

THE FRONTAL SINUS UNOBLITERATION PROCEDURE

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Surgical management of chronic frontal sinus disease continues to undergo change with no universally accepted procedure. The different procedures can be broken down into two main groups, the first involving obliteration or ablation of the sinus with blockage of the frontal sinus drainage pathways. Procedures in this category include the Reidel and Killian operation first described in 1889,²⁹ frontal sinus cranialization, and the osteoplastic frontal sinus procedures. The second group involves re-establishment of the outflow tract and reeration of the sinuses. These frontal sinus preservation procedures include the external frontoethmoidectomy²⁰; the endoscopic intranasal frontal sinusotomy²⁷; the above and below procedure¹⁹; and the recently popularized modified (endoscopic) Lothrop procedures.¹⁷

Early in the century, the preferred method of management of chronic frontal sinus disease involved external procedures, not always with obliteration of the sinus. This was likely secondary to a lack of instrumentation available to visualize and carry out procedures through the nose to re-establish the natural outflow pathways of the frontal sinus. The second option of intranasal frontal sinusotomy with preservation of the frontal sinus, although performed by early sinus surgeons, was a blind intranasal approach to the frontal sinus, which probably explains the problematic results obtained and the major controversy surrounding it. It formed the basis for several studies of frontal sinus drainage into the nose.^{15, 32, 39} There

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was strong opinion at the time that preservation of the frontal sinus was the better option than obliteration if it could be achieved with an external procedure.²⁰ Ogston²⁷ and Luc¹⁹ performed the first external operations on the frontal sinus for the purpose of re-establishing normal drainage through the nose. Kocher, Hajek, and Schonborne^{9,18} first described the technique of raising an osteoplastic flap in the late nineteenth century. Subsequently, an obliterative technique described by Reidel²⁹ became a popular method; however, this radical operation, which removed the anterior frontal sinus table and floor, produced a severe cosmetic deformity. This resulted in the operation being used only for situations where more than half of the anterior or posterior table were involved with osteomyelitis and could not be removed adequately with the proper margins for an osteoplastic operation.³ The osteoplastic flap continued to remain the operation of choice for chronic frontal sinus disease and pathology.

Methods of obliterating the sinus, however, have been more recent contributions.¹³ Several modifications to the original operation have evolved over the years with different surgeons using different methods of marking the boundary of the frontal sinus ranging from using a 6-ft Caldwell film,³⁸ to transilluminating the frontal sinus with an endoscope,⁶ to using computer-assisted sinusotomy with an image-guided navigational device.⁵ Several methods of obliterating the frontal sinus have been used ranging from polymethacrylate; to hydroxyapatite; to plaster of paris; to autologous tissue (fat, muscle, or bone); to using no material and allowing spontaneous osteoneogenesis to self-obliterate the sinus.^{14,23,28,30,33,34}

Fat has been the commonest of all the autologous tissues used in obliterating the frontal sinus. Fat obliteration was popularized after experiments in cats indicated that the procedure had merit and that fat was a satisfactory obliterating material.^{10,25,35} Few comments on the long-term results of these fat grafts were made. Follow-up of obliterated patients usually did not go beyond 3 to 5 years. We are now seeing failures of the osteoplastic flap with development of mucoceles and infected fat grafts in patients who had the procedure done several years ago and in some cases decades previously. A significant proportion of these patients are being unobliterated with the frontal sinus drainage pathways being re-established for reasons discussed in the latter part of this article. More recently, the safety of fat has been questioned when more than 50% of an anterior or posterior wall is missing.⁸ The osteoplastic flap with fat obliteration is not without problems.

With the advent of modern endoscopes and techniques, the development of endoscopic sinus surgery has transformed the current approach to treatment of chronic frontal sinusitis. With experience, intranasal frontal sinusotomy can now be performed for most chronic frontal sinusitis cases with results that are as good as if not better than those with other approaches.³¹ The osteoplastic frontal sinus procedure with obliteration, however, is unfortunately still considered by many to be the standard for chronic frontal sinusitis against which other frontal sinus procedures are judged. It continues to be recommended and carried out by otolaryngologists across the country.

