Endoscopic Modified Lothrop Procedure for Refractory Frontal Sinus Disease: Indications, Surgical Technique, Outcomes, and Complications

Adly Ahmed Tantawy, Magdy Ibrahim Gouda, Isamel Sedik Elnashar, Mohamed Abdelrahman Fatouha

Department of Otorhinolaryngology, Faculty of Medicine, Zagazig University

Corresponding Author: Mohamed Abdelrahman Fatouha

Received: 28 October 2024, **Accepted:** 17 November 2024, **Published:** 20 November 2024

Abstract

Background: The frontal sinus remains one of the most technically demanding regions in endoscopic sinonasal surgery because of its narrow drainage pathway, highly variable pneumatization, acute access angle, and proximity to the orbit and anterior skull base. Although limited frontal sinusotomy is sufficient for many patients, persistent inflammation, osteitis, postoperative scarring, recurrent polyposis, mucoceles, and selected tumors may cause failure of conventional approaches. The Draf III procedure, also known as the endoscopic modified Lothrop procedure, creates a common median drainage pathway for both frontal sinuses by removing the superior nasal septum, adjacent frontal sinus floors, frontal beak, and inferior intersinus septum. This expanded opening improves access, facilitates postoperative surveillance, and enhances the delivery of topical therapy to the frontal sinus mucosa.

Aim: This review examines the anatomical and pathological basis of refractory frontal sinus disease, patient selection for Draf III surgery, preoperative assessment, inside-out and outside-in operative techniques, mucosal reconstruction, postoperative management, clinical outcomes, causes of failure, and procedure-related complications.

Conclusion: Draf III is an effective, predominantly endonasal alternative to open frontal sinus procedures for carefully selected patients with refractory inflammatory disease and several other complex frontal sinus pathologies. Durable success depends less on simply creating a large intraoperative opening than on constructing a smooth, adequately sized, mucosa-preserving neo-ostium that remains accessible to postoperative irrigation and endoscopic care. Persistent type 2 inflammation, extensive polyposis, allergy, narrow frontal anatomy, osteitis, exposed bone, and inadequate postoperative surveillance increase the likelihood of restenosis. Mucosal flaps or grafts appear to improve healing by reducing exposed bone, crusting, and cicatricial contraction, although the supporting literature remains predominantly observational. Despite favorable patency and symptom outcomes in experienced centers, Draf III is an advanced procedure with potential orbital, vascular, olfactory, intracranial, and structural complications. Careful computed tomography–based planning, reliable identification of the first olfactory fibers and orbital boundaries, controlled drilling, preservation or restoration of mucosal coverage, and structured long-term follow-up are therefore central to safe and durable treatment.

Keywords: Draf III; modified Lothrop procedure; frontal sinusotomy; chronic frontal rhinosinusitis

Introduction

The frontal sinus is uniquely susceptible to persistent disease and postoperative failure. Its drainage pathway is narrow, anatomically variable, and bordered by the orbit, anterior skull base, middle turbinate, and frontal beak. Inflammation or scarring within this confined region can obstruct ventilation and mucociliary clearance, while attempts to enlarge the frontal recess may themselves produce mucosal injury, exposed bone, osteoneogenesis, and restenosis. Consequently, frontal sinus disease represents a disproportionate source of failure after endoscopic sinus surgery despite advances in imaging, navigation, instrumentation, and understanding of frontal recess anatomy [1].

Most patients with frontal chronic rhinosinusitis can be managed by appropriate medical therapy followed, when necessary, by a limited Draf I or Draf IIa sinusotomy. A smaller subgroup develops persistent disease because of severe inflammatory biology, narrow anatomy, osteitis, extensive polyposis, prior surgical scarring, retained frontal cells, or incomplete opening of the natural drainage pathway. In these patients, repeated conservative surgery may further distort the anatomy without creating an opening sufficiently large to resist cicatricial contraction or permit effective topical treatment [2].

The Draf III procedure, or endoscopic modified Lothrop procedure, addresses these limitations by combining bilateral extended frontal sinusotomies with superior septectomy and removal of the inferior intersinus septum. This creates one common frontal neo-ostium extending between the medial orbital walls. The operation has evolved from a salvage procedure for recalcitrant inflammatory disease into a versatile route for mucoceles, selected tumors, skull-base lesions, cerebrospinal fluid leaks, and certain post-traumatic abnormalities [3].

Despite wider adoption, important questions remain regarding when Draf III should replace repeated limited sinusotomy, which anatomical measurements predict technical feasibility, whether it should be offered primarily in high-risk disease, and how mucosal reconstruction and stenting affect long-term patency. Much of the literature consists of retrospective series from tertiary centers, with heterogeneous indications and definitions of success. This review therefore aims to integrate contemporary evidence on indications, operative strategy, outcomes, failure mechanisms, and complications while emphasizing the factors that determine durable frontal neo-ostium patency.

