A Short Term Subjective and Objective Analysis of Modified Endoscopic Lothrop's Procedure and Its Functional Outcome: Our Experience

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Abstract To study the short-term functional outcomes of the endoscopic modified Lothrop procedure with well defined subjective and objective criteria. It's a retrospective cohort study with chart review carried out at a tertiary referral center. 31 patients with chronic frontal sinusitis who underwent endoscopic modified Lothrop's procedure with uncinata preservation during the period Jan 2011–2014 were followed up for a period of minimum 6 months. Assessment was done post-operatively based on subjective severity score and Kennedy's 5 point endoscopic criteria. Subjective improvement was seen in all symptoms whereas statistically significant improvement was found for the three parameters headache ($p < 0.025$), nose block ($p < 0.03$) and rhinorrhea ($p < 0.05$). Post operative nasal endoscopy revealed crusting and polypoidal mucosa in few patients which were managed conservatively. Asymptomatic narrowing of ostium seen in two patients. No complications were identified. The study illustrates the benefit obtained from endoscopic modified Lothrop's surgery in chronic frontal sinusitis refractory to medical treatment and standard endoscopic sinus surgery.

Keywords Frontal sinusitis · Draf III procedure · Modified endoscopic Lothrop procedure · Endoscopic sinus surgery

Introduction

Sinus surgery has come a long way after the advent of endoscopes in the mid 1950's by Dr. Hopkins, professor of optics at Reading [1]. Prior to the endoscopic era, sinus surgery was done by various techniques which included probing of the frontal sinus as well as irrigation of the sinus [2]. Berenger Del Carpi was probably the first Anatomist to provide evidence of the existence of the para nasal sinus early in the sixteenth century [3]. Endoscopy was first performed by Hirshmann, "Father of nasal endoscopy" in 1903 using a modified Nitze cystoscope [4] which he used in the nasal cavity and in the maxillary sinus via tooth socket. In 1925, Maltz commissioned Wolf to make a dedicated endoscope and it was him who introduced the term "sinuscopy". These endoscopes using a series of small lenses were used till Hopkins, Professor of Optics at Reading, invented a superior system in the 1950s, based on solid glass rods, which is now universally utilized. Lothrop in 1914 described a surgical procedure to treat frontal sinusitis by creating a wide naso-frontal communication. It was performed with an external ethmoidectomy approach, with resection of the nasal floor of frontal sinuses, intersinus septum, the superior portion of the septum right under the frontal sinuses, and bilateral superior medial orbital walls. A high rate of complication, especially medial collapse of orbital soft tissue with obstruction of frontal sinus drainage was observed and detrimental in loosing popularity among the sinus surgeons leading to the evolution of osteoplastic flap approach. Wolfgang Draf revisited the Lothrop technique and improvised a conservative endoscopic approach with minimal morbidity which got popularized as modified endoscopic Lothrop procedure.

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Relevant Anatomy and Physiology

Frontal Sinus

It is situated in between the inner and outer tables of frontal bone. The size and shape of frontal sinus is highly variable. The two frontal sinuses are often asymmetric and may drain into another or drain separately. Frontal sinus is usually L shaped with a vertical part (in square of frontal bone) and a horizontal part (in the orbital roof) [5].

Frontal bulla refers to the bulge produced in the frontal sinus by anterior ethmoidal cells. Van Alyea [5] found them in 50 % of cases and in one-third it was in the frontal ostium.

Fronto-Nasal Connections

The frontal recess is actually a continuation of the 1st ethmoturbinal groove which develops in the lateral nasal wall. The anterior end of the 1st ethmoturbinal crest forms the agger nasi whereas the posterior end of the 1st ethmoturbinal crests forms the uncinate process. The frontal sinus usually gets pneumatized from the anterior ethmoidal cells [2].

The drainage of the frontal sinus is highly variable and depends on the attachment of the uncinate process. If the uncinate is attached superiorly to the skull base or medially to the middle turbinate, the frontal sinus will drain directly into the infundibulum lateral to the uncinate [5]. Attachment of the uncinate to the lamina papyracea would create a recess terminalis which would make the sinus drain medial to the uncinate process.

The presence of frontal cells also may hinder the mucociliary clearance. According to Kuhn et al. [6], four types of frontal cells may be present. The frontal recess is bounded medially by the middle turbinate, anteriorly by the agger nasi and laterally by the lamina papyracea. Posteriorly, the bulla ethmoidalis is present or the recess may directly communicate with the suprabullar and retrobullar recess if the anterior face of the bulla ethmoidalis is not attached to the skull base.

