Chapter 16 – Endoscopic Approach to the Frontal Sinus

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Endoscopic surgery on the frontal sinus is, for the most part, predicated on understanding the anatomy of the frontal recess. Frontal sinus drainage is influenced and affected by the adjacent cellular structures, much as the maxillary sinus is dependent on the configuration that the patient's uncinate process, ethmoid bulla, and Haller cells exert on the outflow tract.

Most commonly, the uncinate process ascends from its inferior attachment to the inferior turbinate and from its anterior attachment to the lacrimal bone and blends in with the medial wall of the agger nasi cell (Fig. 16-1). In these cases the frontal sinus will drain between the uncinate process and the middle turbinate as it does 85% of the time.[1,2] In the remaining cases, the uncinate attaches to the middle turbinate or the skull base, and the frontal sinus drains directly into the infundibulum. If the uncinate attaches both medially to the middle turbinate and laterally to the agger nasi, the frontal sinus will be seen to drain posteriorly.

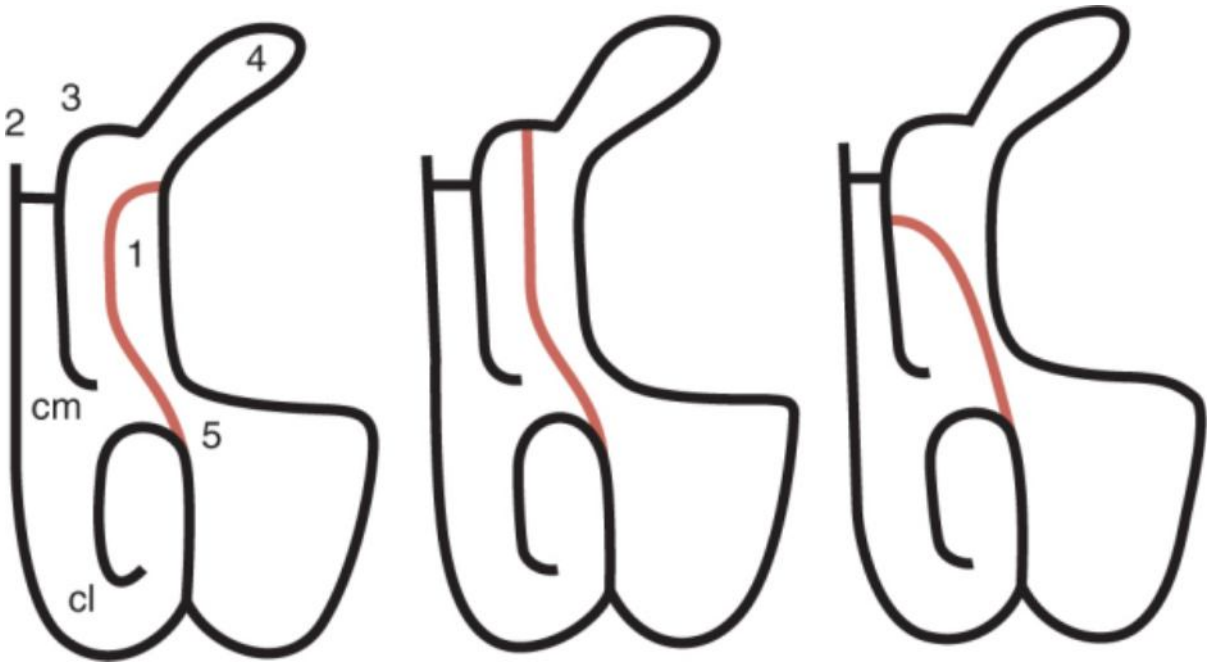

Figure 16-1 Line diagram of the uncinate attachment.
(From Stammberger H, Hawke M: Essentials of Functional Sinus Surgery, Mosby, 1993.)

PATIENT SELECTION

The vast majority of patients who have frontal sinus disease refractory to medical therapy can have their frontal sinus surgery managed endoscopically. However, for certain conditions, including some benign and malignant tumors, pathology situated laterally within the sinus, and very small sinuses, an open approach remains a very good and reliable surgical option (see Chapter 15).

Acute frontal sinusitis is *not* usually a good indication for endoscopic frontal sinus surgery. These patients have intense hyperemia and inflammation, and the likelihood of creating symptomatic scarring in the frontal recess is great. I prefer to manage these patients as true medical emergencies with intravenous antibiotics and classic frontal sinus trephination. Surgery on the frontal recess, if necessary, should be delayed until the acute process has resolved.

The surgeon will generally find that complications of sinus infections involving either the central nervous system or the orbit are most commonly associated with acute and not chronic sinus problems. The frontal sinus is a dangerous sinus in this regard, and meningitis and periorbital and brain abscesses are possible severe

complications.

Those in whom chronic frontal sinus problems develop are considered surgical candidates according to the same criteria as for other endoscopic sinus surgery. Patients should have the criteria for sinusitis proposed by the American Academy of Otolaryngology–Head and Neck Surgery, and they should have failed medical therapy consisting of at least a minimum 3 weeks of antibiotic therapy. Imaging obtained at the end of treatment is used to determine the extent of surgery.[3]

PREOPERATIVE PLANNING

All patients who are to undergo frontal sinus surgery should have computed tomography (CT) scans taken in both the axial and coronal plane. If available and deemed necessary, computerized navigation provides the additional sagittal projection. Radiographs should be reviewed carefully before surgery to evaluate the uncinate process, agger nasi cells, and the size and depth of the frontal sinus. Scans should be reviewed to note the position of the anterior ethmoid artery and the presence or absence of supraorbital ethmoid cells. Patients should be suspected of having supraorbital ethmoid cells if multiple septations are seen within the frontal sinus on coronal images.

Antibiotics and possibly topical and systemic steroids should be used to minimize vascularity and edema in the frontal recess, which could make surgery more dangerous because of bleeding with resultant decreased visibility.

Patients who will undergo an advanced endoscopic drill-out procedure must have a large enough sinus to begin with. A sinus with less than 9-mm anterior posterior space is difficult to keep open in the postoperative period.[4]

Patients with erosion between the frontal sinus and the orbit and those with erosion of the posterior wall of the frontal sinus are more easily treated by an endoscopic drill-out procedure than by an open frontal sinus obliteration operation. This avoids the difficult surgical conundrum of attempting to eradicate all mucosal remnants off the dura or periorbita.

