The International Frontal Sinus Anatomy Classification (IFAC) and Classification of the Extent of Endoscopic Frontal Sinus Surgery (EFSS)

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The International Frontal Sinus Anatomy Classification (IFAC) and Classification of the Extent of Endoscopic Frontal Sinus Surgery (EFSS)

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The frontal recess and frontal sinus anatomy can vary from simple to complex. The variations in the anatomy of the frontal recess and frontal sinus are considerable but almost all variations can be classified if the various cell patterns are analyzed. This consensus document was developed to improve the ability of the surgeon to understand these possible variations, plan the surgery, and communicate these complexities when teaching or reporting outcomes. Once the surgeon understands the anatomical pattern of the frontal sinus and recess cells, the extent of surgery can be planned. This document presents a classification of the extent of surgery based on the anatomical classification.

Key Words:
sinus anatomy; sinus surgery; radiology; frontal sinusotomy; IFAC; EFSS

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Over the last decade there has been increasing interest in the anatomy and surgical approaches to the frontal sinus. The frontal sinus is often cited as the most challenging area to approach in endoscopic sinus surgery (ESS) because the region is situated behind and above the frontal beak requiring an angulated endoscopic approach. The relatively small confines of this region are prone to postoperative cicatrization. The frontal recess is the space into which the frontal sinus drains. This space is usually occupied by a number of cells that affect the direction and position of this drainage pathway. The medial wall of the frontal recess is formed by the lateral lamella of the cribriform plate and the vertical lamella of the middle turbinate and the lateral wall is formed by the lamina papyracea and lacrimal bone. The anterior ethmoidal artery may be situated in the posterior region of the roof of the frontal recess and can be at risk if it runs in a mesentery off the skull base. To avoid complications in this area the surgeon needs to fully conceptualize the anatomy and to have a surgical plan so that dissecting instruments can be precisely placed with minimal risk but can achieve complete clearance of the frontal recess and frontal ostium. Although there have been many

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classification systems proposed[1–6] for the different cells in this area, a classification system that addresses both the number and position of the cells as well as how these cells affect the frontal drainage pathway will help in the understanding of surgical anatomy and approach. The recent European Position Paper (EPOS) on the Anatomical Terminology of the Internal Nose and Paranasal Sinuses suggested classifying all the cells as either anterior or posterior or medial or lateral.[1] The EPOS classification gives the surgeon a general idea as to where a cell is positioned but it does not give enough details of cell relationships in this region that can contribute to the planning of the surgery on the frontal recess and frontal sinus. In the view of the authors of this work, a more precise naming based on the position of the cells allows a more complete picture of the anatomy to be established. In addition it allows easier communication between surgeons and more accurate teaching of the necessary surgical steps in frontal sinus ESS. The authors of this manuscript have developed a consensus classification that has built on the work of van Alyea,[2] Kuhn,[3–6] and other authors.[7–12]

Definitions

Frontal recess

The space into which the frontal sinus drains is called the frontal recess. It is the space posterior to the frontal beak (nasal process of the frontal bone), between the lamina papyracea and the vertical lamella of the middle turbinate continuing on to the lateral wall of the olfactory fossa and is anterior to the basal lamella of the middle turbinate. For the purpose of this anatomical classification of cells, this space includes the cells or space above and anterior to the bulla ethmoidalis.

Agger nasi cell

Agger nasi cell (ANC)[1,3,13] is the most anterior ethmoid cell that sits above the insertion of the anterior middle turbinate into the lateral nasal wall. It often forms the mound seen just anterior to the middle turbinate. It pneumatizes into the frontal process of the maxilla and lacrimal bone area. A large ANC is often associated with a larger anteroposterior frontal opening.

Frontal sinus ostium

The frontal ostium is defined as the narrowest area of the transition zone from the frontal sinus to the frontal recess with its anterior edge formed by the frontal sinus beak and the posterior edge formed by the skull base (best seen on the parasagittal computed tomography [CT] scan). The lateral boundary of the frontal ostium is the lamina papyracea and the medial boundary, the upward extension of the vertical lamella of the middle turbinate and lateral wall of the olfactory fossa. The frontal sinus ostium is the narrowest part of the hour-glass that is formed as the frontal sinus transits to the frontal recess.[11,12] The frontal beak is the posterior bony protrusion of the most inferior aspect of the anterior table of the frontal sinus seen on the parasagittal CT scan.

CT scan requirements for frontal sinus anatomy assessment

When assessing the anatomy and drainage pathway of the frontal sinus it is vital that the surgeon has access to high-quality CT scans. Typically the CT scan should have axial slices less than 1 mm apart so that when the axial CTs are loaded onto a CT viewer the reconstructions do not have a stepped appearance. This results in very high quality images in all 3 planes. When planning surgery, the frontal sinus drainage pathway as formed by the presence or absence of the frontal recess cells needs to be clearly understood. To obtain the best 3-dimensional image of the anatomy, the surgeon should be able to scroll through the CT scans in all 3 planes (coronal, axial, and parasagittal) simultaneously. The 3 planes should be linked so that when the cursor is moved in 1 plane its position is reflected in the other planes. Software is available for both Windows and Macintosh computer platforms that allows surgeons to work carefully through the CT scans and obtain an understanding of the anatomy and surgical approach.[11,12]

Methodology

This consensus document was achieved by the authors putting forward proposals for the classification of cells and the extent of surgery. These initial proposals included the previously recognized classifications in the literature and new classifications. These were collated in a draft and then sent to all authors for their thoughts and comments. Based on this feedback the classifications were modified and all authors were then asked to vote for the classification that they felt most was most appropriate. The 3 classifications that had the most votes were then modified using the comments submitted and then sent out again for further voting. This process was repeated a number of times and until the majority of authors voted for the final classifications presented in this document. This process went through 17 drafts before finalization.

International Frontal Sinus Anatomy Classification (IFAC)

TABLE 1. International Frontal Sinus Anatomy Classification (IFAC)

Cell type	Cell name	Definition	Abbreviation
Anterior cells (push the drainage pathway of the frontal sinus medial, posterior or posteromedially)	Agger nasi cell	Cell that sits either anterior to the origin of the middle turbinate or sits directly above the most anterior insertion of the middle turbinate into the lateral nasal wall.	ANC
	Supra agger cell	Anterior-lateral ethmoidal cell, located above the agger nasi cell (not pneumatizing into the frontal sinus).	SAC
	Supra agger frontal cell	Anterior-lateral ethmoidal cell that extends into the frontal sinus. A small SAFC will only extend into the floor of the frontal sinus, whereas a large SAFC may extend significantly into the frontal sinus and may even reach the roof of the frontal sinus.	SAFC
Posterior cells (push the drainage pathway anteriorly)	Supra bulla cell	Cell above the bulla ethmoidalis that does not enter the frontal sinus.	SBC
	Supra bulla frontal cell	Cell that originates in the supra-bulla region and pneumatizes along the skull base into the posterior region of the frontal sinus. The skull base forms the posterior wall of the cell.	SBFC
	Supraorbital ethmoid cell	An anterior ethmoid cell that pneumatizes around, anterior to, or posterior to the anterior ethmoidal artery over the roof of the orbit. It often forms part of the posterior wall of an extensively pneumatized frontal sinus and may only be separated from the frontal sinus by a bony septation.	SOEC
Medial cells (push the drainage pathway laterally)	Frontal septal cell	Medially based cell of the anterior ethmoid or the inferior frontal sinus, attached to or located in the interfrontal sinus septum, associated with the medial aspect of the frontal sinus outflow tract, pushing the drainage pathway laterally and frequently posteriorly.	FSC

Radiological examples of each of these anatomical cells

Figure 1 is a CT scan demonstrating a single ANC. This CT scan demonstrates how the ANC sits directly behind the frontal process of the maxilla and on the coronal CT its relationship to the middle turbinate.

Figure 2 is a CT scan demonstrating a supra agger cell (SAC). An SAC sits above the ANC behind the beak of the frontal bone. It is usually laterally based as can be seen on the axial scan. In this classification an SAC may be a single cell or consist of a number of cells sitting above the ANC and may affect the frontal drainage pathway depending as to whether it is situated medially or laterally.

Figure 3 is a CT scan of a supra agger frontal cell (SAFC). This CT demonstrates a small SAFC. This cell does not extend significantly into the frontal sinus but occupies a portion of the floor of the frontal sinus. The importance of differentiating between a small and a large SAFC is if a SAFC pneumatizes extensively into the frontal sinus it may require a different surgical approach rather than a standard endoscopic approach. If the full extent of the cell needs to be cleared surgically then an extended endoscopic procedure may be required or even a combined approach (external frontal sinus trephine with endoscopic approach) to completely clear the large SAFC. This should not be the case with a small SAFC.

Figure 4 is a CT scan showing a classical example of a small SAFC. The cell is laterally based and pneumatizing through the frontal ostium into the frontal sinus and pushing the drainage pathway of the frontal sinus medially. The question as to whether a cell reaches the frontal sinus can be answered by looking at the coronal CT scan and looking for the continuity of bone across the base of the frontal sinuses. This continuity is caused by the CT scan being in a plane that cuts the frontal beak and it is the bone of the frontal beak that forms this continuity. A small SAFC cell is seen with a continuity of bone below it on the coronal CT scan. An anterior-based cell that has entered the frontal sinus to sit above the frontal beak is therefore by definition an SAFC.

Figure 5 is an example of a small SAFC in which the frontal sinus is well pneumatized with a small beak. However, the cell can be seen in the frontal sinus both on the coronal and parasagittal CT scans. This illustrates the benefit of assessing cells in this region with a system that links all 3 views and allows active scrolling reflected in all of the views simultaneously.

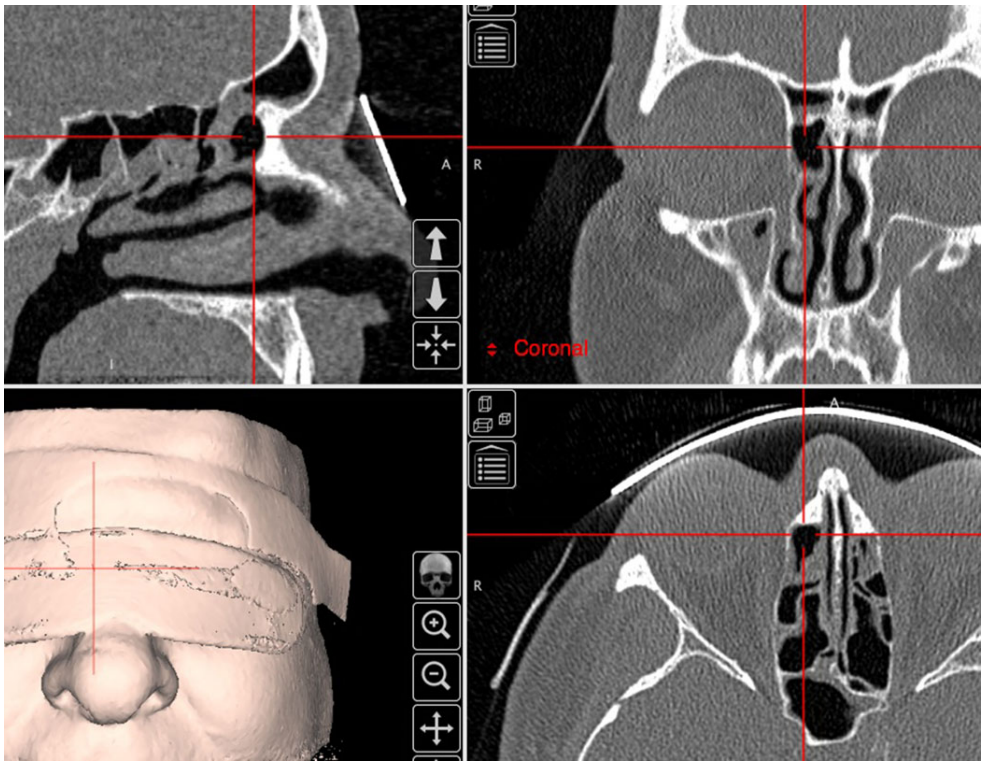


FIGURE 1. CT scan of a single ANC. ANC = agger nasi cell; CT = computed tomography.

