Clinical Outcome of Endoscopic Surgery for Frontal Sinusitis

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Objective: To determine the efficacy of endoscopic surgery for chronic frontal sinusitis.

Design: A prospective analysis of established measures of clinical outcome (Chronic Sinusitis Survey and Short Form 36) that was administered to patients before frontal sinus surgery and at intervals of 3 months, 6 months, and 1 year after surgery.

Interventions: For limited disease, the frontal recess was opened and the frontal ostium probed or enlarged. For more severe cases, a drill was used to resect the frontal sinus floor and interfrontal septum.

Setting: Private and institutional-based practices at an academic medical center.

Subjects: Eighty-seven patients who underwent endoscopic surgery for frontal sinusitis, including 24 patients with severe disease who underwent a frontal sinus drillout procedure.

Main Outcome Measures: Scores on the Chronic Sinusitis Survey, Short Form 36, and surgical revision rate.

Results: Significant improvement in facial pain, nasal drainage, and congestion was observed 1 year after surgery (P < .01). Medication use was also significantly reduced during this period (P < .01). Quality-of-life measures showed greatest improvement in the domain of social functioning (P < .05). Three (12.5%) of 24 patients who underwent a frontal sinus drillout procedure did not respond to surgery secondary to restenosis of the frontal ostium.

Conclusions: Although the long-term results of endoscopic surgery for frontal sinusitis are unknown, this approach appears to be effective for most patients and may provide a reasonable alternative to frontal sinus obliteration surgery in selected cases.


HE EXTERNAL frontoethmoidectomy described by Lynch in the 1920s and the osteoplastic flap frontal sinus obliteration procedure popularized by Montgomery in the 1960s have been the mainstay of surgical treatment for patients with chronic frontal sinusitis. Since the introduction of endoscopic instrumentation for sinus surgery in the 1980s, a variety of intranasal approaches to the frontal sinus have been described that avoid much of the morbidity associated with traditional procedures, including an external incision. Although these endoscopic techniques allow for direct visualization and manipulation within the frontal recess, their efficacy for treatment of more advanced disease remains limited.

For severe cases of frontal sinusitis, Draf described an intranasal approach that used a microscope and drill to remove the frontal sinus floor, as well as the superior nasal septum and interfrontal septum. Close et al and Gross et al described a similar technique for treatment of patients with advanced disease, using endoscopic instrumentation to create a large aperture between the frontal sinuses and nasal cavity. This frontal sinus drillout procedure has been compared with that of Lothrop, who in 1914 described a combined external and intranasal approach to resect the frontal sinus floor and septum.

Despite the growing popularity of endoscopic techniques for the treatment of frontal sinusitis, the effect of such treatment on sinus-specific symptoms and general health remains largely unknown. The purpose of this study was to develop an endoscopic approach to the frontal sinus based on disease severity and to determine the efficacy of this approach through prospective measures of patient-relevant outcome.

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PATIENTS, MATERIALS, AND METHODS

PATIENTS

Eighty-seven consecutive patients who underwent endoscopic frontal sinus surgery in our department constitute the study population. All patients underwent preoperative head and neck examination, including nasal endoscopy. Computed tomographic (CT) scans of the sinuses were obtained in coronal and axial views following treatment with a minimum of 3 weeks of antibiotic therapy. These scans were classified as stage 0 through IV according to a CT rating system that has been used previously and demonstrated to be statistically reliable. The following information describes the CT staging system for chronic rhinosinusitis:

- **Stage 0** Less than 2 mm of mucosal thickening on any sinus wall
- **Stage I** Unilateral disease or anatomical abnormality
- **Stage II** Bilateral ethmoid and/or maxillary sinus disease
- **Stage III** Bilateral disease with sphenoid and/or frontal sinus involvement
- **Stage IV** Pan-sinus disease

Surgical indications for endoscopic frontal sinusotomy include CT evidence of frontal rhinosinusitis (opacification, air-fluid level, mucocele, or mucosal thickening >2 mm) or recurrent frontal headaches in the presence of radiological or endoscopic evidence of paranasal sinus disease. Sixty-three patients who underwent consecutive endoscopic frontal sinus surgeries in our department between August 1993 and May 1995 were followed up in a prospective fashion. They were administered a rhinosinusitis-specific questionnaire, the Chronic Sinusitis Survey (CSS), and a general health survey, the Short Form 36 (SF-36), prior to surgery and at 3-, 6-, and 12-month postoperative intervals. Seven patients were lost to follow-up at 6 months and 10 patients at 1 year.

