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MAIN ARTICLE

The frontal osteoplastic flap: does it still have a place in rhinological surgery?

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Abstract

Objective: To review outcomes and complications in a series of adults undergoing a frontal osteoplastic flap procedure without obliteration, for endoscopically inaccessible sinus disease.

Material and method: Retrospective case note review of patients treated at Glasgow Royal Infirmary between January 2004 and October 2008.

Results: Ten patients were identified (age range 19–81 years, mean age 46.3 years). No major intra- or post-operative complications occurred. There were three minor complications: superficial discharging wound, forehead swelling and haematoma.

Conclusion: The frontal osteoplastic flap still has a role in frontal sinus surgery. With minor technical modifications, this procedure may be performed with minimal complication and morbidity for patients with endoscopically inaccessible frontal sinus disease.

Key words: Frontal sinus; Surgical procedure; Osteoplastic; Complications; Outcome

Introduction

The frontal osteoplastic flap operation was first described in 1894 by Schonborn and then in 1895 by Brieger, and was later popularised by Macbeth.[1] In 1898, Riedel described removing the anterior table and supraorbital rims, resulting in collapse of the forehead skin onto the posterior table. Killian lessened the cosmetic deformity by preserving the supraorbital rims. Schonborn and Brieger were the first to describe a hinged frontal osteoplastic flap reliant upon periosteum for its blood supply, which provided good access to the frontal sinus and nasofrontal ducts.[2]

Previously, the frontal osteoplastic flap procedure was commonly utilised by rhinologists operating upon the frontal sinus. However, the advent of endoscopic sinus surgery has resulted in a decline in its use. Despite this, there is a continuing role for the frontal osteoplastic flap procedure in modern rhinology, in cases involving endoscopically inaccessible disease or extensive areas of dural exposure.

This paper reviews the frontal osteoplastic flap procedure, highlights modern modifications, and discusses the continuing role of frontal osteoplastic flaps in the management of frontal sinus disease. We also present results from 10 consecutive patients operated upon at our institution by the senior author.

Materials and methods

We reviewed the case notes of all patients undergoing a frontal osteoplastic flap procedure at our institution between January 2004 and October 2008, in order to assess outcomes and complications.

The essential steps of the operation remain unchanged from the original description. Below, we describe the various steps of the frontal osteoplastic flap procedure, along with some modifications worthy of note.

Pre-incision

If endoscopic sinus surgery is to be used in conjunction with a frontal osteoplastic flap, it is useful to perform the endoscopic tasks prior to any external work. The senior author found subjectively that his fine motor skills were poorer after external work, use of power tools etc, making simple endoscopic procedures more challenging. We therefore recommend performing the endoscopic component of a combined procedure first.

Incision

The patient's head is shaved and placed on a head ring. The head is prepared in the usual way and draped to expose the vertex. A heavy silk suture is used to mark the bicoronal incision. The suture is placed at

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the root of the helix on each side, carefully incorporating the superficial temporal artery in the bicoronal flap. The bicoronal flap should be placed so that the incision is hidden by the patient's hairline. A straight incision starting 2 cm superior to the root of the helix is made along the mark, down to the loose aponeurotic layer. Raising the flap in this plane provides a relatively bloodless field.

Flap extent

Bleeding from the edges of the flap is controlled by bipolar diathermy and the application of Raney clips. The bicoronal flap is elevated until the supraorbital rim is exposed bilaterally, with preservation of the supraorbital and supratrochlear nerves (Figure 1).

Periosteal flap

The periosteum is incised beyond the frontal sinus outline, and a periosteal flap is elevated carefully to avoid tears. A frontal sinus template (see below) is used to estimate where the periosteal incisions should be made (Figure 2).