Figure 6 is a CT scan showing a large laterally based SAFC pneumatizing into the frontal sinus and extending significantly into the sinus. Often the frontal sinus widens as the cell extends superiorly and the surgeon does not need to remove the full extent of the cell as the remaining superior extent of the cell does not affect the frontal sinus outflow tract. Figure 7 is an example of a large SAFC; the cell is again based laterally pushing the drainage pathway

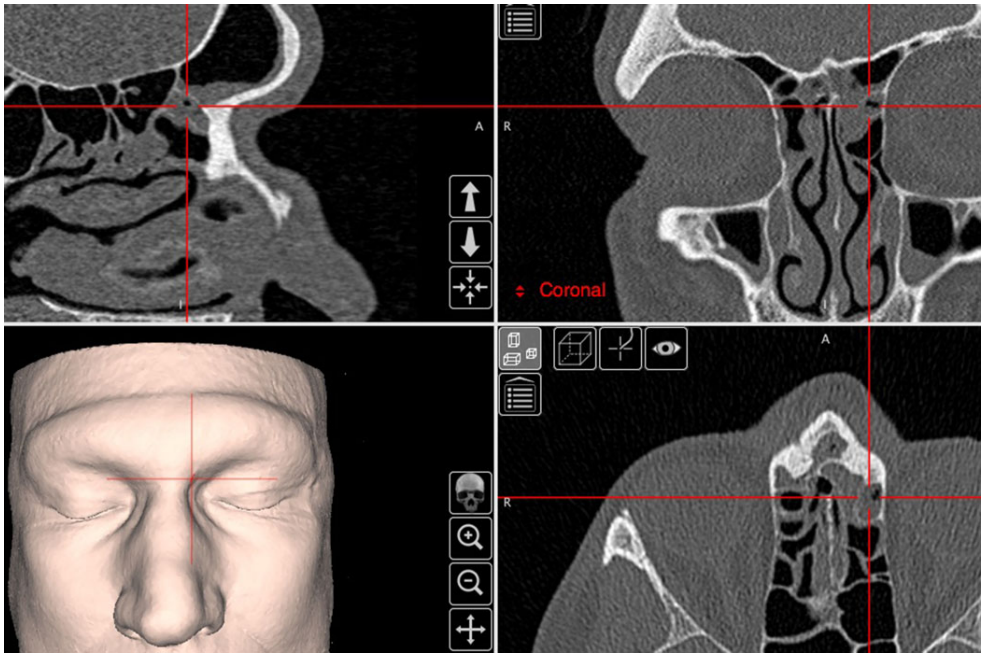


FIGURE 2. CT scan of an SAC sitting above the ANC. ANC = agger nasi cell; CT = computed tomography; SAC = supra agger cell.

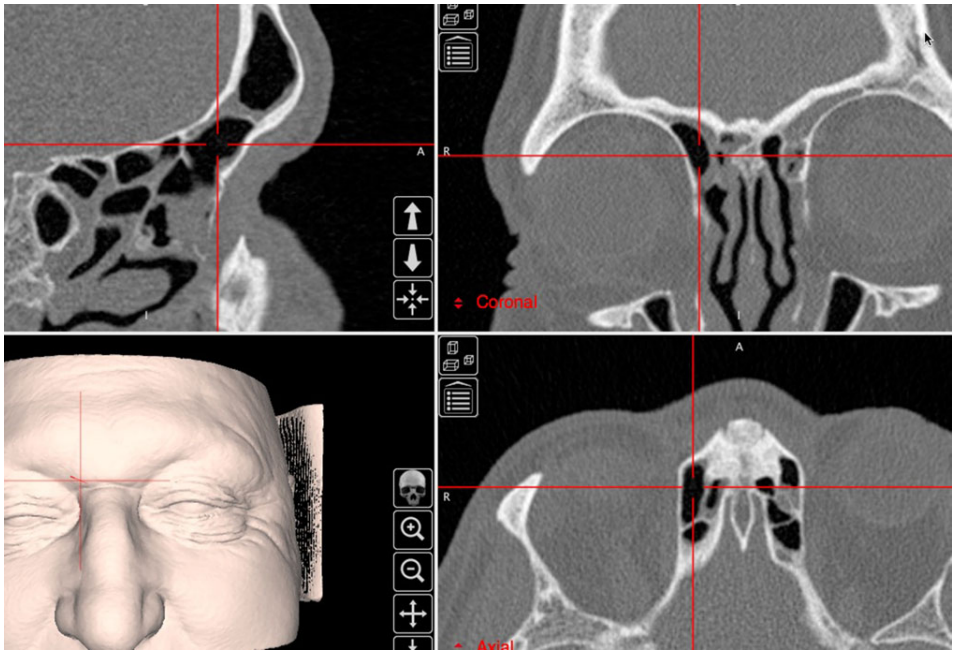


FIGURE 3. CT scan of a small SAFC. This cell does not pneumatized extensively into the frontal sinus. CT = computed tomography; SAFC = supra agger frontal cell.

medially and extending significantly into the frontal sinus. Figure 8 is a CT scan illustrating the bulla ethmoidalis. In the coronal CT scan we can see how the bulla ethmoidalis sits above the horizontal portion of the uncinate process. Figure 9 is a CT scan showing the classical suprabullar cell (SBC) with the cell sitting directly above the bulla ethmoidalis and the anterior wall of the SBC almost in continuity with the anterior face of the bulla ethmoidalis.

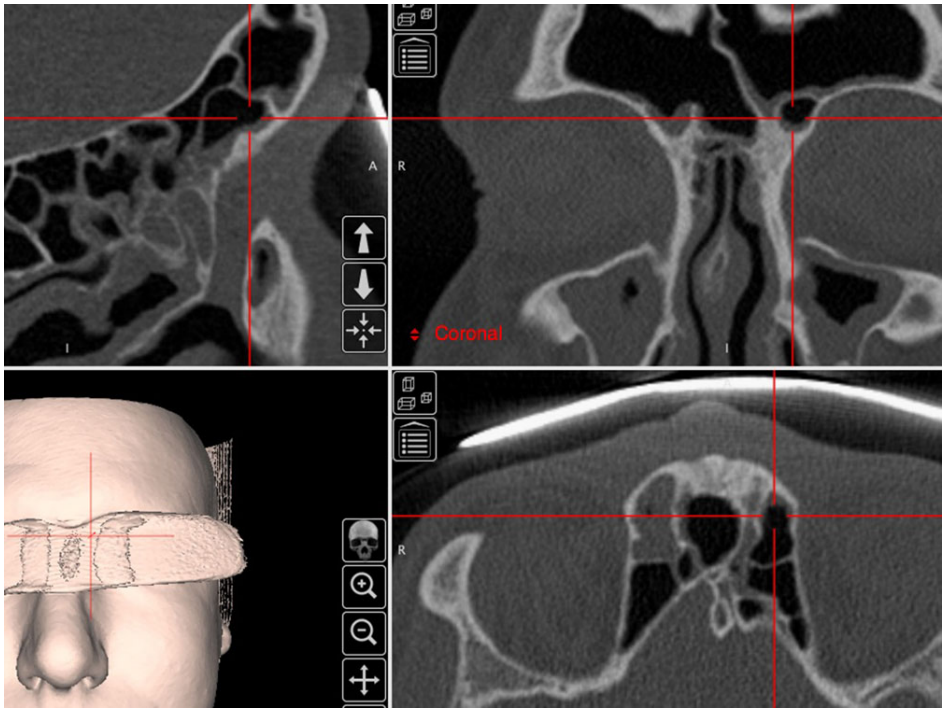


FIGURE 4. CT scan of an SAFC that is laterally based and pneumatizes through the frontal ostium. CT = computed tomography; SAFC = supra agger frontal cell.

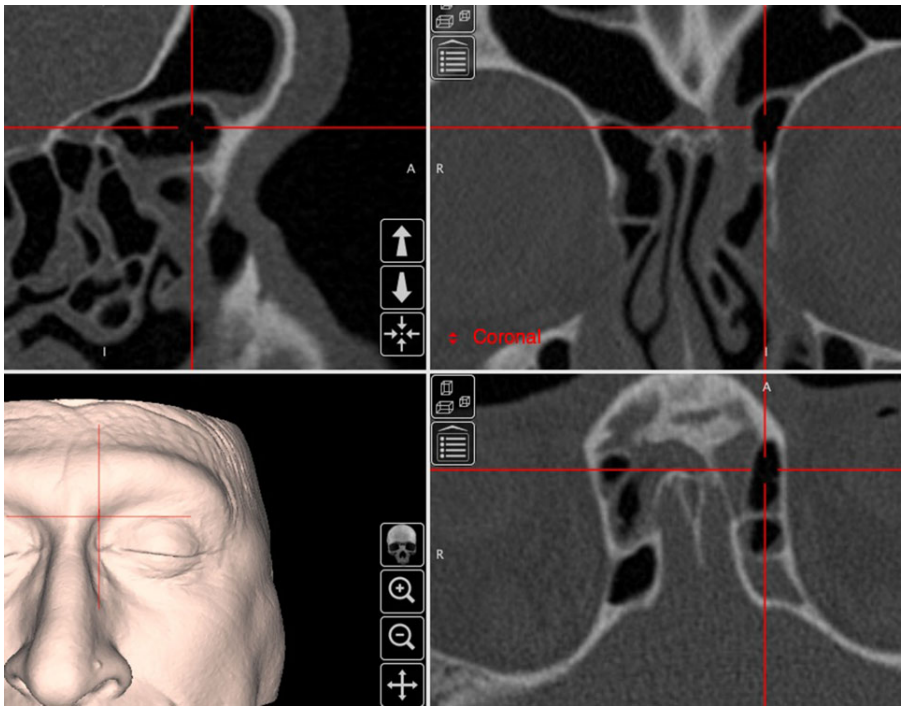


FIGURE 5. CT scan of a small SAFC. Identifying this cell is easier when all 3 planes of the CT scan are viewed simultaneously. CT = computed tomography; SAFC = supra agger frontal cell.

Figure 10 is a CT scan showing a supra bulla frontal cell (SBFC). The parasagittal and axial CT show the important differentiating features of an SBFC with the skull base forming the posterior wall of the cell and the cell pneumatizing through the frontal ostium into the frontal sinus.

