Efficacy of the Modified Endoscopic Frontal Sinus Surgery for Recurrent Chronic Frontal Sinusitis

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Abstract To modify the endoscopic frontal sinus surgery and improve the therapeutic effect of recurrent chronic frontal sinusitis (RCFS). Eighty-five patients with RCFS were divided into two groups. Endoscopic frontal sinus surgery through an approach of Frontomaxillary Process-Agger Nasi, a modified Draf IIb procedure, was carried out in 51 patients (Group A), and conservative medication was applied in 34 patients as control (Group B). The therapeutic effect was prospectively evaluated with statistically validated measures of sinusitis-specific quality of life, sino-nasal outcome test-20 questionnaire (SNOT-20). Compared with pre-treatment, the average total score of SNOT-20 in RCFS patients was significantly decreased at the time of 6, 12 months after modified endoscopic frontal sinus surgery and medical treatments ($p < 0.05$). However, the total score of SNOT20 was significantly lower in group A than group B at the same period of the follow-up after treatments ($p < 0.05$). The overall efficacy evaluated by patients' self showed that the rate of "much improved" and "improved" was respectively 68.6 and 17.6 % in group A, and significantly better than group B ($p < 0.001$). Furthermore, the frontal sinus patency rate in group A was 85 %, and significantly higher than group B ($p < 0.001$). Endoscopic frontal sinus surgery through an approach of Frontomaxillary Process-Agger Nasi, a modified Draf IIb procedure, is an effective procedure to treat the RCFS.

Keywords Frontal sinusitis · Endoscopy · Sinus surgery

Introduction

A variety of surgical procedures had been described for the treatment of chronic frontal sinus disease before the introduction of endoscopic sinus surgery [1]. Those procedures flip-flopped from external to intranasal to external nose, including radical ablation procedures, intranasal and external frontoethmoidectomy [2]. However, these procedures have poor success rates.

The introduction of endoscopic sinus surgery techniques allowed for reestablishing ventilation and drainage with a maximized preservation of frontal sinus mucosa, and restoring the normal function of frontal sinus. The conventional endoscopic frontal surgery is able to deal with the majority of chronic frontal sinusitis. However, recurrent or persisted frontal sinus disease caused by scarring and stenosis has continued to challenge the surgeons. The high degree of anatomic variability presenting in the frontal recess and sinus or distorted intranasal landmarks by failed endoscopic surgery makes visualization difficult to this area from an intranasal approach [3, 4]. Therefore, alternative procedures are required to treat difficult frontal sinus diseases.

In the early 1990s, Draf procedures and endoscopic modified Lothrop procedure were found to be useful for management of difficult frontal sinus diseases with high success rates [5–7]. They have advocated the use of these procedures to treat complicated frontal sinus diseases. However, we have felt that these procedures are technically challenging for many ENT doctors. On the other hand, the extensive resection of bones around the frontonasal duct and anterior wall of the frontal recess sometimes leads to subsequent frontal recess stenosis.

Our endoscopic anatomic observation showed that the anterior-upper attachment of uncinate process can be

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clearly demonstrated after bone drillout of the frontomaxillary process, and the floor of frontal sinus can be observed after the careful removal of uncinate process and agger nasi air cells. This encouraged us to modify the Draf IIb procedure, and carry out endoscopic frontal sinus surgery trans-Frontomaxillary Process-Agger nasi approach (FPA) for patients with recurrent chronic frontal sinusitis (RCFS) in whom previous surgery has failed. It is a brief, less invasive revision endoscopic technique to create an adequate drainage of the frontal sinus.