The CSS is a 6-item questionnaire that measures 2 areas of patient-relevant outcome: symptoms and medication use. Patients were questioned about the duration of facial pain or headache, postnasal drainage or rhinorrhea, and nasal obstruction or congestion over the preceding 8 weeks. Use of antibiotics, nasal sprays, and other sinus medications were quantified for the same period. The CSS has been studied in populations with chronic rhinosinusitis and shown to have good reliability and to be sensitive to longitudinal clinical change.

The SF-36 is a 36-item questionnaire that is divided into 8 subscales of general health: physical functioning, role functioning--physical, bodily pain, general health, vitality, social functioning, role functioning--emotional, and mental health. The reliability of SF-36 scale scores has been well established. Permission to use the SF-36 form was obtained from the Medical Outcomes Study Trust, Boston, Mass. Scores were tabulated according to published algorithms and normalized to a scale ranging from 0 (worst) to 100 (best). Analysis was performed using the Student t test for comparison of means. Correlations reported reflect Spearman rank correlation statistic. All P values are 2-tailed.

A separate analysis was performed on the group of 24 patients who underwent endoscopic drillout of the frontal sinus floor in our department between March 1995 and November 1996. Four of these patients had isolated frontal sinus mucoceles with bony expansion into the orbit and displacement of the globe. The other 20 patients presented with frontal sinus opacification or air-fluid levels following previous sinus surgery. Fifteen patients underwent unilateral frontal sinus drillouts, commonly referred to as Draf 2 procedures. The remainder underwent bilateral drillouts using a transseptal technique, similar to the Draf 3 procedure and modified Lothrop procedures. All surgeries were performed with patients receiving general anesthesia.

SURGICAL TECHNIQUE

The endoscopic technique used to treat frontal sinusitis depended on disease severity. In those patients with disease limited to the frontal recess, an anterior ethmoidectomy was performed and obstructing tissue removed from the recess with an angled Blakesley forceps. The frontal ostium was probed in an atraumatic manner with a ball-tipped probe or curved suction cannula to verify patency. Care was taken not to remove normal mucosa or injure tissue at the perimeter of the ostium, since doing so could lead to postoperative adhesion formation with ostial obstruction.

When probing within the frontal recess region, sometimes a large supraorbital ethmoid cell was initially mistaken for the frontal sinus. The ostium leading to the supraorbital ethmoid cell was commonly encountered in a posterior and lateral aspect of the frontal recess, whereas the frontal sinus ostium was typically found in a more anterior and medial location.

In those patients with more advanced disease, the frontal recess was widely opened with a Hajek forceps using the previously described technique. This maneuver allowed for direct visualization within the recess. Obstructing tissue was cleared from the frontal recess and the ostium was visualized and probed. If the ostium was found to be stenotic (would not allow passage of a 2-mm probe), it was enlarged with a curved frontal sinus curette in an anterior direction to a diameter of approximately 5 mm. In the most severe cases, including frontal sinus mucoceles or frontal sinus opacification following previous surgery with extensive adhesion formation, the ostium was enlarged to at least 10 mm in diameter with a frontal sinus drillout procedure.

FRONTAL SINUS DRILLOUT

An initial attempt was made to identify the frontal sinus ostium using gentle palpation just behind the anterior attachment of the middle turbinate with a 1-mm ball-tipped probe (Figure 1). Care was taken not to apply excessive force on the probe that could cause inadvertent penetration of the skull base. When the sinus was entered, the probe dropped into an air-containing cavity of the same approximate size and configuration noted on CT scan. It was not uncommon for a large supraorbital ethmoid cell to be initially mistaken for the frontal sinus. The ostium leading to the supraorbital ethmoid cell was usually situated in the posterolateral frontal recess, whereas the frontal sinus ostium was found in a more anteromedial location.

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Once the frontal ostium was located, a medium-cutting burr on a long-handled drill was used to widely open the frontal recess by removing bone anterior to the ostium. Any agger nasi cells present were cleared. If the anterior portion of the middle turbinate had not been resected during previous surgery, it was removed, and its anterior attachment to the lateral nasal wall was taken down. After the ostium was exposed and directly visualized, it was enlarged by bone removal along its anterior rim (Figure 2). Care was taken not to drill or injure mucous membrane along the posterior rim of the ostium, since doing so could promote circumferential scar formation. All further drilling was done anterior and superior to the ostium, which serves as a landmark for the posterior limit of resection.