The procedure begins in the holding area with the use of topical decongestants applied 30 minutes before the procedure; repeat topical therapy is given at 15 minutes and on call in the operating room. The patient arrives in the operating room for either general or monitored anesthesia, depending on patient preference and the planned extent of surgery.

Surgical preference will dictate the way that the operating room and the Mayo stand are organized. We use a two-handed technique,[5] which is particularly helpful in patients with acute inflammation and bleeding. Many different systems of powered instruments are available, and optimal settings will vary. In general, if one is having difficulty, the device should be slowed down to allow a greater period when the window is open to entrap the tissue, particularly during surgical removal of polyps with these devices.

There are many ways to clean the lens of the scope and prevent fogging: some scopes are self-irrigating, some *soft tissue shavers* irrigate the lens clear, and in the two-surgeon technique the assistant instills water into the nose with a 60-mL syringe by way of a blunt 18-gauge needle. Defogging agent may be purchased from multiple manufacturers as well. It is helpful but should not be used if an irrigating sleeve is on the scope because the film prevents irrigation of the tip of the scope. A clean scope and a dry field will enable the procedure to progress satisfactorily and decrease frustration and complications.

To maintain a dry field, oxymetazoline and 1:1000 topical adrenaline are applied on ½- by 3-inch radiopaque neuropatties. Both are poured by the circulator into labeled basins. The adrenaline is dyed with a single drop of methylene blue to further decrease the risk of confusing it with local anesthetic and injecting it into the nasal mucosa.

All procedures are done with the injection of a local anesthetic, 1% lidocaine (Xylocaine), and a vasoconstrictor, 1:100,000 epinephrine. The injections sites are at the superior attachment of the middle turbinate and the inferior aspect of the uncinate process, as well as at the tail of the middle turbinate. After 5 minutes have passed, the procedure is begun.

SURGICAL TECHNIQUE

The frontal sinus, like all sinuses, should be treated operatively only if all medical therapy has failed and the sinus is symptomatic. Because the frontal sinus is involved radiographically in just 20% or less of patients, it should be addressed only when absolutely necessary, particularly in the case of the frontal sinus (as opposed to the other paranasal sinuses) since rescuing an iatrogenically impaired sinus can be difficult.

Therefore, when patients lack significant frontal sinus pathology on CT and are asymptomatic, the uncinate process will be taken up as far as the agger nasi cell. A synechia that might form between an intact middle turbinate and the agger region will not usually block the frontal sinus.

In patients with frontal sinus symptoms and pathology, the frontal sinus can be explored if surgically indicated. This entails either frontal sinus trephination to irrigate the frontal sinus or dissection of the agger nasi cell or cells to improve the outflow tract of the frontal sinus.

Frontal Sinus Trephination

Frontal sinus trephination can be used for treatment of a chronically inflamed frontal sinus. This technique is used as an adjunct to endoscopic sinus surgery and is not the same technique that is generally used for draining an acute frontal sinus (Fig. 16-2). The frontal sinus is entered after reviewing the CT scan, with especial notation of the depth of the sinus on an axial scan or on a navigation system. All the trephination sites should be measured for maximum safe penetration, particularly in females, who have smaller sinuses than males do. Commercially available trephination kits are not designed to be used to the maximum depth of penetration in all patients.

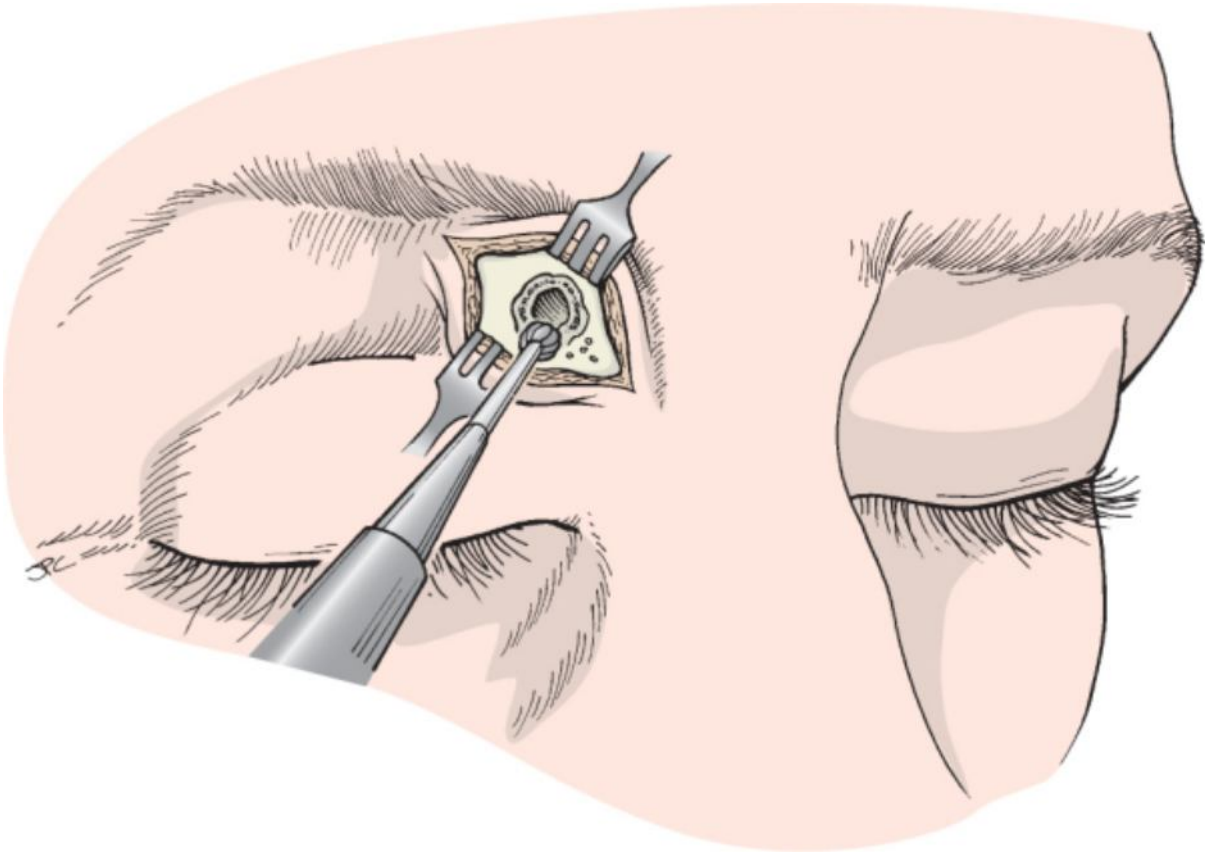

Figure 16-2 Trephination is performed through an incision made in the medial aspect of the brow. The floor of the frontal sinus is exposed and a drill is used to drain the sinus. The lateral wall of the nasal frontal recess is then removed down to provide communication between the frontal sinus and middle meatus.