OSTEOPLASTIC FRONTAL SINUS OBLITERATION

Fate of the Fat Graft

As noted previously, the free fat autograft has become the material of choice after animal experiments demonstrated successful obliteration of the canine and feline frontal sinus in both normal and infected sinuses.^{25, 33, 35} Viability of the fat has been demonstrated up to 1 year after fat obliteration, with revascularization of the autograft occurring after 1 week.^{4, 25, 35} A more recent study on the uninfected feline frontal sinus showed gross obliteration of the sinuses after 200 days, but light microscopy revealed fluid or regrowth of mucous membrane, both considered unfavorable sequelae.⁴ They also reported a less than 50% fat viability in the sinus with most of the obliteration occurring from mixed fibrous-adipose tissue or bony ingrowth. Fat resorption has been shown to vary significantly with the average being about 20%. There is concern that the viability of the fat may depend on how atraumatic the harvesting technique is and how long the harvested fat has been out of the body, thereby allowing drying and necrosis before insertion.¹¹ An interesting study showed that more than 80% of the adipose autograft was resorbed when the mucosal lining was incompletely removed, with regeneration of mucous membrane and incomplete obliteration of the sinus. Epithelial-lined cysts developed within areas of fibrous tissue that had replaced most of the adipose tissue. These cysts were thought to represent early mucocele formation.²⁵ Incomplete auto-obliteration with mucous membrane regeneration and microcyst formation was also noted in some sinuses that were completely stripped of their mucosal lining but not implanted.²⁵

Experiments on a canine frontal sinus model showed that osteoplasty by osteoneogenesis led to partial fibrous obliteration complicated by mucocele formation.³³ They also stated that bony-fibrous obliteration increased with time but was incomplete after 1 year, and mucous membrane regeneration and microcyst formation occurred.^{25, 33}

Indications and Contraindications

The osteoplastic frontal sinus obliteration procedure, since its description in the American literature in 1956,¹⁰ continues to be popular for its long-term ability to control infection. It is used routinely to treat chronic inflammatory disease, osteomas, mucoceles, and trauma of the frontal sinus.¹¹ It also continues to remain popular because of the alternative, intranasal frontal sinusotomy, mastery of which requires significant technical ability and extensive practice over a long period of time, and significant postoperative follow-up.

Contraindications

Almost all chronic frontal sinus disease, most osteomas, and mucoceles, except for those based far laterally in the frontal sinus, can be dealt

with using the intranasal frontal sinusotomy procedure explained in detail elsewhere in this issue.¹⁶ Four situations exist in which the osteoplastic flap with obliteration is strongly contraindicated. (1) Mucocele of the frontal sinus with erosion of the posterior table or orbital roof: It is difficult to comprehend how one can remove all mucous membrane when it is adherent to dura or to the periosteum without using a burr. (2) Frontal sinus allergic fungal sinusitis: A patient with allergic fungal sinusitis involving the frontal sinus needs close follow-up for prolonged periods because recurrence is a common factor in these patients. Obliterated sinuses are difficult to follow for recurrences. (3) Inverting papilloma in the frontal recess: Obliteration of the frontal sinus in a patient with inverting papilloma in the frontal recess region makes it difficult to follow for recurrence.^{22,40} (4) Extensively pneumatized frontal sinuses with well-developed supraorbital ethmoid cells: Removal of all mucous membrane within the deep crevices formed by extensively pneumatized sinuses is difficult if not impossible. All four of these conditions are best managed with an intranasal endoscopic approach where the frontal recess region can be followed postoperatively in the office.

Indications

Endoscopic frontal sinusotomy is not designed for extensively invasive processes in the region of the frontal sinus. Invasive malignancies involving the frontal sinus and extending into the orbit or cranium should not be dealt with endoscopically.¹² Inverting papilloma involving the frontal sinus proper should not be dealt with using a conservative endoscopic procedure by itself. This is better dealt with using an osteoplastic flap without obliteration in conjunction with an endoscopic approach from below in the same operation to obtain the greatest chance of cure and allow postoperative endoscopic tumor follow-up (Fig. 1). Broadly based osteomas are also not adequately dealt with using the conservative technique (Fig. 2).^{21,36}

Complications and Reasons for Failure

Failure of the frontal osteoplastic obliteration has been estimated at between 20% and 30%.³³ Possible intraoperative complications include laceration of the dura, subdural or epidural hematoma formation, meningitis, or brain abscess formation, especially if the posterior table is compromised or if the bony cut is made incorrectly and dura is compromised. Postoperative complications include recurrent disease, infection of the adipose implant, frontal bossing or depression, frontal neuralgia with paresthesia and anesthesia of the forehead, subgaleal infection, osteomyelitis of the bone flap, donor site morbidity, sinus remucosalization, and delayed mucocele formation (Fig. 3). A significant time lapse has been identified between surgery and establishment of certain complications, such as mucoceles.³⁷ In one long-term study, the average interval between the original frontal sinus surgery and surgical confirmation of a frontal sinus mucocele was