Surgically Relevant Anatomy

The frontal sinuses are paired, asymmetrical cavities situated between the anterior and posterior tables of the frontal bone. The anterior table is comparatively thick and contributes to forehead contour, whereas the posterior table may be extremely thin and separates the sinus from the frontal lobes and anterior cranial fossa. Inferiorly, the frontal sinus floor forms part of the orbital roof. This anatomical arrangement explains why inflammatory, expansile, traumatic, and neoplastic disease may extend toward the orbit or intracranial compartment and why dissection beyond the intended boundaries can produce major morbidity [4].

The frontal sinus narrows inferiorly into the frontal infundibulum and drainage pathway. Rather than functioning as a simple cylindrical duct, this region resembles an hourglass whose configuration is determined by surrounding frontoethmoidal cells and their attachment to the skull base, orbit, frontal beak, or middle turbinate. Small changes caused by mucosal edema, polyps, scarring, retained cell partitions, or osteitis may therefore markedly compromise drainage. Variability between the two sides is common, and the technically more restricted side may determine the feasibility of an inside-out Draf III procedure [5].

Standardized anatomical interpretation has improved through the International Frontal Sinus Anatomy Classification. The system categorizes cells according to their effects on the drainage pathway: anterior cells push the pathway posteriorly, posterior cells displace it anteriorly, medial cells shift it laterally, and lateral cells shift it medially. Relevant structures include the agger nasi, supra-agger, supra-agger frontal, supra-bulla, supra-bulla frontal, supraorbital ethmoid, frontal septal, and intersinus septal cells. Recognizing these cells on multiplanar computed tomography prevents entry into a false cavity and enables the surgeon to anticipate the direction of the true

frontal drainage pathway [6].

For Draf III, the practical boundaries are more important than descriptive nomenclature alone. The anterior limit is the periosteum beneath the frontal process of the maxilla and nasal bones; the lateral limits are the laminae papyraceae; and the posterior limit is formed by the first olfactory fibers and adjacent skull base. The anterior ethmoidal artery and its nasal branch lie near the posterior dissection limit. Failure to distinguish the nasal branch from an olfactory fiber may lead either to unnecessarily restricted drilling or dangerous posterior extension [3].

The anteroposterior dimension of the frontal recess and frontal beak has direct technical importance. A reasonably wide recess permits identification of each natural frontal ostium followed by drilling from within the sinus toward the midline. Conversely, a very narrow or severely scarred recess may not safely accept punches or drills. In this situation, identifying the anterior and posterior boundaries below the sinus and drilling the frontal beak from outside inward can provide safer access. Preoperative estimation of the maximum frontal outflow anteroposterior diameter may also help predict the obtainable neo-ostium and the risk of recurrence [7].

The mucosal lining must be regarded as a functional component of the operation. Frontal mucosa transports secretions toward the drainage pathway, while healthy nasal and septal mucosa promotes re-epithelialization of the surgically created opening. Circumferential mucosal stripping exposes bone, promotes crusting and granulation, and may trigger osteoneogenesis followed by concentric stenosis. Modern Draf III surgery therefore combines adequate drilling with mucosal preservation or reconstruction rather than relying exclusively on maximal bone removal [8].

Pathological Basis of Refractory Frontal Sinus Disease

Refractory frontal chronic rhinosinusitis results from an interaction between inflammatory disease and mechanical restriction. Persistent edema, eosinophilic inflammation, biofilm formation, impaired mucociliary clearance, recurrent polyposis, and thick secretions may obstruct even an anatomically adequate recess. Conversely, retained cells, narrow frontal dimensions, scarring, lateralized middle turbinate remnants, and osteitic bone can perpetuate disease despite reasonable medical control. Successful treatment therefore requires both correction of anatomical obstruction and long-term suppression of mucosal inflammation [1].

Failure after previous frontal surgery is commonly related to an incompletely dissected agger nasi or frontal recess cell, unrecognized supraorbital ethmoid anatomy, residual bony partitions, or an opening that was initially too small to tolerate postoperative contraction. Excessive mucosal trauma is another important mechanism. A narrow opening surrounded by exposed, osteitic bone may develop granulation tissue and fibrotic webs, while recurrent polyps can progressively exclude the frontal sinus from topical therapy. Repeated limited procedures may worsen these factors by removing landmarks and increasing scarring [2].

Chronic rhinosinusitis with nasal polyps, particularly in patients with aspirin-exacerbated respiratory disease, asthma, cystic fibrosis, primary ciliary dyskinesia, or severe type 2 inflammation, carries a high risk of recurrence. Draf III does not eliminate the underlying inflammatory disorder, but it creates a cavity that can be irrigated, endoscopically inspected, and treated with topical corticosteroids. Its therapeutic value therefore arises partly from improving postoperative medical access rather than solely restoring physiological drainage [9].