Messerklinger [7] demonstrated the mucociliary transport along inter-frontal septum, roof and lateral sinus walls returning to the floor. The sinus finally drains into frontal recess usually by an hourglass narrowing. Based on the amount of disease, various surgeries of the frontal sinus region have been proposed by Wolfgang Draf. Draf I involves only frontal recess clearance with preservation of healthy mucosa. This is frequently performed during routine functional endoscopic sinus surgery (FESS) if frontal sinus ventilation is needed. Type II a surgery is performed as the next step in refractory frontal sinusitis which included removal of the floor of the frontal sinus till the

attachment of the middle turbinate in the coronal plane on the affected side/bilaterally. The Type II b and Draf type III are performed for severe chronic frontal sinusitis not amenable to above procedure. Draf type II b is type similar to type II a, but removal of the floor is done till the nasal septum. Endoscopic Draf type III procedure is called Modified Lothrop's procedure. The latter terminology is used more frequently in the United States. In this procedure, the entire floor is removed from one lamina papyracea to the other (on the opposite side), including the inter-frontal septum and the superior part of the nasal septum.

Materials and Methods

31 patients with chronic frontal sinusitis refractory to medical treatment and conservative surgical management including Draf I procedure and patients with extensive allergic fungal sinusitis with bilateral frontal sinus disease were included in the study. The study period was for 3 years from January 2011 to January 2014. All patients were followed up for a minimum of 6 months post-surgery. Evaluation was done for patients on the basis of subjective severity scale considering the five common symptoms seen in Indian population and these were analyzed at 2 weeks, 6 weeks, 3 months and 6 months of follow up (Table 1). Indications included chronic frontal sinusitis following trauma, frontal sinus mucocele, osteomyelitis of frontal bone. All patients underwent modified Lothrop procedure. Patients with Sino-nasal tumors that underwent Lothrop procedure as an access approach were excluded from the study.

Four out of the 31 patients had undergone Draf IIa procedure with recurrence of disease and were included in the study. Thirteen patients with previous endoscopic sinus surgery/Draf I, with recurrence of symptoms underwent Lothrop surgery. One patient had frontal bone fracture leading to obstruction of the frontonasal duct with scarring of the mucosa leading to chronic frontal sinus disease. Two patients had frontal mucocele and one patient presented with orbital cellulitis. Rest of the patients had allergic fungal rhinosinusitis.

Table 1 Showing subjective criteria of symptom severity grading and endoscopic objective criteria for evaluation

Subjective criteria	Grading	Lund- Kennedy's endoscopic objective criteria for grading (0,1,2)
Headache	1—no symptoms	Polyps
Post-nasal drip	2—mild	Mucosal edema
Nose block	3—moderate	Crusting
Anosmia/hyposmia	4—severe	Discharge
Rhinorrhea	5—very severe	Narrowing/scarring

Objective endoscopic assessment of the sinus cavity was done using the 5 point criteria suggested by Kennedy et al. [8] in 1995 including polyps, edema, crusting, discharge, scarring. Each criterion was graded from 0 to 2 depending on the severity of the condition and cases which needed a revision cleaning of the cavity were carried out after a waiting period of 6 months post-operatively (Table 1).

Computer tomography scans of the nose and paranasal sinuses was obtained in all planes for all patients pre operatively and postoperatively in certain cases of allergic fungal rhinosinusitis (Fig. 1). The coronal, axial and sagittal planes were studied well for each patient appreciating the anatomical differences, especially at the frontal

sinus ostium. Patients selected were explained about the procedure, the need for post operative follow up and for documentation of signs and symptoms. Surgery was performed under general anesthesia. All procedures were done by the senior author. Uncinate process preservation endoscopic sinus surgery was done as described by Nayak et al. [9]. Ethmoidectomy was performed based on extent of the disease. Interfrontal septum and floor of the frontal sinus was completely removed. The frontal T was created which was formed by the lamina papyracea on either side (forming the lateral limit of the T) or the bony septum were removed using drill till the olfactory epithelium (forming the vertical part of the T) to complete the modified Lothrop procedure (Fig. 2). At the end of the procedure, antibiotic

Fig. 1 a, b Pre operative coronal CT showing frontal sinus disease, c, d Postoperative CT showing clearance of disease after endoscopic modified Lothrop procedure

and steroid impregnated synthetic biodegradable nasal dressing (Nasopore®) was placed in the sinus cavity and the neo ostium. Post operatively, patients were asked to carry out nasal douching with normal saline thrice daily

and use steroid nasal spray 200 µg once daily. Routine course of post operative antibiotics and antihistamines were prescribed for 1 week. They were asked to review at 2 weeks, 6 weeks, 3 months and 6 months in the post-operative period.