If not using a navigation system, the supraorbital foramina can be used as a good surgical landmark (Fig. 16-3A). A line connecting the two palpated foramina generally represents a safe zone in a well-pneumatized frontal bone as shown with image guidance (see Fig. 16-3B). A small stab incision, large enough to admit a soft tissue protector, is made in the most medial aspect of the eyebrow. The eyebrow is then raised up onto the flat surface of the frontal bone on a line above and away from the neurovascular bundle. Water is placed in the protector sleeve and slow forward rotation is used to penetrate the front wall of the frontal sinus only. A trocar, preferably fluted to lock into the bone, is inserted to manage increased intrasinus pressure.

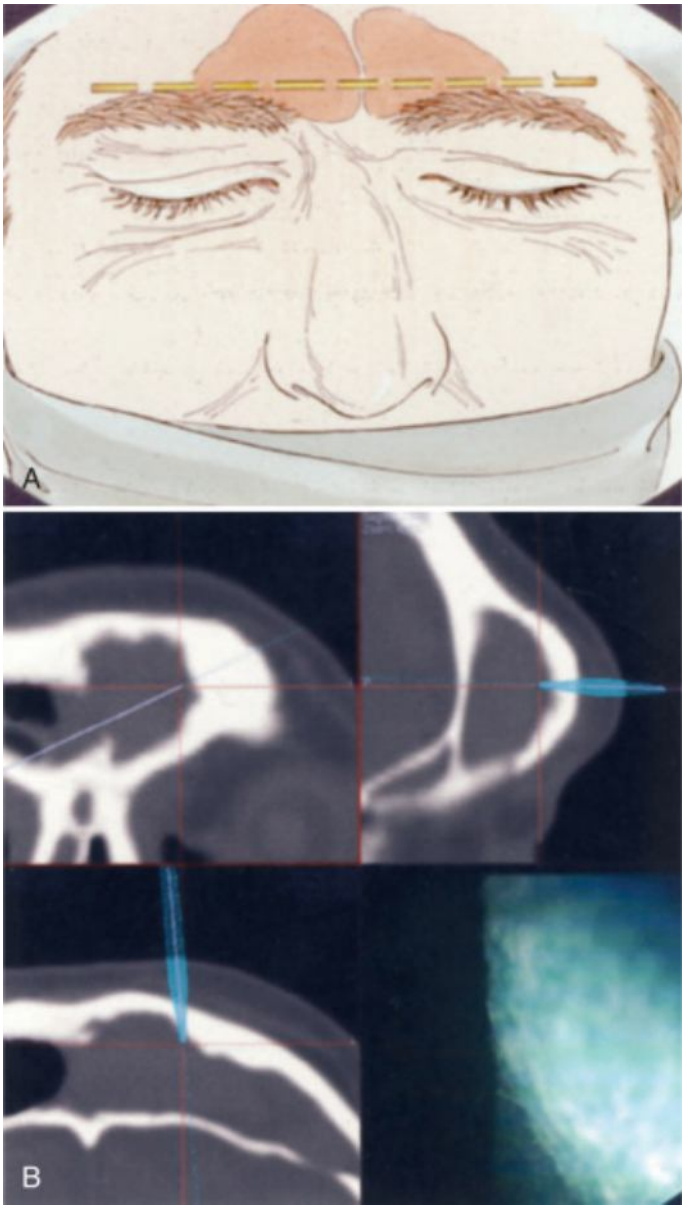

Figure 16-3 Line diagram of a supraorbital foramina line of safe entry (**A**) and use of image guidance to confirm the entry point (**B**).

The surgeon views the nasofrontal recess endoscopically and irrigates the sinus personally to assess the amount of pressure required. Over time one develops a feel for whether the sinus is truly open. The procedure can be ended if the sinus is clearly irrigated at low pressure. This allows treatment of the sinus completely without trauma to the frontal recess.

If the sinus does not open with irrigation, the water can be used to help the surgeon proceed to dissection of the frontal recess. The frontal sinus drainage site is clearly identified by the flow of water.

Basic Endoscopic Surgery on the Frontal Recess

Dissection of the frontal recess requires frontal sinus instruments and a precise understanding of the anatomy of this region, particularly in the current patient. Readers should review the classification of agger nasi cells by Kuhn and Bolger.[6]

Because the frontal sinus most frequently drains between the middle turbinate and the agger nasi–uncinate complex, a frontal sinus with a single agger nasi cell (Kuhn-Bolger type 1) is opened by removing the medial wall of the agger nasi cell. Ideally, this is performed with meticulous and atraumatic technique. If submucosal resection of the bone of the medial wall of the agger is performed, a microdébrider can trim the remaining mucosal sleeve to the desired level. This avoids the dangerous practice of grasping and tearing mucosa in the nasofrontal recess. Once again, the minitrephine can confirm that surgery has been completed and guide the surgeon in cases in which the site of frontal sinus drainage is confusing.

Advanced Surgery on the Frontal Recess

Surgeons should have multiple procedures in their armamentarium for coping endoscopically with a troublesome frontal sinus. This allows more extensive surgery without external incisions to approach neoplasms, mucoceles, fungal processes, and iatrogenic stenoses.

The most common problem is a lateralized middle turbinate stump when the previous surgeon has removed the lower middle turbinate. This is very effectively dealt with in a minimally invasive manner by the frontal sinus rescue procedure described by Kuhn (Fig. 16-4).[7,8] In this procedure the scar is lysed to create three layers of the middle turbinate: mucosa on the medial and lateral surface and the bone of the middle turbinate in the middle. The medial mucosa and bone are removed and the lateral mucosa is used as a flap and draped toward the septum.

