Modified Subtotal Lothrop Procedure for Extended Frontal Sinus and Anterior Skull Base Access: A Cadaveric Feasibility Study with Clinical Correlates

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Abstract

Keywords

- endoscopic modified Lothrop procedure
- Lothrop procedure
- modified hemi-Lothrop procedure
- modified mini-Lothrop procedure
- modified subtotal-Lothrop procedure
- extended Draf IIB
- cadaveric technique

Objective The endoscopic modified Lothrop procedure (EMLP) is an established approach for recalcitrant frontal sinus disease and anterior skull base exposure. However, in select cases, this technique may involve unnecessary resection of sinonasal structures. In this study, we propose a modification of the EMLP, termed the *modified subtotal-Lothrop procedure* (MSLP), to access the anterior skull base and complex frontal sinus disease for which access to the bilateral frontal sinus posterior table is required.

Methods A cadaveric dissection with photo documentation was performed at an academic medical center on four cadaver heads using standard endoscopic techniques to demonstrate the MSLP and its feasibility.

Results The endoscopic MSLP allowed ample access for instrumentation in each of the dissections using a 30- or 70-degree endoscope. Adequate bilateral access to the posterior table of the frontal sinus was gained in all cases without the need for dissection of the contralateral frontal sinus recess (FSR).

Conclusion The MSLP appears to be a feasible technique for exposure of the anterior skull base and accessing complex frontal sinus pathology. This modification provides similar anterior skull base exposure and surgical maneuverability as the EMLP while limiting surgical dissection to one FSR, thereby preserving as much of the natural mucociliary drainage pathways as possible.

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Introduction

Endoscopic approaches to the anterior skull base and frontal sinus have progressed rapidly over the past decade. The endoscopic modified Lothrop procedure (EMLP) is a well-established approach for recalcitrant frontal sinus disease^{1–10} and exposure of the anterior skull base.^{11–20} However, in select cases, this technique may involve unnecessary resection of sinonasal structures. Recently, we described two less-invasive endoscopic variations of the EMLP, termed the *modified hemi-Lothrop procedure* (MHLP)^{21–23} and the *modified mini-Lothrop procedure* (MMLP).^{24–26} The MHLP enhances access to the lateral supraorbital frontal sinus and supraorbital ethmoid regions using a contralateral superior septectomy approach with preservation of the contralateral frontal sinus recess (FSR), whereas the MMLP is geared toward drainage of an ipsilaterally inaccessible FSR through the frontal intersinus septum and contralateral FSR.^{21–25} With the increasing number of endoscopic anterior skull base procedures being performed^{16,18} and the need for preservation of as much of the normal sinonasal architecture and function as feasible, we propose an additional modification of the EMLP, termed the *modified subtotal-Lothrop procedure* (MSLP), to access the anterior skull base and recalcitrant complex frontal sinus disease for which access to the bilateral posterior table of the frontal sinus is required. Although many rhinologists and neurosurgeons with interest in endoscopic skull base surgery have been performing modifications of the EMLP, this variation has not been previously described in the literature.

Materials and Methods

After qualification as exempt status by the Institutional Review Board guidelines, we dissected four cadaver heads using standard endoscopic techniques and surgical instru-

mentation. Standard 30-degree (two cadaver heads) and 70-degree (two cadaver heads) endoscopes were used throughout the dissections (►Table 1).

Surgical Technique

The endoscopic MSLP begins by performing a standard Draf IIB, as we previously described (►Fig. 1A),^{21,24} with identification of the frontal recess and frontal ostium of the ipsilateral side. A standard frontal recess opening is performed by finding the ipsilateral frontal sinus ostium and enlarging it anteriorly and posteriorly through removal of the Agger nasi cell and the anterior face of the bulla ethmoidalis, respectively. The dissection then proceeds medially by resecting the superior medial head of the middle turbinate and laterally until the lamina papyracea is reached. The floor of the frontal sinus and nasofrontal beak are subsequently resected with powered instrumentation (such as a high-speed drill or suction-rotation microdebrider), Kerrison rongeurs (Integra, York, Pennsylvania, USA), or angled curettes, creating an ipsilateral Draf IIB opening (opening of the frontal sinus floor from the nasal septum to the ipsilateral lamina papyracea). As much bone as possible is removed anteriorly from the nasofrontal beak during this portion of the procedure to provide as large a frontal sinus recess opening as allowed anatomically. This is followed by an endoscopic superior septectomy and frontal intersinus septectomy (►Fig. 1B, C) just anterior to the coronal plane of the posterior frontal sinus table. Careful attention is used in keeping the superior septectomy anterior to the coronal plane of the posterior frontal sinus table to prevent inadvertent entry into the anterior cranial fossa. Access to the ipsilateral and medial contralateral frontal sinus is achieved at this point with exposure and adequate visualization of the bilateral frontal sinus and anterior skull base (►Fig. 1D). Although a traditional EMLP would continue with dissection of the contralateral FSR, in a MSLP the contralateral