Even if the ostium was not identified earlier in the procedure, the inferior aspect of the frontal sinus would eventually be encountered with careful drilling in this location. Any bone removal done prior to identification of the frontal ostium is potentially hazardous because of the proximity of the skull base and should be attempted only by experienced endoscopic surgeons. Nevertheless, so long as bone removal proceeds anterior and superior to the approximate location of the ostium within the frontal recess, penetration of the intracranial cavity remains remote. With excessive bone removal in this location, the surgeon encounters skin of the supraorbital region, rather than spinal fluid.

Once the ostium has been adequately enlarged, the interior of the frontal sinus can be visualized with a 30° endoscope that is used for the remainder of the procedure. Removal of the bony sinus floor continues in a lateral direction toward the orbit. The lacrimal bone serves as the lateral limit of resection. The lacrimal sac location can often be verified by movement along the orbital wall seen with palpation over the medial canthal region. With bone removal in a medial direction, the intersinus septum is encountered. If only a unilateral frontal sinus drillout is to be performed, this septum serves as the medial limit of dissection. If a bilateral drillout is to be performed, the intersinus septum is drilled and the contralateral sinus opened through a transseptal approach.

Visualization and access for bone removal of the frontal sinus floor are greatly facilitated using a transseptal technique that allows for passage of the endoscope and drill through opposite sides of the nose (Figure 3). This technique can be used for both unilateral and bilateral procedures, depending on the amount of bone to be removed. For unilateral drillout, a limited septal defect may be created with a vertical full-thickness incision through septal mucosa and cartilage. When a bilateral drillout is performed, an approximately 2-cm perforation is created with removal of full-thickness septal mucosa and bone where the superior septum attaches to the floor of the frontal sinus (Figure 4).

The inferior aspect of the intersinus septum is removed with the drill to create a common opening between both sides of the frontal sinus. The bony floor of the contralateral frontal sinus is then removed by continued enlargement of this medial opening created at the intersinus septum. Alternatively, the frontal ostium can be located and the sinus enlarged from a lateral to medial direction as was done for the initial side. The sinus opening can be further enlarged with bone removal in an anterior direction. The limits of anterior resection depend on the thickness of the anterior flap of bone and the angulation of the drill handle. At the conclusion of surgery, a large common opening should connect both sides of the frontal sinus to each other and the nasal cavity (Figure 5 and Figure 6).

Figure 1. Frontal sinus drillout procedure: view of the right nasal cavity after the anterior wall of the frontal recess has been removed and agger nasi cells opened. The frontal sinus ostium is located with gentle palpation along the roof of the frontal recess with a ball-tipped probe. Note the second ostium located just posterior and lateral to the frontal ostium. This opening drains a supraorbital ethmoid cell that can be easily mistaken for a small frontal sinus. The true frontal ostium is usually found in an anterior and medial location within the recess.

Figure 2. Once the frontal sinus ostium has been visualized, it is enlarged in an anterior direction with a medium-cutting burr on a long-handled drill. Care is taken not to damage mucosa along the posterior rim of the ostium. For unilateral drillout, bone of the frontal sinus floor is removed in a lateral direction to the orbital wall and in a medial direction to the interfrontal septum.
RESULTS

Among the 63 patients followed up prospectively, there were 25 women and 38 men, with an average age of 46.1 years (age range, 24-76 years). Fifteen patients (23.8%) had at least 1 comorbidity. Hypertension was most common and was present in 7 patients (11.1%). Sinus CT findings resulted in classification of 35 patients (55.6%) as having stage III and 28 patients (44.4%) as having stage IV disease according to the rating system described earlier.

Facial pain and headache were the most commonly reported symptoms, occurring in 100% of patients, followed by nasal congestion in 88.9% and drainage in 85.7%. Pain had been present for the maximum measured duration of 8 consecutive weeks in 28.6% of patients. During this same period, 61.9% of patients had taken at least 1 course of antibiotic treatment, and 71.4% had used nasal corticosteroid sprays.

The CSS scores were tabulated using algorithms that normalize results on a scale from 0 to 100, with 100 the best possible score. Preoperative CSS total scores of 46.4 ± 19.5 (mean ± SD) rose to 62.2 ± 18.9 one year following surgery (P < .01), as shown in Figure 7. Symptom subscores improved from 36.7 ± 29.2 to 50.1 ± 20.3 (P < .01). Similar improvements were observed in patients’ reports of pain, congestion, and drainage. Medication subscores rose from 55.7 ± 25.9 to 70.6 ± 27.8 during this period (P < .01).