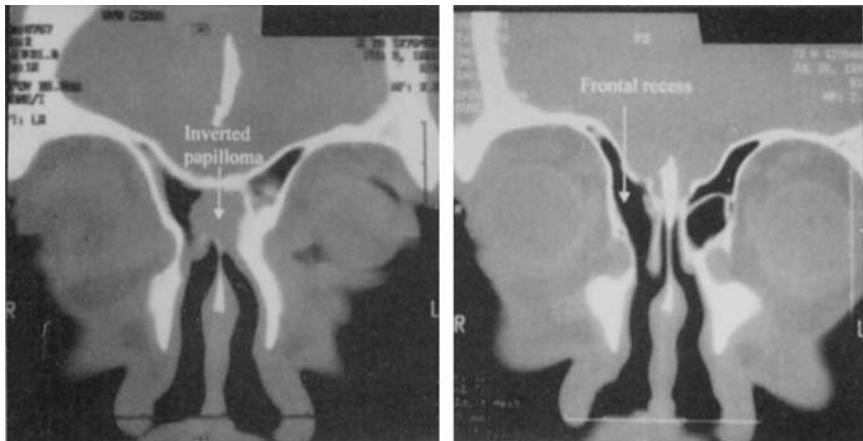


Figure 1. Inverted papilloma treated with wide local excision through an osteoplastic frontal sinusotomy without obliteration. The patient has been followed endoscopically and with CT for 3 years without evidence of recurrence.

7.5 years, with a range from 1 to 42 years.² Such a time lapse makes short-term evaluation of the frontal osteoplastic flap with obliteration uncertain.

Headache, frontal pain, and a sensation of fullness were the most common postoperative complaints in one study.⁷ The persistent frontal pain syndrome was found to be present in 10% of their patients. Symptoms persisted for 2 to 9 years in 10% of the patients. Recurrent disease requiring revision of the frontal sinus obliteration was needed in 6.7% of patients.

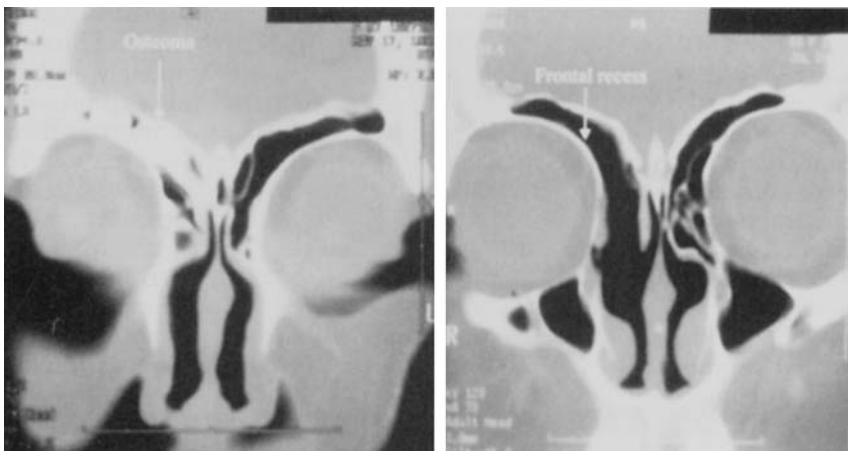


Figure 2. Frontal sinus osteoma treated with a unilateral osteoplastic frontal sinusotomy and endoscopic intranasal frontal sinusotomy without obliteration. There has been no evidence of recurrent disease.

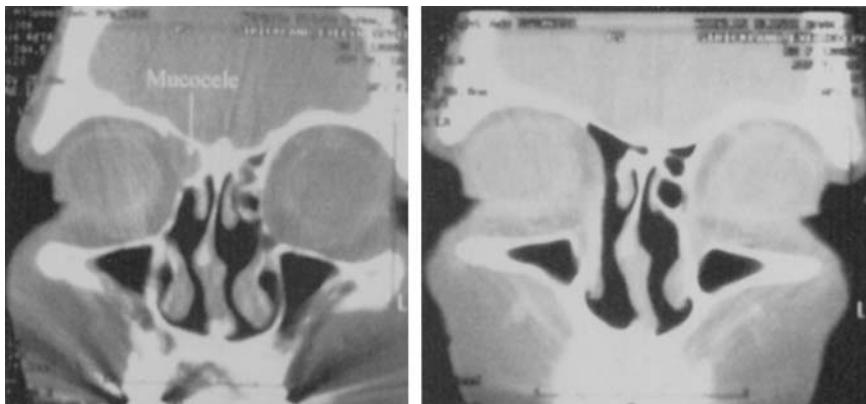


Figure 3. Patient who underwent previous frontal sinus obliteration. There is a mucocele involving a supraorbital ethmoid air cell that was successfully marsupialized with endoscopic techniques.

