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Draf III frontal sinusotomy: influence of patient characteristics on outcome

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Abstract. *Draf III frontal sinusotomy: influence of patient characteristics on outcome. Objective*: To identify positive and negative predictive outcome factors for the Draf III procedure based on the experience of a single center.
Methods: Seventy-two patients who underwent a Draf III procedure between 2005 and 2011 at the ENT department of University Hospitals Leuven were included. Patient demographics, history of frontal sinus surgery, clinical features, and computed tomographic evaluations were reviewed and analyzed for associations with symptom control and endoscopic outcome.
Results: The mean age was 48 years (16-82 years), and the male-to-female-ratio was 2:1. Major indications were chronic rhinosinusitis (with or without nasal polyps) and mucoceles. Supplementary frontal (recess) cells were found in the majority of patients. Osteoneogenesis was present in one out of four patients. At the end of follow-up (mean 35 months), the neo-ostium patency rate was 89%. Stenosis or closure of the neo-ostium was seen in 11% of patients, and 15% of patients required revision surgery. Subjective improvement was reported by 88%.
Conclusion: The results of Draf III frontal sinusotomy were positive in the long term. Previous frontal sinus surgery, the presence of allergy or aspirin-exacerbated respiratory disease (AERD), asthma, smoking, and variants in frontal recess anatomy did not affect outcome. Osteoneogenesis and chronic mucosal inflammation could be controlled by creating a large drainage pathway.

Introduction

Advances in imaging and endoscopic techniques have facilitated the endoscopic approach in sinus surgery, which is now considered the gold standard for surgical management of sinus disease. Frontal sinus surgery remains challenging due to the importance of the surrounding structures and the complex anatomy of the drainage pathway.[1] The Draf III or endoscopic modified Lothrop procedure was first described in the 1990s.[2] This type of endoscopic sinusotomy creates the largest possible opening for frontal sinus drainage by removing the inferior portion of the interfrontal septum, the superior part of the nasal septum, and the frontal sinus floor.[3] Draf *et al*. recommend extensive frontal sinusotomy in cases of persistent chronic sinusitis after failure of medical therapy, unsuccessful primary frontal sinus surgery, frontal sinus mucoceles and benign tumors, and, finally, as a last-resort procedure prior to osteoplastic obliteration.[2,3]

The results of endoscopic frontal sinusotomy have been studied with both short- and long-term follow-up. Several authors have reported a high overall success rate that varies from 79% to 98%.[4-6] Earlier studies have identified factors related to surgical failure, such as recurrent *S. aureus* infections, the presence of eosinophilic fungal rhinosinusitis, allergy, and neo-ostia with a intraoperatively measured ostium size smaller than 5 mm.[5,7-10]

The influences of previous sinus surgery, indications for surgery, specific radiological findings such as osteoneogenesis, and frontal sinus outflow tract anatomy have not been studied to date. Our aim was to analyze the experience with the Draf III procedure of the ENT department of the University Hospitals of Leuven as well as reports on preoperative evaluation and subjective and objective outcomes.

Materials and methods

Study population

This observational study retrospectively reviewed a series of patients who underwent Draf III frontal

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sinusotomy between January 2005 and December 2011. We studied the medical records and noted indications, patient characteristics, history of frontal sinus surgery, preoperative computed tomography (CT) scan, subjective and objective outcomes, and the need for revision surgery.

Diagnostic work-up

All patients underwent a preoperative assessment consisting of a detailed health history and clinical and endoscopic evaluations, with special attention to the frontal recess and sinus and a multiplanar CT study with a minimum of axial and coronal planes. Data collected included the presence of allergy or asthma, active smoking, non-active (i.e., passive or a history of) smoking, aspirin-exacerbated respiratory disease (AERD, formerly Samter's triad) and indication for surgery. CT scans were retrospectively reviewed for the presence of supplementary frontoethmoid cells and for the existence of osteoneogenesis. Frontoethmoid cells were described according to the Kuhn classification. Osteoneogenesis refers to the process of bone remodeling and formation due to local inflammation. On CT, this process is characterized by thickening of the bony sinus walls and often accompanied by signs of chronic inflammation such as mucosal edema and scarring.[11]