Table 1 Cadaveric Dissection Results

Cadaver #	Procedure	Endoscope	A-P (mm)	Results
1	R MSLP	30 degree	10	Right Draf IIB with superior septectomy and FIS provided binostril access to the bilateral posterior frontal sinus table with preservation of the left FSR
2	L MSLP	30 degree	12	Left Draf IIB with superior septectomy and FIS provided binostril access to the bilateral posterior frontal sinus table with preservation of the right FSR
3	R MSLP	70 degree	10	Right Draf IIB with superior septectomy and FIS provided binostril access to the bilateral posterior frontal sinus table with preservation of the left FSR
4	L MSLP	70 degree	14	Left Draf IIB with superior septectomy and FIS provided binostril access to the bilateral posterior frontal sinus table with preservation of the right FSR

Abbreviations: A-P, anterior-posterior frontal sinus recess dimensions; FIS, frontal intersinus septectomy; FSR, frontal sinus recess; L, left; MSLP, modified subtotal-Lothrop procedure; R, right.

Fig. 1 Endonasal view of cadaveric modified subtotal-Lothrop procedure in cadaver 1. (A) Using a 30-degree endoscope, a right Draf IIB is performed. (B) A superior septectomy is performed and the medial contralateral frontal sinus floor is resected. (C) The intersinus septectomy is subsequently started. (D) View from the contralateral (left) nasal cavity after completion of right Draf II B, superior septectomy, and intersinus septectomy.

FSR is left untouched, thus preserving the mucociliary clearance of that recess.

Results

Four cadaver dissections were performed with photodocumentation of the surgical steps. The anterior-posterior dimensions of the FSRs were estimated using a 4-mm suction tip. The endoscopic MSLP allowed ample access for instrumentation in each of the dissections using a 30- or 70-degree endoscope (►Table 1). Adequate bilateral access to the posterior table of the frontal sinus was gained in all cases without the need for dissection of the contralateral FSR.

Illustrative Cases

Case I

A 52-year-old woman with recurrent right-sided CSF rhinorrhea and admission at an outside hospital for meningitis was referred to our tertiary care institution. On nasal endoscopy, a grayish right sinonasal mass suggestive of an encephalocele was found. Computed tomography (CT) scan of the paranasal sinuses showed a right sinonasal mass extending to the frontal sinus (►Fig. 2A, B). There was evidence of destruction of the posterior table of the frontal sinus. The patient underwent endoscopic resection of the encephalocele through an endoscopic MSLP (►Fig. 2C, D). Her postoperative care was unremarkable. She was asymptomatic and well

healed at her 6-month follow-up and was lost to follow-up afterward.

Case II

A 62-year-old man presented with chronic left-sided nasal obstruction from a left sinonasal anterior skull base mass. CT scan of the paranasal sinuses revealed an expansile left sinonasal mass with anterior skull base erosion (►Fig. 3A). Magnetic resonance imaging (MRI) confirmed the CT findings (►Fig. 3B). The patient underwent endoscopic resection of the mass using the MSLP without complications (►Fig. 3C). The final pathology was consistent with schwannoma. The patient's postoperative MRI showed enhancement of the nasoseptal flap at the skull base without evidence of recurrence (►Fig. 3D). His postoperative care was unremarkable. He remained asymptomatic without recurrence or frontal sinus disease after 5 months.

Case III

A 15-year-old adolescent girl presented with a recurrent osteoblastoma at the right-sided cribriform region (►Fig. 4A, B). The patient underwent an endoscopic endonasal right hemi-skull base resection using the MSLP for exposure (►Fig. 4C). Immediate postoperative CT scans revealed adequate resection with undissected left frontal sinus recess (►Fig. 4D, E). Her postoperative care was unremarkable. Her 4-month postoperative MRI showed no recurrent disease and a patent undissected left frontal sinus recess (►Fig. 4F).

Fig. 2 (A) Axial and (B) coronal paranasal sinus computed tomography scans of a patient with a large right frontal sinus encephalocele. The patient underwent endoscopic resection of the encephalocele through an endoscopic modified subtotal-Lothrop procedure (MSLP). (C) Intraoperative 30-degree endoscopic view of the encephalocele after intrathecal fluorescein injection. (D) Seventy-degree endoscopic view of the base of the encephalocele after resection through the MSLP approach.