Figure 11 is an example of an SBFC; the cell pushes the frontal sinus drainage pathway anteriorly. The anterior

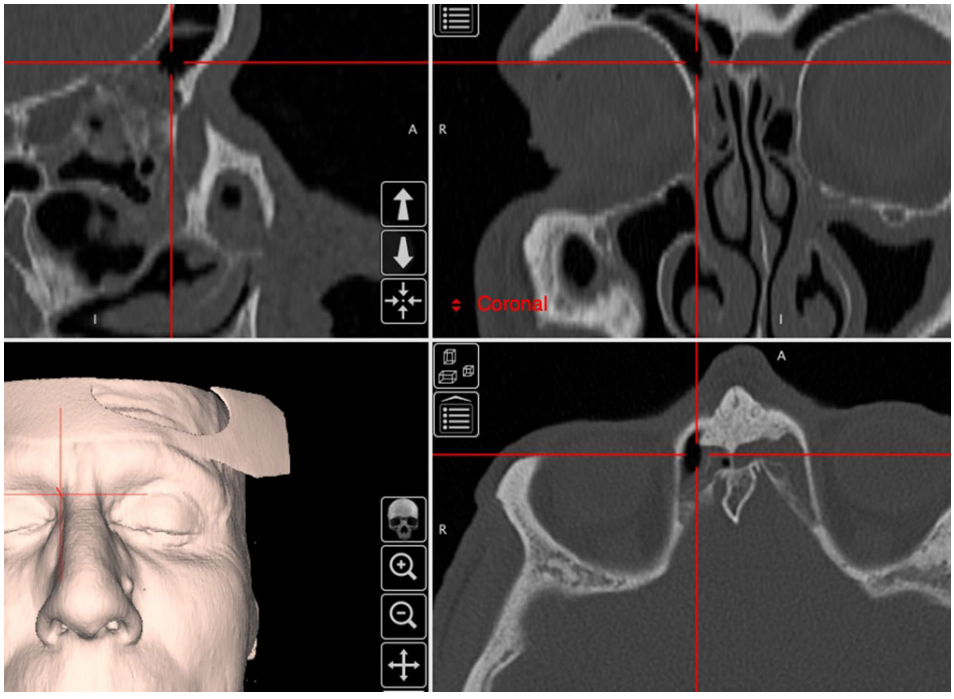


FIGURE 6. This CT scan illustrates a large SAFC. The SAFC pneumatizes significantly into the frontal sinus. CT = computed tomography; SAFC = supra agger frontal cell.

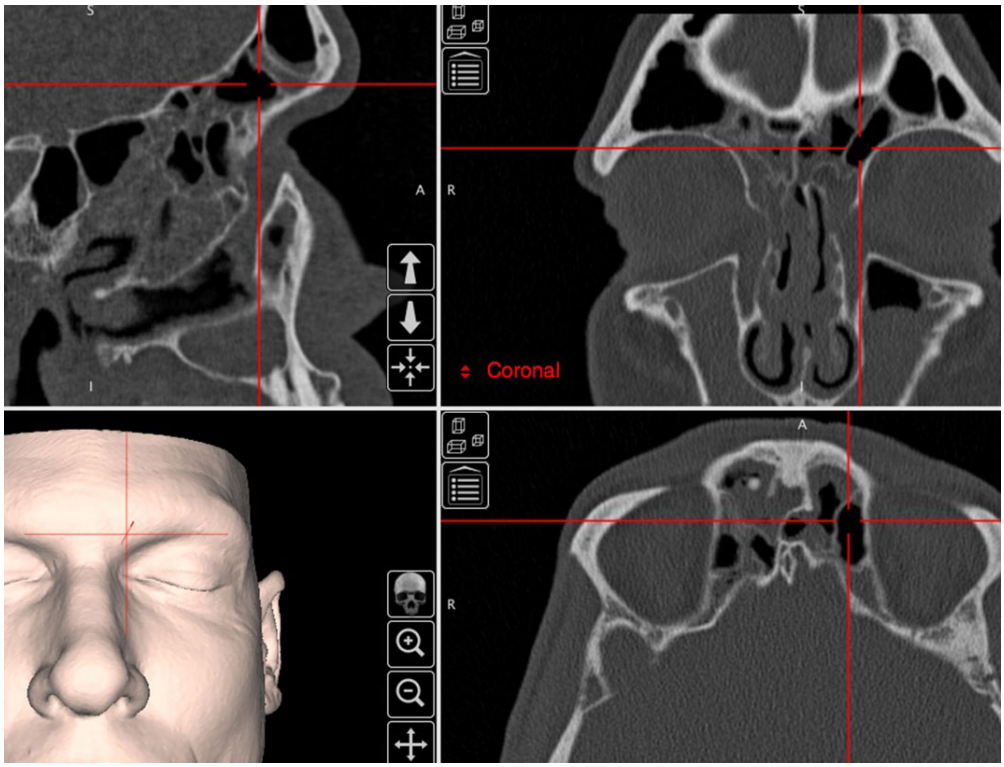


FIGURE 7. CT scan of a large SAFC that is laterally based and pushes the frontal drainage pathway medially. CT = computed tomography; SAFC = supra agger frontal cell.

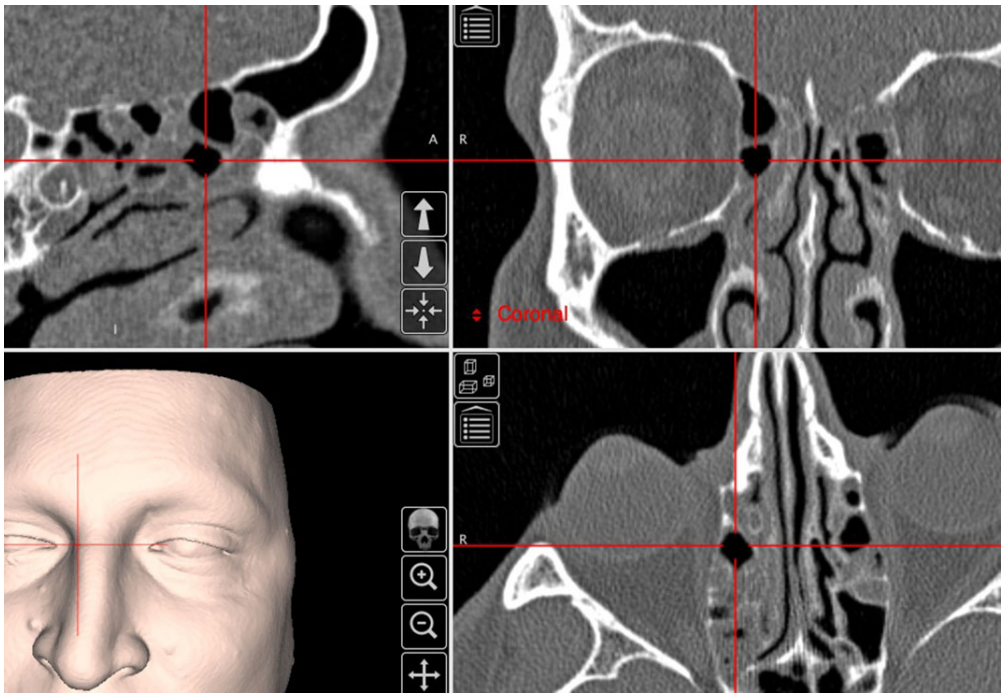


FIGURE 8. CT scan of a bulla ethmoidalis. This cell sits above the horizontal portion of the uncinate process. CT = computed tomography.

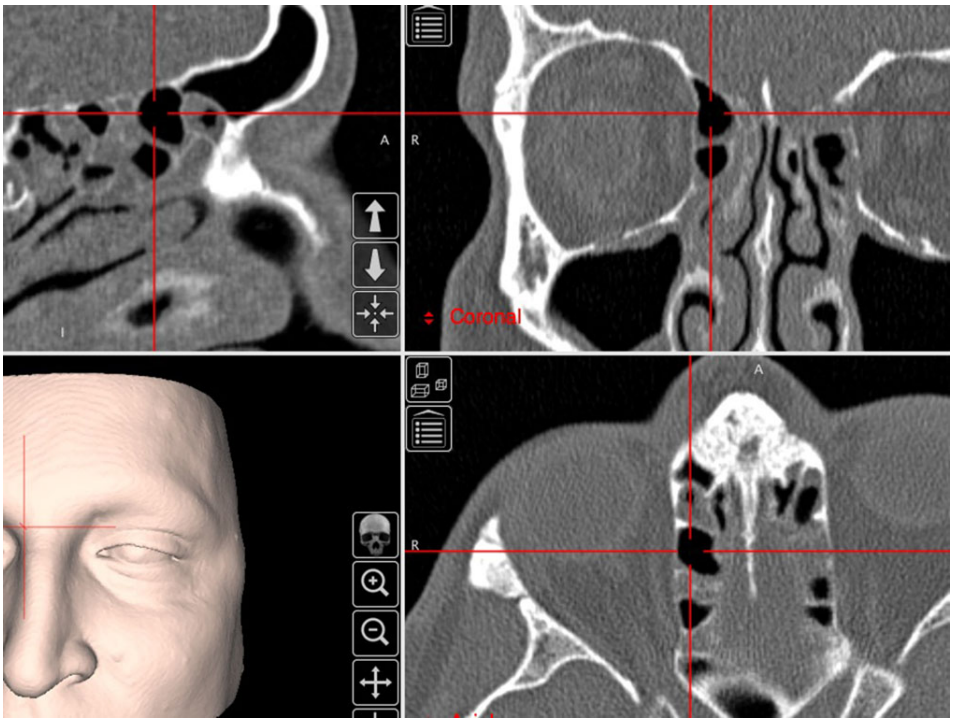


FIGURE 9. CT scan of an SBC. This cell is above the bulla ethmoidalis but doesn't pneumatized through the frontal ostium. CT = computed tomography; SBC = supra bulla cell.

pathway is further narrowed by a small SAFC so that the pathway is not only pushed anteriorly but also pushed medially by the SAFC, resulting in an anteromedial drainage pathway.

Figure 12 is a CT scan again illustrating the SBFC pushing the frontal sinus drainage pathway anteriorly until it touches the SAFC. Again the pathway becomes an anteromedial pathway.

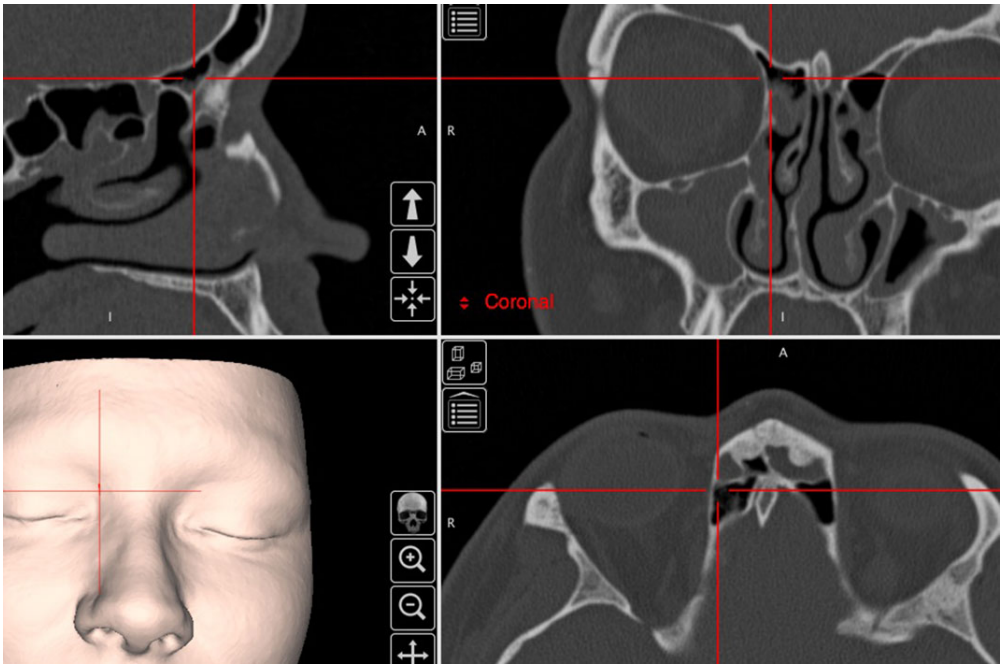


FIGURE 10. CT scan of an SBFC, which is a supra bulla cell that pneumatizes along the skull base through the frontal ostium. CT = computed tomography; SBFC = supra bulla frontal cell.