Osteotomy and template

The frontal sinus outline is drawn on the anterior table of the skull using a frontal sinus template (Figure 3a). This is made from an occipitofrontal X-ray, using exposed X-ray film. The occipitofrontal film with overlying exposed X-ray film is placed on an illuminated X-ray box. A tracing of the frontal sinus outline is made on the exposed X-ray film (being careful to stay within the frontal sinus outline, to avoid overestimating the extent of the frontal sinus and to accommodate the slight magnification of the plain X-ray). An extension is made in the midline inferiorly; laterally, the film is cut to the supraorbital rims. These extensions beyond the frontal sinus outline ease intra-operative orientation and positioning of the template. We mark the sides by making a punch hole on the right (Figure 3b). The template is wet-sterilised.

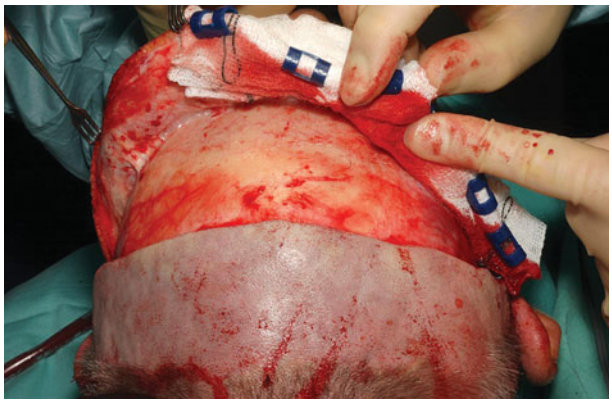

FIG. 1
Raising the bicoronal scalp flap. Raney clips are placed on the edges of the flap.

Osteotomies are made on the inner aspect of the drawn outline (to prevent overestimating the extent of the frontal sinus and entering the cranial cavity). An oscillating saw is used at a 30° angle towards the sinus to create a chamfered osteotomy, prior to careful elevation of the anterior sinus table with a chisel. The angle may be closer to 90° in the inferior osteotomy, to avoid nerve bundles and the periosteal flaps. As the frontal table is thicker in the region of the inter-sinus septum, care must be taken to avoid fracturing the anterior table in this region; this will facilitate the removal of the anterior table in one piece (Figures 4 to 6). Once elevated, the bony plate is placed in saline.

Stent placement (optional)

Should frontal sinus stenting or post-operative irrigation be required, O'Donoghue splints with malleable guide wires (Figure 7) are passed externally into the frontal ostium and are received endoscopically at the frontal recess. These are then used to 'railroad' the stent easily through the sinus ostium.

Closure

On closure, the bony plate is replaced and fixed with fibrin sealant glue (Tisseel®; Baxter International, US) (Figure 8). Care should be taken to ensure that the fibrin glue does not seep into the frontal sinus cavity. No screws or plates are required. The periosteal flap is replaced and fixed with fibrin glue. Corrugated wound drains are left bilaterally. The galea aponeurosis is closed with 3/0 Vicryl sutures and the skin is closed with skin clips. A pressure bandage is applied for 24 hours, and the drains often left for a further 24 hours.

Results

Ten patients aged 19 to 81 years (mean age 46.3 years; eight men and two women) were operated upon by the senior author (GWM) between January 2004 and October 2008. All patients underwent the frontal osteoplastic flap procedure; none required frontal sinus obliteration. The indications for the operation were osteomyelitis, osteoma, recurrent inverted papilloma

FIG. 2
Periosteal elevation.