Frontal mucoceles and mucopyoceles represent another important pathological group. Obstruction converts the sinus into a progressively expanding mucus-filled cavity, producing pressure-related bone remodeling or erosion. Patients may develop forehead swelling, headache, proptosis, diplopia, visual impairment, or intracranial complications. Wide endoscopic marsupialization is usually preferable when the lesion can be reached safely, and Draf III is especially useful for bilateral, medially located, recurrent, or post-surgical mucoceles that require a durable common drainage route [10].

Benign and selected malignant lesions may also involve the frontal sinus or frontal recess. Osteomas, inverted papillomas, ossifying fibromas, fibrous dysplasia, encephaloceles, and other

lesions may require expanded access for visualization, drilling of the attachment, resection, or postoperative surveillance. Nevertheless, Draf III is an access corridor rather than an oncological principle. Tumor biology, attachment site, lateral extension, dural or orbital involvement, and the ability to achieve safe margins determine whether a purely endoscopic, combined, or open approach is appropriate [11].

The Draf Classification and Rationale for Draf III

The Draf classification describes progressively enlarged frontal sinusotomies. Draf I clears obstructing cells below the frontal ostium without extensive removal of the sinus floor. Draf IIa enlarges the unilateral drainage pathway between the middle turbinate medially and lamina papyracea laterally. Draf IIb extends medially from the lamina papyracea to the nasal septum and generally requires removal of part of the frontal sinus floor and anterosuperior middle turbinate attachment. Draf III essentially connects bilateral Draf IIb openings by removing the superior septum and inferior intersinus septum [3].

The classification should not be interpreted as a mandatory sequence through which every patient must progress. Limited disease deserves limited surgery, and unilateral pathology may be controlled by Draf IIa or IIb without disrupting the contralateral recess. A systematic review of Draf IIb demonstrated high patency and symptomatic improvement for appropriately selected unilateral disease. Draf III is justified when bilateral access, maximal midline enlargement, enhanced topical delivery, or cross-cavity visualization offers a meaningful advantage [12].

The rationale for Draf III is based on the relationship between ostium size and long-term stability. Small frontal openings are vulnerable to complete obstruction after even modest circumferential contraction. A larger, smoothly saucerized neo-ostium may narrow during healing yet remain functionally patent. Combining the two frontal sinuses also facilitates office surveillance and permits irrigation to reach both cavities. However, greater surgical extent produces more exposed bone and potentially greater postoperative morbidity; the value of the procedure therefore depends on appropriate selection and meticulous healing management [13].

Indications and Patient Selection

The most established indication is persistent frontal chronic rhinosinusitis after adequate medical therapy and previous endoscopic frontal surgery. Patients should have compatible symptoms accompanied by objective endoscopic or radiological disease. Frontal headache alone is insufficient because headache may persist despite a patent sinus when its origin is neurological, musculoskeletal, or primary headache disease. Before revision surgery, clinicians should confirm that symptoms correlate with frontal inflammation or obstruction and exclude non-rhinogenic pain [2].

Draf III is commonly considered after failure of bilateral Draf IIa procedures, especially when restenosis results from scarring, osteitis, recurrent polyposis, or an inadequately sized opening. Failure should not be defined solely by radiographic opacification; symptom burden, frequency of acute exacerbations, endoscopic inflammation, complications, and dependence on systemic therapy should be considered. A patent but inflamed sinus may benefit more from intensified topical or biologic treatment than additional drilling [3].

Primary Draf III may be reasonable when the likelihood of failure after limited surgery is predictably high. Examples include severe bilateral frontal polyposis, aspirin-exacerbated respiratory disease, cystic fibrosis, ciliary dysfunction, pronounced osteitis, exceptionally narrow frontal openings, or anatomy that would leave a Draf IIa diameter below approximately 4–5 mm. This approach avoids multiple operations and performs the definitive dissection before surgical landmarks are destroyed. However, primary use should be individualized because the evidence is largely observational and many patients remain controllable with less extensive surgery [3].

Mucoceles are the most frequent non-inflammatory indication. Draf III is useful for bilateral mucoceles, lesions involving the intersinus septum, recurrent mucoceles after prior surgery, or cavities that cannot be reliably marsupialized through a limited unilateral opening. Far-lateral

lesions remain challenging because instrument reach and visualization may be restricted even after maximal midline drilling. Orbital displacement, periorbital suspension, angled instrumentation, or a combined external approach may occasionally be required [14].

Selected benign tumors can be addressed through Draf III when the approach provides direct access to their attachment and permits complete removal without unacceptable injury. Inverted papilloma requires identification and drilling of the attachment site, while osteomas may require progressive central debulking before mobilization. Lesions involving the far-lateral sinus, anterior table, extensive posterior table, orbit, or dura may exceed the endoscopic corridor. Malignant tumors require multidisciplinary planning and should not be forced through an endoscopic approach if oncological resection would be compromised [11].

