an epithelial migration of the Ethmoidal cells often enter the frontal bone during the 16th week.

The supraorbital and zygomatic parietal recesses of the FS can be expanded due to the enormous anatomical and dimensional variance of the FS.3-5% of people with unilateral or bilateral FS aplasia.[3] The frontal sinus opens inferiorly through the ostium to the FR in the three-dimensional FSOT. The FR is a bony area that resembles an inverted cone and narrows superiorly towards the internel frontal aperture. The ethmoidal infundibulum is where the lower boundary widens and opens. The FR is restricted laterally by lamina papyracea.[4,5] medially by middle turbinate, anteriorly by bony beak and agar nasi cell(ANC), posteriorly by ethmoidal bulla, and by the middle turbinate. The


ISSN (O): 2687-5365; ISSN (P): 2753-6556

main causes of blockage and illnesses are variations in the lower portion of the FSOT.

A landmark used to identify FR is the ANC, which is the ethmoid cell that is anterior to the anterior limit. The main factor affecting the FS's endoscopic accessibility is the degree of pneumatization. The connecting of medial wall of ANC with Uncinate forming the "vertical Bar" is a crucial referral point for correct identification of FR and FS. The FSOT is situated posteromedial to the ANC because the ANC is distinct from the middle turbinate and the ethmoidal bulla. The FSDP is shortened and located behind the ANC when the ANC pneumatises in a mediolateral orientation, dislodging the bony bar. The vertical bar and middle turbinate have enough space between them to allow FSOT to lie medial to an ANC that is not well pneumatized. Pneumatization of ethmoidal cells and uncinate attachmentThe FSOT's shape and width are also significantly influenced by pneumatization. According to Stammberger6, different anatomical attachments of the superior uncinate are also employed as landmarks to distinguish the FR. When the uncinate attaches to the skullbase or middle turbinate, the FR directly drains into the ethmoidal infundibulum. If this insertion occurs to the lamina papyraceae, the FR drains into the middle meatus. The anterior wall of the ethmoidal bulla connects to the skull base, capping the anterior ethmoidal artery, which is situated posteriorly and is located 2-3 mm behind the FR. The bulla can occasionally serve as a useful landmark for the posterior limit of dissection (intact bulla technique). Depending on the degree of pneumatization of the ethmoidal cell, the FR has varying dimensions in the mediolateral and anteroposterior directions. Above the ethmoid and behind the FR, above the orbit, suprabullar cells pneumatise into the skull base. Sometimes an intersinus septal cell pneumatises, causing FR7 to narrow and move to the side.

On the anterior wall, there are additional cell types that fit Bent and Kuhn's classification the best. One cell above ANC is kind 1, several cells above ANC is type 2, a cell pneumatises into the frontal sinus wall is type 3, and a single isolated cell is present in the frontal sinus is type.[4]

computed multiplanner reconstruction Given the intricate structure of the frontal sinus, tomography is now required before performing any type of surgery. Whereas the mediolateral space is better observed in coronal planes, the anteroposterior dimension is best assessed in the saggital plane. The measurements will determine how simple it is to perform surgery in the area while estimating any potential challenges the surgeon may encounter. More caution must be taken when working in a small FR space to avoid damaging the sinus mucosa, as scarring could result and increase the likelihood of failure. When there is intraorbital or cerebral expansion or when there is a suspicion of malignancy, magnetic resonance imaging is required.[9]

## MATERIALS AND METHODS

**Clinical and Surgical Consideration**

Preoperative imaging and operative planning are guided by the illness progression. In the majority of benign conditions, surgery aims to increase the FR space. On the other hand, malignancy may need substantial bone work in addition to mucosal resection.