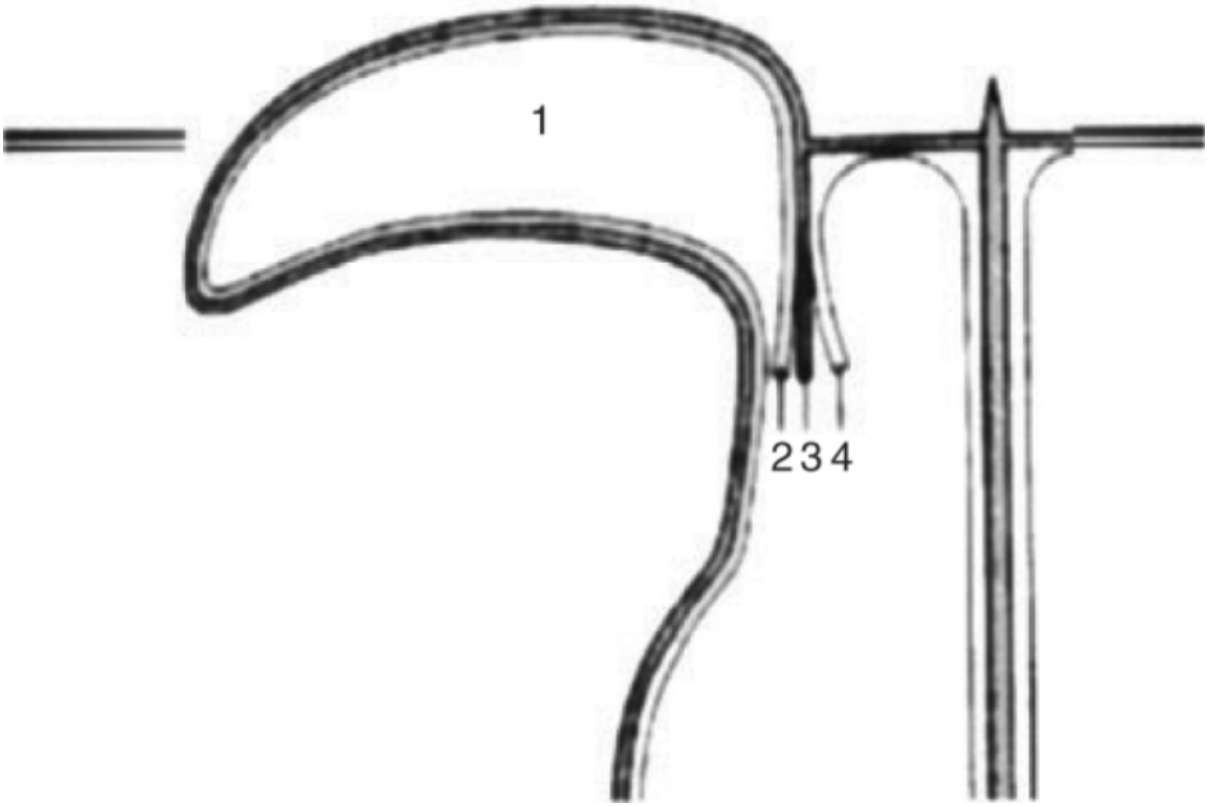

Figure 16-4 Line diagram of three layers of Kuhn frontal sinus rescue.
(From Kuhn FA, Javer A, Nagpal K, Citardi M: The frontal sinus rescue procedure: Early experience and 3 year follow-up. Am J Rhinol 14:211-216, 2000.)

The next level of intervention involves more extensive bone removal in the frontal recess. Wormald has introduced the axillary flap procedure whereby a flap is raised above the attachment site of the middle turbinate, which is rotated out and replaced.[9] Kerrison forceps allow more direct access to the frontal recess without resorting to angled telescopes. Caution must be used when removing inflamed bone in this area because obliterating scar tissue can form in this setting.

Frontal sinus drill-out procedures are the most radical of endoscopic procedures for inflammatory disease. The procedure (which has been called a drill-out procedure, Draf procedure, modified Lothrop procedure, and other names) involves removing a variable amount of the floor of the frontal sinus. The floor can be removed from the orbit to the middle turbinate, from the orbit to the septum, and from orbit to orbit with removal of the upper nasal septum.

For all drill-out procedures we always use a navigation system. These systems, when properly calibrated, allow more precise documentation of the anatomic landmarks before beginning to use the drill. The surgical description here is for an orbit-to-orbit exposure, which the reader can modify if unilateral exposure is desired.

The procedure begins with removal of a quarter-sized area of the nasal septum anterior to the middle turbinates (Fig. 16-5). Exposure allows visualization of the confluence of the nasal and frontal bones (the keel) and both middle turbinates (Figs. 16-6 and 16-7). The frontal sinus is most easily approached with a curved high-speed drill with suction. Irrigation can be added by an assistant. In a unilateral approach, the bone above the middle turbinate

attachment side is gradually taken down while avoiding perforation of the nasal bone. Once entered (Fig. 16-8), the sinus can be enlarged toward the septum, and this opening is communicated to the nasofrontal recess. For bilateral procedures the sinus can most safely be entered in the midline through the frontal sinus floor, which is progressively enlarged laterally (Fig. 16-9). As with the unilateral procedure, the procedure ends when the drilled-out sinus floor communicates with the natural ostium. The inner sinus septum should be taken down as high as possible with preservation of mucosa in this area. It is vitally important to preserve the mucosa on the posterior aspect of the sinus to achieve a favorable healing result. Some wound contraction occurs over time but is tolerated if the opening remains generous, as Figure 16-10 shows in a 5-year postoperative endoscopic view (see also Video 16-1).