Additional indications include access for repair of cerebrospinal fluid leaks or encephaloceles, management of selected complications after frontal craniotomy, and treatment of post-traumatic outflow obstruction. Draf III can restore drainage and provide a route for reconstruction, but displaced posterior-table fractures, major dural disruption, intracranial injury, or conditions requiring cranialization remain indications for open or combined management. In previously obliterated sinuses, the feasibility of endoscopic salvage depends on residual aeration, location of disease, obliteration material, and integrity of the cranial and orbital boundaries [15].

Relative contraindications include an extremely narrow anteroposterior surgical corridor, anatomy in which drilling would threaten forehead skin or the posterior table, uncontrolled systemic or sinonasal inflammation, inability to comply with postoperative care, and pathology inaccessible through the midline corridor. Severe coagulopathy and unstable medical conditions should be corrected before surgery. Lack of advanced frontal sinus experience is also a practical contraindication because successful Draf III requires reliable landmark identification, angled endoscopy, powered drilling near critical structures, and prolonged postoperative management [3].

Preoperative Evaluation and Planning

Evaluation begins with a detailed history covering prior operations, response to medical treatment, asthma, aspirin sensitivity, allergy, cystic fibrosis, immune dysfunction, ciliary disease, smoking, headache characteristics, visual symptoms, and previous orbital or intracranial complications. Operative notes and earlier imaging should be reviewed whenever possible because previous surgery may have removed normal landmarks or produced skull-base and orbital dehiscence. Nasal endoscopy documents polyps, purulence, scarring, middle turbinate position, septal deviation, and accessibility of the frontal recess [1].

Thin-slice computed tomography with axial, coronal, and sagittal reconstructions is indispensable. The surgeon should map the drainage pathway using IFAC principles; determine the position of the orbit, skull base, anterior ethmoidal arteries, and first olfactory region; measure the frontal beak and anteroposterior corridor; and identify intersinus septal deviation, supraorbital ethmoid cells, osteitis, previous surgical defects, mucoceles, or tumors. Sagittal images are especially useful for judging the frontal beak, posterior table, and anterior–posterior limits [6].

Magnetic resonance imaging is added when retained secretions cannot be distinguished from tumor, when fungal disease is suspected, or when orbital, intracranial, dural, or neural involvement must be defined. Contrast-enhanced MRI helps characterize soft tissue, encephaloceles, abscesses, and perineural or intracranial extension. For tumors, imaging should determine the attachment and whether disease extends beyond the reach of angled endoscopes and instruments [11].

Image guidance is strongly advisable in revision surgery, distorted anatomy, tumors, mucoceles, skull-base defects, or lateral frontal disease. Navigation supplements but cannot replace anatomical knowledge because registration error may become consequential near the posterior table or orbit. Required equipment commonly includes 0°, 30°, 45°, and 70° endoscopes, curved frontal instruments, irrigating angled drills, cutting and diamond burrs, navigation, and instruments capable of working through one nostril while visualizing through the other [3].

The surgical plan should specify whether an inside-out or outside-in approach will be used, whether

septoplasty is required, which mucosal flaps or grafts will cover exposed bone, and whether tumor removal or skull-base reconstruction is anticipated. The surgeon should also determine the postoperative medical regimen before operating. Draf III should be viewed as one component of an integrated inflammatory-disease strategy rather than an isolated mechanical intervention [8].

Surgical Technique

Preparation and Exposure

The procedure is usually performed under general anesthesia with controlled hypotension when appropriate. Topical vasoconstriction and local infiltration improve visualization. Any necessary septoplasty should preserve sufficient dorsal and caudal support. Associated maxillary, ethmoid, or sphenoid disease is addressed according to its extent, while complete bilateral anterior ethmoidectomy provides orientation to the medial orbital walls and skull base [3].

The superior uncinate process and agger nasi region are opened carefully. Existing frontal openings are identified whenever possible, and obstructing frontal cells are removed with mucosal preservation. The lamina papyracea establishes the lateral limit on each side, whereas the skull base and first olfactory fibers determine the posterior boundary. A superior septectomy allows the endoscope and instruments to cross between nasal cavities, providing binarial visualization and improving drilling angles [16].

Inside-Out Technique

The inside-out technique is preferred when each frontal recess is sufficiently wide to accommodate instruments safely. Bilateral frontal ostia are first identified and enlarged. Drilling then proceeds from within each drainage pathway in an anteromedial direction, progressively removing the medial frontal sinus floor, thick frontal beak, and intersinus septum until the two openings are connected. Working from known sinus lumens helps maintain orientation, but narrow recesses can restrict visualization and place mucosa or adjacent structures at risk [3].

The superior septal window is created below the frontal sinus floor without extending excessively anteriorly or inferiorly. Preservation of dorsal septal support is essential to prevent deformity. Mucosal flaps may be designed before drilling because tissue that could cover the neo-ostium should not be inadvertently destroyed. The anterior attachment of the middle turbinate is removed only to the extent necessary for exposure, with the first olfactory fiber preserved as the posterior limit [16].