Subjects and Methods

Patients

Eighty-five patients with RCFS were selected from Jan 2005 to Aug 2009 in Department of Otolaryngology-Head Neck Surgery, Third Xiangya Hospital of Central South University. This study was approved by the institutional review board in our hospital. There were 49 males and 36 females with an age range of 16–69 years old. All patients had been treated with previous at least one time bilateral endoscopic sinus surgery and underwent frontal sinus opening with Draf I or IIa procedure. Post-operative RCFS was diagnosed by symptoms of chronic frontal pain, findings of both polyps and scar under endoscope and on high-resolution axial and coronal CT Scans. 85 patients with RCFS were divided into two groups. First, physician introduced the following two therapeutic methods in detail for selected patients: modified frontal endoscopic sinus surgery (group A); conservative treatment (group B), including local steroidal nasal spray and oral low-dose macrolide antibiotics. Second, patients selected 1 of 2 treatments. Of 85 patients, 51 patients chose surgery, and 34 patients chose conservative treatment. Two patients were lost in group B due to changes in phone numbers and home addresses. The basic information of both groups was showed in Table 1. There is no significant difference in sex, age and history between groups ($p > 0.05$).

Surgical Procedure

The procedure of endoscopic frontal sinus surgery trans-FPA was performed with general anaesthesia or the lateral wall and anterior roof of the nose were infiltrated with 1 % lidocaine mixed with 1:100,000 adrenaline. The patient was positioned supine on the operating table with the head slightly lowered.

The operative procedure was conducted using imaging guidance via a wide-angle endoscope (0 degree, 4 mm). After an incision on the agger mucosa, separate the mucosa to expose the bone surface of frontomaxillary process and attachment of the middle turbinate. The bone of

Table 1 The basic information of RCFS patients

	Sex		Age	RCFS	
	Male	Female		Unilateral	Bilateral
Group A	32	19	42.6 ± 12.5	22	29
Group B	19	13	38.8 ± 14.7	15	17
$t(\chi^2)$ value	$\chi^2 = 1.125$		$t = 0.566$	$\chi^2 = 0.121$	
p value	0.289		0.214	0.724	

RCFS recurrent chronic frontal sinusitis

frontomaxillary process was directly drilled out upward between the orbital plate of the ethmoid bone and attachment of middle turbinate using angled diamond burs of OSSEODUO system (Bien Air, Swiss), and then the anterior-upper attachment of uncinate process and the agger cells were completely visualized. After any fragile partitions of uncinate process, frontal recess, agger cells and surrounds are removed with curettes or fine forceps under a direct visualization, the floor of frontal sinus was identified and resected by an angled diamond burs to create a more than 6 mm frontal drainage pathway (Fig. 1). These procedures permit a direct visualization of the anterior ethmoidal arterial canal and the mucosa of inferior portion of posterior and lateral wall of frontal sinus. Endoscopic management of the ethmoid, maxillary, and sphenoid sinus was then performed as necessary. In case of recurrent nasal polypus blocked the agger nasi, the polypus was removed previously, and then the above procedures were followed.

All patients underwent FPA endoscopic frontal sinus surgery had underwent a post-operative comprehensive management including cleaning of the operative cavity, nasal douche, medical therapy. The surgical results for all patients had been assessed for a minimum of 12 months after the operation.

Follow-Up

All patients were asked for clinic review at 1, 3, 6 and 12 months after initial treatment. In order to improve patient referral rates, specialist nurses regularly made telephone interview for all patients. During each clinic review, in addition to conventional examination of nasal cavity, each patient was required to complete the SNOT-20 questionnaire [8] for assessment of treatment effectiveness and quality-of-life (QOL).

The patients were also required to response to the global disease-specific QOL rating question at the end of the 12-month follow-up after operation, and responses included “Much-improved”, “Improved”, “Not improved”. “Much-improved”: that patient had been asymptomatic or mild symptoms after treatment, there was no impact on QOL; “Improved”: that symptoms were significantly improved, but QOL was still affected; “not improved”: that symptoms

Fig. 1 Schematic drawing showing nasal endoscopic frontal sinus surgery through an approach of frontomaxillary process-agger nasi. **a** Operation incision; **b** frontomaxillary process was removed;

c Frontal ostium was opened. *FS* frontal sinus, *UP* uncinate process, *MT* middle turbinate, *S* septum

were improved slightly or worsen, and seriously affected QOL.

