Surgical Management of Lateral Frontal Sinus Disease

Saad Almohanna R5
Rhinology Chair
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Introduction

The management of frontal sinus disease still remains a challenging issue for rhinologists.

Although endoscopic frontal sinus surgery has significantly advanced over the past years, there are some conditions in which the external approaches are still necessary.

Recently, the increasing experience in endoscopic sinus surgery together with important technologic advancements have allowed expansion of the indications for selected lesions localized more and more lateral into the frontal sinus.
Anatomy

Anatomy of the frontal sinus is crucial in accessing frontal sinus and its lateral extension.
Anatomy

When the frontal sinus is very pneumatized, it may not be possible to reach lesions localized in the far lateral aspect of the sinus.

The convexity of the orbital roof is also another limit to access laterally the frontal sinus.

The anteroposterior diameter of the frontal recess must be adequate (minimum distance, 1 cm) to allow the passage of the instruments.

The interorbital distance is another important aspect because the access to the frontal sinus is restricted laterally by the orbital walls. The relatively large distance allows increased lateral access to the instruments, whereas the opposite is true for a narrow nasal inlet.

**FIGURE 5.** Coronal CT demonstrating orbital zones. Zone 1: medial quarter of the orbit; Zone 2: From Zone 1 to the midorbital point; Zone 3: lateral to the midorbital point to halfway between the midorbital point and the lateral aspect of the orbit; Zone 4: the lateral-most quarter. CT = computed tomography.
<table>
<thead>
<tr>
<th>Degree of frontal extension</th>
<th>Area involved</th>
<th>Procedure required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjacent to frontal recess</td>
<td>Anterior ethmoid, middle turbinate, or medial orbital wall</td>
<td>Draf IIIa for identification to ensure whether resection, reconstruction, or packing is going to interfere with the frontal recess</td>
</tr>
<tr>
<td>Frontal recess</td>
<td>Frontal beak, intersinus septum, or frontal recess proper</td>
<td>Draf IIb/III: reconstruction and short-term silastic stenting required in extensive bone exposure</td>
</tr>
<tr>
<td>Frontal sinus</td>
<td>Anterior/posterior walls</td>
<td>Draf IIb/III: trephine/OPF may be required for superiorly based lesions</td>
</tr>
<tr>
<td></td>
<td>Orbital roof: Zone 1</td>
<td>Draf IIb/III</td>
</tr>
<tr>
<td></td>
<td>Orbital roof: Zone 2</td>
<td>Draf IIb/III ± trephine/OPF</td>
</tr>
<tr>
<td></td>
<td>Orbital roof: beyond midorbital point</td>
<td>Trephine/OPF</td>
</tr>
</tbody>
</table>


**FIGURE 5.** Coronal CT demonstrating orbital zones. Zone 1: medial quarter of the orbit; Zone 2: From Zone 1 to the midorbital point; Zone 3: lateral to the midorbital point to halfway between the midorbital point and the lateral aspect of the orbit; Zone 4: the lateral-most quarter. CT = computed tomography.
In case of osteomas and inverted papillomas, what really matters is the site of attachment of the lesion; those that extend laterally but with a more medial attachment can be removed with curved drills and instruments. The more laterally the attachment is located, the more difficult is the removal of the lesion.
mucocele that extends laterally in the frontal sinus but reaches medially to the lamina papyracea can be easily marsupialized through the frontal recess; its lateral extension is not a difficult issue to treat because, when the medial wall of the mucocele is perforated, all the contents of the mucocele are drained.
Endoscopic endonasal orbital transposition to expand the frontal sinus approaches

Figure 2. (A) Paradigmatic intraoperative image during a purely endoscopic endonasal approach for a far lateral frontal sinus lesion, showing a curved drill that reaches the far lateral aspect of the frontal sinus after performing a Draf type III frontal sinusotomy. Schematic illustrations. (B) A Draf type IIb frontal sinusotomy (yellow) with removal of the superomedial orbital bony wall offers more space to reach a lateral lesion (green) of the frontal sinus (blue) by laterally displacing the orbit (red arrow). (C) In case of a more laterally located lesion (green), a Draf type III frontal sinusotomy (yellow) with superomedial orbital wall decompression enables transposing the orbit and gaining a more lateral bent of the instruments in the frontal sinus (blue) when passing through the contralateral nasal fossa (red arrow).
Endoscopic endonasal orbital transposition to expand the frontal sinus approaches

