

The Endoscopic Modified Lothrop Procedure: Review of Single Institution Experience and Long-Term Outcomes

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Background: Endoscopic Modified Lothrop Procedure (EMLP) has become a fundamental practice in rhinology. Improvements in symptom burden, ostial patency, morbidity, and costs have surpassed that of an open approach to the frontal sinus. Long-term efficacy has not been well established.

Objective: This study details the long-term outcomes of EMLP and risk factors for subsequent surgical revision at a single institution.

Methods: This study utilized a retrospective review of patients who underwent EMLP from September 2006 to February 2017 by a single surgeon at an academic tertiary referral center. Patient demographics, indications, symptom burden, and endoscopic assessment of frontal ostium patency were analyzed for their effect on surgical outcome. Risk factors for failures were identified.

Results: Seventy-six consecutive patients with an average age of 58.1 years met the inclusion and exclusion criteria and underwent EMLP for chronic rhinosinusitis (CRS, 59%), neoplasm (26%), and mucoceles (15%). The average number of standard endoscopic sinus surgeries prior to EMLP was 2.9. The mean follow-up of the cohort was 34.8 months, at the end of which, EMLP was successful in 78% of all patients, requiring no further surgery. Ninety percent of patients reported significant clinical improvement at the most recent follow-up. Subgroup analysis of CRS patients revealed an equally high success rate but a higher likelihood of ostial closure. Recurrent disease necessitated revision endoscopic surgery in 17 patients, the majority of whom suffered CRS. Only tissue eosinophilia was identified to significantly increase the risk of revision surgery.

Conclusions: The majority of the patients who undergo EMLP achieve sustained patency of the frontal sinus outflow tract and adequate symptom improvement. Prominent tissue eosinophilia identifies patients at risk of requiring additional frontal sinus surgery.

Key Words: Chronic rhinosinusitis, frontal drill-out, modified Lothrop procedure, Draf III procedure, outcomes.

Level of Evidence: 4.

INTRODUCTION

Recalcitrant frontal sinusitis presents a multitude of challenges to patients and sinus surgeons. The complexity of the frontal sinus drainage lends to difficult endonasal visualization and propensity for postoperative stenosis.

The advent of endoscopic technology has allowed the development of multiple endoscopic techniques. The stepwise approach of these techniques has been advocated to manage recurrent disease.¹ When frontal sinusotomy fails, endoscopic modified Lothrop procedure (EMLP)—also known as frontal sinus drill-out or Draf type III—allows for enlargement of the frontonasal communication by removing

the frontal sinus floor, inter-sinus septum, superior nasal septum, and frontal beak. As modified by Draf² and Gross³ to be completely endonasal and endoscopic, EMLP has been increasingly utilized for a number of frontal sinus disorders, most commonly refractory chronic rhinosinusitis. Importantly, this endonasal approach to the anterior skull base has also become a viable alternative to anterior craniofacial resection. EMLP has largely replaced the open approach using the osteoplastic flap due to its reduced morbidity, improved cosmesis, ease of endoscopic surveillance, and decreased hospitalization and frontal pain.^{4,5}

As the modified Lothrop procedure becomes more routine, short-term efficacy of EMLP has been summarized in a systematic review.⁶ Despite this, the long-term efficacy of EMLP is not well characterized, with variable rates of failure and reports of delayed stenosis.⁷ The purpose of this study was to evaluate the long-term efficacy of frontal sinus drill-out and to determine the risk factors for failure in the treatment of patients with recalcitrant sinus disease.

MATERIALS AND METHODS

Study Design

This study was a retrospective review of all consecutive patients undergoing endoscopic modified Lothrop procedure in the tertiary referral rhinology practice of a single surgeon (B.B.W.) over a 10-year period between September 2006 to February 2017.