Comparison of the SF-36 general health survey subscale scores before and 6 months after surgery demonstrated a significant improvement in 4 domains (P < .05). The largest improvement was a 13.8% increase in the vitality score, which increased from 57.1 ± 23.8 to 65.0 ± 24.2. Other improvements were observed for general health (68.8 ± 20.3 to 71.1 ± 23.0), mental health (75.0 ± 18.9 to 79.2 ± 18.6), and social functioning scores (78.2 ± 27.3 to 85.8 ± 21.9). No significant differences were identified between scores at the 3- and 6-month postoperative testings. One year after surgery, similar improvements were observed for these domains (Table 1), but not all changes remained significant because of a decrease in sample size. Only the social functioning score continued to show a significant improvement (P < .05).

Figure 8 compares these changes in general health with reported normal values for the general population.

Among the group of patients who underwent the frontal sinus drillout procedure, 24 were retrospectively analyzed; there were 18 females and 6 males, with a mean age of 42.7 years (age range, 14-73 years). Frontal headache was the most common presenting complaint. Four patients with isolated frontal sinus mucoceles expanding into the orbit were classified as having CT stage I disease (Table 2). The other patients demonstrated either frontal sinus opacification without bony expansion (62%) or air-fluid level (21%). Intraoperative frontal sinus cultures were positive for organisms in 8 of 15 patients for whom specimens were sent. Bacteria isolated included Staphylococcus aureus (n = 5), Staphylococcus epidermidis (n = 2), Streptococcus pneumoniae (n = 1), Klebsiella pneumoniae (n = 1), Enterobacter asburia (n = 1), and Alcaligenes xylosoxi (n = 1).

A unilateral frontal sinus drillout procedure was performed in 63% of patients. The remainder underwent a bilateral procedure using a transeptal technique. There were no intraoperative complications. All patients were
discharged within 24 hours of surgery. As an expected result of the surgery, a permanent superior septal perforation occurred in the 9 patients who underwent the bilateral drillout procedure. The only morbidity associated with this perforation was increased crust formation, requiring more intensive postoperative cleaning and follow-up. Patients who underwent unilateral frontal sinusotomy required no more than 2 visits for crust removal, whereas those who underwent the transseptal bilateral drillout procedure typically required crust removal on a weekly basis for up to 1 month following surgery. Postoperative follow-up ranged from 12 to 32 months, with a mean of 22.7 months.

Although most patients obtained postoperative relief from their frontal discomfort, 3 patients (12.5%) were considered surgical failures and required frontal sinus obliteration with abdominal fat to relieve their headaches. Each of these patients had undergone a unilateral drillout procedure. They all developed recurrent frontal headaches within 6 weeks of their procedure, and a repeated CT scan demonstrated persistent frontal sinus opacification. A bilateral drillout technique could have been performed as an alternative to obliteration surgery in these cases; however, we chose to proceed directly to the obliteration procedure because of its known long-term success rate.

The first surgical failure involved a 44-year-old man who had undergone 2 previous endoscopic sinus surgeries, as well as an external trephination for chronic frontal sinusitis. Because of persistent headaches and left frontal sinus opacification shown on a CT scan, he was referred for a left frontal sinus drillout procedure. Intraoperative cultures grew *S epidermidis*. His headaches recurred within 1 month of surgery, and a repeated CT scan showed persistent sinus opacification, prompting frontal sinus obliteration surgery.

The second patient who did not respond to the frontal drillout procedure was a 45-year-old woman who was referred for persistent frontal headaches following 2 endoscopic sinus surgeries. Her first procedure was an endoscopic ethmoidectomy; the second was a left endoscopic frontal sinusotomy. Because preoperative cultures had grown *Pseudomonas aeruginosa*, she received 3 weeks of intravenous antibiotic therapy at home following her left frontal sinus drillout procedure. Frontal headaches returned, and she underwent obliteration surgery 7 months following the drillout procedure.

The most rapid failure involved a 41-year-old woman who had undergone a left external frontoethmoidectomy (Lynch procedure) 3 years earlier. Three weeks after unilateral frontal sinus drillout, she reported a recurrence of her preoperative headaches that did not resolve with antibiotic therapy. Absence of lateral bony support from previous surgery was thought to be a contributing factor to soft tissue collapse and early failure. Subsequent patients who have presented with frontal sinus opacification following a unilateral Lynch procedure have been treated with a bilateral drillout technique to decrease the likelihood of a similar occurrence. Those pa-
tients who have presented with disease following bilateral Lynch procedures have proceeded directly to obliteration surgery.

**COMMENT**

Surgical intervention for frontal sinusitis is indicated in patients unresponsive to medical therapy. In this study, endoscopic surgery for frontal rhinosinusitis resulted in significant improvement in both sinusitis-specific and general health status. The CSS symptom scores improved 37% 1 year after surgery. The CSS medication scores improved by 25%, indicating a significant reduction in the use of medications following surgery. These improvements are less than those previously reported for surgery of the ethmoid, maxillary, and sphenoid sinuses, confirming clinical suspicion that disease of the frontal sinus is more refractory to therapy than that of the other paranasal sinuses. Nevertheless, the improvements seen in this cohort of patients with frontal sinusitis are both statistically and clinically significant ($P<.05$).