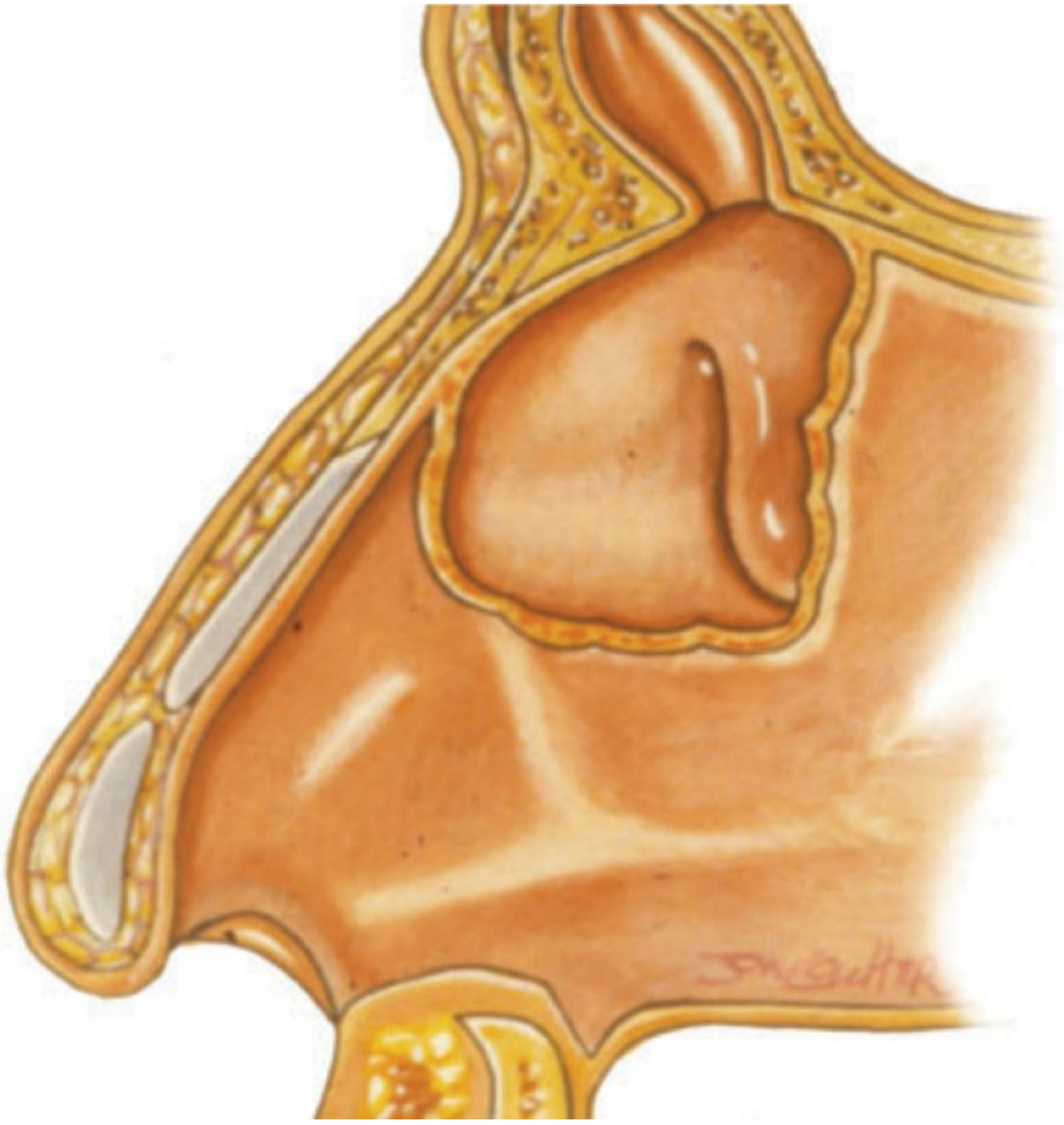

Figure 16-5 Creating the septal window.
(May M, Schaitkin B: Frontal sinus surgery: Endonasal drainage instead of an external osteoplastic approach. Op Tech Otolaryngol Head Neck Surg 31:184-192, 1995.)

