

Management Algorithm for Delayed Complications of Frontal Sinus Fractures

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ABSTRACT

Introduction: Patients presenting with delayed complications after primary management of Frontal Sinus Fracture (FSFr) are increasing considerably due to delayed primary management and/or new trends to preserve frontal sinus. Delayed complications of frontal sinus fractures could be aesthetic, functional or combined. This study aims to set a protocol for management of delayed frontal sinus complications after primary management of Frontal Sinus Fracture.

Patients and Methods: Seventeen patients presenting to the Plastic Surgery out-patient clinic at Ain-Shams University Hospitals between January 2012 and January 2015 with delayed complications were examined and new CTs were done and analysed. Management was done according to the designed algorithm. Patients presented with contour deformities were subjected to camouflage procedures. Patients with chronic sinusitis/chronic headache were managed medically. Frontal sinus obliteration was chosen to manage cases presenting with mucocele/pyocele and an intact posterior table. When the posterior table was involved cranialization of the frontal sinus was done. Management of cases presenting with both aesthetic & functional complications depend on the presence of signs of infection. In absence of frank signs of infection, cranialization along with removal of osteomyelitic bones and cranioplasty was done in one setting. In presence of frank signs of infection, cranialization then six months later cranioplasty was done.

Results: All contour deformities were corrected with minimal asymmetry. Chronic sinusitis patients showed transit improvement on medical treatment and anti-migraine medications for longer periods. Mucocele and mucopyocele patients showed dramatic improvement of pressure symptoms after sinus obliteration or cranialization. Mucopyocele needed longer duration of antibiotics. Combined cases with frank signs of infection suffered of aesthetic deformity postoperatively after first stage till it was corrected later with a cranioplasty procedure. There were no major postoperative complications for patients in all groups and no recurrence of mucocele or mucopyocele. Patient satisfaction; 13 patients (76.47%) were highly satisfied, 3 patients (17.64%) were moderately satisfied and 1 patient (5.88%) mildly satisfied.

Conclusion: Effective primary management of fractures of the frontal sinus is important to avoid occurrence of delayed complications. An algorithm for management of delayed complications of fractures of the frontal sinus is presented. Eradication of pathology is crucial to treat mucocele, pyo-

cele, and osteomyelitis. Camouflage can be used to correct contour deformities.

Key Words: Algorithm – Frontal sinus – Fractures.

INTRODUCTION

Frontal Sinus Fractures (FSFr) represent only 5-12% of all facial fractures. The frontal bone is not prominent as nasal bones and need high-energy trauma to be fractured. They are commonly associated with other facial fractures [1,2]. Although frontal sinus fractures incidence is less than other facial fractures; the number of patients presenting with delayed complications after primary management is increasing considerably. In severely traumatized patients, other associated injuries as brain, cardiothoracic and/or abdominal injuries; may commonly delay the definitive management [3]. This delay of interference may affect the outcome adversely [4,5].

General goals of FSFr management are isolation of brain, correction of CSF leakage, restoration of frontal sinus function without increasing infection rates, and restoration of the aesthetic frontal contour [6]. Debatable approaches are suggested for frontal sinus fractures management with pros and cons to avoid severe complications [7-10].

The involvement of the Nasofrontal Outflow Tract [NFOT] in the primary injury is present in 13 to 55% in the primary injury [2,5]. This could increase the risk for occurrence of delayed complications. Determining the patency of the NFOT is vital in choosing the treatment options. NFOT involvement is not always detectable with CT imaging. NFOT injury is strongly suspected when the CT scan shows involvement of the frontal sinus base, frontal recess or, anterior ethmoid complex. Unrecognized frontal recess injury has been thought to occur in more than a third of frontal sinus trauma

and it commonly results in long-term sequelae [11-13]. Stanwix et al., 2010 found that (98.5%) of all patients with complications had NFOT injury [13].

Traditional management of FSFr is done according to severity, CSF leakage, involvement of anterior and posterior walls and NFOT. In severe posterior wall fracture, sinus obliteration or cranialization is recommended. In the case of a severely displaced anterior wall fracture, reconstruction of anterior wall is indicated to prevent contour changes [14-16]. Recently there is a tendency to preserve frontal sinus which may increase risk for occurrence of complications. Sinus preservation can be considered in selected patients with frontal sinus fractures. Selection criteria include, minimally displaced fractures of anterior wall; non displaced or minimally displaced posterior wall without significant intracranial injury or persistent CSF leak which were traditionally cranialized; displaced anterior wall fractures with suspected NFOT involvement which were traditionally obliterated; and displaced anterior and minimally displaced posterior wall fractures without significant intracranial injury or persistent CSF leak which were traditionally obliterated or cranialized [11].