Postoperative headaches secondary to the surgery itself can pose a diagnostic dilemma because it can clinically mimic recurrent disease. Hardy and Montgomery's¹¹ study of 250 operations, 83% of which were followed for 3 years, also revealed a distressing problem of persistent postoperative frontal pain in 6% of patients. Persistent abnormal forehead sensation was present in 35% of patients, although most patients described the symptoms as a minor annoyance. They had a 6% revision rate because of recurrent sinus infection with an overall revision rate of 9.5%. Many patients require neurologic consultation for chronic pain evaluation.

Patients with ongoing symptomatology after frontal sinus obliteration should undergo endoscopic evaluation of other adjacent paranasal sinuses and CT and MR imaging to rule out pathology in the previously obliterated sinus.^{7,37} It should be noted, however, that CT cannot completely evaluate the obliterated frontal sinus and MR imaging commonly misses mucocoeles.

The most common reasons for failure are incomplete mucous membrane removal with microcyst development and mucocele formation. The most common site of late mucocele development is the frontal recess. The frontal recess is commonly a problem because of persistent mucosa trapped between the fat and unresected cells obstructing the frontal recess. The second is mucosal-lined pockets around the periphery of the sinus under ledges of anterior table that were not included in the original bone flap. Other reasons for failure include unidentified and improperly treated supraorbital ethmoid cells; recurrence of frontal sinus pathology (e.g., osteoma); and chronic inflammation.

UNOBLITERATION OF THE FRONTAL SINUS

Unobliteration is a concept and procedure developed by the senior author (FAK) beginning in 1991, which arose from removing frontal recess

obstruction in patients whose obliterated frontal sinus had been re-explored. With the osteoplastic flap up and the mucosal-lined frontal recess open to the nose the question arose as to why the fat should be replaced in the sinus and what would happen if the drainage pathway were stented open. Consequently, the unobliteration was born. Results have been mixed in repneumatization and relief of pain; however, the mucoceles requiring re-exploration have uniformly been eliminated and the source of the original frontal sinusitis (i.e., an obstructed frontal recess) has been resolved.

Indications

Unobliterating the previously obliterated sinus is indicated for patients with evidence of frontal sinus pathology on CT and MR imaging scans that is not amenable to endoscopic treatment. Some patients with equivocal radiographic evaluation require re-exploration for persistent pain and suspicion of mucocele development. Patients with enlarged mucoceles that have resulted in loss of bone along the posterior table or orbital roof, patients with infected fat grafts, patients with frontal sinus anatomy that is difficult or impossible to obliterate (Fig. 4), and patients with intracranial complications of frontal sinusitis are potential candidates for unobliteration. Technical considerations include raising the osteoplastic flap, removing the fat graft, and reconstructing the sinus and its outflow tract into the frontal recess. Placement of stents is addressed intraoperatively. The reopened frontal sinus can be reventilated and remucosalized or reobliterated with the placement of a new fat graft.

One of the possible outcomes of unobliteration (trying to repneumatize the frontal sinus) is auto-obliteration by new bone formation and



Figure 4. Patient with extensively pneumatized supraorbital ethmoid cells and frontal sinuses with two failed fat obliterations.

ossification of postoperative blood as illustrated in case 6 below. Perhaps this occurs because of slow ingrowth of frontal recess mucosa into the frontal sinus. The process of repneumatization, which is dependent on growth of mucous membrane into the sinus from the frontal recess, seems to be enhanced when there is good mucous membrane in the frontal sinus, or a flap that can be laid from a supraorbital ethmoid cell into the sinus. If blood fills the sinus and organizes this may prevent mucous membrane from growing very far into the sinus.

CASE EXAMPLES

Case 1: G.B. G.B. is a 46-year-old white man from Alabama with a history of allergic fungal sinusitis for which he had previously undergone a total of 14 endoscopic sinus surgeries and two frontal sinus obliteration procedures. The second fat obliteration procedure was carried out 8 years previously. He continued to suffer from chronic frontal headaches and presented with a 3-week history of frontal pain with swelling of the mid-portion of the forehead. He had worsened even while on antibiotics. A few days before being seen he developed marked swelling above the right medial canthus where he previously had a trephine. A CT scan obtained at his initial visit showed hyperpneumatized sinuses with laterally extending supraorbital ethmoid cells (see Fig. 4), sclerotic bone indicating chronic sinusitis, and possibly previous osteomyelitis (Fig. 5). There was concern that his frontal sinuses were infected and because of the extensive crevices created by the supraorbital ethmoid cells, obliteration had been unsuccessful. Complete intranasal frontal endoscopic sinus surgery was carried out and entrance into the region of the supraorbital ethmoid cells resulted in drainage of purulence. The previous osteoplastic flap was opened, which revealed a mixture of fat and mucopurulence in the frontal sinus (Fig. 6). Mucosa was identified in several areas, especially in a cavity superiorly in the frontal sinus and in the crevices behind the



Figure 5. Sclerotic, thickened bone indicating chronic sinusitis and possible previous osteomyelitis.