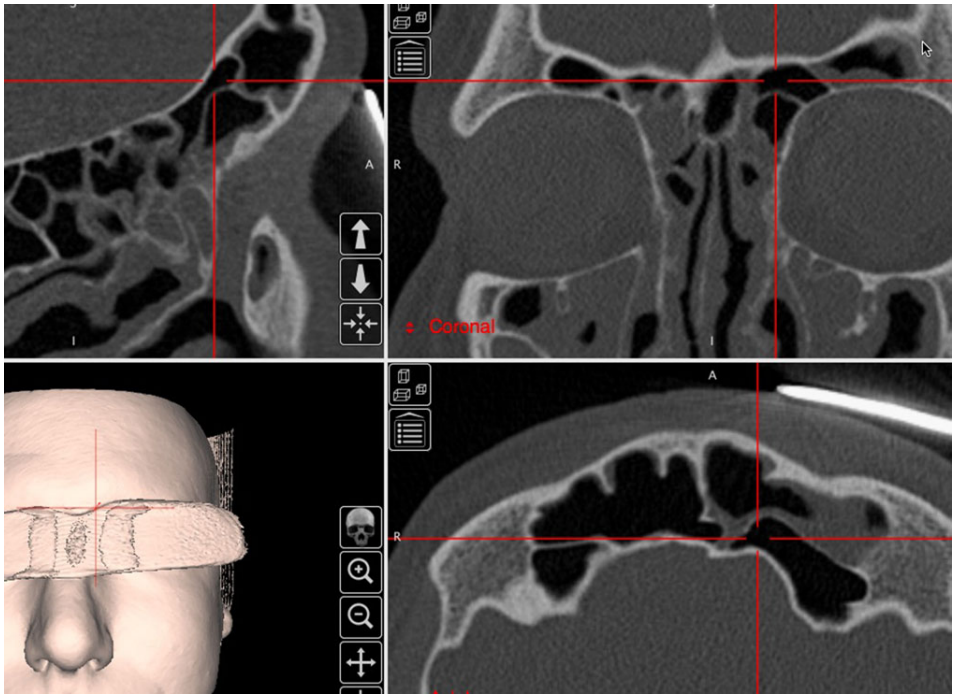


FIGURE 11. CT of an SBFC with the skull base as its posterior wall. CT = computed tomography; SBFC = supra bulla frontal cell.

Figure 13 is a radiological example of a left supra orbital ethmoid cell (SOEC). On the axial CT the cell looks similar to an SBFC as it migrates up toward the frontal sinus; however, on the coronal and parasagittal CT scans the cell is seen to pneumatize over the orbit, making this an SOEC rather than an SBFC.

Figure 14 is a radiological example of the right SOEC taking its origin from around and above the anterior

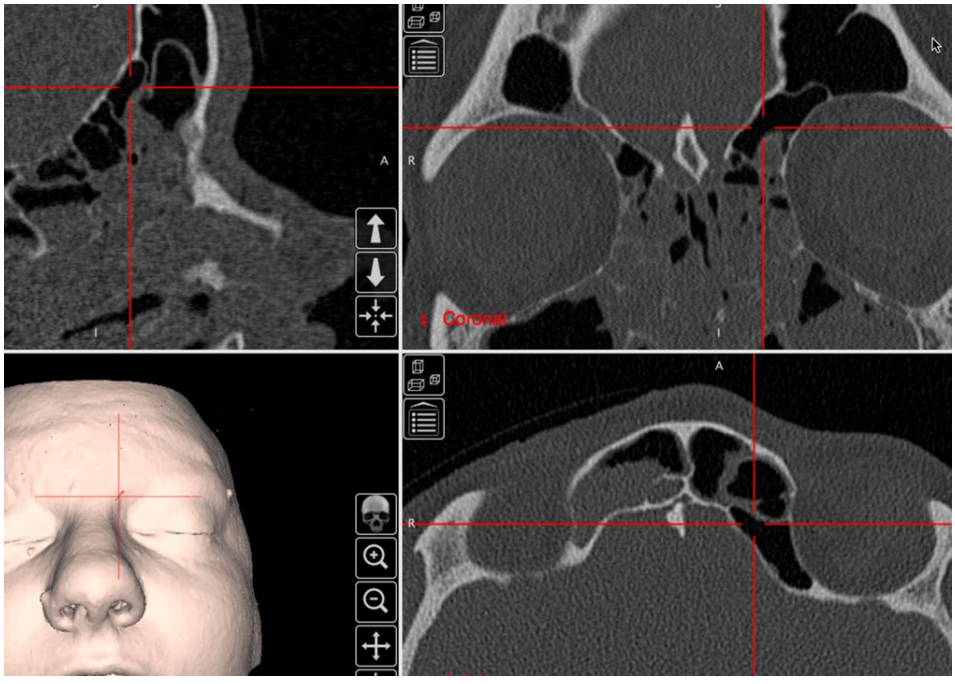


FIGURE 12. CT scan of an SBFC that pushes the frontal sinus drainage pathway anteriorly as it pneumatizes through the frontal ostium. CT = computed tomography; SBFC = supra bulla frontal cell.

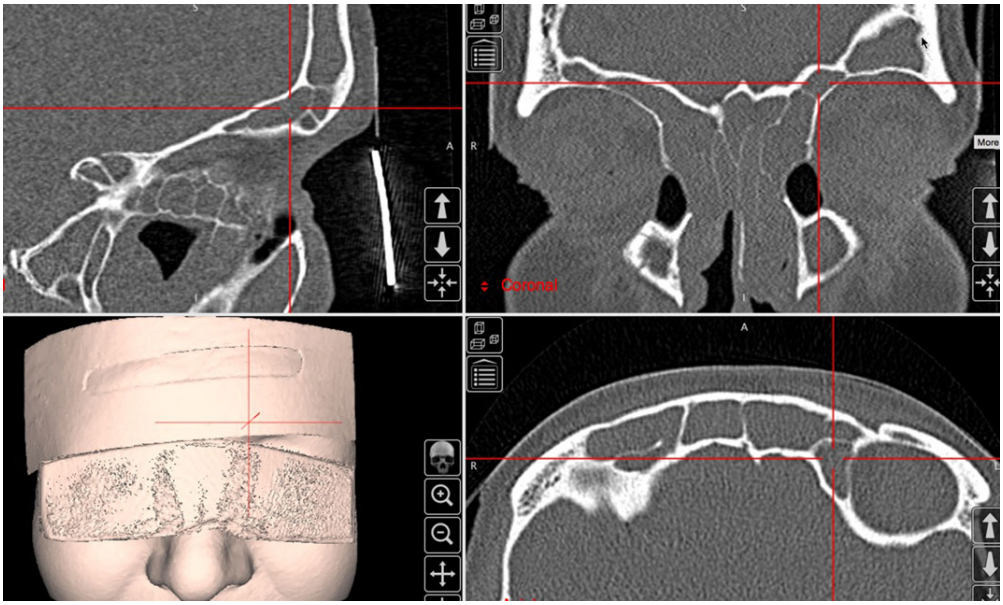


FIGURE 13. CT scan of an SOEC. This cell is best identified on the coronal and parasagittal CT scans as it pneumatizes over the orbit. CT = computed tomography; SOEC = supra orbital ethmoid cell.

ethmoid artery. Again, in the axial CT it could be confused with an SBFC but the differentiation is the pneumatization over the orbit seen on the coronal and parasagittal CT scans.

Figure 15 is a CT scan of a frontal septal cell (FSC). The cell can be seen originating from the region of the interfrontal sinus septum and occupying a significant part of the frontal drainage pathway, pushing this pathway laterally and often posteriorly. The bony septation separating the frontal drainage pathway from the cell (the lateral wall of the cell) can be quite thick in some patients and difficult to remove with conventional hand-held instruments.

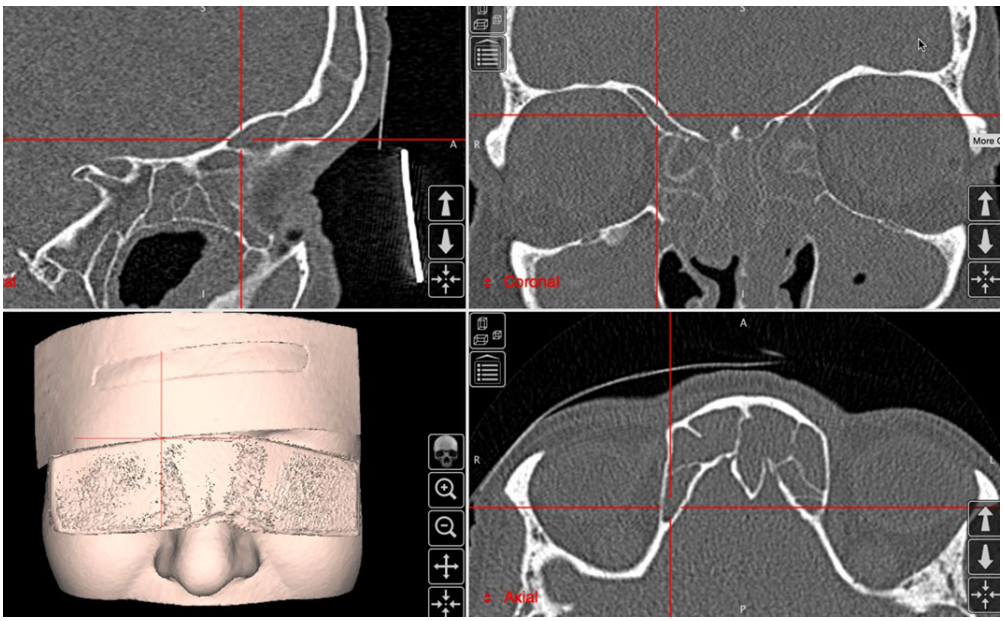


FIGURE 14. CT scan of an SOEC that originates around the anterior ethmoidal artery. CT = computed tomography; SOEC = supra orbital ethmoid cell.

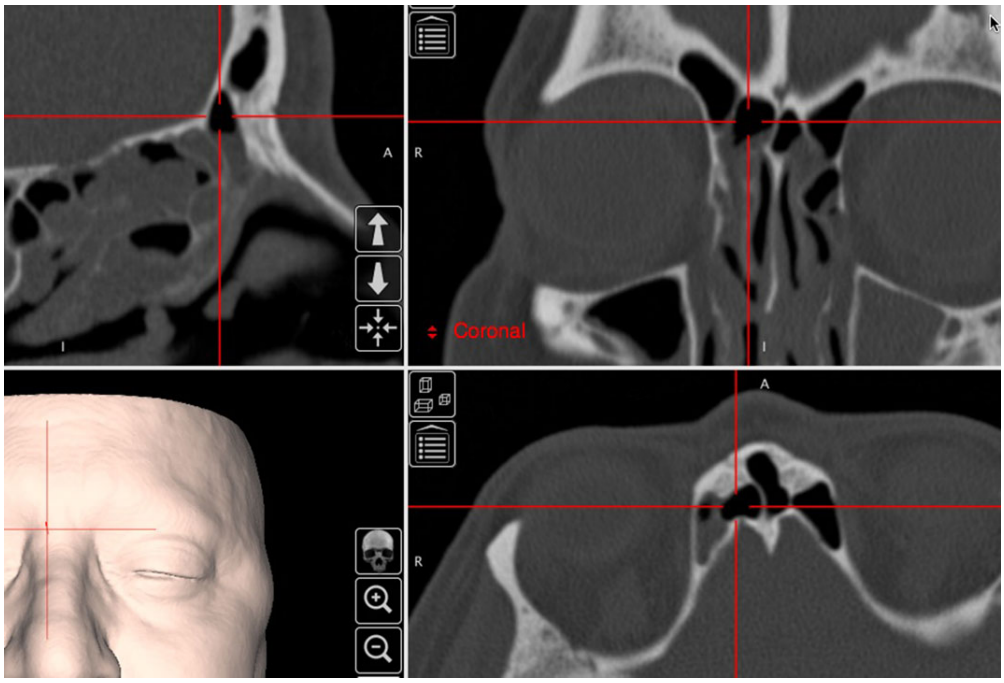


FIGURE 15. CT scan of an FSC. This cell has its medial wall the inter frontal septum. CT = computed tomography; FSC = frontal septal cell.