A cutting burr efficiently removes thick anterior bone, whereas a diamond burr is preferred near the posterior table, orbit, and first olfactory fibers. Continuous irrigation reduces thermal injury and clears bone dust. Drilling should create a smooth transition from the nasal bones and frontal process of the maxilla into the frontal cavity. Residual shelves or irregular edges may retain secretions, restrict endoscopic access, or become sites of scar formation [7].

The inferior intersinus septum is removed to unify the frontal sinuses. Complete removal of superior septations is unnecessary if they do not obstruct drainage or access, and aggressive superior drilling increases risk without improving the neo-ostium. At completion, both frontal sinuses should be widely visible through a common opening, and instruments should pass without catching on residual bony projections [3].

Outside-In Technique

The outside-in technique is valuable when the frontal recess is too narrow, scarred, or osteitic for safe inside-out instrumentation. After defining the lateral orbital boundaries and posterior olfactory limits, drilling begins at the frontal beak below the frontal sinus rather than within the natural ostia. Bone is progressively removed superiorly until the frontal sinus is entered. This converts a restricted drainage pathway into a controlled anterior corridor without forcing instruments through a narrow recess [16].

Accurate identification of the first olfactory fibers is crucial because the posterior drilling limit must be established before entering the frontal sinus. The frontal process of the maxilla and frontal beak are saucerized between the defined boundaries, after which the sinus floors and inferior intersinus

septum are removed. The technique may offer a wider working space and reduce dependence on identifying scarred natural ostia, but it requires advanced understanding of the midline skull-base anatomy [16].

The inside-out and outside-in approaches are complementary rather than competing procedures. Some operations use a hybrid strategy, entering through the more accessible side and drilling toward a severely narrowed contralateral recess. Selection depends on anatomy, previous surgery, disease location, and surgeon experience. Regardless of direction, the final goals are identical: a broad common neo-ostium, smooth bony contours, preserved critical boundaries, and adequate mucosal coverage [3].

Mucosal Reconstruction and Adjuncts

The extent of exposed bone after Draf III makes healing strategy central to success. Pedicled flaps may be raised from the nasal septum, lateral nasal wall, or middle turbinate region and draped over the frontal beak or posterior neo-ostium. Free mucosal grafts harvested from septal or turbinate tissue can cover residual defects. Reconstruction accelerates epithelialization, reduces crusting and granulation, and may limit circumferential scar contraction [8].

A retrospective study of 111 Draf III procedures found favorable effects from grafts and flaps on postoperative healing and neo-ostium stability, although selection bias and technical heterogeneity limit causal conclusions. More recent systematic evidence similarly suggests better patency with mucosal reconstruction. These findings support covering critical exposed surfaces, particularly the frontal beak and posterior margin, while recognizing that flap design should be tailored to the available mucosa and planned drilling [17].

Stents remain controversial. Silastic or steroid-eluting implants may separate raw surfaces, stabilize grafts, and locally suppress inflammation, but they may also cause crusting, infection, granulation, discomfort, or mucosal injury. Routine prolonged stenting is not supported by strong comparative evidence. Selective use may be reasonable in revision cases, severe inflammation, unstable grafts, or a high risk of early cicatricial narrowing, provided that removal and surveillance are carefully planned [18].

Postoperative Management

Postoperative care is an extension of the operation rather than an optional adjunct. High-volume saline irrigation removes clots, crusts, and inflammatory debris. Topical corticosteroid irrigations are particularly important in polypoid or type 2 disease because they exploit the surgically enlarged pathway to treat frontal mucosa. Systemic corticosteroids or antibiotics may be used selectively according to inflammatory burden, infection, culture findings, and patient comorbidity rather than prescribed routinely to every patient [1].

Early endoscopic follow-up allows removal of obstructive crusts, confirmation of flap position, and detection of granulation or infection. Debridement is commonly performed during the first postoperative weeks, with subsequent visits individualized according to healing. Excessively traumatic debridement should be avoided because repeated mucosal injury may worsen scarring. A fibrotic web developing across the frontal beak can sometimes be managed by office division, topical therapy, intralesional corticosteroid, or limited revision before mature stenosis develops [3]. Long-term surveillance is necessary because narrowing can continue for many months and restenosis may appear up to 2 years after surgery. Patients with allergy, aspirin-exacerbated respiratory disease, cystic fibrosis, recurrent polyposis, or previous failure require particularly close observation. Biologic therapy may be appropriate for uncontrolled severe type 2 disease despite technically successful surgery, because the operation cannot independently correct the systemic inflammatory phenotype [9].

Outcomes and Durability

Reported success depends on whether it is defined by endoscopic patency, radiological ventilation, symptom improvement, freedom from revision, or control of the underlying disease. These outcomes are related but not interchangeable. A neo-ostium may remain open while symptoms

persist from diffuse rhinosinusitis or non-rhinogenic headache, and a narrowed opening may remain clinically adequate. Studies should therefore report anatomical and patient-reported outcomes separately [13].