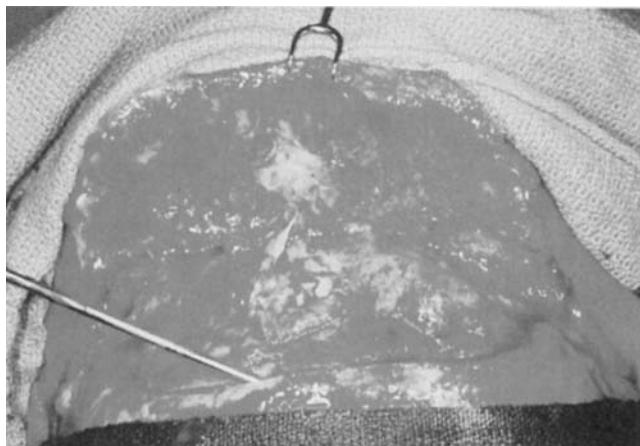


Figure 6. Intraoperative view of frontal sinus after elevation of bone flap. Mixture of fat and mucopurulence with several mucosa lined cavities identified. Probe lying in a superior mucosa lined cavity.

orbit created by the supraorbital ethmoid cells (see Fig. 6). All fat and mucopurulence was removed, and both internal frontal ostia enlarged. Thin rolled Silastic sheeting was then placed into each of the openings to extend into the middle meati. The patient did well postoperatively and a CT scan at 1 month showed good aeration of the supraorbital ethmoid cells and frontal sinus (Fig. 7). The right Silastic stent fell out 2 weeks postoperatively. A 70-degree scope shows a patent right internal frontal ostium at 2 months postoperatively (Fig. 8). The Silastic stent in the left



Figure 7. CT at 1 month postoperatively showing good aeration of supraorbital ethmoid cells and frontal sinus.



Figure 8. Seventy degree telescopic view showing a patent right internal frontal ostium at 2 months.

frontal recess remains in good position 6 months postoperatively and the patient remains free of symptoms as of this writing.

Case 2: J.M. This is a 56-year-old white woman from South Carolina with a history of three previous frontal sinus operations. Her first sinus operation was a left osteoplastic frontal sinus obliteration done 22 years previously. Eighteen months before seeing us, she developed a large left frontal mucocele with accompanying left proptosis for which she underwent revision of the osteoplastic flap. The operative note indicated that the mucocele had eroded away the roof of the orbit and was adjacent to the periorbita. This prevented the surgeons from removing the mucus membrane attached to periorbita and a pathway to the left frontal recess was made by drilling away new bone that had obliterated the outflow tract of the left frontal sinus. A Silastic stent was placed through this opening but removed 4 weeks postoperatively. Over the ensuing 11 months the left frontal recess stenosed completely and the left frontal mucocele recurred with left periorbital swelling and headaches. A temporizing trephine with removal of mucocele contents was carried out 1 month before the patient was seen by us.

A CT scan at our institution revealed a large left mucocele that had completely eroded away the roof of the orbit (Fig. 9). A bony bridge 5-mm thick separated the mucocele from the left frontal recess (Fig. 10). The patient's frontal sinus was re-explored, the mucocele was opened, and all mucus was removed. An otologic drill was used to remove the bone separating the mucocele from the left frontal recess and mucosal flaps from the mucocele laid over the drilled bone. A wide opening into the left frontal recess was obtained after which two Silastic sheets were rolled and sutured in a T shape with the upper one lying horizontally within the newly re-established frontal sinus and the lower one extending vertically into the frontal recess. Postoperatively she has done extremely well and remains symptom free with the stent lying in perfect position at 3 months postsurgery (Fig. 11).

Case 3: J.D. This 39-year-old woman was seen with a history of 19 sinus operations in the last 20 years including four frontal sinus obliterations. She had been having recurrent frontal sinus infections with midfrontal swelling treated with intravenous antibiotics about three times per year. Her CT scan demonstrated an