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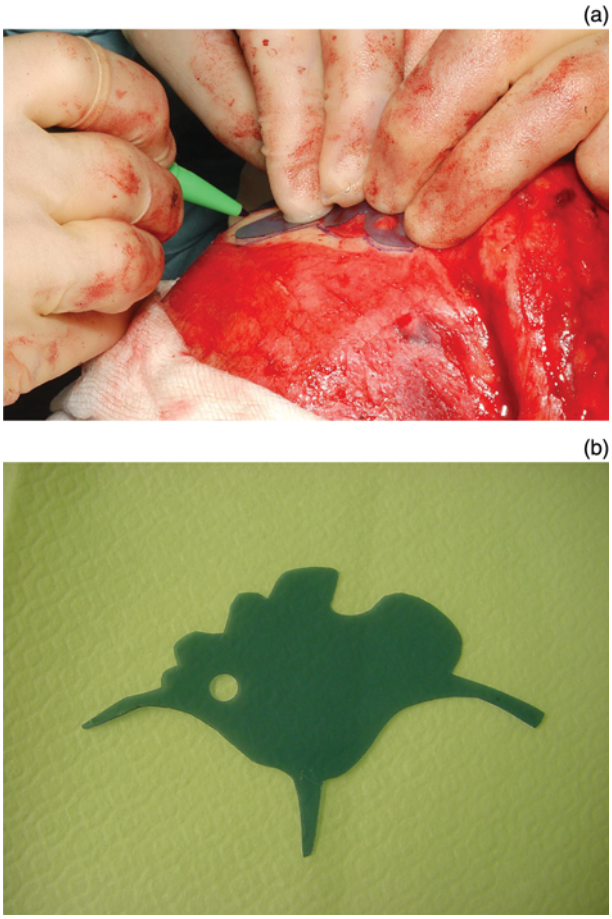

FIG. 3
(a) Outlining the frontal sinus. (b) The frontal sinus template.

and mucocele (Table I). The mean hospital stay was 4 days (range 2–5 days) and the mean follow-up period 2.2 years (range 0.1–4.2 years).

No intra-operative complications occurred. All the patients had preservation of the forehead contour, with none requiring a revision frontal osteoplastic flap procedure. Frontal and supra-orbital sensation was preserved in all patients. There were three minor post-operative complications: superficial discharging wound, forehead swelling and haematoma. The patient with the discharging wound had a pin-point area which healed without any need for scar revision or antibiotics. The second patient had a haematoma in the temple region, which was expressed through the wound on the ward on post-operative day two; he was treated with oral antibiotics (co-amoxiclav) and did not need to return to theatre, nor did he require a prolonged hospital stay. This patient subsequently healed, and was asymptomatic at the time of writing. The third patient was discharged uneventfully but was noted to have a swelling over his forehead on review in the clinic on post-operative day five. He was given a course of oral co-amoxiclav; when seen a week later, the swelling had resolved.

FIG. 5
Chisel used to elevate the anterior table.

Unfortunately, two patients suffered from recurrent sinusitis, requiring revision functional endoscopic sinus surgery (FESS). The first patient, an asthmatic, had a frontal mucocele excised via a frontal osteoplastic flap procedure, and suffered an infective exacerbation of chronic rhinosinusitis. He underwent revision FESS 22 months after his frontal osteoplastic flap procedure. The second patient had undergone a frontal osteoplastic flap procedure for recurrent inverted papilloma, after multiple previous endoscopic and external

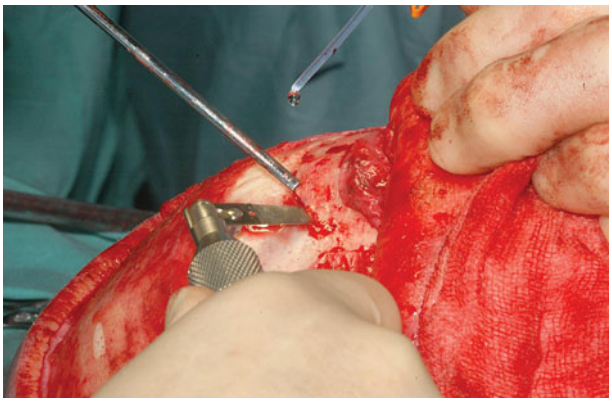

FIG. 4
Oscillating saw used to perform frontal osteotomy.

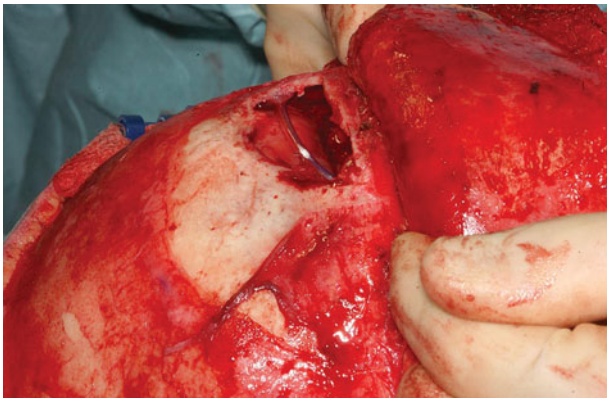

FIG. 6
The frontal sinus window.