Surgical technique

Performing surgeons were MJ or PH. The procedure was always performed under general anesthesia after decongestion of the nasal mucosa and infiltration of the lateral nasal wall with 2% xylocaine and 1:80,000 adrenaline. In general, the procedure was conducted from lateral to medial. First, the anterior ethmoid cells were cleared out, followed by removal of the anterior part (0.5 cm) of the middle turbinate. The first olfactory fiber was identified on both sides to achieve the maximal possible opening of the frontal sinus. Next, the anterosuperior part of the nasal septum was removed to create a window at a level anterior to the axilla of the middle turbinate. This facilitated visualization and introduction of instruments from one side to the other. A 40° cutting or 70° diamond burr was used to open the frontal sinus floor by removing the bone above the axilla. At this point, the anterior skull base lay medial to the burr, so further drilling continued in the anterosuperior direction. The same steps were followed to open the contralateral axilla until the skull base was visible on both sides. The next step was removal of the posterior part of the frontal beak and removal of the intersinus septum to a level as high as technically possible. Using curved drills of different angles enabled superior reach into the frontal sinus, facilitating accurate removal of superiorly located frontal cells, the interfrontal septum, and frontal septa. This resulted in the creation of the largest possible median drainage pathway for both frontal sinuses. The exposed bone was not covered with free mucosal grafts. Standard postoperative care consisted of daily frontal sinus lavage with saline and administration of antibiotics (amoxicillin/clavulanic acid three times a day for 10 days) and corticosteroids. Frequent hospital visits were necessary for evaluation of healing and suction cleaning.

Postoperative outcome

At the end of follow-up, subjective and objective outcomes were evaluated by assessing postoperative symptom control as well as endoscopic results. Subjective outcome was based on the patient's history; they were asked if their main symptoms were better controlled, the same, or worse compared to the preoperative period. Objective outcome was evaluated as the frontal neo-ostium being open, stenotic, or closed.

Statistical analysis

We used descriptive statistics with means and frequencies. Correlations between objective and subjective outcomes were made with Pearson's test. Odds ratios for specific patient characteristics were calculated with Fisher's exact test.

Results

Patient characteristics

Patient characteristics are summarized in Table 1. The total number of patients was 72, and the male-to-female ratio was 2:1. The mean age was 47 years and varied from 16 to 82 years. In 15 patients (21%), allergy to airborne particles was noted. Pre-existing asthma was observed in 13 patients (18%), of whom seven (10%) had AERD. Twelve patients (17%) used tobacco actively, while non-active

Table 1
Patient characteristics

Total number of patients	72
Male-to-female ratio	2:1
Mean age, years	46.9 (16-82)
Allergy, *n* (%)	15 (21%)
Active smoking, *n* (%)	12 (17%)
Non-active smoking, *n* (%)	14 (19%)
AERD, *n* (%)	7 (10%)
Asthma, *n* (%)	6 (8%)

AERD: aspirin-exacerbated respiratory disease.

smoking was noted in 14 patients (19%). The presence of allergy, asthma, AERD, and smoking was not significantly associated with a higher risk of restenosis (Table 2).

History of frontal sinus surgery

Patients were divided into subgroups depending on the number and type of previous frontal sinus surgeries. Only a minority (11 patients) underwent a primary Draf III procedure (Table 3); in all of these cases, the frontal neo-ostium stayed open at the end of follow-up. Indications for surgery in these patients were chronic rhinosinusitis (CRS) (five patients), mucocele (three patients), and osteoma (three patients). Thirty-five patients (49%) reported a history of two or less endoscopic sinus surgeries, and 16 patients (22%) had undergone more than two functional endoscopic sinus surgeries (FESS). The mean patency rates in these patient groups were 86% and 81%, respectively. Extensive previous frontal sinus surgery with a combination of endonasal and external procedures was reported in 14% of patients. In 90% of patients, the neo-ostium stayed open. There was no statistically significant difference in the patency rate among the following subgroups: no surgery, one or two surgeries, and extensive frontal surgery.

Radiological characteristics

In 64 out of 72 patients, multiplanar CT scan was available for evaluation of the presence of frontoethmoid air cells and osteoneogenesis. CT scans for the remaining eight patients were of poorer quality, not multiplanar, or not available at the time of the study. Frontal recess cells (i.e., agger nasi cells, Kuhn cells, or other frontoethmoid air cells) were seen in 26 patients (40%). Frontal sinus cells (i.e., supraorbital ethmoid cells, frontal bullar cells, interfrontal septum cells, or type 4 Kuhn cells) were observed in nine patients (14%). In another ten patients (16%), we found a combination of frontoethmoid air cells in both the frontal sinus and recess. *p* values were calculated to determine risk for restenosis in the presence of these anatomical variants, but none reached the level of significance. Osteoneogenesis was present on CT examination in 18 patients (28%). Again, this was not significantly correlated with a higher risk for restenosis of the neo-ostium (Table 4).