Determination of Frontal Sinus Patency

The therapeutic results for all patients had been assessed for a minimum of 12 months after operation. Patency was confirmed by direct visualization and probing of the frontal opening under post-operative endoscopic examination (Fig. 2). Recurrence of symptoms with restenosis that required additional surgery was considered as a failure [9].

Statistical Analysis

Data are mean $\pm$ standard deviation. SPSS 13.0 statistical package was used for statistical analysis. *t* test and Mann–Whitney *U* test were used for comparative analysis of the scores of QOL and the overall efficacy of patients. $p < 0.05$ was set for statistically significant.

Results

Pre-Treatment Imaging Evaluations in 85 Patients with Recurrent Frontal Sinusitis

Evaluation by endoscopic examination and high-resolution CT scan showed that mucosal polyposis and scar of frontal recess in all patients, and 98 of 129 sides (75.9 %) accompanied with recurrent maxillary sinusitis, ethmoidal sinusitis and (or) nasal polypus, and residual supra-uncinate process and diseased agger nasi air cells presented in 124 sides (96.1 %) of 129 sides.

Dynamic Change of QOL Scores After Different Treatments

Rhinosinusitis-specific QOL was measured by SNOT-20 questionnaire at different time course in all 85 patients with RCFS. Compared with pre-treatment, the average total

Fig. 2 Endoscopic evaluation of pre-operation (**a**) and post-FPA endoscopic frontal sinus surgery (**b**) in patients with recurrent frontal sinusitis. *FP* Frontomaxillary process; *P* polyp, *MT* middle turbinate, *S* nasal septum, *FS* Frontal sinus, *EA* anterior ethmoid artery

Table 2 The total score and mean score of each item of SNOT-20 in patients with recurrent frontal sinusitis who underwent different treatments

Items	Baseline		6 months		1 year	
	A	B	A	B	A	B
Frontal pain/fullness	2.73 ± 0.54	2.69 ± 0.72	0.85 ± 0.84*	1.92 ± 0.96* [†]	0.79 ± 0.87*	1.89 ± 0.94* [†]
Need to blow nose	2.71 ± 0.52	2.75 ± 0.66	1.27 ± 0.63*	1.68 ± 0.87* [†]	1.26 ± 0.57*	1.95 ± 1.21* [†]
Thick nasal discharge	2.59 ± 0.57	2.68 ± 0.82	1.16 ± 0.71*	1.05 ± 0.95*	1.12 ± 0.69*	1.32 ± 0.75*
Postnasal discharge	2.57 ± 0.61	2.49 ± 0.57	1.07 ± 0.83*	1.84 ± 0.59* [†]	1.14 ± 0.94*	1.28 ± 0.63*
Dizziness	2.33 ± 0.71	2.45 ± 0.69	1.25 ± 0.69*	1.21 ± 0.79*	1.38 ± 0.74*	1.57 ± 0.95*
Sneezing	0.31 ± 0.47	0.26 ± 0.43	0.28 ± 0.43	0.35 ± 0.49	0.34 ± 0.51	0.39 ± 0.41
Runny nose	0.39 ± 0.42	0.45 ± 0.55	0.33 ± 0.39	0.59 ± 0.68	0.41 ± 0.44	0.44 ± 0.37
Cough	1.46 ± 1.12	1.68 ± 1.05	0.86 ± 0.73*	0.77 ± 0.69*	0.74 ± 0.68*	0.95 ± 0.45*
Ear fullness	1.16 ± 0.97	0.91 ± 0.88	0.89 ± 0.66	0.81 ± 0.63	0.66 ± 0.61*	0.79 ± 0.49
Ear pain	0.22 ± 0.41	0.33 ± 0.53	0.14 ± 0.36	0.42 ± 0.55	0.19 ± 0.43	0.28 ± 0.23
Difficulty fall asleep	1.83 ± 0.91	1.96 ± 1.09	1.15 ± 0.75*	1.51 ± 0.98* [†]	1.23 ± 0.86*	1.66 ± 0.87 [†]
Wake up at night	1.78 ± 0.83	1.45 ± 0.78	1.06 ± 0.73*	1.33 ± 0.84	1.24 ± 0.69*	1.41 ± 0.66
Lack of a good sleep	1.89 ± 0.61	1.93 ± 0.77	1.23 ± 0.82*	1.58 ± 0.97*	1.12 ± 0.71*	1.46 ± 0.91* [†]
Wake up tired	1.92 ± 1.64	1.69 ± 1.31	1.01 ± 0.92*	1.24 ± 0.88*	0.96 ± 0.84*	1.43 ± 0.82 [†]
Fatigue	1.94 ± 1.39	1.88 ± 1.25	0.79 ± 0.47*	1.34 ± 0.72* [†]	0.62 ± 0.43*	1.38 ± 0.69* [†]
Reduced productivity	1.64 ± 0.78	1.81 ± 1.19	1.03 ± 0.82*	1.25 ± 0.93*	0.92 ± 0.57*	1.54 ± 0.94 [†]
Reduced concentration	1.75 ± 0.96	1.91 ± 1.26	0.74 ± 0.34*	0.98 ± 0.54*	0.79 ± 0.49*	1.33 ± 0.73* [†]
Frustrated/irritable	1.69 ± 1.51	1.47 ± 1.48	0.61 ± 0.48*	1.02 ± 0.67* [†]	0.58 ± 0.53*	1.17 ± 0.62 [†]
Sad	0.68 ± 0.39	0.56 ± 0.69	0.28 ± 0.51*	0.43 ± 0.45	0.33 ± 0.41*	0.39 ± 0.34
Embarrassed	0.89 ± 0.82	0.48 ± 0.75	0.49 ± 0.55	0.51 ± 0.48	0.38 ± 0.43*	0.44 ± 0.28
Total score	32.5 ± 7.8	31.8 ± 9.1	16.5 ± 7.0*	22.4 ± 6.5* [†]	16.2 ± 6.8*	24.5 ± 6.1* [†]