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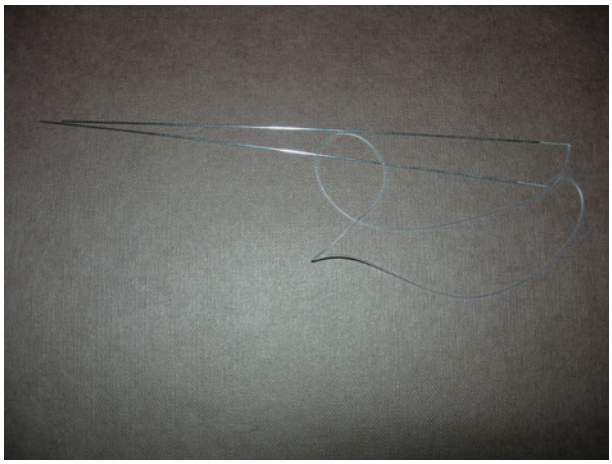

FIG. 7
Long O'Donoghue splints.

procedures, with pre-operative imaging showing erosion of the posterior table. He underwent revision FESS 31 months after his frontal osteoplastic flap procedure, with removal of recurrent polyposis and re-exploration of the left frontal recess. Polypoidal tissue and a mucocele were removed from the frontal recess. Histopathological examination of tissue from this area revealed small deposits of inverted papilloma. This patient was well at the time of writing.

Discussion

The frontal osteoplastic flap procedure combined with frontal sinus obliteration was once the 'gold standard' for the surgical management of medically refractory frontal sinus disease. It offered easy access and direct visualisation of the frontal sinus, with success rates ranging from 82 to 93 per cent.[3,4] However, this surgery can be associated with significant morbidity. In a series of 82 frontal osteoplastic flap procedures with fat obliteration, Weber *et al.* reported the following intra-operative complications: exposure of orbital fat (19.8 per cent), unintentional fracture of the anterior wall of the frontal sinus (19.5 per cent), incorrect placement of the anterior wall (17 per cent, 14 patients), and dural exposure or dural injury due to the anterior flap being too large (seven patients).[4] A further six patients sustained dural injury in the course of disease removal; these patients underwent successful intra-operative repair. In the majority of patients (14 of 16), injury to the periorbita was caused by burring of the orbital roof. There is also a risk of injuring the superior sagittal sinus if the anterior flap is too large. Ulualp *et al.* reported one case of intra-operative cerebrospinal fluid (CSF) leakage, which was repaired immediately, in a series of 43 patients; they encountered no other intra-operative complications.[5]

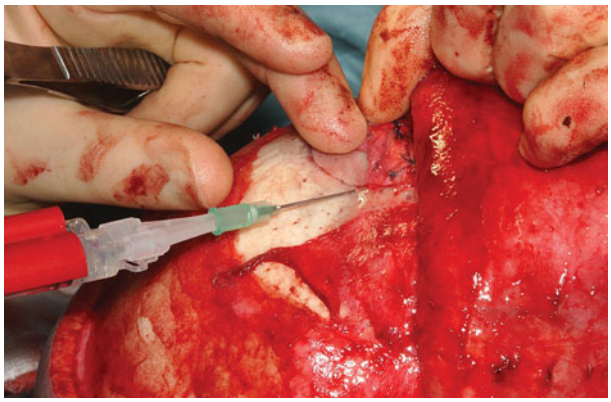

FIG. 8
Bony closure with fibrin sealant glue.