• a Draf type III frontal sinusotomy is performed, the superomedial bony wall of the orbit is drilled out with a diamond burr. (B)

• The orbit is laterally displaced, which allows the removal of the superior portion of the bone between the orbit and the supraorbital recess (white arrowhead, showing the orbital roof). (C)

• A malleable retractor is placed to protect the periorbit while drilling the bone of the supraorbital recess. (D)

• An endoscopic endonasal image of the orbital transposition, showing the drilled superomedial orbital bony angle that exposes the lateral portion of the frontal sinus. (E)

• Closer view, showing the removal of the bony supraorbital recess with the exposure of the medial orbital roof. (F)

• By using angled forceps, it is now possible to remove the lateral frontal sinus portion of the inverted papilloma.
Utility of intraoperative flexible endoscopy in frontal sinus surgery
An 82-year-old man who was admitted for pneumonia was noted to have left-sided ptosis for 3 weeks.

(CT) demonstrated a left frontal sinus mass that caused expansion of the sinus as well as erosion of the posterior frontal sinus table and superior orbital wall.

The patient underwent a Draf IIa procedure. A 70° endoscope could not provide adequate visualization of the lateral recess of the frontal sinus.

Before proceeding to a modified hemi-Lothrop procedure (MHLIP) or a modified Lothrop procedure, a flexible endoscope was used for visualization.

On confirming the presence of a remnant fungus ball, the frontal sinus was irrigated until cleared of disease.

**Figure 2.** (A) A maximal lateral view of the frontal sinus when using a rigid 70° endoscope. (B) Further lateral view when using a flexible endoscope. (C) Lateral recess completely visualized by using a flexible endoscope.
A 31-year-old woman was referred for CRS. CT and MR revealed a left-sided frontal sinus mucocele with bony destruction and protrusion into the superior extraconal space.

A Draf IIa procedure was then performed. Copious irrigation was used to clear concretions from the sinus cavity.

The 70° telescope could not fully visualize the lateral frontal sinus recess.

A flexible endoscope was successfully used to inspect the frontal sinus.
PREOPERATIVE PLANNING

- Preoperative imaging with CT and MRI represents the cornerstone of the surgical planning by analyzing several parameters, such as the anteroposterior diameter of the frontal recess, the interorbital distance, the site of attachment, the solidity of the lesion, and the presence of multiple lesions.

- The intraoperative use of navigation systems is another important technical advancement useful to reduce skull base and orbital complications.
Current and common methods of classification for endonasal frontal sinus drainage techniques include the Draf and nasofrontal approaches.

New classification system consolidating included 3 recently published modifications (as well as a new modification) has been designed.
Type I draf encompasses drainage of the frontal recess without major frontal sinus disease.

It entails removal of the anterosuperior ethmoidal cells obstructing the frontal sinus outflow tract and serves to expose the frontal ostium. The roof of the agger nasi (or most superior frontal infundibular cell) is left intact.

It is not frequently used, especially when frontal sinus pathology is present.
In a Draf IIA, this procedure entails the removal of the anterior ethmoidal cells and frontal cells protruding into the frontal sinus outflow pathway, creating an opening between the middle turbinate medially and the lamina papyracea laterally.
Draf 2b This procedure also enlarges the frontal sinus outflow pathway and consists of the removal of the frontal sinus floor between the nasal septum medially and the lamina papyracea laterally.
Draf III (nasofrontal approach IV or Eloy III): In this procedure, bilateral removal of the floor of the frontal sinus anterior to the middle turbinates from 1 lamina papyracea to the next is performed, with a superior septectomy and intersinus septectomy; AKA modified Lothrop procedure.
**Table 1**
Outcomes of endoscopic modified Lothrop procedures (EMLP)