Figure 16 is an example of an FSC in which the cell itself is narrower in the axial and coronal plane, thus contributing less to the obstruction of the frontal sinus drainage pathway. The lateral wall of this FSC is thinner and usually easily removed with hand-held instruments.

Figure 17 is an example of an FSC showing the cell sitting higher in the frontal sinus and narrowing the frontal sinus

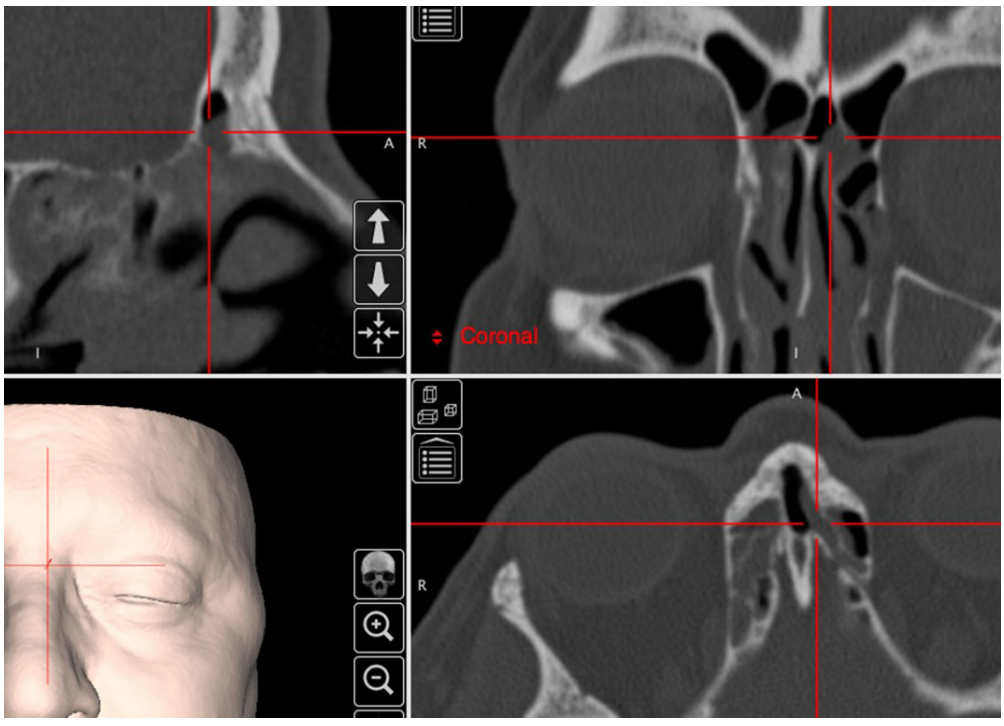


FIGURE 16. CT scan of an FSC that has a thinner medial wall which may be able to be removed with hand-held instruments. CT = computed tomography; FSC = frontal septal cell.

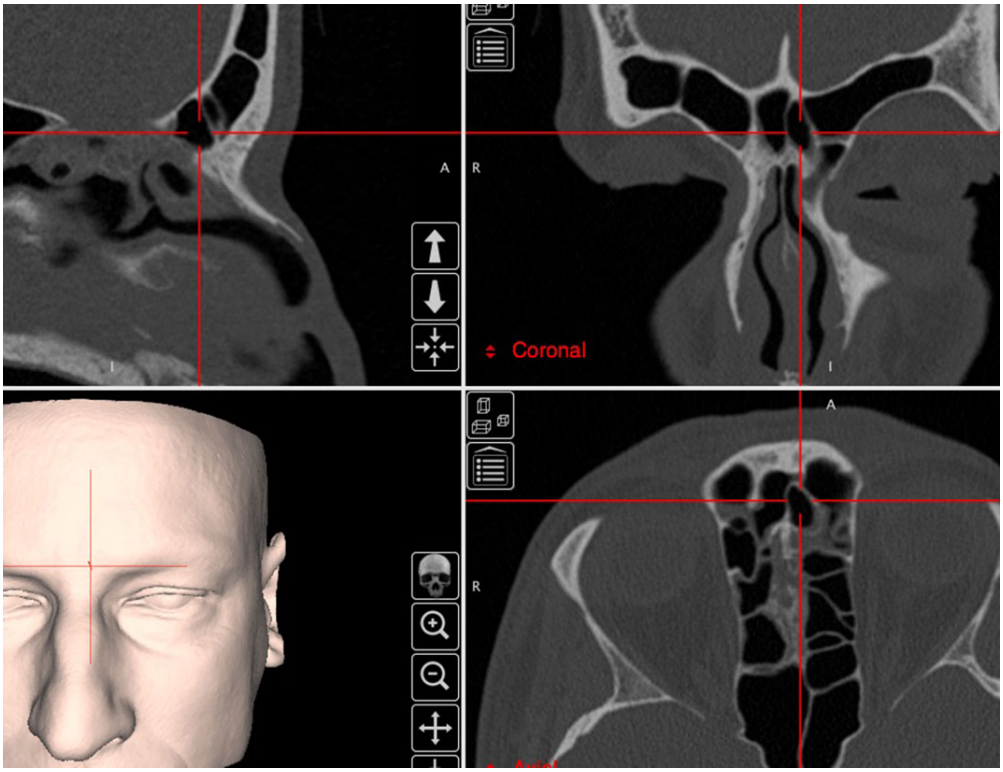


FIGURE 17. CT scan of an FSC that in this case is sitting higher on the inter frontal septum but still narrows and pushes the frontal drainage pathway laterally. CT = computed tomography; FSC = frontal septal cell.

drainage pathway as the frontal sinus transitions into the frontal recess.

Classification of the extent of endoscopic frontal sinus surgery (EFSS)

It is important that a new classification of the extent of endoscopic surgery of the frontal recess and frontal sinus takes into account the anatomical configurations and surgical difficulty. Such a classification would not only allow the graduated progression of a trainee through the various levels of sinus surgery during the training period but also allow communication between surgeons about patients. Reporting of outcomes can be improved by allowing surgical procedures to be graduated into levels of difficulty.

This classification hinges on the definition of the frontal ostium or opening. The frontal ostium is defined as the narrowest area of the transition zone from the frontal sinus to the frontal recess with its anterior edge formed by the frontal sinus beak (best seen on the parasagittal CT scan[12]).

Currently the most common classification in use is the Draf classification.[14–16] Although this has been widely quoted and used in the past, it is often misinterpreted and poorly understood especially the difference between a Draf 1 and Draf 2a procedure. [14–16] This proposed new classification will give surgeons the framework to be able to compare outcomes scientifically on surgeries conducted in the frontal recess region. Additionally this classification allows a trainee's teaching to be addressed in a stepwise and logical fashion. It can also be used to limit an individual trainee's surgery until the appropriate grade has been achieved before the trainee can progress onto the next level. Grades 0 to 3 of the classification of the extent of surgery relates to surgery of the frontal recess rather than surgery with the frontal sinus itself. In addition, these grades involve dilation/fracture or removal of cells that obstruct the frontal ostium or frontal drainage pathway without enlargement of the boney frontal sinus ostium. Grades 4 to 6 involve bone removal to enlarge the ostium. It is well recognized that clearance of the frontal recess is a vital part of frontal sinus surgery[7–10,15] and that incomplete clearance of cells from the frontal recess predisposes the patient to adhesions and ongoing frontal sinusitis.

International classification of the extent of EFSS

Grade 0: Balloon sinus dilation (no tissue removal) (Fig. 18A, B).

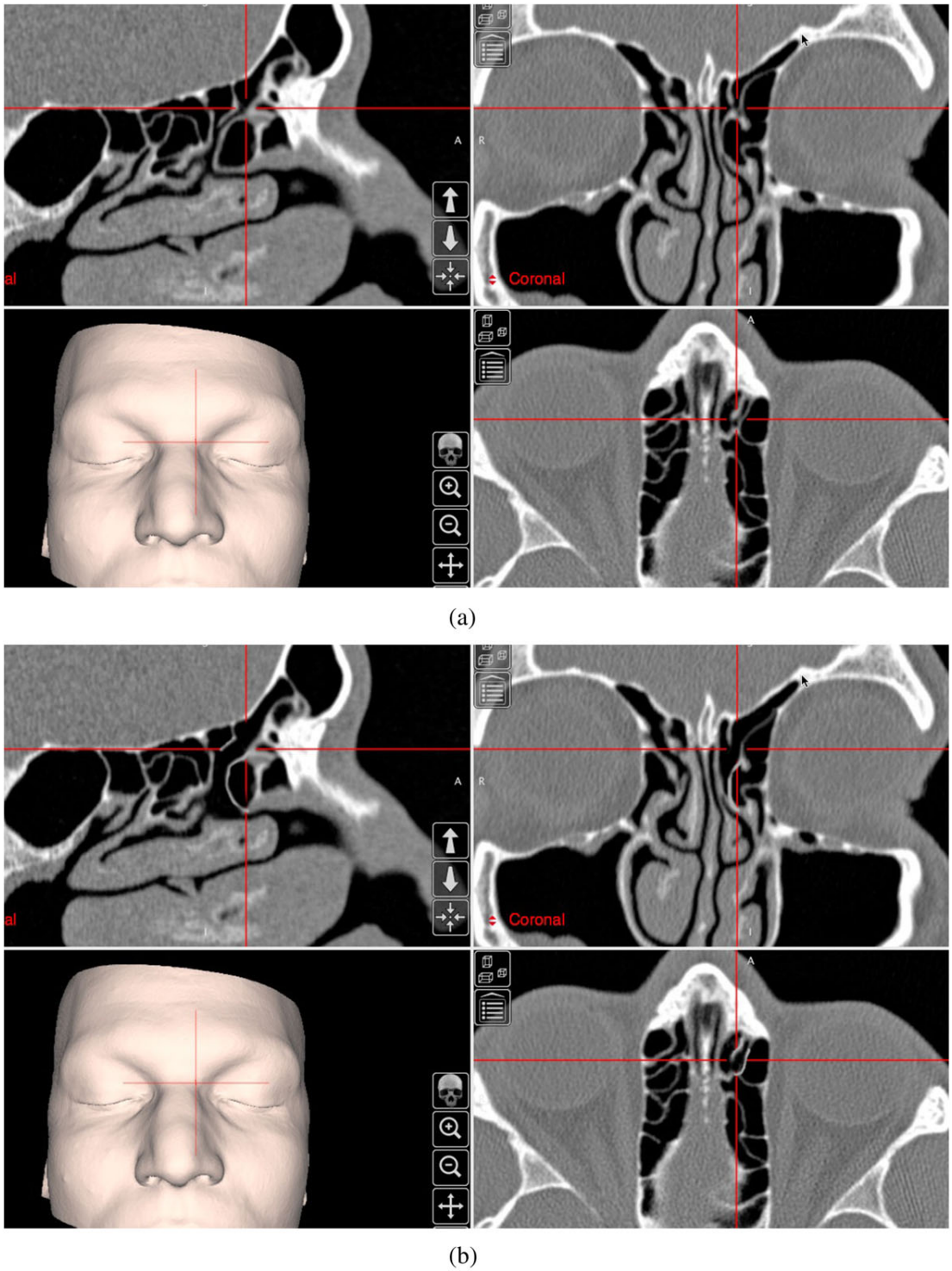


FIGURE 18. (A, B) CT scan of frontal recess illustrating grade 0 extent of surgery. (B) The frontal recess drainage pathway is dilated.