Fig. 3 (A) Coronal paranasal sinus computed tomography scan and (B) gadolinium enhanced T1-weighted magnetic resonance (MR) imaging of a patient with a large left anterior skull base lesion abutting the midline. This patient underwent endoscopic resection of the lesion using the modified subtotal-Lothrop procedure for anterior skull base exposure with preservation of the right frontal sinus recess. (C) Intraoperative endoscopic view of the modified subtotal-Lothrop procedure using a 30-degree endoscope. (D) Five-months postoperative MR showed enhancement of the nasoseptal flap at the skull base without evidence of recurrence.

Fig. 4 (A) Axial T1-weighted and (B) coronal T2-weighted magnetic resonance imaging (MRI) of a patient with recurrent right cribriform osteoblastoma. (C) Thirty-degree endoscopic view after endoscopic endonasal right hemi-skull base resection using the modified subtotal-Lothrop procedure for exposure. (D) Immediate axial and (E) coronal postoperative computed tomography scans revealed adequate resection with undissected left frontal sinus recess. (F) Four-months postoperative MRI shows no recurrent disease and a patent undissected left frontal sinus recess.

She remained asymptomatic and free of disease after 6 months.

Discussion

The EMLP is a well-established technique for treatment of complex intractable frontal sinus disease^{1-4,6-10,27,28} and anterior access to the skull base during endoscopic anterior skull base tumor resection.^{11,12} However, in some scenarios, performing a standard EMLP may be associated with unnecessary resection of sinonasal structures and potentially increased morbidity. We have previously described two less-invasive modifications of this technique (termed the MHLF and MMLP) to address specific frontal sinus and supraorbital ethmoid pathologies in which a complete EMLP is avoidable.²¹⁻²⁵ The MHLF provides access to the far lateral supraorbital frontal sinus and supraorbital ethmoid region from the contralateral side by adding a superior septectomy to an ipsilateral Draf IIB.²¹⁻²³ This technique provides adequate surgical freedom by allowing binostril bimanual instrumentation and preserves the contralateral FSR.^{21,22} The MMLP allows drainage of an inaccessible ipsilateral FSR by performing a contralateral Draf IIB with the addition of a frontal intersinus septectomy.^{24,25} In this current study, we provide a third modification of the EMLP that has the advantages of (1) allowing exposure of the anterior skull base in cases where

unilateral anterior skull base lesions are present, (2) allowing simultaneous access to the ipsilateral far lateral and contralateral medial segments of the pathologic frontal sinus, and (3) preserving one FSR.

The MSLP is ideal for large unilateral frontal sinus and anterior skull base lesions requiring bilateral frontal sinus exposure and significant surgical maneuverability. Such pathologies include large posterior frontal sinus table encephaloceles (→Fig. 2) and anterior skull base tumors approaching the midline (→Figs. 3 and 4). Although these pathologic entities can be treated with the EMLP, we feel that dissection of the contralateral FSR is unnecessary and may potentially increase morbidity. A Draf IIB, MHLF, or MMLP alone would not provide both the necessary exposure and surgical freedom in these scenarios. A Draf IIB only provides access to the ipsilateral FSR and has limited surgical freedom secondary to mononostril dissection. By adding a frontal intersinus septectomy to the Draf IIB and maintaining an intact nasal septum, a MMLP is created.²⁴ This modification allows access to both posterior frontal sinus table but has limited surgical freedom due to mononostril access. The addition of a superior septectomy to the Draf IIB (MHLF) significantly increases surgical freedom by allowing binostril bimanual instrumentation and provides for better far lateral access through the superior septotomy window from the contralateral nasal cavity.²¹⁻²³ However, by preserving the frontal intersinus

septum, an MHL does not provide access to the contralateral frontal sinus and would be limited for lesions that approach or cross the midline.^{21–23} The MSLP includes the addition of a superior septectomy and frontal intersinus septectomy to a Draf IIB and preserves the contralateral FSR (–Fig. 1). This modification of the standard EMLP would provide adequate exposure and surgical maneuverability in accessing complex frontal sinus pathology and also preserve the integrity of one FSR.

Conclusions

Based on our findings, in a patient with appropriate anatomy, the MSLP is a feasible method for exposure of the anterior skull base and accessing complex frontal sinus pathology. This modification provides similar anterior skull base exposure and surgical maneuverability as the EMLP, with the added benefits of limiting surgical dissection to one FSR, thereby preserving as much of the natural mucociliary drainage pathways as possible. The preservation of one of the FSRs is especially important in patients prone to scarring and osteogenesis. Additionally by limiting the dissection to one FSR, the MSLP prevents unnecessary resection of sinonasal structures and may potentially decrease operative time. Further clinical validation is needed in a case series model.

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