<table>
<thead>
<tr>
<th>Author</th>
<th>Patients</th>
<th>Mean Follow-up (mo)</th>
<th>Patency(^a) (%)</th>
<th>Symptoms (%)</th>
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<tr>
<td>Becker et al,(^\text{25}) 1995</td>
<td>14</td>
<td>9</td>
<td>100</td>
<td>14</td>
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<td>Casiano &amp; Livingston,(^\text{15}) 1998</td>
<td>21</td>
<td>24</td>
<td>57</td>
<td>21</td>
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<td>Wormald,(^\text{26}) 2003</td>
<td>83</td>
<td>21.9</td>
<td>93</td>
<td>25</td>
</tr>
<tr>
<td>Shirazi et al,(^\text{27}) 2007</td>
<td>97</td>
<td>18</td>
<td>77</td>
<td>23</td>
</tr>
<tr>
<td>Anderson &amp; Sindwani,(^\text{28}) 2009</td>
<td>612</td>
<td>28.5</td>
<td>95.9</td>
<td>16</td>
</tr>
<tr>
<td>Wormald et al,(^\text{29}) 2014</td>
<td>229</td>
<td>45</td>
<td>95</td>
<td>5</td>
</tr>
</tbody>
</table>
The modified hemi-Lothrop procedure (Eloy IIC) improves access to the lateral recess (supraorbital extension) of an affected frontal sinus.

The procedure combines an ipsilateral Draf IIB (removal of the frontal sinus floor from the nasal septum medially to the lamina papyracea laterally) and a superior septectomy.

The superior septectomy window allows insertion of an endoscope and instruments via the contralateral side, thus providing greater access and visualization of the lateral frontal sinus recess of the affected ipsilateral frontal sinus or supraorbital ethmoid.

This technique also provides for binostriol and bimanual instrumentation.

Fig. 2. (A) Artwork in the coronal plane showing the approach to the contralateral frontal sinus with Eloy IIC procedure, also known as the modified hemi-Lothrop procedure. (B) Coronal CT scan in patient postprocedure. (C, D) This technique allows for binostriol ([C] through left nostril and [D] through right nostril) bimanual instrumentation. Dotted line in (A) depicts location of the superior septectomy. Red arrow in (A) depicts limited lateral reach through the ipsilateral left nostril. Blue arrow in (A) depicts improvement in lateral reach through the contralateral nostril by using the superior septectomy window. (© 2015 Chris Gralapp, Fairfax, CA.)
Fig. 3. (A) Axial and (B) coronal CT scans of a patient with an obstructed right frontal sinus. There is improved access with Eloy IIC (green arrow), with white bracket showing the septectomy window, compared with standard ipsilateral approach (red arrow). (© 2013 American Academy of Otolaryngology – Head and Neck Surgery Foundation, Alexandria, VA; with permission.)
The modified mini-Lothrop procedure (Eloy IID) is a procedure intended to treat frontal sinus disease when ipsilateral access to the frontal sinus recess is not possible. e.g. scarring, fat prolapse.

The procedure combines (Draf IIB) and an endoscopic frontal intersinus septectomy.
The modified subtotal-Lothrop procedure (Eloy IIE) is designed for the treatment of recalcitrant bilateral frontal sinus disease and ipsilateral anterior skull base lesion resection, with an emphasis on preserving as much of the normal sinonasal architecture as possible.

This procedure can be used for large posterior frontal sinus encephaloceles in which access to the bilateral posterior frontal sinus table and bimanual manipulation are desired.

This technique is also appropriate for unilateral sinonasal tumor resection in which the contralateral frontal sinus recess is uninvolved.

The procedure involves (Draf IIB) with the addition of a superior septectomy and an intersinus septectomy. This allows for access and visualization of the ipsilateral and contralateral frontal sinus and binostril and bimanual instrumentation.