**Imaging**

A through preoperative radiological analysis of the FS and FSOT helps in successful operative procedure. A CT scan and MRI if needed should be available to the surgeon all the time during surgery. Key anatomical factors that needs to be seen and reviewed prior to surgery includes:

- Nasal cavity-vestibular patency,synechia
- Inferior turbinate
- Middle turbinate-anatomical variation, attachments, concha bullosa. Lateralization
- Uncinate process-attachments.proximity to orbit,previous surgery
- Maxillary sinus- haller cell,accessory ostium,pneumatisation orbit relation
- Frontal sinus/FR/Ethmoid cells-pneumatisation, FSOT beak thickness,lamina papyrace,Anterior ethmoidal artery
- Posterior ethmoid/sphenoid sinus-pneumatisation onodi cell optic and carotid location, bony dehiscence
- brain/orbit /skullbase- foveal depth and symmetry.

## RESULTS

**Equipments**

Endoscopic sinus surgery is used to treat the majority of pathological conditions. Every sinus surgeon's equipment basket is built on angled endoscopes, specifically models 300, 450, and 750, and angled instruments. Endoscopes offer a high definition image and a large field of view. The frontal set includes the horseman forcep, the angled kerrison rongeur angled cucurerres frontal sinus seeker, and the giraffe sinus forcep. Microdebriders are powered tools that remove tissue by spinning or oscillating knives inside a cannula. It assists in maintaining a clear, blood-free field for good visualisation, which is crucial when operating in this area, by continuously sucking up blood and secretions. In our setup, the most commonly utilised debrider blades are 4m 3600 rotatable 12,0 400, 600 angled blades. Vigilantly and consistently visualising the tip is essential to prevent cerebral and ocular injuries as well as vascular damage. Aside from the 400 and 600 diamond burrs that are utilised to drill bones at important places, we mostly use coarse diamond 4mm 150 400 angled burrs for bony work in extensive resections.


ISSN (O): 2687-5365; ISSN (P): 2753-6556

A recent development in the arsenal of sinus surgeons is navigation, which offers more precise orientation of crucial structures in sinus surgery. Due to the exorbitant cost of the procedure, it is only used in rare circumstances, such as revision surgery when a previous operation or the illness process has severely altered the anatomy. Yet, the technology is a supplement and not a substitute for solid anatomical understanding and a surgeon's skill.

**Operative Preparation**

**Anaesthesia**

In our setup, total intravenous anaesthesia with propofol and ramifentanil is favoured. Heart rate is kept close to 60 beats per minute, which reduces capillary bleed.[10]

**Positioning**

The patient is poisoned 300 while facing the surgeon and in the anti-Trendelenberg position with the head slightly extended. It enhances the surgical area and lessens bleeding.[11]

**Prophylactic Antibiotics**

we prefer to give antibiotics perioperatively usually 1 hour prior to the procedure. a broad spectrum antibiotics is preferred although it can be individualized. We give Amoxicillin and clavulanate(60-90mg/kg/24 hours ) as it is broad spectrum and is cost effective.

**Topical Preparation**

We always prefer to give topical preparation in the form of saline adrenaline (1 in 1 lakh) soaked in cotton neuropatties before sinus surgery. Infiltration is avoided to avoid systemic side effect.

**Surgical Procedure**

The type of surgery is individualized based on patient"s symptoms, radiological finding and associated comorbidities. A septoplasty should be performed whenever necessary to expose the field and avoid blocking the FSDP postoperatively. A fullview of the axillary region of middle turbinate is necessary before doing work in frontal sinus.[12]

Draf systematized frontal surgery into four types with successive increase in the complexities of the procedure (Draf 1, 2a, 2b,3 or modified Lothrop)

**Draf 1**

A Draf 1 is a procedure of ethmoidectomy that aims to improve the FR aeration.it concludes with uncinectomy, removal of the anterior face of Bulla and resection of the parts of the medial lamella of the ANC. Further extension of the resection is avoided to prevent scarring which can be detrimental to the FSOT. The procedure is done when there is minimal disease like acute complicated frontal sinusitis failed to medical management. The initial steps sre done with 00 endoscope.the Middle Turbinate is medialised using a elevator and uncinectomy is done completely by removing its attachments to lateral wall and its horizontal and vertical parts are also removed widening the maxillary ostium.[13]

Anterior ethmoidectomy is done with resection of anterior ethmoidal cells that surround FR without manipulating frontoethmoidal cell.[14]

**Draf 2a**

This procedure involves the clearance of above mentioned ethmoidal cell along with complete ethmoidectomy and removal of all cells related to FR and FS between lamina papyraceae and middle turbinate. It is indicated for procedures like refractory chronic rhinosinusitis, nasal polyposis mucocele and benign tumor limited to frontal sinus. We prefer to procede with an intact Bulla technique for Draf 2 dissection. The anterior bulla should be preserved as long as it is possible as per Rudert.[15,16] Initially using 00 endoscopy uncinectomy is performed with complete exposure of wide maxillary ostium.