Frontal recess clearance procedures (tissue removal)

Grade 1: Clearance of cells in the frontal recess (that do not directly obstruct the frontal sinus ostium) without any surgery within the frontal ostium. These are SACs and SBCs that do not encroaching on or obstruct the frontal ostium (Fig. 19A, B).

Grade 2: Clearance of cell/s directly obstructing the frontal sinus ostium. These are SACs or SBCs that encroach on and obstruct the frontal sinus drainage. Typically, these

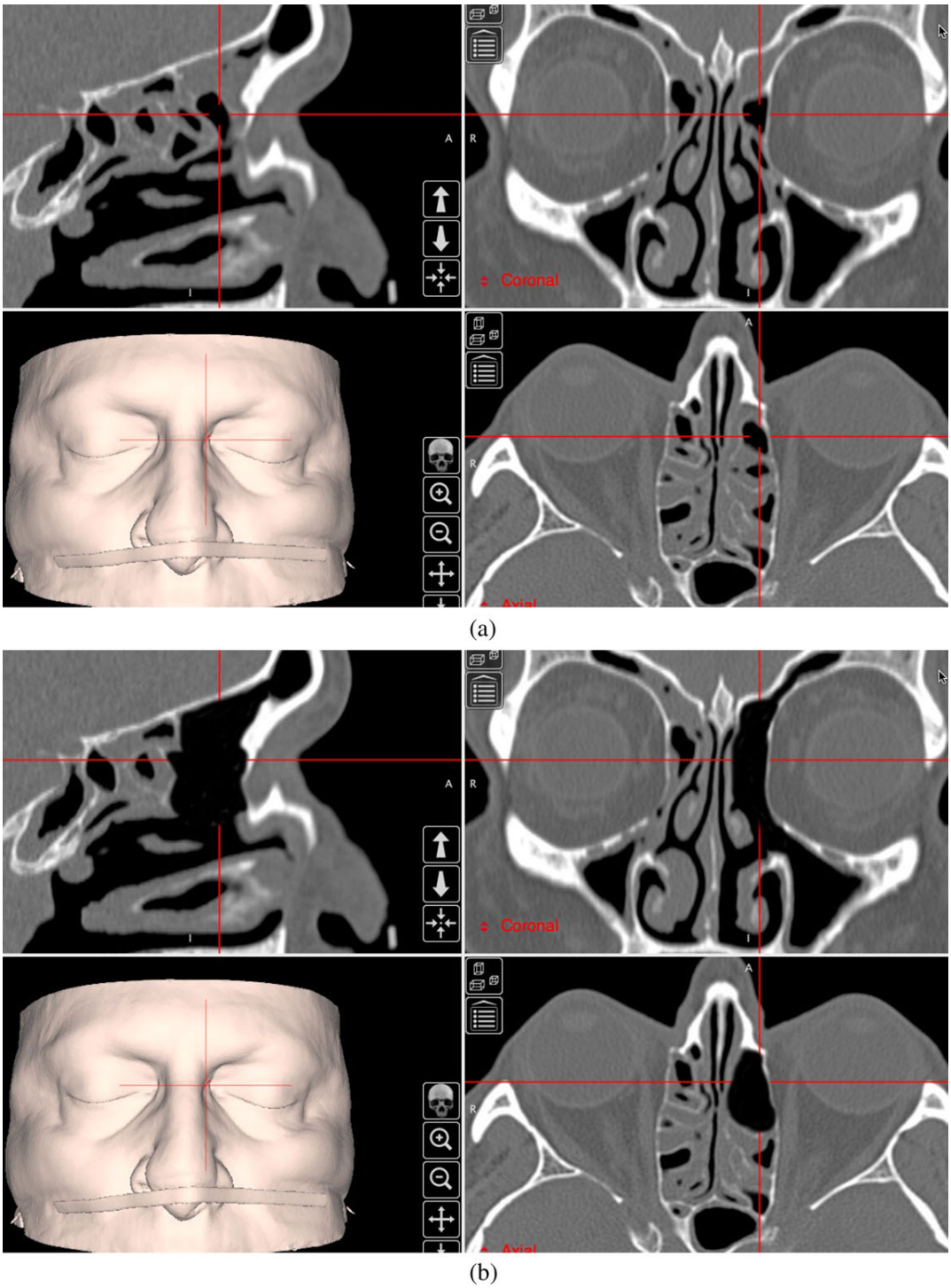
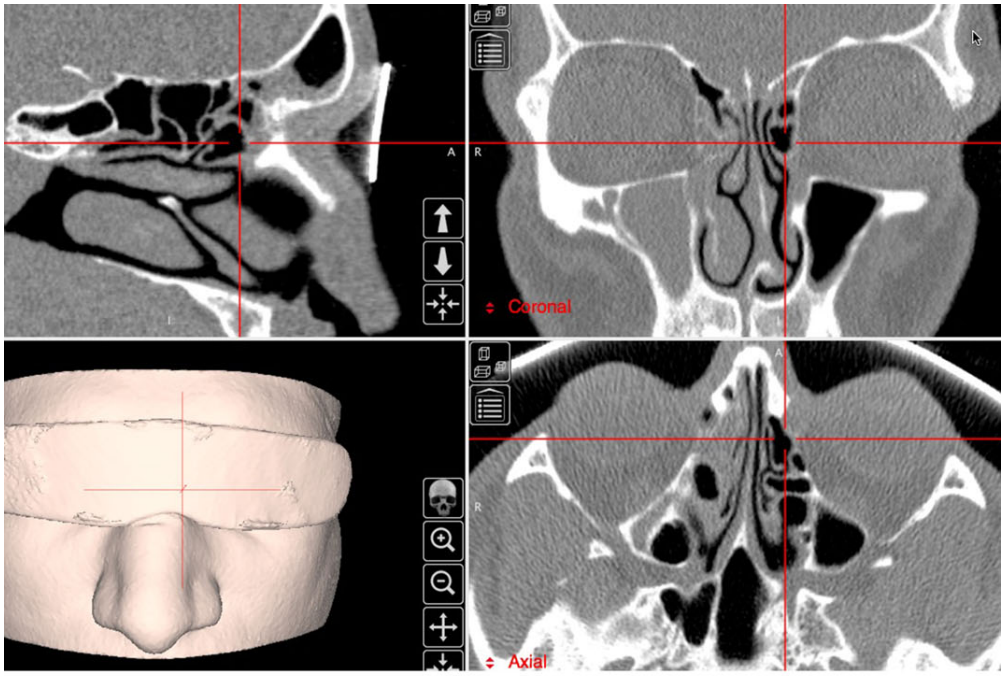


FIGURE 19. (A, B) CT scan illustrating grade 1 extent of surgery. (A) The cells do not encroach on the frontal ostium so that removal clears the frontal recess (B), but surgery was not performed in the frontal ostium.

cells occupy the space directly below the frontal sinus ostium and narrow the drainage pathway of the frontal sinus (Fig. 20A, B). This does not include patients with SAFCs, SBFCs, or FSCs.

Grade 3: Clearance of cell pneumatizing through the frontal ostium into the frontal sinus without enlargement of the frontal ostium. These are typically SAFCs, SBFCs, and FSCs (Fig. 21A, B).



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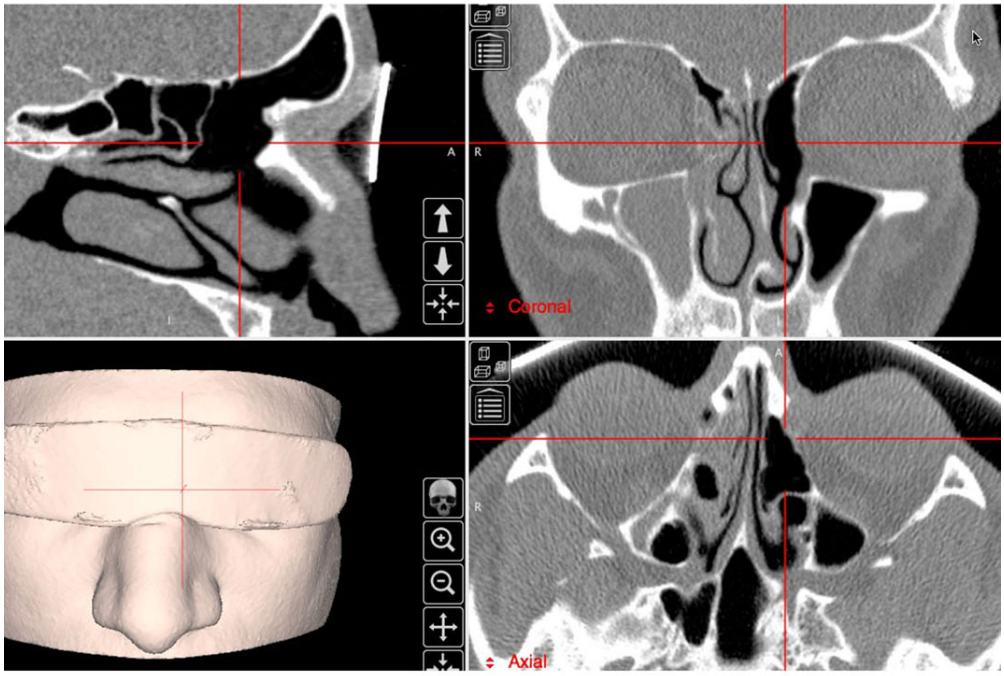


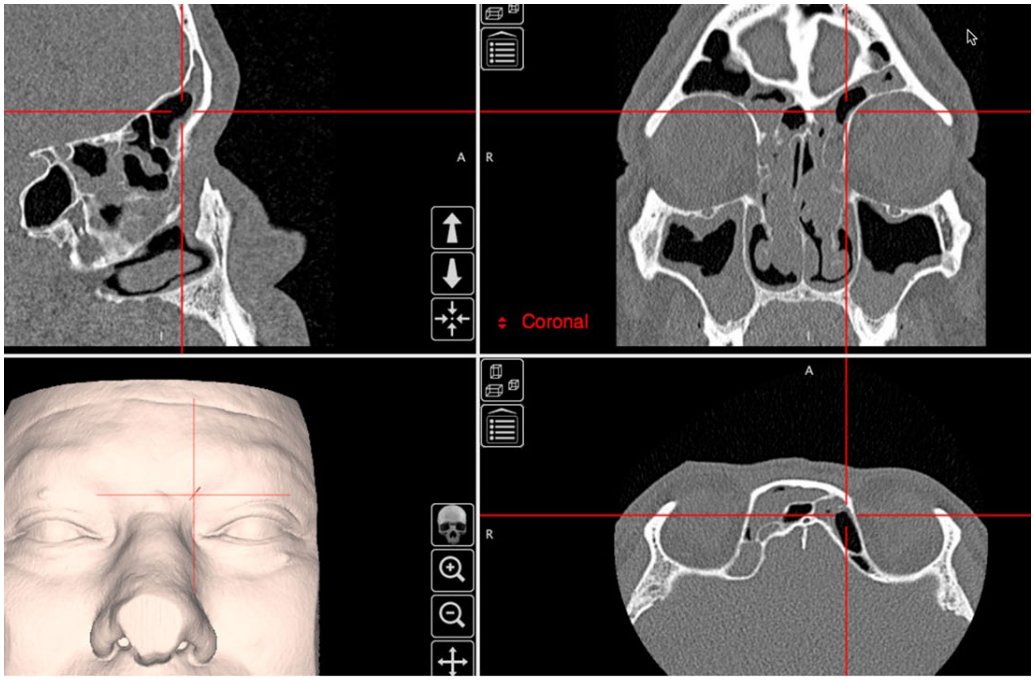
(b)

FIGURE 20. (A, B) CT scan illustrating grade 2 extent of surgery. (A) The SAC encroaches on the frontal ostium without extending through the frontal ostium. (B) Removal of these cells opens the drainage pathway. CT = computed tomography; SAC = supra agger cell.