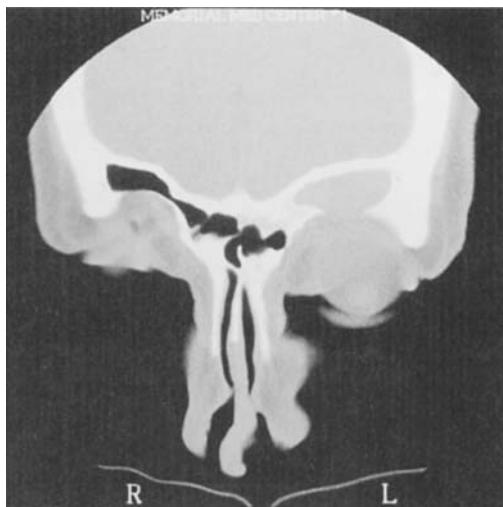


Figure 9. CT illustrating a large left mucocele with complete erosion of the bony orbital roof.

opaque frontal sinus and two aerated cells just below the frontal sinus (Fig. 12) on either side of the septum. Because of a Pott's puffy tumor, her frontal sinus was re-explored. The fat graft was intact and there was no mucocele in the frontal sinus proper; however, there was an infected mucocele below the frontal sinus and between the two aerated supraorbital ethmoid cells, probably representing an interfrontal sinus septal cell. After the frontal sinus was opened and the fat graft removed the interfrontal sinus septal cell was opened and exenterated, making it confluent with the two supraorbital ethmoid cells and the frontal sinus. The two



Figure 10. CT illustrating a 5-mm bony ridge separating the mucocele from the left frontal recess.

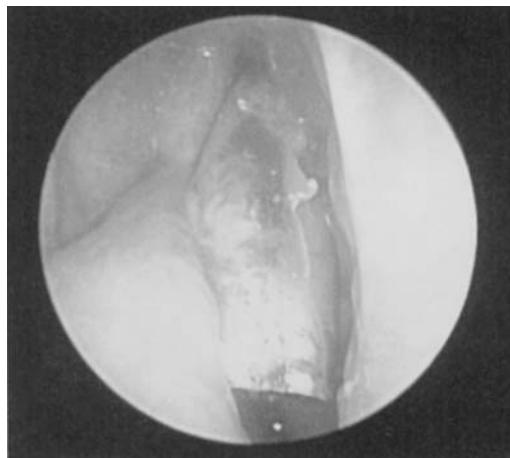


Figure 11. Endoscopic view of Silastic stent at 1 month postoperatively.

supraorbital ethmoid cells were then opened using a standard intranasal endoscopic frontal sinusotomy approach. All of the cells were then open to each other and the nose. The osteoplastic flap was then closed without replacing the fat. Over time, the frontal sinus partially scarred in around the periphery; however, the central portion and the drainage pathway into the nose remucosalized yielding a reventilated and functioning frontal sinus with a safe nasofrontal connection 1 year postoperatively (Fig. 13).



Figure 12. Preoperative coronal CT view of a patient with multiple previous obliteration procedures.



Figure 13. A postoperative CT follow up showing a pneumatized frontal cavity with scarring and new bone formation laterally.

Case 4: C.K. A 44-year-old black man with a history of allergic fungal sinusitis and Pott's puffy tumor had undergone sinus surgery, which included frontal sinus obliteration and reconstruction of the frontal sinus anterior table with methylmethacrylate several years before presentation. He was noted to have frontal swelling and tenderness, nasal polyposis with allergic mucin, and multiple densities associated with pansinus opacification on CT scan (Fig. 14). With a preliminary diagnosis of allergic fungal sinusitis and Pott's puffy tumor, the patient was taken

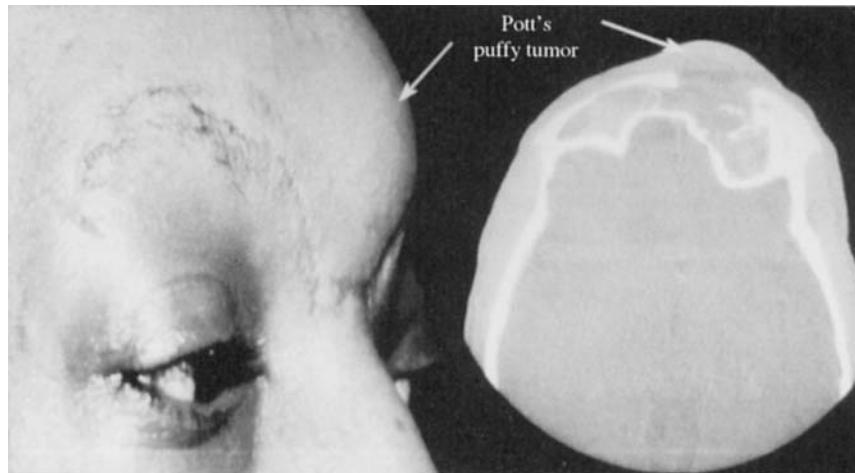


Figure 14. Patient with allergic fungal sinusitis and Pott's puffy tumor after frontal sinus obliteration and frontal sinus reconstruction with methylmethacrylate.

to the operating room after institution of intravenous antibiotics. A brow incision was used through a pre-existing scar, and the methylmethacrylate was identified and removed. The frontal sinus was filled with purulence and fungal debris that was removed. There was a large opening leading from the frontal sinus into the nasal cavity (Fig. 15). The large frontal bone defect was reconstructed with a split calvarial parietal bone graft (Fig. 16). No stent was placed. A concomitant bilateral functional endoscopic sinus procedure was used to address the remainder of his paranasal sinus disease.