An 300 scope and microdebrider are then used to expose the anterior wall of terminal recess. Dissection is continued superiorly till the lacrimal bone lateral to anterior wall of terminal recess with middle turbinate and medial to lamina papyracea.Anterior wall of ANC is partially debrided and then using sinus seeker FR is identified. The medial wall of ANC is then debrided. The posterior limit of resection is intact anterior wall of bulla. The intact bulla technique preserves the anterior ethmoidal artery.the o0 endoscope is again used to to clear the bulla and the remaining frontoethmoidal cell till the internal frontal sinus ostium is vidualised with no bony chips around it. Any further sinus surgery is then continued depending upon the disease extention.

**Draf 2b**

The procedure begins with dissection of anterior part of middle turbinate and axilla. The frontal sinus floor is then drilled out between septum and lamina opapyracea. The frontal beak is drilled to widen the anterior face of sinusotomy. The indications are mostly unilateral benign diseases like mucocele and benign tumor. In our experience draf2b procedure is less frequently indicated for inflammatory pathology. The neoosteogenesis that follows the drilling posed more harm than the inflammatory disease process itself. So we resort to a draf3 when there is a need to drill the frontal floor in case of CRS.

**Draf 3**

The procedure begins with joining of the two sides of frontal sinuses through complete removal of anterior ethmoid cells, anterior part of middle turbinates FS floor bilaterally and intersinus septum along with adjacent nasal septum.The indications for the procedure are massive sinonasal polyposis any disease causing massive frontal osteitis CSF leak in Frontal sinus encephalocele and big frontal mucocele.for most inflammatory pathology Draf3 is done when well performed Draf2 procedure and medical therapy fail to control disease. Draf 3 can be accomplished by a "inside out" or an "outside in" approach. Inside out technique is our procedure of choice for a routine Draf3. The anterior limit of maximal dissection is periosteum of frontal process, medial limit is medial wall of orbit and posterior


ISSN (O): 2687-5365; ISSN (P): 2753-6556

limit is first olfactory neuron (Filum) on both sides.[17]

The surgery starts with bilateral frontal sinusotomy as described above. Septal window is created around 2 cm in the caudal area of FS floor which extends till the septal attachment to FS floor dorsally and lower limit being the axilla and the anterior limit is nasal bone. This window allows visibility of axilla of middle turbinate from either sides. Monopolar with low coagulation setting can be used to mark the limits. Mucosal graft from septectomy can be harvested which can be used at the end of the surgery to cover exposed bone.

The anterior middle turbinate is trimmed and mucosa on axilla cut and cauterized. Nasoseptal angulation identified and mucosal flap is elevated by a freer's elevator posteriorly till the nasal branch of anterior ethmoidal artery just anterior to first olfactory fibre with which it is commonly mistaken.[18] is identified. A 4mm 150 coarse diamond burr along with suction irrigation is introduced through one nostril and a 450 endoscope is introduced from other nostril to allow for more work space. Drilling starts from the FS floor in an antero-medial direction and whole floor rontal beak, and junction of bony septum to sinus floor is drilled out. Finally frontal process of maxilla is thinned until periosteum is visible. The intersinus septum is then meticulously drilled till the frontal roof. Sufficient irrigation is done at the end of the procedure to flush out bone dust and chips. The surgical site can be covered with mucosal flaps after achieving hemostais. At the end "soframycin" soaked formal gauze can be placed to pack the cavity which provides a sterile humid mileu reducing granulation and causing early mucosalisation. Literature shows upto 95% patency rate at 28.5 months after draf 3.[19]

Although long term patency rates vary,but large FS aperature following Draf3 is critical for long term high patency rate.