Indications for Draf III frontal sinusotomy

Table 5 summarizes the indications for Draf III surgery, as well as subjective and objective outcomes. Most patients had chronic frontal sinusitis (with and without nasal polyps in 20 and 32 cases, respectively); in the majority, an open neo-ostium was observed at the end of follow-up. Symptomatic relief was reported in 95% and 81% of cases of CRS without nasal polyps (CRSsNP) and CRS with nasal polyps (CRSwNP), respectively. Patients with frontal mucoceles showed a 100% patency rate and subjective improvement in 90%. Other indications were frontal osteoma (three cases), inverted papilloma (three cases), acute frontal sinusitis (two cases), fibrous dysplasia (one

Table 2
Patient characteristics vs. outcome

	n	Neo-ostium stenotic/closed	Odds ratio	*p* value
Active smoking	12	2 (17%)	1.9	0.6
Non-active smoking	14	2 (14%)	0.9	1
Allergic rhinitis	15	1 (7%)	0.5	1
AERD	7	1 (14%)	0.4	1
Asthma	6	1 (17%)	1.5	1

AERD: aspirin-exacerbated respiratory disease.

Table 3
History of (frontal) sinus surgery

	N	Open ostium
Primary surgery	11 (15%)	11 (100%)
Revision surgery	61 (85%)	52 (85%)
History of FESS ≤2 times	35	30 (86%)
History of FESS >2 times	16	13 (88%)
History of FESS and external surgery	10	9 (90%)

case), and adenocarcinoma (one case). All of these patients showed excellent patency and symptomatic relief.

Objective and subjective outcomes

Success of surgery was defined as the presence of an open neo-ostium at the end of follow-up, without need for revision surgery. The mean follow-up was 35 months (minimum 12 months, maximum 72 months), with a standard deviation of 14 months and a median of 35 months. Patency of the neo-ostium was observed in 89% of patients. Closure or stenosis was seen in 11% of patients. At the end of follow-up, 88% of patients reported "fewer or no complaints," which we defined as successful symptom control. A correlation between objective and subjective outcome was calculated and found to be significant (Pearson's $r=0.66$). Revision surgery was required in 11 patients (15%) after a mean follow-up period of 15 months. In the majority of these cases, a revision median drainage approach (five patients) was made because of restenosis of the neo-ostium. In these patients, the main preoperative finding was osteoneogenesis. One patient underwent revision external frontal surgery because of recurrence of fibrous dysplasia. In five patients, the reason for revision surgery was persisting symptoms due to ongoing inflammation in either the frontal (two patients) or other paranasal sinuses (three patients). These patients underwent a less extensive type of endoscopic surgery directed toward the pathologic sinus.

Discussion

We reviewed the outcome of Draf III frontal sinusotomy. Indications for a Draf III procedure comprise all cases where medical failure occurs or when standard and/or less extensive frontal sinusotomies fail to control sinus disease. In these cases, the Draf III procedure serves as a last resort prior to osteoplastic obliteration.[3,8] Surgical success was defined by neo-ostium patency without the need for revision surgery at the end of follow-up. The patency rate of 89% in our study confirms the results of other authors.[6,8,10] Regarding subjective outcome, 88% of our patients reported improvement or the absence of symptoms at the end of follow-up. Patency rate (objective outcome) and symptom relief (subjective outcome) were significantly correlated. Other authors, such as Georgalas *et al*. and Shirazi *et al*., published a comparable subjective outcome after a follow-up of >1.5 years, but with a higher revision rate (32% and 25%, respectively).[8,12] Wormald also reported low symptom recurrence (25% of patients) after a mean follow-up of 22 months. In the Wormald study population, a minority had CRS (ten out of 88), which was the largest subgroup in our study.[13] In this specific patient group, we noticed a discrepancy between objective and subjective outcome in the short term, but the long-term results were more positive. This was also reported by Batra *et al*. in smaller population groups.[14] Short-term restenosis of the frontal ostium occurred in 13% of patients after an