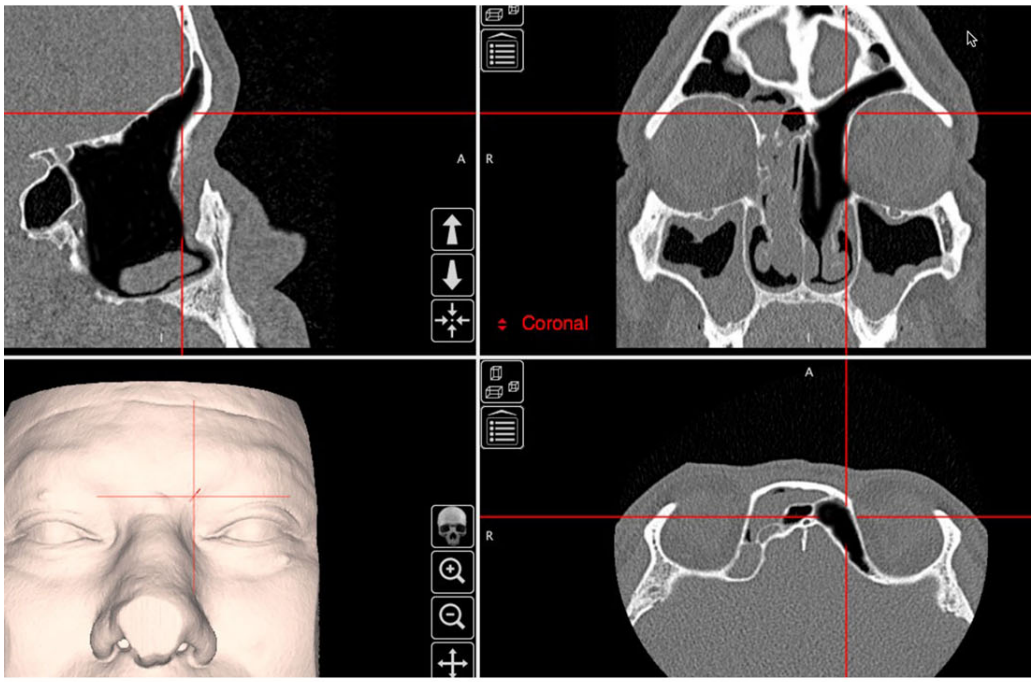
Frontal ostium enlargement procedures by removal of bone from the frontal beak

Grade 4: Clearance of a cell pneumatizing through the frontal ostium into the frontal sinus with enlargement of the frontal ostium (not just removal of cell walls but removal of bone of the frontal beak). These are typically large SAFCs, large SBFCs, or FSCs with a narrow frontal ostium (narrow anteroposterior [AP] diameter) (Fig. 22A, B).

Grade 5: Enlargement of the frontal ostium from the lamina papyracea to the nasal septum (unilateral frontal



(a)

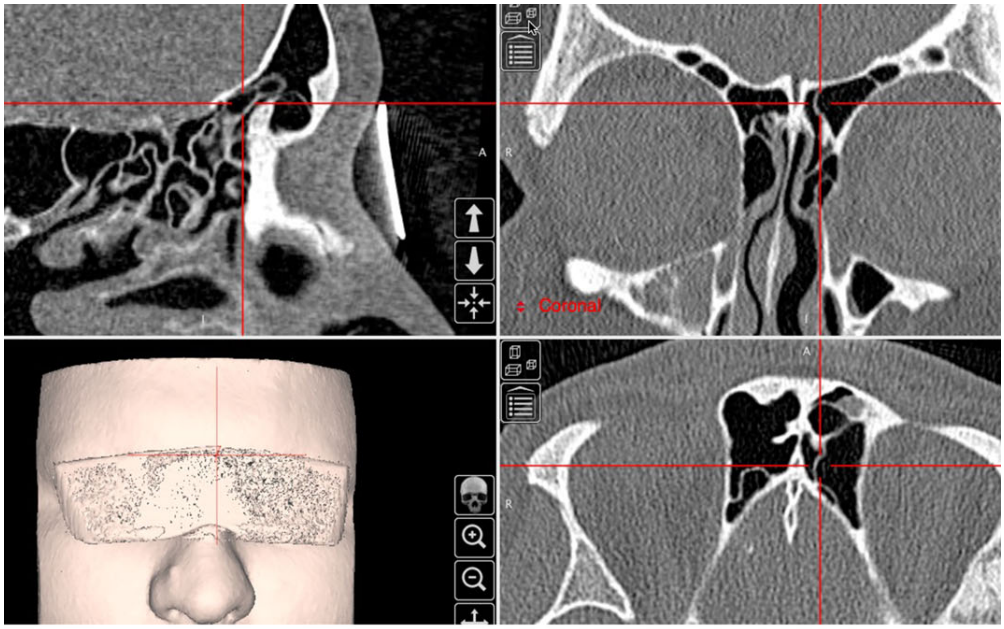


(b)

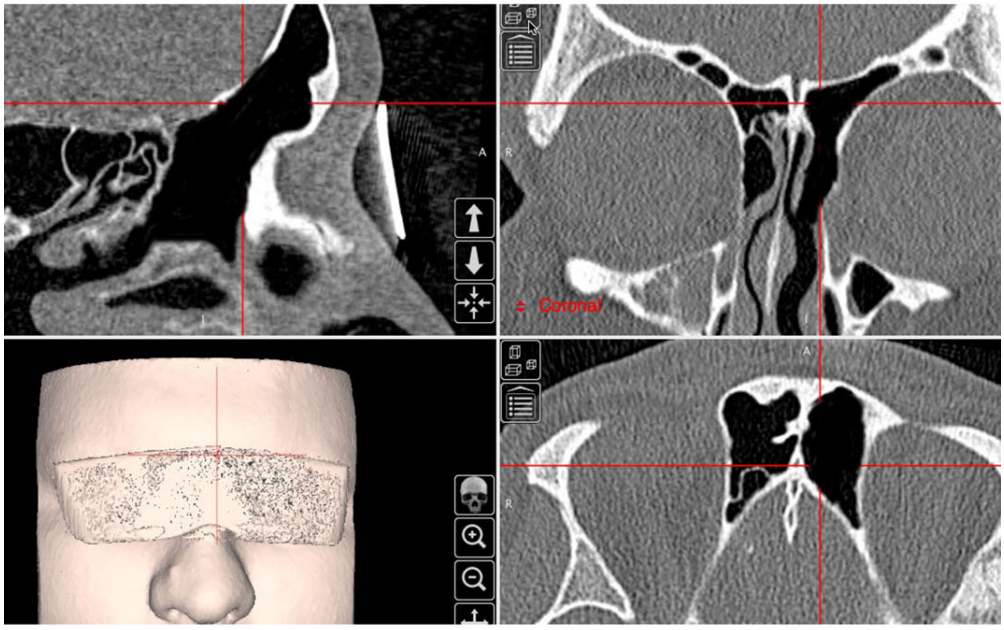
FIGURE 21. (A, B) CT scan illustrating grade 3 extent of surgery. (A) The SAFC migrates through the frontal ostium into the frontal sinus. (B) Removal of the cell without any widening of the bony frontal ostium. CT = computed tomography; SAFC = supra agger frontal cell.

drillout with removal of the floor of the frontal sinus). These are typically large SAFCs, large SBFCs or FSC with a narrow frontal ostium (narrow AP diameter) where the surgeon deems that the AP diameter is compromised to the extent that maximum unilateral AP neo-ostium is required (Fig. 23A, B)

Grade 6: Removal of the entire floor of the frontal sinus with joining of the left and right ostia into a common



(a)



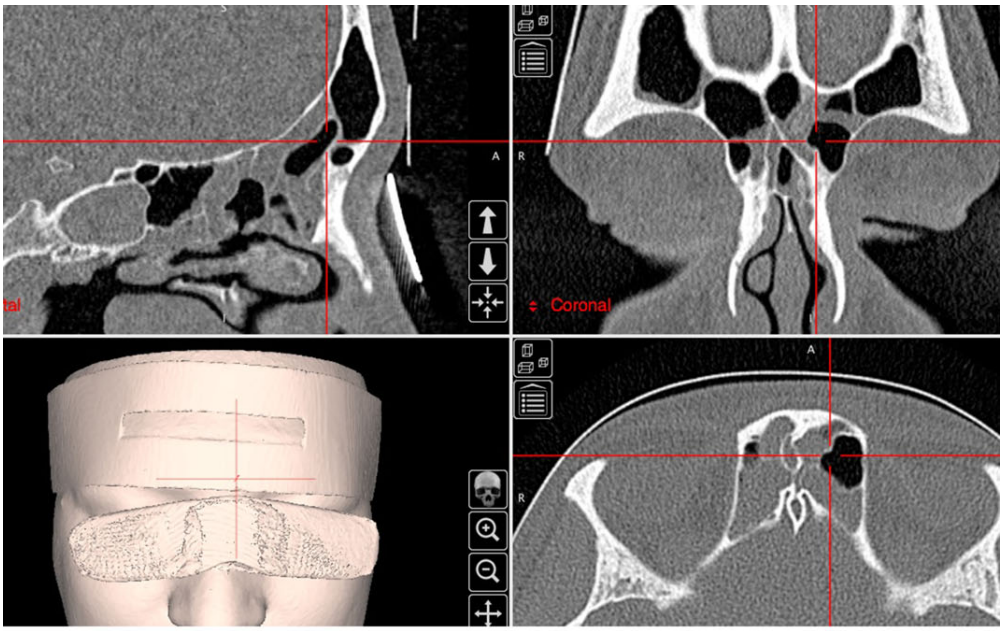
(b)

FIGURE 22. (A, B) CT scan illustrating grade 4 extent of surgery. (A) There is an SAFC and an SBFC obstructing the drainage of the frontal sinus. In addition the frontal boney beak obstructs the drainage. (B) The frontal ostium has been enlarged by removal of bone in the anterior region of the frontal ostium. CT = computed tomography; SAFC = supra agger frontal cell; SBFC = supra bulla frontal cell.