The contralateral frontal sinus recess and contralateral middle turbinate are left undisturbed.
Fig. 8. (A) Preoperative coronal T1-weighted gadolinium enhanced paranasal sinus MRI of a patient with a left sinonasal olfactory neuroblastoma. (B) Intraoperative endoscopic view of the anterior skull base defect after tumor resection. (C) Coronal postoperative CT scan of the same patient showing a patent modified subtotal-Lothrop procedure (Eloy IIE). (D) Six-month postoperative endoscopic image of the patent frontal sinus cavity. (© 2014 American Rhinological Society – American Academy of Otolaryngic Allergy, Reston, VA; with permission.)
Fig. 7. (A) Artwork in the coronal plane showing bilateral frontal sinus access with a left Eloy IIE (modified subtotal-Lothrop procedure) with preservation of contralateral frontal recess. Endonasal view of intraoperative modified subtotal-Lothrop procedure in a patient with an olfactory neuroblastoma. (B) Initial intraoperative view of the lesion. (C) Using a 30° rigid endoscope, a left Draf IIIB is performed. (D) A superior septectomy is performed and the medial contralateral frontal sinus floor is resected. (E) The intersinus septectomy is subsequently performed. The right (contralateral) frontal sinus recess as well as the right middle turbinate are preserved. (F) View from the contralateral (right) nasal cavity after completion of left Draf IIIB, superior septectomy, and intersinus septectomy. (© 2014 American Rhinological Society – American Academy of Otolaryngic Allergy, Reston, VA; with permission.)
The procedure involves the removal of the medial frontal sinus floor bilaterally with the addition of a superior septectomy and an intersinus septectomy. This allows for access and visualization of both frontal sinuses and affords binostril and bimanual instrumentation.

It can result in scarring and subsequent obstruction of the created central opening. However, preservation of both frontal sinus recesses lateral to the midline opening, and resection of the frontal intersinus septum should allow ample communication between the two sides with an exit pathway in either of the untouched frontal sinus recess.

Fig. 9. (A) Artwork in the coronal plane showing bilateral frontal sinus access with Eloy IIF (modified central-Lothrop procedure) with preservation of the bilateral frontal sinus recesses. (B) Intraoperative 30° endoscopic view of the modified central-Lothrop procedure (Eloy IIF). (C) Close-up view of the central opening. (D) Endoscopic view of steroid eluting stent placement. (© 2015 Chris Gralapp, Fairfax, CA.)
<table>
<thead>
<tr>
<th>Draft</th>
<th>Nasofrontal Approach</th>
<th>Eloy’s Proposed Modifications</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>I</td>
<td>I</td>
<td>I</td>
<td>Anterior ethmoidectomy with drainage of the frontal sinus recess without touching the frontal sinus outflow pathway</td>
</tr>
<tr>
<td>IIA</td>
<td>II</td>
<td>IIA</td>
<td>Removal of the anterior ethmoidal cells and frontal cells protruding into the frontal sinus outflow pathway creating an opening between the middle turbinate medially and the lamina papyracea laterally</td>
</tr>
<tr>
<td>IIB</td>
<td>III</td>
<td>II B</td>
<td>Removal of the frontal sinus floor between the nasal septum medially and the lamina papyracea laterally; ipsilateral removal of the frontal sinus floor between the nasal septum medially and the lamina papyracea laterally; superior septectomy for access from the contra lateral side and enhanced access to the lateral supraorbital frontal sinus and supraorbital ethmoid regions. This also provides binostril, bimanual manipulation; previously described as a modified hemi-Lothrop procedure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IIC</td>
<td>Contralateral removal of the frontal sinus floor between the nasal septum medially and the lamina papyracea laterally with addition of an intersinus septectomy for drainage of the diseased frontal sinus to the contralateral recess; previously described as a modified mini-Lothrop procedure</td>
</tr>
<tr>
<td>IIE</td>
<td></td>
<td>IID</td>
<td>Ipsilateral removal of the frontal sinus floor between the nasal septum medially and the lamina papyracea laterally; superior septectomy for access from the contra lateral side and enhanced access to the lateral supraorbital frontal sinus and supraorbital ethmoid regions; intersinus septectomy for access to the entire posterior wall of the frontal sinus; preservation of the contralateral frontal sinus recess; previously described as a modified subtotal-Lothrop procedure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IIF</td>
<td>Central resection of the frontal sinus floor bilaterally, with a superior septectomy and frontal intersinus septectomy, while preserving both frontal sinus recesses; also termed a modified central-Lothrop procedure</td>
</tr>
<tr>
<td>III</td>
<td>IV</td>
<td>III</td>
<td>Bilateral removal of the floor of the frontal sinus anterior to the middle turbinates from 1 lamina papyracea to the next with superior septectomy and intersinus septectomy; also termed a modified Lothrop procedure</td>
</tr>
</tbody>
</table>
Utilization of combined endoscopic with limited external incisions may be indicated in select cases. This may involve limited transverse forehead crease, superior lid, lateral brow, or a more formal bicoronal incision.