Table 4
Radiological findings

	n	Neo-ostium stenotic/closed	Odds ratio	*p* value
Frontal recess cells	26	3 (12%)	1.1	1
Frontal sinus cells	9	0	—	—
Frontal recess and sinus cells	10	2 (20%)	1.5	1
Osteoneogenesis	18	2 (11%)	0.8	1

Table 5
Indications for surgery

	n	Neo-ostium open	No or fewer complaints
CRSwNP	20	19 (95%)	19 (95%)
CRSsNP	32	26 (81%)	26 (81%)
Mucocele	10	9 (90%)	9 (90%)
Osteoma	3	3 (100%)	2 (67%)
Acute frontal sinusitis	2	2 (100%)	2 (100%)
Inverted papilloma	3	3 (100%)	3 (100%)
Frontal adenocarcinoma	1	1 (100%)	1 (100%)
Fibrous dysplasia	1	1 (100%)	1 (100%)

CRSwNP: chronic rhinosinusitis with nasal polyps; CRSsNP: chronic rhinosinusitis without nasal polyps.

average follow-up of 11 months, which is comparable to the results of other authors.[6,8,15] A comparison of the patency rate in different subgroups according to the number of previous sinus surgeries did not reveal a significant difference. We could not confirm the presence of allergic rhinitis as a risk factor for restenosis of the neo-ostium, which was observed by Shirazi *et al*.[12] When we divided patients into subgroups according to indication, we saw a correlation between objective and subjective findings, which was most evident in the CRSwNP and CRSsNP subgroups. For short-term follow-up, we found a discrepancy between objective and subjective results in these patients, which could be explained by the fact that these patients had chronic mucosal disease and often had associated disease in the remaining paranasal sinuses. In the long term, we assume that ongoing mucosal disease was being controlled by the creation of a large frontal outflow tract. In patients with isolated frontal disease such as frontal mucoceles, the 100% patency of the neo-ostium was associated with 90% symptom control. One of the three patients who underwent resection of their frontal osteoma by Draf III reported headache at the end of follow-up, which could not be attributed to regrowth of the osteoma or stenosis of the neo-ostium. Our findings emphasize the importance of long-term follow-up and informing patients about a possible initial discrepancy between subjective and objective outcome. In the long term, we believe that mucosal disease can be controlled by the Draf III procedure.

Regarding the presence of different types of frontoethmoid air cells as visualized on CT, we did not find significant differences in the patency rate of the neo-ostium. We used a classification based on their preoperative obstruction of the frontal recess, the frontal sinus, or both, depending on their more inferior or superior location. As these cells represent variants of anterior ethmoid pneumatization, total clearance by means of Draf III drainage will result in a wide neo-ostium and less risk of postoperative narrowing. We are aware that the 40% presence of agger nasi cells is rather low, but this may have been due to their removal during a previous surgery, as most of our patients were revision cases. We confirm the importance of scrupulous preoperative evaluation of multiplanar CT scans to obtain a clear understanding of all the anatomical variations.

CT scans are also helpful in detecting osteoneogenesis, which was present in 28% of patients. Osteoneogenesis has been described as associated with poorer objective outcome, as it acts as a local inflammatory agent to promote ongoing inflammation after surgery.[16] A recent study by Günel *et al*. revealed a correlation between osteoneogenesis and tissue eosinophilia and the presence of inflammatory cells.[17] In our study, we found poorer endoscopic results in the short term in these patients; however, at the end of follow-up, there was no higher risk for restenosis.We assume that the process of osteoneogenesis can be controlled by creating a large median drainage. In the literature, mucosal grafting of the exposed frontal bone has been suggested as an assisting technique in the prevention of postoperative closure, with good results in the short term.[18]

The major limitations of this study were the retrospective setting and observational set-up. Our statistical analysis led to hypotheses and general conclusions, but seems for the most part to confirm previously reported results. It would be interesting

to conduct a prospective study that includes specific indications and findings on CT examination, reports subjective outcome parameters on a standardized scale such as the visual analog scale, and performs endoscopic and/or CT measurements at well-defined postoperative time points.

Conclusions

We investigated specific clinical and radiological preoperative factors to gain insight into predicting the outcome of Draf III frontal sinusotomy. Postoperative narrowing or closure of the frontal ostium area was found in 11% of patients within the first year. Number and type of previous sinus surgery; the presence of allergy, AERD, or asthma; smoking; and variations in the frontal recess anatomy did not affect outcome. There was a correlation between objective and subjective outcomes at the end of follow-up. Osteoneogenesis and chronic inflammatory frontal sinus disease can be controlled in the long term by creating a large frontal sinus drainage pathway.