## DISCUSSION

**Surgical Complications**

**Csf Leak:**

CSF Leak encountered during surgery should be repaired at the same sitting. Variations like a low and deep fovea ethmoidalis is more prone to be associated with iatrogenic CSF Leak. A late repair may predispose patients to recurrent bouts of meningitis. An early repair carries success rate upto 905 in primary setting and 97% in rvision cases20. A precise localization is key to successful repair using standard technique. The choice of procedure again depends on site of leak and size of defect.

**Orbital Complication**

The commonly encounterd compilcations are fat prolapsed and medial rectus disruption and orbital hematoma. Minor fat prolapsed can be addressed by bipolarization and loose nasal pack at the end of surgery. Powered shaver should be used cautiously at a breached lamina papyracea. Lack of periorbita identification might land up the surgeon in injuring optic nerve and medial rectus. Anterior ethmoidal artery injury in most cases can be cauterized or a tight pack can be considered. An accidental transcection may lead to intraorbital hematoma which is a surgical emergency. A lateral cathotomy along with upper and lower eye lid cantholysis must be done to ensure relief or intraocular pressure. Subacute orbital hematoma which appears hours after surgery usually is a result of slow venous bleeding due to breach in lamina. It can cause orbital swelling pain vision loss. Ipsilateral nasal pack has to be immediately loosened or removed in such situation.

**Synechia and Scarring**

Middle turbinate lateralization can lead to middle meatus synechia formation and failure of FS surgery which might require revision surgery.[21] Measures taken reduce such incidences are preserving horizontal part of basal lamella and "Bolgerisation" , a willful creation of synechia between Middle turbinate and adjacent septum by targeted injury.

**Mucocele**

When mucus is confined to bony spaces, they form mucocele and cause obstruction of FSOT. The symptoms can be proptosis, opthalmoplegia diplopia etc. In FS surgery mucosa preservation and maintaining patency of FSOT helps prevent mucocele formation.[22] The standard of care is endoscopic marsupialisation

## CONCLUSION

Without a doubt, the anatomy of the frontal sinus is complex. If the surgeon has a decent awareness of the anatomical variety, uses accurate technique, and uses the right instrumentation, including image guiding surgery, they can safely and confidently treat the disorders that affect FS and FR. FS surgery is still quite difficult, and if surgical principles are not taken into account and followed, essential structures may be damaged, inviting dreaded complications.

## REFERENCES


1. Shama SA. Frontal sinus outflow tract: Multi-detector CT assessment. Egypt J Radiol Nucl Med 2017:48(04) 897-903
2. Peynegre R, Rouvier P. Anatomy and Anatomical Variations of the Paranasal Sinuses. In: GershwinME, Incaudo GA, editors. Diseases of the Sinuses [Internet]. Totowa, NJ: Humana Press; 1996:3–32. Available from: http://link.springer.com/10.1007/978-1-4612-0225-7
3. Duque CS, Casiano RR. Surgical Anatomy and Embryology of the Frontal Sinus. In: Kountakis SE, Senior BA, DrafW, editors. The Frontal Sinus [Internet]. Berlin/Heidelberg: Springer-Verlag; 2005:21–31. Available from: http://link.springer.com/10.1007/3-540-27607-6_3
4. Friedman M, Bliznikas D, Vidyasagar R, Landsberg R. Frontal sinus surgery 2004: update of clinical anatomy and surgical techniques1 1The authors received no financial support in connection with this article, and deny any off-label