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Data regarding patient demographics, previous paranasal surgeries, comorbidities, surgical indications, intraoperative blood loss and findings, complications, histopathology, need for and time to revision surgery, perioperative symptomatology, and endoscopic exam were recorded. Potential predictive factors such as asthma, aspirin sensitivity, allergies, and history of smoking, were collected. Most up-to-date postoperative clinic notes were reviewed to corroborate patient reported changes in symptom burden and medication requirements. Clinical outcomes were graded on patient reported change of main symptom as asymptomatic, improved, persistent, or worsened. Frontal sinus patency was graded endoscopically as patent (wide, quiescent neo-ostium with no evidence of mucosal edema or polyposis), partially open (any evidence of edema or polyposis without complete closure of neo-ostium), or closed (complete obstruction of neo-ostium). Failure of the EMLP was defined as need for subsequent revision frontal sinus surgery from restenosis of the drainage pathway or persistent disease. The Health Science Institutional Review Board of the Keck Medical Center approved the study (HS-13-00115).

Patient Selection

The study cohort represented consecutive patients undergoing endoscopic modified Lothrop procedure without exclusion by diagnosis. EMLP was reserved for symptomatic patients who had failed appropriate medical therapy and prior functional endoscopic frontal sinus procedures with radiologic or endoscopic evidence of frontal recess closure amenable to surgical treatment. Appropriate medical therapy for chronic rhinosinusitis (CRS) in our institution consists of patient-specific regimen of intranasal corticosteroid, saline irrigation, oral corticosteroid, and/or culture-directed antibiotics for a minimum of 3–4 weeks. Frontal sinus tumors that warranted wider surgical exposure were offered primary frontal sinus drill-out. Indicators of potentially challenging surgery, ie, poorly pneumatized frontal sinus or narrowed antero-posterior (AP) diameter of frontal sinus ostium, were not considered to be contraindications.

Surgical Management

Intraoperative image guidance (Stealth, Medtronic, Jacksonville, Florida, U.S.A.) was used in all EMLP and revision endoscopic sinus surgery cases. The technique for performing the EMLP has been previously described.⁸ Regular outpatient follow-up and routine postoperative medical therapy was used, which included intranasal corticosteroid, oral antibiotics course, nasal saline irrigation, and oral prednisone taper for recurring evidence of polypoid disease. At each visit, self-reported symptom burden and endoscopic patency of the drainage pathway was recorded and graded by the senior author.

Statistics

Statistical analyses were performed using GraphPad Prism 6.0 software for Mac (GraphPad Software, Inc., La Jolla, California, U.S.A.). Continuous data of age, number of prior procedures, and months to revision surgery are displayed as mean with standard deviation (SD). Categorical variables of the two comparison groups were compared using Fisher exact tests with two-tailed *p*-values, and normally distributed variables by unpaired *t* test where appropriate. The level of statistical significance was set at *p* < .05 for double-sided comparisons.

RESULTS

Seventy-six patients were included in this study with a mean age of 58.1 (range: 23–87) who met the inclusion and exclusion criteria. There were 39 males

who comprised 51% of the study population and 37 females (49%). The vast majority of the patients had prior standard sinus surgeries, the average of which was 2.9 (95% CI: 2.4–3.4, SD 2.2). The mean length of follow-up after EMLP was 34.8 months (95% CI: 27.9–41.7, SD: 25.4 months). There were four patients who had undergone prior external osteoplastic flap. Overall, 42% of patients had reported skin-pricked confirmed allergy and 35% had asthma. Twenty-one percent reported smoking history, and 17% reported aspirin sensitivity as part of Samter's Triad.

Surgical indications included recalcitrant chronic frontal sinusitis in 45 (59%) patients (78% CRS with nasal polyposis, CRSwNP; 22% CRS without nasal polyposis, CRSsNP). Of the patients with CRS, four had IgG deficiency while two had cystic fibrosis. Eleven patients (15%) had frontal sinus mucoceles. Twenty patients (28%) had tumors involving the frontal sinus of which seven diagnoses were inverted papillomas (meningiomas-4, esthesioneuroblastoma-4, osteomas-3, melanoma-1, sarcoma-1). Six of these patients underwent concomitant nasoseptal flap as part of skull base reconstruction after tumor resection (Table I).