Depending on the choice of surgical incision and the patient's hair distribution, scarring can be obvious. In our practice, we use the bicoronal incision to good effect. Other incisions used for access include the eyebrow incision, forehead fold or zig-zag bicoronal incision.[4–6] Depression or embossment of the anterior table can be equally unattractive deformities of the bony contour of the forehead; these result from a depression occurring along the line of osteotomy, or enlargement of the frontal bony flap both externally and internally, respectively.[2,7] None of our patients developed either of these complications, although Weber *et al.* reported 3.4 and 6.8 per cent rates of embossment and frontal depression, respectively, in a series of 59 patients seen one to 12 years after surgery.[4] Lawson and Reino found a 10 per cent incidence of embossment in a group of 103 patients; in these patients, embossment began to develop within a few months of surgery and gradually progressed for up to approximately a year.[7]

We believe that performing the osteotomy with an oscillating saw at 30° creates a chamfered edge which supports the anterior bony fragment on closure, preventing it from falling into the frontal sinus. The oscillating saw seems to cause less bony loss along the osteotomy, compared with a burr, decreasing the likelihood of embossment. The use of fibrin sealant glue for bony and periosteal closure obviates the need for plating, thus avoiding the risk of plate or screw extrusion or infection. Although Weber *et al.* utilised similar techniques, unlike us they drilled out the frontal sinus in preparation for frontal sinus obliteration.[4] The possible effect of this on the occurrence of frontal depression or embossment can only be presumed. Unlike some authors, we have been unable to keep the anterior table hinged inferiorly, as we have found that this area often breaks off.[5] Therefore, we remove the bony anterior table but keep the periosteum intact and hinged inferiorly.

Although none of our patients had persistent numbness of the supraorbital and frontal region, this complication has been described in 8.5 to 13 per cent of patients in other series.[4,5] Diligent preservation of the supraorbital bundles seems to prevent this complication. As obliterated sinuses cannot be examined directly, mucoceles may be undetected, and only discovered on radiological survey.

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TABLE I
PATIENT DATA, INCLUDING SURGICAL INDICATION

Pt no	Indication	Sex	Age (y)	Prev surg (*n*)	FU (y)	Comment	Surg comps	Rev surg?
1	Osteoma	M	53	0	0.4	Osteoma eroding through ant & post table with exposed dura	Superficial discharging wound, settled conservatively	No
2	Mucocele	M	35	2	1.5	FOF for osteoma 16 y prev	Small wound haematoma, settled conservatively	No
3	Osteomyelitis	F	81	1	2.4	Bone debridement required, Pott's puffy tumour	None	No
4	Mucocele	M	19	1	2.6	Eroded post table, possible exposed dura	None	FESS 22 mth after FOF
5	Mucocele	M	66	3	2.9	Eroded post table, exposed dura	None	No
6	Mucocele	F	21	1	2.6	Eroded post table, exposed dura	None	No
7	Recurrent inverted papilloma	M	19	Many	4.2	Eroded post table	None	Rev FESS 31 mth after FOF
8	Mucocele	M	66	2	1.4	Eroded post table	None	No
9	Frontal osteoma	M	42	0	0.1	Not accessible endoscopically	None	No
10	Recurrent inverted papilloma	M	61	3	4	Not accessible endoscopically	Forehead swelling day 5, settled on antibiotics	No

Pt no = patient number; y = years; prev surg = previous surgical procedures; FU = follow up; surg comps = surgical complications; rev = revision; M = male; ant = anterior; post = posterior; FOF = frontal osteoplastic flap procedure; F = female; FESS = functional endoscopic sinus surgery; mth = months

In a series of 86 patients, Weber *et al.* evaluated 51 individuals who were between two weeks and 130 months post-operative, using magnetic resonance imaging (MRI).[4] Mucoceles were detected in four patients, with one patient having two mucocele recurrences. The time interval between surgery and mucocele occurrence in this group ranged from 11 to 130 months. Post-operative MRI assessment of a smaller series of 13 patients found three mucoceles.[8]