A Group A, B Group B

* Compared with the score of baseline, $p < 0.05$; [†] Compared with the score of group A, $p < 0.05$

score of SNOT-20 in patients with RCFS was significantly decreased at 6 and 12 months after FPA-endoscopic sinus surgery or the conservative medication (Table 2, $p < 0.05$). However, it was significantly lower in group A than group B at the same time of the follow-up after treatments ($p < 0.05$). It indicated that FPA endoscopic frontal sinus surgery could significantly improve the symptoms and QOL of RCFS (Table 2).

The Overall Efficacy of Patients Who Underwent Different Treatments by Patient's Self-Evaluation

All patients were required to make subjective judgments on the efficacy at the end of the 12-month follow-up. The results showed that the rate of “Much improved” and “Improved” was respectively 68.6 % (35/51) and 17.6 % (9/51) in group A, 21.9 % (7/32) and 34.4 % (11/32) in group B. However, the rate of “Not-improved” was 13.7 % (7/51) in group A and 43.8 % (14/32) in group B. The Mann–Whitney test was used for comparison analysis, and results demonstrated that the efficacy of surgical treatment were better than the conservative medication ($Z = 3.854$, $p < 0.001$, Fig. 3).

Sinus Patency Rate After Operation

At the end of the 12-month follow-up, the patients in both group A and B were evaluated by nasal endoscopy. The frontal sinus patency rate was achieved in 85 % of patients (68 of 80 sides) in group A, and only 26.5 % (13 of 49 sides) in group B. The patency rate in group A was significantly higher than group B ($\chi^2 = 5.371$, $p < 0.001$). The rate of restenosis of the frontal opening was 15 % (12 of 80 sides) in group A. There were neither intraoperative nor postoperative severe complications in surgical group.