Fig. 2 **a** Showing post operative endoscopic modified Lothrop and ethmoidal cavity with intact uncinate and anterior wall of bulla. **b** Showing post Lothrop frontal sinus cavity

Fig. 3 Showing the pre operative (pre-op) and post operative (post-op) subjective symptomatic improvement graph

Results

Signs and symptoms along with endoscopic picture of the surgical cavity were assessed at each follow up. The five most troublesome symptoms with respect to Indian population were analyzed. We found an incidence of headache (82 %), postnasal drip (78 %), nasal obstruction (81 %), hyposmia/anosmia (86 %), rhinorrhea (76 %) in our study population. Characteristics of the two groups were compared using Fisher exact, and t tests where appropriate. Statistical significance was accepted when $P < 0.05$.

Even though there was an improvement in the overall symptom score, statistically significant improvement was found for the three parameters headache ($p < 0.025$), nose block ($p < 0.03$) and rhinorrhea ($p < 0.05$). No statistical significance noted with respect to postnasal drip ($p < 0.06$) and anosmia ($p < 0.073$),

As seen from the graphical representation (Fig. 3) there was improvement of symptoms probably due to continuous healing of frontal mucosa and adequate drainage. A conservative endoscopic approach with mucosal preservation has been previously shown to have better results both subjectively and objectively and was the procedure of choice over conventional endoscopic sinus surgery in conjunction with modified Lothrop's procedure [9].

Post-operative endoscopic assessment of the sinus cavity was done using Kennedy's 5 point scale [8] showed significant improvement in all the criteria (Fig. 4). Edematous, polypoidal mucosa was seen in about 3 patients, of

Fig. 4 Showing pre-operative (pre-op) and post operative (post-op) improvement in Kennedy's 5 point objective scoring

which two patients underwent endoscopic cleaning of the sinus cavity under general anesthesia. Minimal crusting was seen in four patients and was removed during post-op endoscopic cleaning. Two patients had mucoid discharge in the sinus cavity which was treated medically with antibiotic, nasal douching and steroid nasal sprays. Two of the patients had an associated fracture of frontal bone which was corrected in the same sitting. One patient had granulation tissue at the neo-ostium region at 3 months follow up and had to undergo a short procedure to remove the granulation tissue. Two patients had asymptomatic narrowing of the neo-ostium. Narrowing of the neo-ostium is defined as a loss of 60 % or more of the intra-operative area.

Discussion

The frontal sinus is particularly a difficult region to operate for a novice or an experienced surgeon due to limited access, aim of preserving the precious frontal recess mucosa and variable anatomy at the site. As endoscopic procedures evolved, it became clear that mucosal disease was reversible and that all diseased mucosa need not be removed. Preserving the mucociliary clearance pathway of the sinuses, minimal injury to the sinus mucosa and widening their passageways came to be the aim of endoscopic sinus surgeries. Moreover, traumatizing the nasal mucosa could have detrimental effects like scarring and synechia. Prior to this idea, removal of nasal mucosa of the maxillary sinus was regularly performed via the Caldwell Luc approach. The time lapse studies on nasal mucosa by Messerklinger et al. [7] demonstrated that limited surgery with mucosal preservation was the procedure of choice. They also demonstrated the various pathways of mucociliary drainage and that mucosal disease was brought about

by areas of contact between mucosal surfaces. This could occur in narrow areas such as the infundibulum, the hiatus semilunaris, the ethmoidal labyrinth or the Fronto-nasal recess. Contact between mucosal surfaces could be due to anatomical variation, edema, allergies etc. This contact would lead to obstruction in mucociliary clearance leading to stasis of secretions, infection and edema which then became a cycle. However, limited surgery may not always hold good in cases of problem frontal sinus or conditions prone for refractory frontal sinusitis such as cystic fibrosis, Young's syndrome, Kartagener's syndrome and other ciliary dyskinesias. Eloy et al. [10] have discussed the feasibility of such a procedure in a patient with complex frontal sinus pathology and other surgeries of the anterior skull base [9]. Gotlib et al. [11] have also demonstrated the use of modified Lothrop procedure for treatment of inverted papilloma involving the frontal sinuses [10]. Extensive chronic pathology like allergic fungal rhinosinusitis, polyposis involving frontal sinus are quite challenging and call for an aggressive approach [12].

Conclusion

In our experience, modified Lothrop procedure in conjunction with FENS is the procedure of choice for problematic frontal sinus disease refractory to medical treatment and other less radical frontal sinus procedures. This being a preliminary report, long term results are yet to be documented and published. However, the short term results seem to be promising for such patients.

Compliance with Ethical Standards

Conflict of interest The authors declare no conflict of interest in the submission of this manuscript.

Human and Animal Rights This article is a retrospective analysis of data and does not contain any studies with human participants or animals performed by any of the authors.

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