Quality-of-life measures demonstrated improvement in the domains of vitality, general health, mental health, and social functioning following surgery. However, compared with normative population data, patients with frontal sinusitis following surgery continue to report more bodily pain and fatigue than the general US population. This finding indicates that frontal sinusitis is a chronic disease that is ameliorated but often not cured with endoscopic intervention. Furthermore, these results demonstrate the importance of evaluating both disease-specific symptoms and general health measures when studying treatment outcomes for this disease.

The endoscopic approach we used to treat frontal sinusitis was based on disease severity. When obstructing tissue was restricted to the frontal recess, surgery was limited to clearing the recess and probing the frontal ostium to ensure patency. When disease extended to within the ostium or sinus, the frontal recess was opened and the ostium inspected with direct visualization to clear obstructing tissue. If the ostium was found to be stenotic, it was enlarged with a curette in an anterior direction.
In the most severe cases, patients with expanding mucoceles and those who were not helped with previous frontal sinus surgery, a frontal sinus drillout procedure was performed. A modification of the Draf and endoscopic Lothrop procedures used a transseptal approach to remove the floor of the frontal sinuses and provide a wide aperture for intranasal drainage. In contrast to the technique of Close et al, the middle turbinates were resected to allow for wide lateral exposure with incorporation of the natural frontal ostia into the surgical opening. When disease was limited to 1 side, a unilateral drillout was performed. This procedure used a vertical incision in the nasal septum to allow for passage of instruments through both sides of the nasal cavity without compromising the integrity of the septum. When a bilateral procedure was performed, a superior septectomy facilitated access to the frontal sinus floor and interfrontal septum. The resultant septic perforation resulted in increased crust formation during the immediate postoperative period, but no associated long-term sequelae were noted.

The failure rate of 12.5% found for frontal sinus drillout will undoubtedly increase with longer patient follow-up. It is interesting to note that all 3 drillout failures occurred in patients who underwent unilateral procedures. This finding may reflect the smaller sinusotomy aperture created with a unilateral approach. A bilateral drillout procedure creates a surgical opening that is twice the size and may be less susceptible to postoperative closure. Becker et al reported no ostial closure in 14 patients who underwent bilateral frontal drillout with a mean follow-up of 9 months; however, frontal headaches occurred in 2 patients (14.3%). Close et al reported symptoms of recurrent rhinosinusitis in 1 of 7 patients who underwent frontal sinus drillout who had been followed up for at least 3 months for a similar short-term failure rate of 14.3%. One of the patients developed a cerebrospinal fluid leak that was repaired intraoperatively.

Unlike external approaches to reestablish frontal sinus drainage, endoscopic surgery creates an enlarged ostium that is bounded on all sides by bone. Thus, soft tissue collapse with reobstruction of nasofrontal drainage, a common cause of recurrent rhinosinusitis following Lynch frontoethmoidectomy, is avoided. In this series, the earliest failure occurred in a patient who had undergone a previous Lynch procedure. Frontal headaches with sinus opacification occurred within 1 month of drillout. In a report of 12 patients who underwent removal of the frontal sinus floor, superior nasal septum, and interfrontal septum with an operating microscope, Draf described his only complication as postoperative mucocele formation in patients who had undergone prior surgery on the frontal sinus through an external approach. It appears that patients who have undergone previous external procedures may be at increased risk for recurrent frontal sinusitis following an endoscopic drillout procedure. We now favor a bilateral drillout technique to ensure the largest surgical opening possible in all patients who present with frontal sinusitis following a Lynch procedure, even those with unilateral disease. Patients who have not responded to bilateral Lynch procedures proceed directly to frontal sinus obliteration surgery.

The 4 patients in this series who presented with isolated frontal sinus mucoceles were all successfully treated with the unilateral drillout procedure. This procedure appears to offer a satisfactory alternative to frontal sinus obliteration surgery for such patients. In the case of revision surgery, the frontal sinus drillout procedure also appears to provide a safe alternative to external procedures. With a short-term success rate of more than 80%, the drillout technique provides most patients with immediate symptomatic relief. However, this success rate will undoubtedly decrease with longer patient follow-up. Additional studies are needed to determine the long-term efficacy of this procedure. For those patients who develop recurrent disease, frontal sinus obliteration remains a viable treatment option.

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