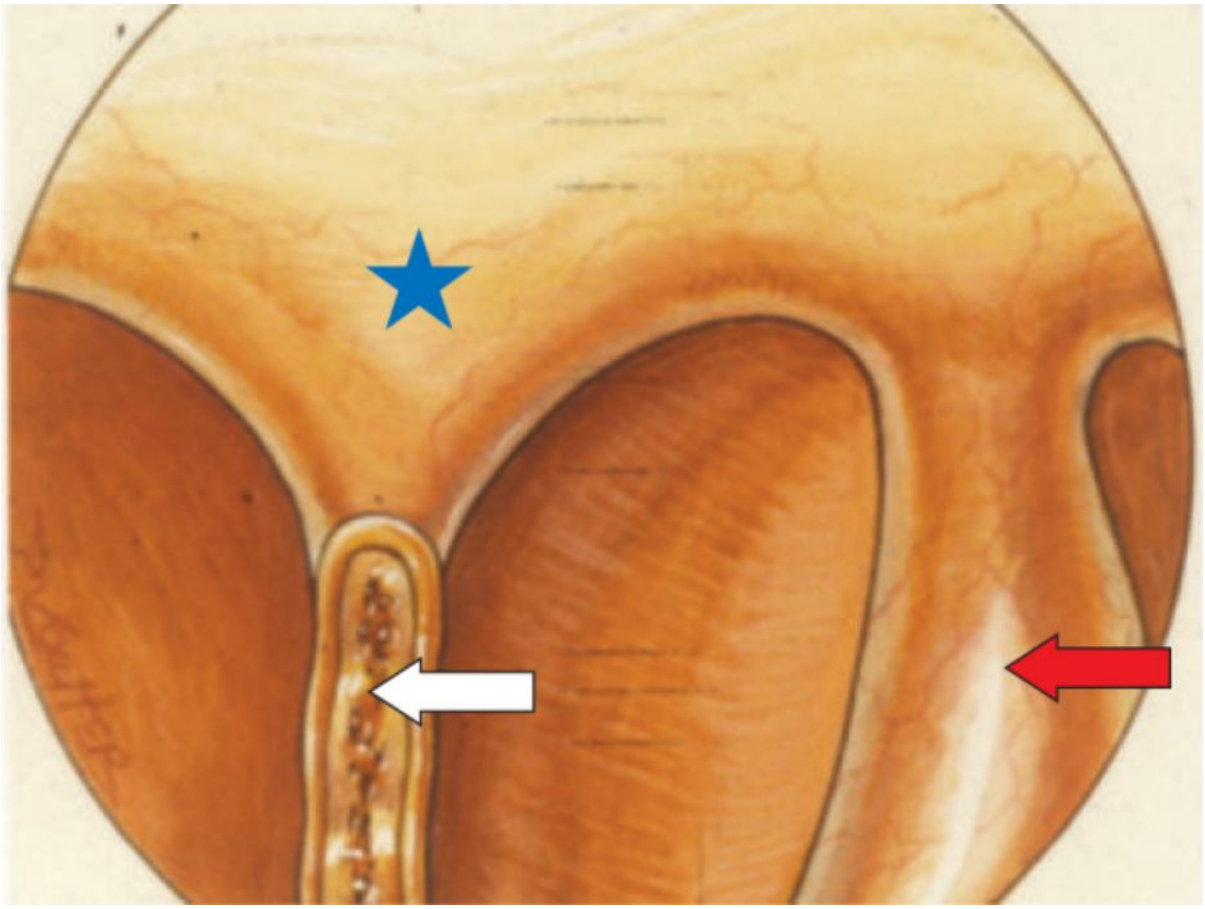

Figure 16-6 Midline appearance of the frontal sinus floor after removal of the septal window (the *white arrow* is the superior cut edge of the nasal septum, the *red arrow* is the left middle turbinate, and the *blue star* is the confluence of the nasal bone and the frontal bone, which forms the frontal sinus floor). *(May M, Schaitkin B: Frontal sinus surgery: Endonasal drainage instead of an external osteoplastic approach. Op Tech Otolaryngol Head Neck Surg 31:184-192, 1995.)*

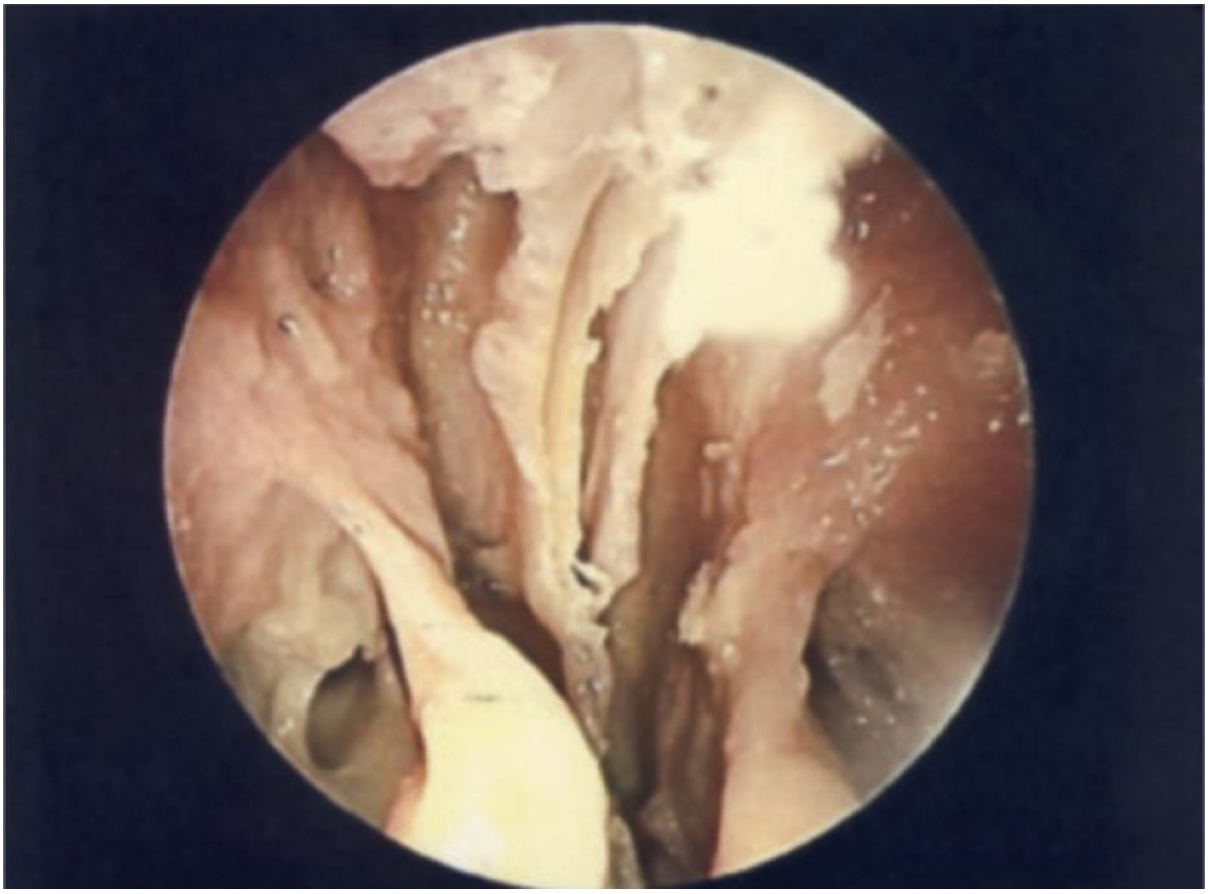

Figure 16-7 Thirty-degree endoscopic appearance of the frontal floor in the midline with both middle turbinates in place.