Discussion

The frontal recess is adjacent to numerous air cells present there. Its patency is a critical in the treatment of frontal rhinosinusitis. However, the high degree of anatomic variability presenting in this area usually makes frontal surgical operation difficult. Agger nasi air cells are considered to be the most anterior ethmoid air cells and originate in the superior aspect of the infundibular groove and form the anterior wall of the frontal recess. The variability of agger

Fig. 3 The overall efficacy of FPA endoscopic frontal sinus surgery in patients with RCFS. **a** patients underwent FPA endoscopic frontal sinus surgery; **b** patients was as controls

air cells contribute to the variability of the anatomy of the frontal recess. The importance of agger nasi air cells has been extensively noticed in chronic frontal sinusitis and endoscopic frontal surgery. Enlargement of agger nasi air cells can lead to narrowing of the nasofrontal duct and frontal recess stenosis [10]. Agger nasi air cell disease has been associated with chronic frontal rhinosinusitis and frontoethmoidal pain and patients with agger nasi encroachment on the nasofrontal duct are twice as likely to require surgical treatment [11]. The most common cause of primary sinus surgery failure was residual air cells in the ethmoid and frontal recess region [12]. Bradley's data indicated a significant association between patients requiring revision sinus surgery for frontal rhinosinusitis and agger nasi air cell disease [13]. Our data show that mucosal polyposis of frontal recess presented in all patients, and residual supra-uncinate process and diseased agger nasi cells in 96 % of patients, which might play important role in recurrence of frontal sinusitis. Therefore, complete cleaning of these residual air cells and uncinate process is critical to allow a better drainage of frontal sinus.

Endoscopic frontal sinus surgery usually consists of an anterior ethmoidectomy and clearing of agger nasi cells within the frontal recess. The frontal sinus patency can be achieved by merely exposing the natural sinus ostium with only a rare need to enlarge it [14]. This procedure usually has the superior attachment of uncinate process and supra-infundibular plates as the most important landmarks [4, 15, 16]. However, the anatomical structures and landmarks can be compromised by severe polypoid lesions in anterior ethmoid sinus or by previous surgery or by postoperative scarring. Therefore, alternative procedures have been reported by Draf, May, Becker, Gross [17, 18] to treat these

complicated frontal diseases. These endonasal techniques were used to remove the floor of the sinus or/and inter-frontal septum to reestablish a large endonasal drainage for the frontal sinus. Success rates of these procedures varied in a large range as reported. In our present study, FPA endoscopic frontal surgery, a modified Draf IIb procedure, can proceed ignoring these anatomic landmarks, directly drill out frontomaxillary process to enter a narrow space containing anterior-upper attachment of uncinate process, agger nasi air cells, frontal recess. These variable structures can be easily removed by using fine forceps or curettes without extensive resection of bone and mucous membrane, to expose the floor or inferior portion of frontal sinus, and create a patent drainage pathway. This technique offers several advantages in that it preserves the anterior-upper attachment of middle turbinate and mucous epithelia in the medial and posterior wall of the frontal ostium, create an adequate drainage pathway of frontal sinus, and allows re-mucosalization, which helps to prevent scarring, granulation, and restenosis.

Here, we also demonstrated the efficacy of FPA endoscopic frontal sinus surgery in RCFS patients through a prospective case–control study. The QOL of patients was significantly improved by FPA endoscopic frontal sinus surgery or medication. However, the average total score of SNOT-20 in surgical group was significantly lower than medication group at 6 and 12 months after treatments. The overall efficacy of frontal sinus surgery showed that the rate of “Much improved” and “Improved” was 68.6 and 17.6 %, and significantly better than the medication group. Furthermore, the frontal sinus patency rate in patients who underwent FPA frontal sinus surgery was also significantly higher than controls. These results suggested that FPA endoscopic frontal sinus surgery is an effective method for RCFS.

Conclusions

Endoscopic frontal sinus surgery through an approach of FPA, a modified Draf IIb procedure, is a brief, less invasive endoscopic procedure to treat the RCFS.

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Conflict of interest None.

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