Advances in angled endoscopes, endoscopic drilling and intra-operative stereotactic image guidance have led to a resurgence of interest in the Lothrop procedure. The endoscopic modified Lothrop procedure is an entirely endoscopic procedure which involves the removal of the floor of the frontal sinus, the intersinus septum and the superior nasal septum, creating the largest opening possible into both frontal sinuses. The advantages of this procedure are the lack of external scarring and the ability to examine the frontal sinus cavity endoscopically, although the procedure requires advanced endoscopic skills and is technically demanding, as operating through angled endoscopes can be disorientating. A thorough knowledge of frontal sinus anatomy and proper training are required, even with the assistance of intra-operative image guidance.[9,10]

Frontal osteoplastic flap versus modified Lothrop procedure

As the endoscopic modified Lothrop procedure is usually performed on an out-patient basis, it is generally cheaper than treatment requiring hospital admission. Gross *et al.* reported the cost advantage of the endoscopic modified Lothrop procedure over the frontal osteoplastic flap procedure with obliteration.[11] However, unlike the frontal osteoplastic flap procedure with obliteration, patients who undergo an endoscopic modified Lothrop procedure require frequent post-operative clinic visits to ensure patency of the frontal sinus opening, with toileting of the frontal sinus cavity to remove clots, crust, polyps and/or granulation. The additional cost of these clinic visits was not included in Gross and colleagues' cost analysis.

A systematic review by Scott *et al.* assessing the safety and efficacy of the endoscopic modified Lothrop procedure reported a CSF leakage rate of 6.7 to 11.1 per cent.[9] However, these rates were for a small series of patients ranging in age from nine to 20 years. More recently, Shirazi *et al.* reported a CSF leakage rate of 1 per cent in 97 patients undergoing an endoscopic modified Lothrop procedure, and Samaha *et al.* reported no intra-operative complications in a series of 100 patients (although 4 per cent suffered post-operative epistaxis).[10,12] Other complications reported for the endoscopic modified Lothrop procedure include transient blurring of vision, which in one study resolved spontaneously by post-operative day one.[11]

To stent or not to stent

Maintaining nasofrontal patency can be problematic following the endoscopic modified Lothrop procedure. Frontal sinus patency with control of symptoms was achieved in 80 per cent of 100 patients followed up for a mean of 4.1 years by Samaha *et al.*[12] Eleven per cent were treated with revision endoscopic modified Lothrop procedure, whilst the other 9 per cent proceeded to frontal osteoplastic flap with obliteration. The reasons for the different revision surgery

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approaches were not given. Tran *et al.* reported a series of 77 patients who underwent endoscopic modified Lothrop procedures and were followed up for a mean period of 29.2 months; of these, 22 patients had restenosis, nine of whom were symptomatic and required a revision endoscopic modified Lothrop procedure.[13] Tran *et al.* found that the intra-operative frontal ostium area had a significant influence on the size of the post-operative ostium, and also that the presence of eosinophilic mucin chronic rhinosinusitis was a predictive factor for restenosis and revision surgery.

The issue of whether to use stents to maintain frontal ostium patency has proponents on either side. Weber *et al.* performed a prospective study of 21 patients who underwent a Draf type II procedure and were followed up for 12–16 months post-operatively. Patients who were stented with a silicone stent for six months post-operatively were found to have a significantly higher patency rate.[14] However, no advantage was found in a retrospective study by Banhiran *et al.* observing the effect of stenting the frontal ostium with a rolled-up Silastic® sheet for two months following endoscopic modified Lothrop procedure.[15] Twenty-five patients received post-operative stenting while 39 did not, and there were no significant differences in long term frontal ostium patency or symptom improvement (mean follow up 22 months). Another suggested method of maintaining frontal ostium patency involves the use of topical mitomycin C. In a pilot study, Amonoo-Kuofi *et al.* reported a frontal ostium patency rate of 86 per cent in patients who had received a topical application of mitomycin C after revision FESS for a completely stenosed frontal ostium.[16] Repeated mitomycin C application was subsequently performed, either in the out-patients department or in the operating theatre during examination of the nose under general anaesthesia. Patients were followed up for a mean of 19 months and received one to three topical mitomycin C applications (mean 1.5; 0.6 mg/ml for 5 minutes).[16] Chan *et al.* performed a prospective, double-blinded, randomised, placebo-controlled study in which patients received one intra-operative application of either mitomycin C (0.5 mg/ml) or placebo, for 4 minutes.[17] They found no significant difference in frontal ostium patency. As the mitomycin C concentration and application time differed in these two studies, further research may be required to elucidate the effect, if any, of mitomycin C on frontal ostium patency.