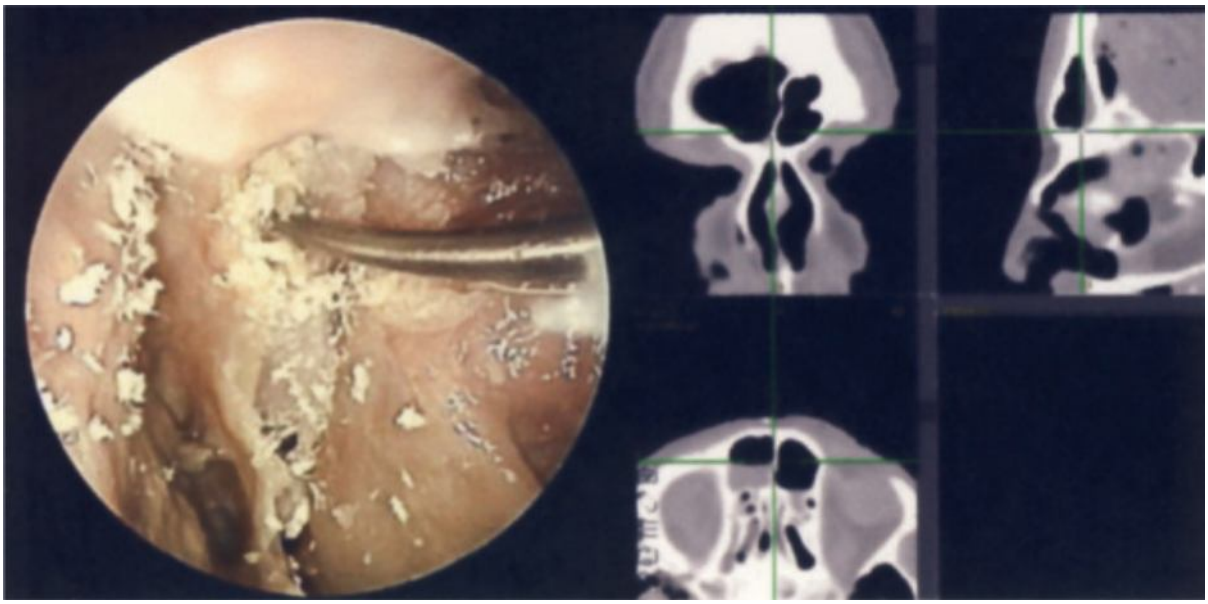

Figure 16-8 Computerized navigation showing perforation of the midline and entry into the frontal sinus.

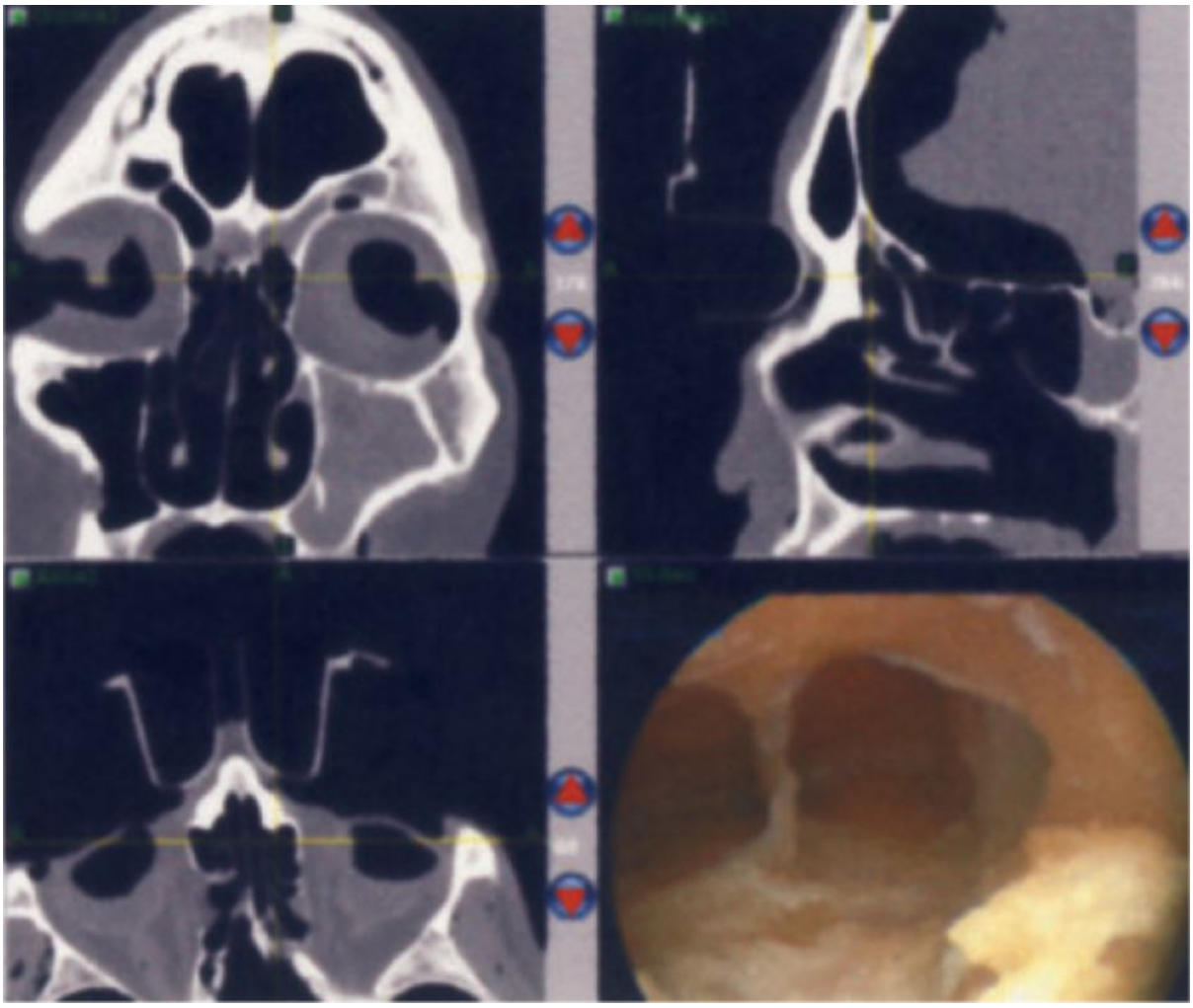

Figure 16-9 Endoscopic appearance (*bottom right*) of cadaver dissection of a completed drill-out procedure with navigation guidance.