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Author contributions

MT and MJ designed and conducted the study, analyzed the data, and wrote the manuscript. All patients were treated by PH or MJ. All authors have critically revised the manuscript. All authors state they have no conflict of interest in relation to this study and the results described in the manuscript.

References

1. Daniels DL, Mafee MF, Smith MM, Smith TL, Naidich TP, Brown WD, Bolger WE, Leighton MP, Ulmer JL, Lofti HB, Strottman JM. The frontal sinus drainage pathway and related structures. *AJNR Am J Neuroradiol*. 2003;24(8):1618-1627.
2. Draf W. Endonasal micro-endoscopic frontal sinus surgery: The Fulda concept. *Op Tech Otolaryng*. 2001;2(4):234-240.
3. Kountakis SE, Senior BA, Draf W. *The frontal sinus*. Springer, Berlin: 2005.
4. Weber R, Draf W, Kratzsch B, Hosemann W, Schaefer S. Modern concepts of frontal sinus surgery. *Laryngoscope*. 2001;111(1):137-146.
5. Naidoo Y, Bassiouni A, Keen M, Wormald PJ. Long-term outcomes for the endoscopic modified Lothrop/Draf III procedure: a 10-year review. *Laryngoscope*. 2014;124(1):43-49.
6. Eloy P, Vlaminck S, Jorissen M, Hellings P, Timmermans M, Daele J, Ransky P, Hassid S, Van Zele T, Bachert C, Poirrier AL, Bertrand B. Type III frontal sinusotomy: surgical technique, indications, outcomes, a multi-university retrospective study of 120 cases. *B-ENT*. 2011;7 Suppl 17:3-13.
7. Tran KN, Beule AG, Singal D, Wormald P-J. Frontal ostium restenosis after the endoscopic modified Lothrop procedure. *Laryngoscope*. 2007;117(8):1457-1462.
8. Georgalas C, Hansen F, Videler WJM, Fokkens WJ. Long terms results of Draf type III (modified endoscopic Lothrop) frontal sinus drainage procedure in 122 patients: a single centre experience. *Rhinology*. 2011;49(2):195-201.
9. Naidoo Y, Wen D, Bassiouni A, Keen M, Wormald PJ. Long-term results after primary frontal sinus surgery. *Int Forum Allergy Rhinol*. 2012;2(3):185-190.
10. Hosemann W, Kühnel T, Held P, Wagner W, Felderhoff A. Endonasal frontal sinusotomy in surgical management of chronic sinusitis: a critical evaluation. *Am J Rhinol*. 1997;11(1):1-9.
11. Huang BY, Lloyd KM, DelGaudio JM, Jablonowski E, Hudgins PA. Failed endoscopic sinus surgery: spectrum of CT findings in the frontal recess. *Radiogr Rev Publ Radiol Soc N Am Inc*. 2009;29(1):177-195.
12. Shirazi MA, Silver AL, Stankiewicz JA. Surgical outcomes following the endoscopic modified Lothrop procedure. *Laryngoscope*. 2007;117(5):765-769.
13. Wormald PJ. Salvage frontal sinus surgery: the endoscopic modified Lothrop procedure. *Laryngoscope*. 2003;113(2):276-283.
14. Batra PS, Cannady SB, Lanza DC. Surgical outcomes of drillout procedures for complex frontal sinus pathology. *Laryngoscope*. 2007;117(5):927-931.
15. Anderson P, Sindwani R. Safety and efficacy of the endoscopic modified Lothrop procedure: a systematic review and meta-analysis. *Laryngoscope*. 2009;119(9):1828-1833.
16. Sethi N. The significance of osteitis in rhinosinusitis. *Eur Arch Otorhinolaryngol*. 2015;272(4):821-826.
17. Günel C, Yükselen OO, Başak HS, Eryilmaz A, Başal Y. Chronic rhinosinusitis; histopathologic study of osteitis in surgery cases. *B-ENT*. 2015;11(2):135-139.
18. Conger BT, Riley K, Woodworth BA. The Draf III mucosal grafting technique: a prospective study. *Otolaryngol – Head Neck Surg*. 2012;146(4):664-688.

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