Subjectively, most commonly reported symptoms preoperatively included nasal obstruction (82%), facial pressure (74%), rhinorrhea (62%), headaches (41%), post-nasal drip (24%), and anosmia (18%). When classified into degree of symptom resolution, 45 (59.2%) were asymptomatic at the end of follow-up while 24 (31.6%) had significant improvement of their symptoms for a total of 90.8% of patients who found clinical benefit postoperatively. The six remaining patients (7.9%), had persistent symptoms while no patients complained of worsening symptoms following the EMLP.

Ostial Patency

Objectively, most recent endoscopic examinations showed that the frontal neo-ostium remained widely patent in 64 patients, reflecting a patency rate of 84% in this cohort. This ostial patency rate is lower (80%) in the subpopulation of CRS patients (Table II). The remaining 12 patients suffered partial or complete closure of the frontal neo-ostium by cicatricial effects on the mucosa or osteoneogenesis of persistent inflammation. Of these 12 patients with partial or complete closure, 9 patients suffered from CRS, 7 of whom had nasal polyposis.

Surgical Success

Seventeen patients (22%) required revision surgery at an average of 15.8 months after the initial EMLP, or 78% overall surgical success. Revision surgeries were performed for persistent symptoms unresponsive to medical treatment combined with objective, treatable disease or tumor recurrence within the frontal sinus. The majority of the surgical failures (10/17) suffered from CRS, nine of whom had recurrent nasal polyps leading to thickened mucous drainage and recurrent infections. In our series, EMLP was successful in 78% of CRS patients, 73% of mucocele patients, and 80% of tumor patients (Table I).

TABLE I.
Demographics and Comorbidities (n = 76).

| | All Patients (n = 76) | No Revision Surgery (n = 59) | Revision Surgery (n = 17) | p-value | Patent Ostium (n = 64) | Partially Open/Closed Ostium (n = 12) | p-value |
|---------------------------------|--------------------------|---------------------------------|------------------------------|---------|---------------------------|--|---------|
| Demographics | | | | | | | |
| Age (mean) | 58.1 | 57.4 | 60.1 | 0.44 | 59.7 | 48.8 | .06 |
| Gender (male) | 39 (51.3) | 27 (45.8) | 12 (70.6) | 0.09 | 33 (51.2) | 6 (50.0) | .92 |
| Previous sinus surgeries (mean) | 2.9 | 2.7 | 3.6 | 0.25 | 2.8 | 3.6 | .25 |
| Indications, n (%) | | | | | | | |
| CRS | 45 (59.2) | 35 (59.3) | 10 (58.8) | 0.46 | 35 (54.7) | 9 (75.0) | .22 |
| Mucoceles | 11 (14.5) | 8 (13.6) | 3 (17.6) | 0.70 | 9 (14.1) | 2 (16.7) | .81 |
| Tumors | 20 (26.3) | 16 (27.1) | 4 (23.5) | 0.76 | 20 (31.3) | 1 (8.3) | .16 |
| Comorbidities, n (%) | | | | | | | |
| Asthma | 24 (31.6) | 19 (32.2) | 5 (29.4) | 0.82 | 21 (32.8) | 3 (25.0) | .74 |
| Allergy | 32 (42.1) | 23 (39.0) | 9 (52.9) | 0.40 | 26 (40.6) | 8 (66.7) | .08 |
| Aspirin sensitivity | 13 (17.1) | 9 (15.3) | 4 (23.5) | 0.47 | 10 (15.6) | 3 (25.0) | .42 |
| Smoking | 16 (21.1) | 13 (22.0) | 3 (17.6) | 0.95 | 15 (23.4) | 1 (8.3) | .44 |
| Eosinophilia [^] | 26 (34.2) | 17 (28.8) | 9 (52.9) | 0.04* | 21 (32.8) | 5 (41.7) | .38 |

*p < .05; [^]Eosinophilia defined as moderate to significant on histopathology or >10 eosinophilia per high power field. CRS = chronic rhinosinusitis.