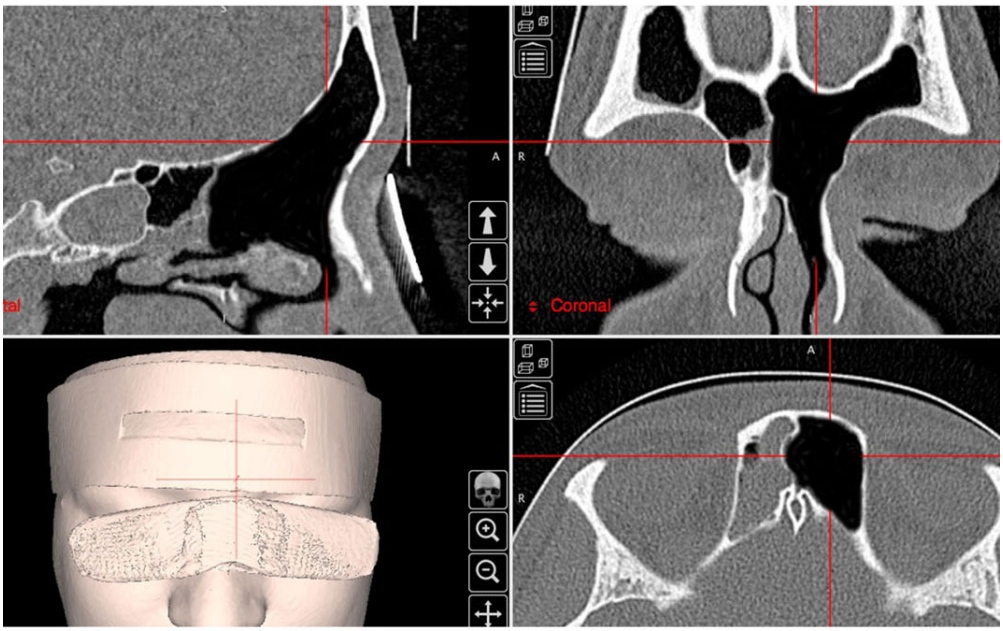
ostium with septal window–frontal drillout/modified Lothrop or Draf 3. This surgery is most often performed after failure of previous standard sinus surgery where the frontal ostium is stenosed with scar tissue or new bone formation but may be used to address large SAFCs, large SBFCs, or FSCs with a narrow frontal ostium (narrow AP diameter). This surgery results in the maximum possible AP and lateral diameter of the frontal ostium (Fig. 24A, B).

Controversial issues

It will always be the case in consensus documents that not every member of the group fully agrees with all the anatomical terms and classifications. However, in this document we were able to achieve consensus by the vast majority of the authors. The following items generated discussion. Most agreed on the term frontal ostium (for



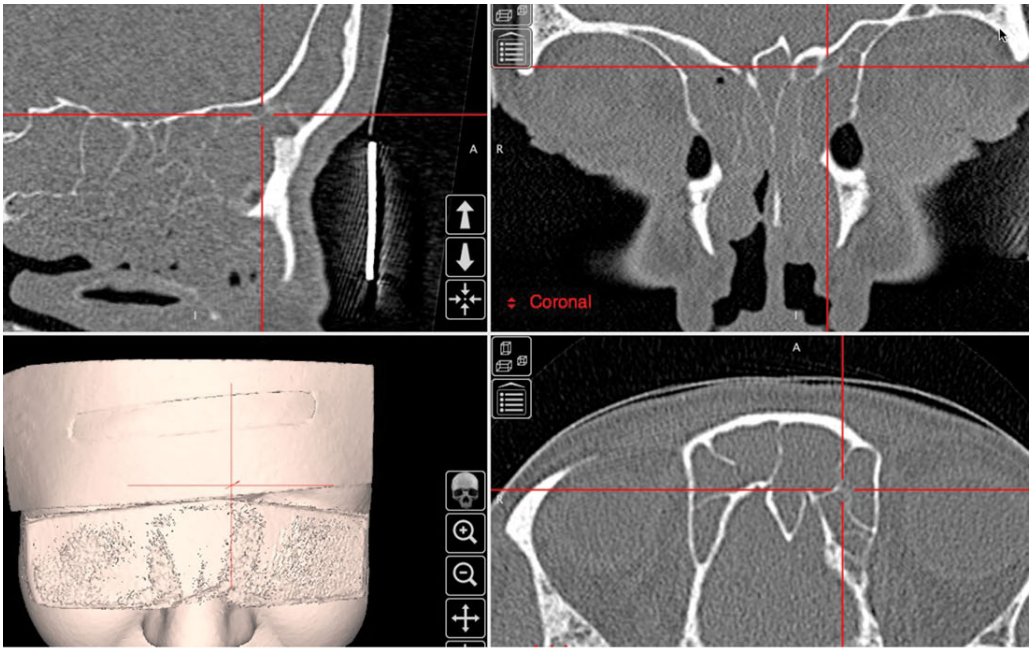
(a)



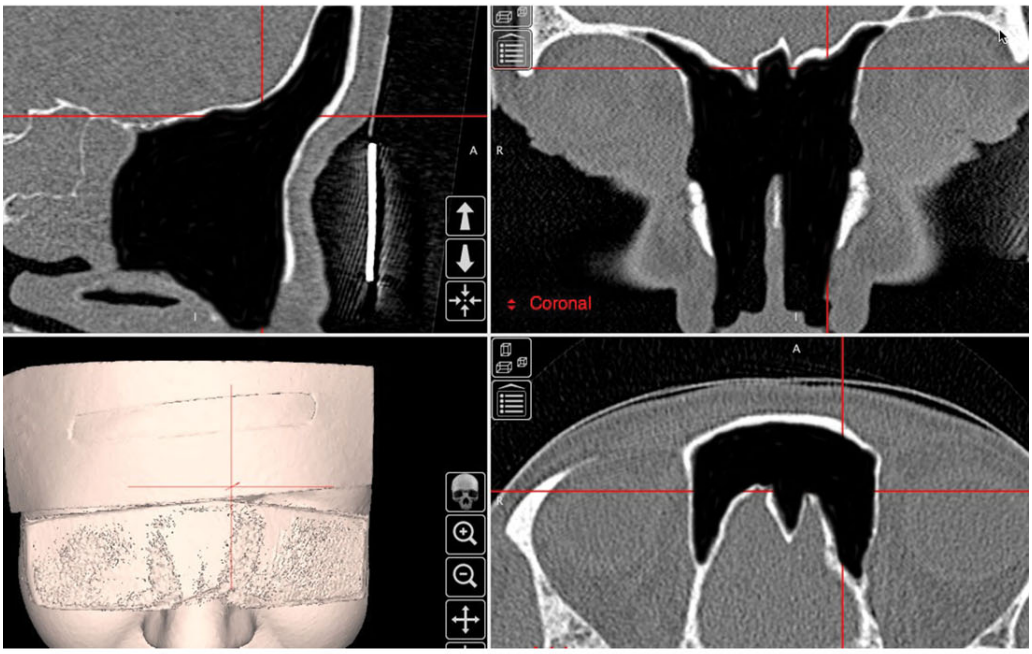
(b)

FIGURE 23. (A, B) CT scans illustrating grade 5 extent of surgery. (A) There is an SAFC, an SBFC, and an FSC all narrowing the drainage of the frontal sinus. (B) The frontal ostium has been widened by removal of the beak, and removal of the floor of the frontal sinus from the lamina papyracea up to the septum. CT = computed tomography; FSC = frontal septal cell; SAFC = supra agger frontal cell; SBFC = supra bulla frontal cell.

the purpose of a better understanding of how the cells related to the frontal sinus). However, because the frontal sinus does not have a distinct soft tissue ostium such as the maxillary sinus, the term "frontal sinus opening" was proposed as well.[16] The definition of the frontal recess was also discussed. This is an inverted funnel-shaped structure and is not synonymous with the frontal drainage pathway. The frontal drainage pathway forms part of the frontal recess but also includes the cells presented in the International Frontal Sinus Anatomy Classification (IFAC) (Table 1).



(a)



(b)

FIGURE 24. (A, B) CT scans illustrating grade 6 extent of surgery. (A) Severe disease with previous surgery and narrow frontal ostium. (B) Surgery where the entire floor of both frontal sinus has been removed and a superior septal window created allowing for the largest possible neo-ostium incorporating both frontal sinuses into a single ostium (previously known as a Draf 3, frontal drillout, or modified Lothrop procedure).

Conclusion

This consensus article was produced by a group of leading rhinologists from around the world agreeing on a pragmatic classification that has value in both understanding the anatomy and in planning the surgical approach to the frontal sinus. In addition, a new classification of the extent of surgery is also proposed to reflect the different surgeries that are performed in a gradated manner in the frontal recess and frontal sinus during ESS.

References

1. Lund VJ, Stammberger H, Fokkens WJ, et al. European position paper on the anatomical terminology of the internal nose and paranasal sinuses. *Rhinol Suppl*. 2014;(24):1–34.
2. Van Alyea OE. Frontal sinus drainage. *Ann Otol Rhinol Laryngol*. 1946;55:267–277.
3. Bent JP, Cuilty-Siller C, Kuhn FA. The frontal cell as a cause of frontal sinus obstruction. *Am J Rhinol*. 1994;8:185–191.
4. Kuhn FA. Chronic frontal sinusitis: the endoscopic frontal recess approach. *Otolaryngol Head Neck Surg*. 1996;7:222–229.
5. Kuhn FA. An integrated approach to frontal sinus surgery. *Otolaryngol Clin North Am*. 2006;39:437–461.
6. Lee WT, Kuhn FA, Citardi MJ. 3D computed tomographic analysis of frontal recess anatomy in patients without frontal sinusitis. *Otolaryngol Head Neck Surg*. 2004;131:164–173.
7. Wormald PJ. *Endoscopic Sinus Surgery: Anatomy, Three-Dimensional Reconstruction and Surgical Technique*. 3rd ed. New York: Thieme; 2012.
8. Wormald PJ. The agger nasi cell: the key to understanding the anatomy of the frontal recess. *Otolaryngol Head Neck Surg*. 2003;129:497–507.
9. Wormald PJ. Surgery of the frontal recess and frontal sinus. *Rhinology*. 2005;43:83–85.
10. Wormald PJ, Chan SZX. Surgical techniques for the removal of frontal recess cells obstructing the frontal ostium. *Am J Rhinol*. 2003;17:221–226.
11. Wormald PJ. Three dimensional building block approach to understanding the anatomy of the frontal recess and frontal sinus. *Operative Techniques in Otolaryngology–Head and Neck Surgery*. 2006;17:2–5. doi: 10.1016/j.otot.2005.11.001.
12. Kew J, Rees G, Close D, Sdralis T, Sebben R, Wormald PJ. Multiplanar reconstructed CT images improve depiction and understanding of the anatomy of the frontal sinus and recess. *Am J Rhinol*. 2002;16:119–123.
13. Bolger WE, Butzin CA, Parsons DS. Paranasal sinus, bony anatomic variations and mucosal abnormalities: CT analysis for endoscopic sinus surgery. *Laryngoscope*. 1991;101;56–64.
14. Draf W. Endonasal microendoscopic frontal sinus surgery, the Fulda concept. *Operative Techniques in Otolaryngology–Head and Neck Surgery*. 1991;2:234–240. doi: 10.1016/S1043-1810(10)80087-9.
15. Weber R, Draf W, Kratzsch B, Hosemann W, Schaefer SD. Modern concepts of frontal sinus surgery. *Laryngoscope*. 2001;111:137–146.
16. Weber RK, Hosemann W. Comprehensive review on endonasal endoscopic sinus surgery. *GMS Curr Top Otorhinolaryngol Head Neck Surg*. 2015;14:Doc08. doi: 10.3205/cto000123.