When describing the outcomes of the endoscopic modified Lothrop procedure, authors acknowledge that the follow-up periods reported for this procedure are shorter than those reported for frontal osteoplastic flap and frontal sinus obliteration procedures, and that endoscopic modified Lothrop procedure success rates may therefore decrease with longer follow up. These authors argue that a lower success rate following endoscopic modified Lothrop procedure would be acceptable due to this procedure's reduced morbidity, and that the procedure does not preclude patients from undergoing further surgical procedures, including frontal osteoplastic flap with obliteration.[9,12] The general consensus is that the endoscopic modified Lothrop procedure may not replace the frontal osteoplastic flap with obliteration procedure, but may serve as an intermediate procedure in selected patients for whom FESS is the first option and frontal osteoplastic flap with obliteration the last.

Even so, the disease process or the anatomy of the frontal sinus occasionally lends itself to utilisation of a frontal osteoplastic flap without obliteration procedure as the first option, or as part of a combined endoscopic and external approach. Dubin *et al.* reported a series of six patients with frontal sinus inverted papilloma.[18] They reserved the frontal osteoplastic flap procedure for disease that extended into the lateral, far superior or anterior aspects of the frontal sinus, although patients with a narrow frontal recess (viewed on imaging) were also deemed less likely to have a successful endoscopic resection. Of the six patients, one was managed successfully with a frontal osteoplastic flap. The other five underwent endoscopic resection; three of these patients were deemed to require further resection via a frontal osteoplastic flap procedure, while two had early recurrences which were treated with frontal osteoplastic flap and endoscopic resection. The authors stressed the importance of the frontal osteoplastic flap without obliteration procedure in the patients who had undergone frontal osteoplastic flap procedures to enable visualisation of the sinus and detection of disease recurrence. Notably, none of Dubin and colleagues' patients underwent an endoscopic modified Lothrop procedure.

Herndon *et al.*[19] presented a series of 13 patients with extensive fronto-orbito-ethmoidal mucoceles. Orbital wall erosion was present in 92.3 per cent of patients and skull base erosion in 84.6 per cent. Four patients underwent endoscopic decompression of the mucocele, eight underwent frontal osteoplastic flap with obliteration and one underwent frontal osteoplastic flap without obliteration. Where undertaken, frontal osteoplastic flap procedures were performed in order to reconstruct the anterior frontal sinus wall.

- **The frontal osteoplastic flap procedure still has a role in frontal sinus surgery**
- **In this series of 10 patients, no major complications occurred, and minor complications (haematoma, forehead swelling and superficial discharging wound) resolved with conservative treatment**
- **Attention to surgical detail minimises potential complications**

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There have also been case reports of frontal osteoplastic flap procedures being utilised for access during treatment of extensive polyposis in patients with Samter's triad, in the presence of skull base dehiscence and extension of polyps into the extradural space.[20]

We have found the frontal osteoplastic flap procedure to be useful in the following situations: (1) laterally placed lesions (i.e. beyond endoscopic reach); (2) extensive tumours; (3) in the presence of exposed posterior wall dura; and (4) erosion of the anterior wall of the frontal sinus.

Conclusion

Advances in angled endoscopes, endoscopic drilling and intra-operative image guidance have led to an increase in the use of endoscopic access to the frontal sinus.

Even with current endoscopic techniques, certain anatomical and disease factors may be more suitably addressed using a frontal osteoplastic flap procedure with or without obliteration. The frontal osteoplastic flap technique has evolved since its first conception. Numerous minor modifications have improved the utility of the operation. It continues to have a role in modern rhinological practice.

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