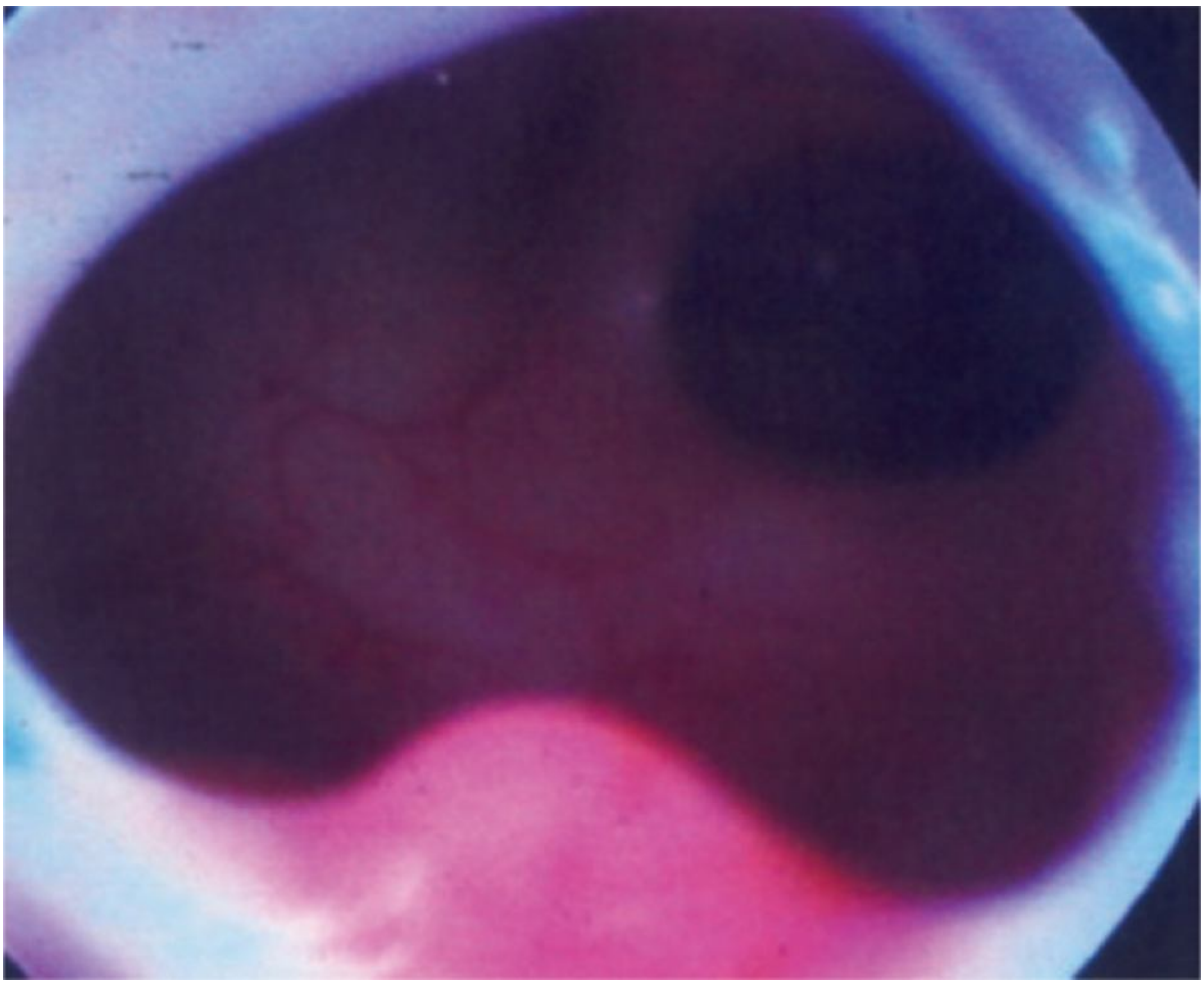

Figure 16-10 Endoscopic appearance of a healed drill-out procedure after some wound contraction.

POSTOPERATIVE CARE

Basic frontal sinus procedures are treated as all endoscopic sinus procedures, with saline irrigation and minimal postoperative débridement. Packing is avoided in all patients, and less than 25% of patients receive some type of self-absorbing hyaluronic acid dressing.

Drill-out procedures are treated similarly without packing or stents. Antibiotics and systemic and topical steroids are used in all drill-out proceduresd until the bone has remucosalized. Patients in whom a drill has been used will have more mucosal loss than the majority of endoscopic sinus surgery patients and may require more débridement than usual. The surgeon should see these patients at 1, 3, and 6 weeks postoperatively to perform gentle débridement and determine the extent of antibiotic and steroid treatment needed. This is highly individualized and based on the patient's original pathology and the healing result seen endoscopically.

COMPLICATIONS

Unintended entry into the central nervous system and orbit is the main serious risk associated with all frontal sinus procures and is exceedingly rare. Epistaxis and orbital ecchymosis are the most common complications, but they occur in less than 1% of patients. Synechiae formation continues to be a significant problem in this area and is best avoided by meticulous technique with minimal removal of mucous membrane. Results by numerous authors put the success rate of this procedure in avoiding an osteoplastic flap at 80% to 90%.[10–12]

CONCLUSION

Frontal sinus surgery requires precision in diagnosis and surgical technique. Detailed review of the patient's endoscopic and imaging findings preoperatively with consideration of the uncinate process, agger nasi region, and size and configuration of the frontal sinus allows individually tailored approaches. Iatrogenic frontal sinus occlusion is difficult to rescue and should be avoided if possible.

PEARLS

- Excellent understanding of the anatomy of the frontal recess is imperative.
- Frequent cadaver dissections are necessary for performing advanced frontal sinus surgery.
- Computerized navigation is essential for advanced frontal sinus surgery.
- Frontal sinus trephination can improve understanding of the frontal recess by showing where the frontal sinus drains and decreasing the extent of surgery and trauma.
- Only patients who are candidates for an osteoplastic flap procedure are candidates for a frontal sinus drill-out procedure.
- The surgeon should become proficient in all other paranasal sinus surgery before attempting the frontal sinus, which tends to be less forgiving.
- Frequent review of CT scan anatomy in this area, including three-dimensional reconstructions, is strongly encouraged.
- Dedicated frontal sinus instruments, including curved microdébrider tips and drills, allow minimal approaches designed to minimize trauma to the frontal recess.

PITFALLS

- Extensive use of powered instruments in the frontal sinus can cause stenosis.
- Operating in the face of acute infection decreases visualization and increases the risk for scar formation.
- Drilling too far anteriorly in a frontal sinus drill-out procedure will cause fenestration of the nasal bones (Fig. 16-10).
- Leaving the frontal sinus septum in place increases the risk for stenosis.
- Bare bone should be covered as much as possible to improve healing.
- The posterior mucosal covering of the newly created ostium of a frontal drill-out procedure should not be disturbed.