Earlier evidence-based review found high short- to intermediate-term endoscopic patency after Draf III, although substantial heterogeneity and incomplete long-term follow-up limited certainty. These results established the procedure as a credible alternative to frontal sinus obliteration for refractory disease. However, favorable outcomes from tertiary rhinology centers may not generalize to lower-volume practice because technical experience and postoperative surveillance strongly influence success [13].

A large series of 204 patients followed for a mean of approximately 10 years demonstrated that the modified Lothrop procedure can provide durable disease control. Most failures occurred within the early postoperative years, but late failure remained possible, supporting prolonged surveillance. The series also illustrated that anatomical patency alone does not guarantee complete symptom resolution, particularly in patients with severe inflammatory disease [19].

In another long-term cohort, Draf III produced significant improvement in general and nasal symptoms and was considered a valid alternative to frontal obliteration. Allergy showed an association with restenosis, whereas major complications were uncommon. Such findings reinforce the importance of inflammatory phenotype: the quality of surgery determines the initial opening, but ongoing mucosal disease contributes substantially to its long-term behavior [20].

The recent systematic review by Chiari and colleagues identified refractory frontal chronic rhinosinusitis as the dominant indication, followed by mucoceles and skull-base or paranasal tumors. Reported success was approximately 83.5% after primary Draf III and 71% after revision Draf III. Mucosal flaps were associated with better patency than stenting, although the underlying studies were heterogeneous and mainly retrospective [21].

A 2025 meta-analysis comparing Draf IIb with Draf III reported lower pooled restenosis and revision rates after Draf IIb. This should not be interpreted as evidence that Draf IIb is intrinsically superior, because Draf III is generally used for more extensive, bilateral, scarred, or biologically aggressive disease. The finding instead supports matching surgical extent to pathology and avoiding Draf III when a unilateral Draf IIb can adequately control disease [22].

Preoperative anatomy may refine prognostication. In a 2024 study, patients without recurrence had a larger maximum frontal outflow anteroposterior diameter than those requiring revision, and this measurement correlated with the achieved postoperative diameter. The small sample prevents a definitive threshold, but the study supports incorporating measurable anatomical constraints into counseling and surgical planning [7].

Patient-reported recovery should also be discussed. Compared with less extensive frontal surgery, Draf III can require more postoperative visits, debridements, and antibiotic treatment, with greater early extranasal and facial symptoms. Patients should therefore understand that the operation may offer greater long-term access and disease control at the cost of a more demanding early recovery and sustained maintenance [23].

Failure and Revision Surgery

Neo-ostium restenosis is the principal delayed cause of failure. Early narrowing is generally driven by edema, crusting, granulation, and opposing raw surfaces, whereas later narrowing reflects fibrosis, osteoneogenesis, recurrent polyposis, or persistent infection. Excessive exposed bone, inadequate anterior drilling, residual bony shelves, small initial dimensions, and poor adherence to irrigation or follow-up increase risk [8].

Failure may also result from disease beyond the created pathway. Far-lateral mucoceles, supraorbital cells, tumor attachments, or isolated compartments can remain obstructed despite a patent midline neo-ostium. Similarly, persistent symptoms may arise from inadequately controlled lower sinus disease or non-sinogenic headache. Revision planning must therefore identify the specific failure mechanism rather than reflexively enlarging the opening [14].

Revision Draf III usually involves removal of scar tissue, drilling of osteoneogenic bone, enlargement of the frontal beak, and renewed mucosal coverage. Image guidance is particularly valuable because landmarks may be absent and the skull base or orbit may be dehiscent. Outcomes after revision are generally inferior to primary surgery, reflecting both more difficult anatomy and more aggressive underlying disease [21].

When repeated endoscopic revision cannot provide durable drainage, combined or open approaches should be reconsidered. Frontal trephination, osteoplastic flap surgery, obliteration, cranialization, or multidisciplinary skull-base surgery may be appropriate for inaccessible lateral pathology, major posterior-table disease, uncontrolled cerebrospinal fluid leakage, extensive malignancy, or repeated endoscopic failure. Choosing an open approach in such circumstances is appropriate escalation rather than failure of endoscopic philosophy [15].

Complications

Intraoperative bleeding may arise from mucosal vessels, the anterior ethmoidal artery, or other regional vasculature. Injury to the anterior ethmoidal artery is particularly dangerous because the vessel may retract into the orbit and produce a rapidly expanding retrobulbar hematoma. Proptosis, increased orbital pressure, impaired pupillary responses, reduced vision, or restricted ocular movement require immediate recognition and decompression to prevent permanent visual loss [3].

Violation of the lamina papyracea may expose orbital fat or injure the medial rectus, superior oblique, or orbital contents. Powered instruments should not be activated blindly near prolapsed orbital tissue. Although orbital complications are uncommon in experienced hands, their consequences can be severe, and informed consent should address diplopia, hematoma, visual impairment, and extremely rare blindness [2].