Case 5: H.H. This is a 73-year-old white woman with a history of chronic rhinosinusitis and multiple previous sinus surgeries including frontal sinus obliteration. She presented with complaints of severe frontal pain, which had been refractory to medical therapy, nerve blocks, and chronic pain management. Nasal endoscopy demonstrated edema in the frontal recess, but CT and MR imaging were consistent with obliteration. The fat graft was removed but no obvious pathology was encountered. A modified Lothrop procedure was performed to re-establish frontal sinus ventilation and drainage (Fig. 17). Histology of the fat graft showed fibrosis and chronic inflammation. The frontal sinus was successfully repneumatized. The patient is now 24-months postoperative with pneumatized frontal sinus.

Case 6: J.R. A 39-year-old white man presented with an orbital abscess secondary to a frontal sinus osteoma and acute obstructive frontal sinusitis. After initiation of intravenous antibiotics, an osteoplastic frontal sinusotomy with removal of the frontal sinus osteoma and drainage of the orbital abscess was performed. Once the osteoma had been removed, there was a 2×3 cm opening leading into the nasal cavity. It was elected not to obliterate the frontal sinus. Intravenous antibiotics were continued, but within 2 weeks the frontal recess scarred closed and the patient developed acute frontal sinusitis. Conservative endoscopic management failed, and

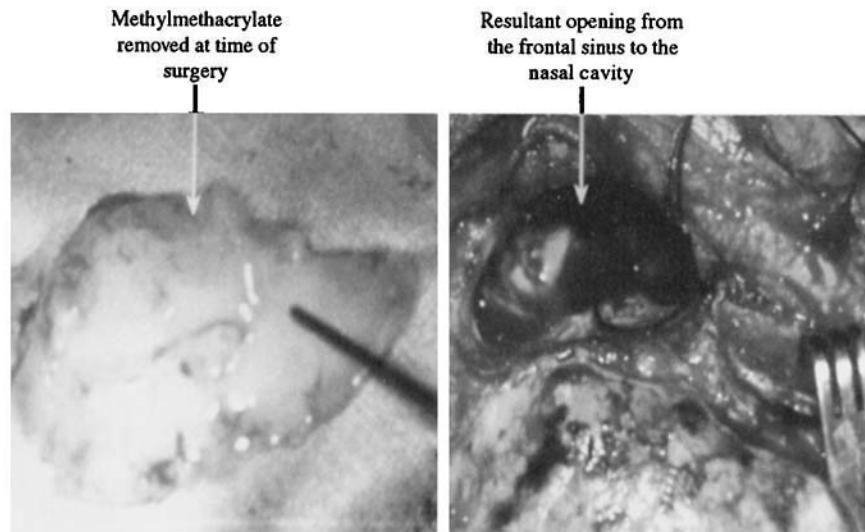


Figure 15. Intraoperative view of methylmethacrylate and opening from frontal sinus into nasal cavity.

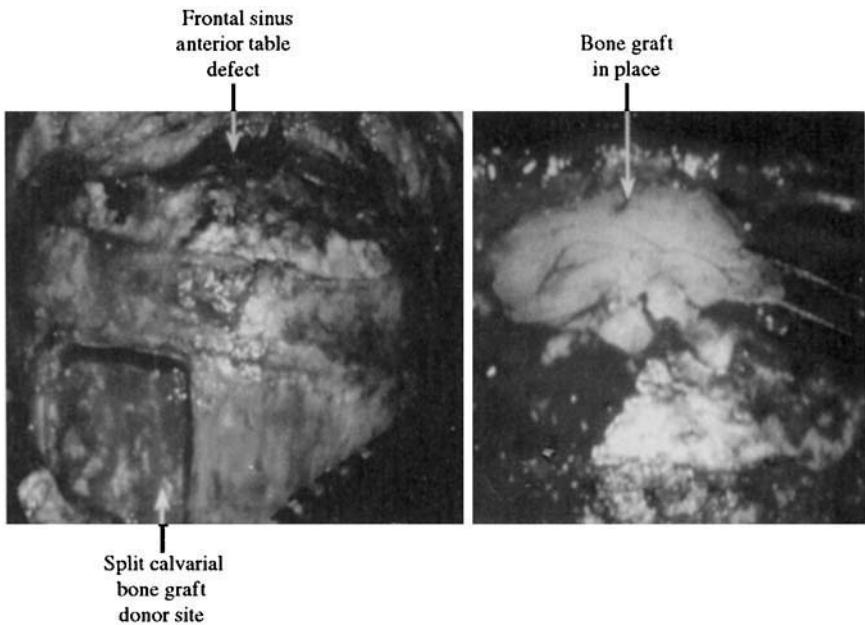


Figure 16. Intraoperative views of split calvarial bone graft for frontal sinus anterior table reconstruction.