Of the 17 surgical failures, 10 (58.8%) patients required an initial revision surgery within the first year, followed by 3 patients (17.6%) during the second year, 2 patients in the third, and 1 patient in the fourth and fifth years postoperatively (Fig. 1). Four patients underwent a second revision surgery. Of these patients requiring revision, 14 (82.3%) maintained wide endoscopic patency by the end of follow-up and 12 (70.5%) ultimately became asymptomatic or significantly improved clinically.

Risk Factors of Surgical Failure

Preoperative demographics and comorbidities including age, number of previous sinus procedures, nasal polyposis, allergy, asthma, aspirin sensitivity, smoking, surgical indications, and tissue eosinophilia were analyzed as possible predictor factors for revision surgery or neo-ostium restenosis (Table I). Only prominent eosinophilia on surgical pathology was found to be predictive of the need for

revision surgery after drill-out (p = .03). This is defined as moderate to significant eosinophilia or >10 eosinophilia per high power field. Asthma, allergy, aspirin sensitivity, and smoking were not found to be associated with surgical failure. Furthermore, no risk factors were found to be predictive of frontal ostial closure.

There was no significant difference between the mean estimated blood loss in patients with and without need for revision surgery. We report two postoperative cellulitis over nasal bridge that improved with steroids and antibiotics and one patient who developed nasal vestibular stenosis from the heat of the drill. There were no major orbital or cranial complications noted.

DISCUSSION

Despite the complexity of the frontal sinus drainage and the extent of resection, our findings demonstrated that this technically demanding drill-out is safe and efficacious with low rates of complications in over 30

TABLE II.
Analysis of CRS Patients (n = 45).

| | CRS Patients (n = 45) | No Revision Surgery (n = 35) | Revision Surgery (n = 10) | p-value | Patent Ostium (n = 36) | Partially Open/Closed Ostium (n = 9) | p-value |
|-----------------------------|--------------------------|---------------------------------|------------------------------|---------|---------------------------|---|---------|
| Presence of Polyps | | | | | | | |
| With NP | 33 (73.3) | 24 (68.6) | 9 (90) | 0.24 | 26 (72.2) | 7 (77.8) | .74 |
| Without NP | 12 (26.7) | 11 (31.4) | 1 (10) | | 10 (27.8) | 2 (22.2) | |
| Comorbidities, n (%) | | | | | | | |
| Asthma | 20 (44.4) | 16 (45.7) | 4 (40) | 0.75 | 17 (47.2) | 3 (33.3) | .71 |
| Allergy | 22 (48.9) | 16 (45.7) | 6 (60) | 0.49 | 17 (47.2) | 5 (55.6) | .72 |
| Aspirin sensitivity | 11 (24.4) | 7 (20) | 4 (40) | 0.23 | 8 (22.2) | 3 (33.3) | .66 |
| Smoking | 10 (22.2) | 8 (22.9) | 2 (20) | 0.61 | 9 (25) | 1 (11.1) | .65 |
| Eosinophilia [^] | 24 (53.3) | 15 (42.8) | 9 (90) | 0.01* | 20 (55.6) | 4 (44.4) | .41 |

*p < .05; [^]Eosinophilia defined as moderate to significant on histopathology or >10 eosinophilia per high power field; NP = nasal polyps; CRS = chronic rhinosinusitis.