Posterior extension beyond the first olfactory fibers can injure the cribriform plate or fovea ethmoidalis, causing cerebrospinal fluid leakage and risk of meningitis. Small recognized defects may be repaired endoscopically during the same operation, whereas larger or complex injuries require multilayer reconstruction. The safest strategy is consistent identification of the posterior boundary before extensive drilling and use of diamond burrs near the skull base [3].

Olfactory impairment can result from direct injury to the first olfactory fibers, thermal damage, postoperative inflammation, crusting, or altered airflow. Some patients may experience temporary hyposmia during healing, whereas permanent loss is possible if olfactory structures are damaged. Preservation of the posterior limit and avoidance of unnecessary superior septectomy reduce this risk [16].

Structural complications include excessive removal of dorsal septal support, which can contribute to saddle-nose deformity, and injury to the anterior nasal soft tissue or forehead skin during aggressive drilling. Thermal injury can be minimized through continuous irrigation, sharp burrs, intermittent drilling, and avoidance of prolonged pressure against thin bone. Septal perforation may be inherent to the superior surgical window but should not extend beyond the planned area [3].

Postoperative complications include hemorrhage, infection, crusting, adhesions, granulation, flap necrosis, stent-related irritation, and neo-ostium stenosis. Intracranial infection is rare but must be considered when fever, severe headache, neck stiffness, neurological change, or cerebrospinal fluid leakage occurs. Persistent orbital pain, swelling, diplopia, or visual symptoms likewise require urgent evaluation [21].

Current Limitations and Future Directions

The Draf III evidence base is limited by retrospective designs, referral bias, mixed pathologies, variable surgical techniques, and inconsistent definitions of patency and failure. Outcomes from inflammatory disease cannot be directly pooled with results for mucoceles or tumors, while primary and revision procedures represent different risk populations. Future studies should report indication-specific anatomical, patient-reported, medication, complication, and revision outcomes using standardized follow-up intervals [21].

Research should better define the role of primary Draf III in severe inflammatory disease and

determine whether early maximal surgery improves long-term control or merely increases treatment burden. Comparative studies should incorporate biologic therapy, inflammatory endotype, prior surgery, osteitis, frontal dimensions, and topical-treatment adherence. Cost-effectiveness analyses may help establish when one definitive operation is preferable to repeated limited procedures [24]. Further refinement of mucosal reconstruction is also needed. Prospective comparison of standardized flap designs, free grafts, steroid-eluting implants, and no reconstruction could clarify which technique best prevents stenosis. Quantitative analysis of neo-ostium area and mucosalization over time may be more informative than simple binary patency. Improved angled drills, high-definition visualization, navigation, and augmented anatomical guidance may expand safe access while reducing unnecessary tissue injury [17].

Conclusion

The endoscopic modified Lothrop procedure is a valuable advanced option for refractory frontal sinus disease, particularly after failure of limited frontal surgery and in selected patients with severe bilateral inflammation, mucoceles, tumors, traumatic obstruction, or skull-base pathology. Durable success requires appropriate patient selection, meticulous CT-based anatomical planning, a sufficiently wide and smoothly contoured common neo-ostium, preservation or reconstruction of mucosa, control of the underlying inflammatory disorder, and structured long-term postoperative surveillance.

References

1. Fokkens WJ, Lund VJ, Hopkins C, et al. European Position Paper on Rhinosinusitis and Nasal Polyps 2020. *Rhinology*. 2020;58(suppl S29):1-464.
2. DeConde AS, Smith TL. Outcomes after frontal sinus surgery: an evidence-based review. *Otolaryngol Clin North Am*. 2016;49(4):1019-1033.
3. Noller M, Fischer JL, Gudis DA, Riley CA. The Draf III procedure: a review of indications and techniques. *World J Otorhinolaryngol Head Neck Surg*. 2022;8(1):1-7.
4. Chmielewski PP. Clinical anatomy of the paranasal sinuses and its terminology. *Anat Sci Int*. 2024;99(4):454-460.
5. Papadopoulou AM, Bakogiannis N, Skrapari I, Bakoyiannis C. Anatomical variations of the sinonasal area and their clinical impact on sinus pathology: a systematic review. *Int Arch Otorhinolaryngol*. 2022;26(3):e491-e498.
6. Wormald PJ, Hoseman W, Callejas C, et al. The International Frontal Sinus Anatomy Classification and an anatomic classification of the extent of endoscopic frontal sinus surgery. *Int Forum Allergy Rhinol*. 2016;6(7):677-696.
7. Alicandri-Ciufelli M, Cantaffa C, Basso M, Colacurcio V, Marchioni D, Lucidi D. Influence of pre-operative estimation of Draf III expected diameter on surgical outcome. *J Pers Med*. 2024;14(9):951.
8. Wei CC, Sama A. What is the evidence for the use of mucosal flaps in Draf III procedures? *Curr Opin Otolaryngol Head Neck Surg*. 2014;22(1):63-67.
9. Ji K, Gudis DA, Overdevest JB, et al. Rate of dupilumab use and symptom severity of patients with refractory chronic rhinosinusitis with nasal polyps after Draf III frontal sinusotomy. *Int Forum Allergy Rhinol*. Published online August 2024.
10. Bockmühl U, Kratzsch B, Benda K, Draf W. Surgery for paranasal sinus mucocoeles: efficacy of endonasal micro-endoscopic management and long-term results of 185 patients. *Rhinology*. 2006;44(1):62-67.
11. Lund VJ, Stammberger H, Nicolai P, et al. European position paper on endoscopic management of tumours of the nose, paranasal sinuses and skull base. *Rhinol Suppl*. 2010;(22):1-143.
12. Haddad R, Khoueir N, Smaily H, Rassi S, Abou Hamad W. Safety and efficacy of the Draf IIb procedure: a systematic review. *Otolaryngol Head Neck Surg*. 2021;165(6):784-790.
13. DeConde AS, Mace JC, Smith TL. Outcomes after frontal sinus surgery: an evidence-based review. *Otolaryngol Clin North Am*. 2016;49(4):1019-1033.
14. Tilak A, Purvis J, Peña-Garcia A, et al. Above and beyond: periorbital suspension for endoscopic access to difficult frontal sinus pathology. *Laryngoscope*. 2022;132(3):538-544.
15. Crocetta FM, Farneti P, Sollini G, et al. Endoscopic management of frontal sinus diseases after frontal