ISSN (O): 2687-5365; ISSN (P): 2753-6556

or investigational usage of any product. Oper Tech Otolaryngol–Head Neck Surg 2004;15 (01):23–31
5. Ximendes R, Mangussi-Gomes J, Balieiro FO, et al. Anatomical relations between the frontal sinus drainage pathway and the agger nasi cell. J Otolaryngol ENT Res 2018
6. H S. W P. Functional Endoscopic Sinus Surgery. Concept, Indications and Results of the Messerklinger Technique [Internet]. European archives of oto-rhino-laryngology: official journal of the European Federation of Oto-Rhino-Laryngological Societies (EUFOS): affiliated with the German Society for Oto-Rhino-Laryngology - Head and Neck Surgery. 1990 [cited 2020 Mar 13]. Available from: https://pubmed.ncbi.nlm.nih.gov/2180446/?from_term=stammberger+frontal+sinus & from_pos=9
7. Karanfilov BI, Kuhn FA. The Endoscopic Frontal Recess Approach. In: Kountakis SE, Senior BA, Draf W, editors. The Frontal Sinus [Internet]. Berlin/Heidelberg: Springer-Verlag; 2005:179–89. Available from: http://link.springer.com/10.1007
8. Bent JP, Cuilty-Siller C, Kuhn FA. The Frontal Cell As a Cause of Frontal Sinus Obstruction. Am J Rhinol 1994;8(04):185–191
9. Weber RK, Hosemann W. Comprehensive review on endonasal endoscopic sinus surgery. GMS Curr Top Otorhinolaryngol Head Neck Surg 2015;14:Doc08
10. Wormald PJ, van Renen G, Perks J, Jones JA, Langton-Hewer CD. The effect of the total intravenous anesthesia compared with inhalational anesthesia on the surgical field during endoscopic sinus surgery. Am J Rhinol 2005;19(05):514–520
11. Hathorn IF, Habib A-RR, Manji J, Javer AR. Comparing the reverse Trendelenburg and horizontal position for endoscopic sinus surgery: a randomized controlled trial. Otolaryngol Head Neck Surg 2013;148(02):308–313
12. Shah J, Roxbury CR, Sindwani R. Techniques in Septoplasty: Traditional Versus Endoscopic Approaches. Otolaryngol Clin North Am 2018;51(05):909–917
13. Draf W. Endonasal Frontal Sinus Drainage Type I–III According to Draf. In: Kountakis SE, Senior BA, DrafW, editors. The Frontal Sinus [Internet]. Berlin/Heidelberg: Springer-Verlag; 2005:219–32. Available from: http://link.springer.com/1
14. Karanfilov BI, Kuhn FA. The Endoscopic Frontal Recess Approach. In: Kountakis SE, Senior BA, Draf W, editors. The Frontal Sinus [Internet]. Berlin/Heidelberg: Springer-Verlag; 2005:179–89. Available from: http://link.springer.com/10.1
15. Stamm AC, Draf W, Eds. Micro-endoscopic Surgery of the Paranasal Sinuses and the Skull Base [Internet]. Berlin, Heidelberg: Springer Berlin Heidelberg; 2000. Available from: http://link. springer.com/10.1007/978-3-642-57153-4
16. Rudert H. [Microscope and endoscope-assisted surgery of inflammatory diseases of the paranasal sinuses. Value of the Messerklinger infundibulotom
17. Carney AS. Draf III frontal sinus surgery: “How I do it”. Am J Rhinol Allergy 2017;31(05):338–340
18. Sahu N, Casiano RR. Nasal branch of the anterior ethmoid artery: a consistent landmark for a midline approach to the frontal sinus. Int Forum Allergy Rhinol 2019;9(05):562–566
19. Anderson P, Sindwani R. Safety and efficacy of the endoscopic modified Lothrop procedure: a systematic review and metaanalysis. Laryngoscope 2009:124(01) 1828-1823
20. Psaltis AJ, Schlosser RJ, Banks CA, Yawn J, Soler ZM. A systematic review of the endoscopic repair of cerebrospinal fluid leaks. Otolaryngol Head Neck Surg 2012;147(02):196–203
21. Han JK, Higgins TS. Management of orbital complications in endoscopic sinus surgery. Curr Opin Otolaryngol Head Neck Surg 2010;18(01):32–36
22. Friedman M, Bliznikas D, Vidyasagar R, Landsberg R. Frontal sinus surgery 2004: Oper Tech Otolaryngol–Head Neck Surg 2004;15 (01):23–31.


ISSN (O): 2687-5365; ISSN (P): 2753-6556