Combined approaches may be necessary to maximize visualization and introduction of instrumentation, to safely access the cavity and facilitate dissection.

Combined techniques also may be required for adequate and safe margins in oncological resection of other malignant of benign neoplasms.

These techniques also may be used to establish frontal sinus drainage when no pathway can be achieved endoscopically.
Twelve cadaveric specimens were obtained for anatomic research and frontal sinuses divided into 3 zones

Zone 1 was defined as medial to the supraorbital neurovascular bundle (SON).

The remaining orbit was then bisected to define zone 2 (centrally) and zone 3 (laterally)

Twenty-four UBAs were performed followed by 12 modified endoscopic Lothrop procedures (MELP).

The ability to instrument each wall of the frontal sinus was recorded for the MELP, UBA, and combined approach
• The UBA provided excellent access to the lateral frontal sinus in zones 2 and 3 (89% and 100%).

• Access for zone 1 through the UBA was limited

**Table 3. Percentage of Sinus Walls Accessible With the Upper Blepharoplasty/Lateral Trephination Approach.**

<table>
<thead>
<tr>
<th></th>
<th>Zone 1</th>
<th>Zone 2</th>
<th>Zone 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medial</td>
<td>22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anterior wall</td>
<td>0</td>
<td>44</td>
<td>100</td>
</tr>
<tr>
<td>Posterior wall</td>
<td>67</td>
<td>89</td>
<td>100</td>
</tr>
<tr>
<td>Orbital roof</td>
<td>33</td>
<td>89</td>
<td>100</td>
</tr>
<tr>
<td>Lateral wall</td>
<td>78</td>
<td>89</td>
<td>100</td>
</tr>
</tbody>
</table>
The MELP provided poorer access in zone 3 (67%) but improved access in zone 1 (83%-100%)

Table 2. Percentage Of Sinus Walls Accessible With the Modified Endoscopic Lothrop Procedure.

<table>
<thead>
<tr>
<th></th>
<th>Zone 1</th>
<th>Zone 2</th>
<th>Zone 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medial</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anterior wall</td>
<td>96</td>
<td>85</td>
<td>33</td>
</tr>
<tr>
<td>Posterior wall</td>
<td>83</td>
<td>30</td>
<td>0</td>
</tr>
<tr>
<td>Orbital roof</td>
<td>83</td>
<td>60</td>
<td>33</td>
</tr>
<tr>
<td>Lateral wall</td>
<td>96</td>
<td>80</td>
<td>67</td>
</tr>
</tbody>
</table>
Postoperative management

Postoperative management is aimed at maintaining patency of the frontal sinus cavity.

Nasal saline irrigations and postoperative debridements are essential in minimizing postoperative wound infections, granulation overgrowth, and potential restenosis or closure of the frontal sinus outflow tract, especially in patients who had significant mucosa and bone removal (Draf IIb and III).
Patients should present for their first postoperative debridement 7 to 10 days after surgery for removal of crusts and inflamed tissue, and to reduce local inflammation and consequent infection.

They are then seen approximately 1 month later. After their second postoperative visit, further follow-ups and debridements are individualized depending on the specific needs of the patients.
Some investigators advocate the use of stents, placed intraoperatively, to prevent future stenosis and promote mucosalization.

Controversy exists and no standardized indications are available, however. Stents may be considered for narrow neo-ostiums, and circumferential exposure of bone.

However, granulation tissue formation, biofilm production, and crusting can ensue from the use of stents.

In-office management of symptomatic, stenotic ostia also may be necessary but using a variety of instrumentation, including balloon sinuplasty.
References Articles

• Jean Anderson Eloy, Alejandro Vazquez, , James K. Liu, Soly Baredes, (2016) . Endoscopic Approaches to the Frontal Sinus Modifications of the Existing Techniques and Proposed Classification