the osteoplastic flap was raised, mucosa removed, and a fat graft placed. The patient had persistent pain in spite of continued antibiotic therapy and aggressive pain management. Within 3 months of obliteration, the patient developed severe pain and frontal tenderness. CT and MR imaging scans, however, were not helpful.

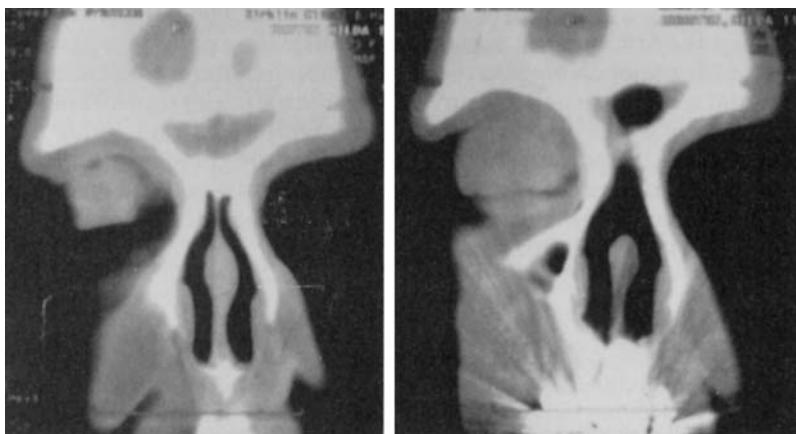


Figure 17. Patient with prior frontal sinus obliteration and repneumatized frontal sinus after removal of chronic inflamed fat graft and modified Lothrop procedure.

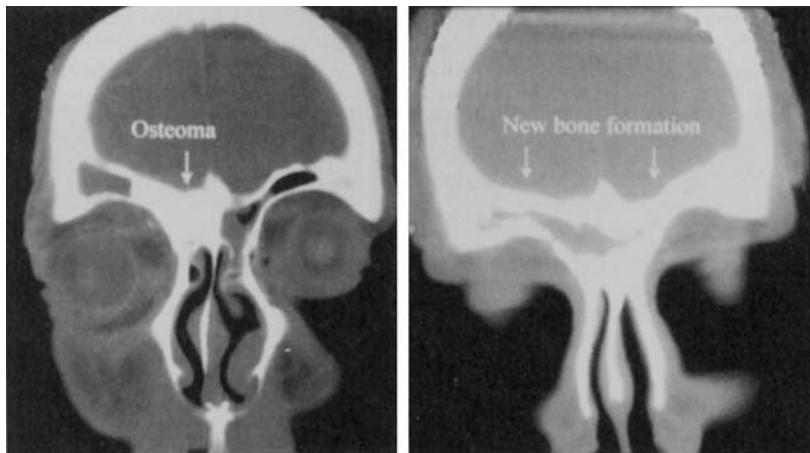


Figure 18. Patient with complicated history of acute frontal sinusitis, osteoma, and orbital abscess. Postoperative CT shows new bone formation and auto-obliteration of the frontal sinus.

The fat graft was removed, and there was evidence of new bone formation at the time of surgery. It was elected to allow the frontal sinus to auto-obliterate with continued new bone formation (Fig. 18). Histology of the fat graft was consistent with acute and chronic inflammation. The patient is now 3 years since his last operation. He has persistent neuralgia but no signs of infection or inflammation.

POSTOPERATIVE MANAGEMENT

Postoperative management consists of close follow-up with gentle endoscopic débridement carried out at each visit. The patient is followed closely for the first 6 weeks, which is the critical time period for fibrosis and new scar formation. New scar tissue or webbing that may start obstructing the frontal recess is usually removed in the clinic under topical anesthesia. The patient is advised to irrigate the nose with hypertonic saline using a 60-mL syringe as per published protocol.¹⁸ Culture-directed antibiotics are used preoperative and postoperative. Analgesics are used on an as needed basis and most patients have been able to taper to plain acetaminophen within 24 to 48 hours after surgery.

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