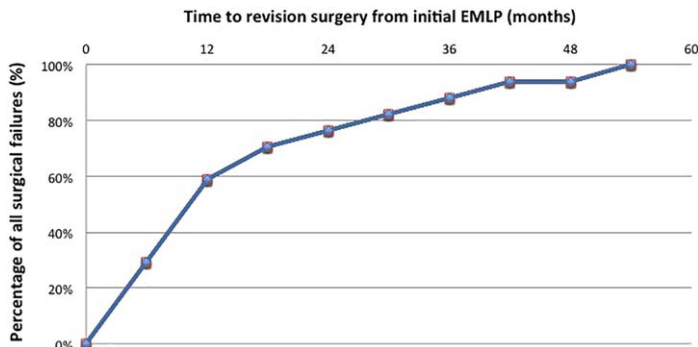


Fig. 1. Fifty-nine percent of endoscopic modified Lothrop procedures failures occurred within 12 months, and 76% by 24 months. Thereafter, delayed failure was observed up to 53 months. (n = 17)

months of follow-up. Given this, EMLP is routinely offered in a graduated approach as a salvage procedure for refractory chronic frontal sinusitis or more selectively as a primary procedure to anterior skull base tumors.

The majority of our cohort achieved significant subjective improvement (90%) and sustained patency of the neo-ostium (84%). Previous meta-analysis reported an 82% symptomatic improvement rate with 86% patency rate.⁶ Interestingly, neo-ostium restenosis did not correlate significantly with symptom severity or the need for revision surgery. This underscores our incomplete understanding of what drives CRS symptoms and may suggest a component of mucosal inflammation not immediately measurable on endoscopy.

In our series, surgical failure was defined as the need for revision frontal sinus surgery following the initial drill-out. In this cohort of 76 patients, the revision rate was 22% (17/76). The success rate was augmented from 78% (59/76) to 88% (67/76) if effective revision surgeries were included. (Fig. 2) Although our revision rate

may appear higher than the 14% noted in a previous meta-analysis,⁶ inadequate postoperative follow-up in those studies may have contributed to an underestimate of surgical failures.

In our subanalysis of CRS patients (n = 45), EMLP achieved similar levels of objective frontal patency in 80% and surgical success rate of 78% (Table II). However, CRSwNP disproportionately contributed to surgical failures and ostial closure when compared to CRSsNP. In fact, EMLP was highly successful (92%) in treating cases of CRSsNP without a revision surgery when compared to CRSwNP (72%).

As such, our results are consistent with the few long-term outcomes studies with at least 20 patients and over 24 months follow-up. Schlosser et al.⁹ evaluated 44 patients over an average of 40 months and found revision rate of 32%. Ting et al.⁷ had a 30% revision rate in a cohort of 204 patients with 10-year follow-up. Remarkably, a higher success rate (5% revision) was achieved in 229 patients with chronic rhinosinusitis with an average of 45-month follow-up.¹⁰