craniotomy: a case series and review of the literature. *Eur Arch Otorhinolaryngol*. 2021;278(4):1035-1045.

16. Papatsoutsos E, Kalyvas A, Drosos E, et al. Defining the limits and indications of the Draf III endoscopic approach to the lateral frontal sinus and maximizing visualization and maneuverability: a cadaveric and radiological study. *Eur Arch Otorhinolaryngol*. 2022;279(10):4969-4976.
17. Leventi A, Chatzinakis V, Papargyriou GE, Georgalas C. Enhancing frontal sinus surgery: assessing the long-term impact of free grafts and flaps in Draf III procedures. *J Pers Med*. 2024;14(4):396.
18. Chiari F, Guarino P, Caporale CD, et al. Clinical features, operative management and surgical results of first Draf III procedure, revision Draf III approach and the use of mucosal flaps and stents: a systematic review. *Eur Arch Otorhinolaryngol*. 2025;282(2):611-622.
19. 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.
20. Georgalas C, Hansen F, Videler WJM, Fokkens WJ. Long terms results of Draf type III frontal sinus drainage procedure in 122 patients: a single centre experience. *Rhinology*. 2011;49(2):195-201.
21. Chiari F, Guarino P, Caporale CD, et al. Clinical features, operative management and surgical results of first Draf III procedure, revision Draf III approach and the use of mucosal flaps and stents: a systematic review. *Eur Arch Otorhinolaryngol*. 2025;282(2):611-622.
22. Hirayama Y, Shahid MS, Finney HA, et al. Comparison of outcomes for Draf IIb vs Draf III in endoscopic frontal sinus surgery: a comprehensive systematic review and meta-analysis. *Rhinology*. 2025;63(3):294-305.
23. Jafari A, Tringale KR, Panuganti BA, DeConde AS. Short-term morbidity after the endoscopic modified Lothrop procedure compared with Draf IIa frontal sinusotomy. *Int Forum Allergy Rhinol*. 2017;7(10):941-947.
24. Lerner DK, Patel S, Phung C, et al. Upfront Draf III strategy often less costly for severe chronic rhinosinusitis requiring surgery. *Am J Rhinol Allergy*. Published online 2025.
25. Batra PS, Cannady SB, Lanza DC. Surgical outcomes of drillout procedures for complex frontal sinus pathology. *Laryngoscope*. 2007;117(5):927-931.
26. Draf W. Endonasal micro-endoscopic frontal sinus surgery: the Fulda concept. *Oper Tech Otolaryngol Head Neck Surg*. 1991;2(4):234-240.
27. Weber R, Draf W, Kratzsch B, Hosemann W, Schaefer SD. Modern concepts of frontal sinus surgery. *Laryngoscope*. 2001;111(1):137-146.
28. Fawzi NEA, Lazim NM, Aziz ME, Mohammad ZW, Abdullah B. The prevalence of frontal cell variants according to the International Frontal Sinus Anatomy Classification and their associations with frontal sinusitis. *Eur Arch Otorhinolaryngol*. 2022;279(2):765-771.
29. Nofal AAB, El-Anwar MW. Frontal recess cells in International Frontal Sinus Anatomy Classification: prevalence, infection incidence, and relation to frontal sinus infection in chronic sinusitis patients. *Indian J Otolaryngol Head Neck Surg*. 2022;74(suppl 3):4748-4755.
30. Turri-Zanoni M, Battaglia P, Bignami M, Castelnuovo P, Arosio AD. Comprehensive access strategies to the frontal sinus. *Curr Opin Otolaryngol Head Neck Surg*. 2023;31(1):57-64.