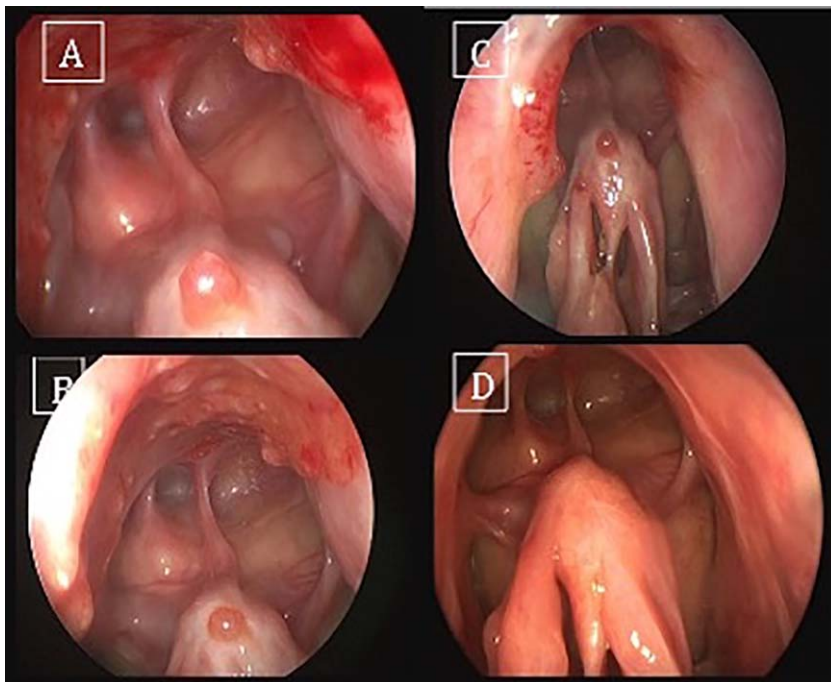


Fig. 2. Postoperative endoscopic view of the frontal sinus neo-ostium, 4 weeks (A), 6 weeks (B), 8 weeks (C), and 40 weeks (D) after initial EMLP using a 30-degree scope. Patient had complete resolution of preoperative symptoms.

In our study, the majority of surgical revision was performed within the initial 24 months of follow-up. Other studies similarly noted 61% to 82% of the revisions performed within the first two years of the initial drill-out.^{7,11} Predominant early surgical failures preceded a gradual tapering of late failures that may span many years. Revision surgeries occurred as late as 53 months after the initial EMLP in our cohort, which attests to the importance of long-term surveillance after a drill-out. Indeed, surgical success could decrease significantly when follow-up is extended, and delayed failures were observed up to 12 years after drill-out in another study.⁷

Studies have shown some predictive value of the presence of eosinophilic mucin, allergic fungal sinusitis, and recalcitrant *S. aureus* infections on the rate of frontonasal restenosis in CRS patients.^{12,13} Others have found the surgical indications of tumors or mucocele to be associated with a higher risk of revision surgery than that of CRS.⁷ In this analysis, prominent eosinophilia was correlated with increased surgical failure, and this association was even stronger in the CRS subcohort. Eosinophilic inflammatory process has been characterized as a primary immune dysregulation, which may be less amenable to single-modality, surgical intervention.¹⁴ Indeed, many have proposed using markers of eosinophilia to subclassify CRS as it is found to be associated with increased inflammatory burden and a recalcitrant course of treatment.^{15–17} A recent study has suggested a higher revision rate of EMLP in those with aspirin-exacerbated respiratory disease (AERD) with nasal polyposis, a process driven by robust eosinophilic inflammation.¹⁸

No other predictive factors in demographics, indications, and comorbidities were found to significantly impact the revision rate of frontal drill-out surgery in this study. These included factors such as asthma, allergy, aspirin sensitivity, and smoking. Although recalcitrant frontal sinusitis carries a greater inflammatory load than other frontal sinus pathology, a higher likelihood of scarring, polyp recurrence, osteogenesis, and mucosal remodeling, its association with ostial obstruction or surgical failure was not statistically significant in this cohort. Furthermore, while a previous study had shown an association between allergy and frontal neo-ostium obstruction, we only observed a trend toward significance in these patients ($p = 0.08$).¹⁰

The retrospective, single-institution nature of this longitudinal study contributes to its inherent limitations, given that practice biases can be introduced and follow-up may not be uniform. Its lack of power may also restrict the study of infrequent risk factors such as AERD. However, rigorous prospective multi-institutional studies may be prohibitively difficult in long-term outcomes studies. Future research should focus on the standardization of perioperative demographics and outcomes parameters including the use of validated outcome scores to allow for improved inter-study comparisons across institutions.

CONCLUSION

With advances in technique and instrumentation, there is an emerging consensus that EMLP provides a valuable option in the management of select patients with medically and surgically recalcitrant inflammatory sinus disease.¹⁹ This study augments the growing evidence on the long-term efficacy of EMLP. It confirms that lasting postoperative frontonasal patency and symptom relief that can be achieved in the overwhelming majority of patients with wide-ranging pathology. Although eosinophilia has been identified as a risk factor for failure, more research is needed to determine predictors of failure and identify the most appropriate treatment in the small number of refractory patients.

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