These newly evolved sinus preservation concepts along with delayed primary management due to associated injuries resulted in an increase in the presentation of delayed complications that can be devastating and life threatening [12,13]. Damaged frontal sinus mucosa with blocked frontonasal duct has a potential to develop into a mucocele. Mucoceles have a tendency to slowly erode through bone into the orbital cavity or into the cranial cavity. Frontal sinus mucoceles may present years after the original trauma. The interval between the initial injury and the presenting signs and symptoms may range from few months up to 50 years [14,15].

In this study, a classification of the delayed complications after primary management of FSFr is presented and an algorithm for management is suggested.

PATIENTS AND METHODS

This study was conducted during the period between January 2012 and January 2015 and included seventeen patients presenting to Plastic Surgery Outpatient clinic at Ain Shams University Hospitals with history of FSFr and delayed complications at least six months after primary management. They were 16 males and 1 female. Their ages ranged between 19 and 54 (mean age was 32.5). The primary injury was caused by blunt

heavy trauma due to RTA, assault, fall from height, explosions and industrial accidents (Table 1). Data and radio-images of primary injury and primary management were retrieved and reviewed from medical records. Fifteen (88.2%) patients had associated injuries. Eight patients had fracture of anterior table of frontal sinus. Nine patients had both anterior and posterior tables (Table 2). Twelve (70.5%) cases had primary management within the first week. Five (29.5%) cases had delayed interference 1-3 weeks after trauma. Radiological findings suspecting (NFOT) involvement were found in 11 patients. Two of the eleven patients had isolated anterior table fracture and were managed conservatively. Nine patients had involvement of both anterior and posterior tables and were managed conservatively due to bad general condition and associated injuries.

Clinical examination was carried out, standard medical photographs were taken, new CTs were done and analysed for aeration, function of the sinus and NFOT. Every patient has signed a formal consent. Consultation of neurosurgery is done whenever an intracranial approach was planned. Six patients had aesthetic complications and their original trauma was isolated anterior table fractures. Eleven patients had functional or combined complications; nine of the eleven patients had both anterior and posterior tables of frontal sinus involved.

Surgical technique:

Patients were divided into three main groups; Group A with aesthetic problems, Group B with functional problems and Group C with combined aesthetic and functional problems. Each group is managed according to the designed algorithm Fig. (1). Table (3) shows patients' numbers and surgical technique in each group.

Group A: (Aesthetic problems):

Patients presenting with only contour deformities and a well aerated functioning sinus were subjected to camouflage procedures using; dermofat graft, fat graft, bone graft or bone substitute. Since no intervention was done directly to the sinus, all patients were instructed to abstain from smoking and be followed-up annually for life should any late complications related to sinus mucosa may occur. Three patients were treated by lipo-injection and in one of them it was repeated twice to reach a satisfactory contour. One patient underwent scar subcision and dermofat grafting. On-lay bone grafting was used in one patient and bone substitutes (bone cement, and methyl methacrylate) in the other patient.

*Group B: (Functional problems):**Chronic sinusitis/chronic headache:*

Patients were referred to ENT for medical management. Antihistaminic medications were prescribed and migraine medications were advised during severe headache episodes.

Mucoceoles and mucopyoceoles:

Frontal sinus obliteration or cranialization was planned for such patients. Surgical access was done through the already present scars (located at forehead or coronal) or through a new coronal approach. To access the frontal sinus, transcranial approach or direct approach was used to remove the anterior wall of frontal sinus. Elevated bones were repositioned and fixed.

Mucoceole/mucopyoceole with intact posterior table:

Frontal sinus obliteration was the chosen manoeuvre. It was done in four cases. The frontal sinus was directly approached through the involved anterior table and the mucus membrane was removed while ensuring its removal from difficult areas in the recesses using small size burrs. A pedicled pericranial flap was used to fill and obliterate the frontal sinus. The nasofrontal duct orifice was occluded with bone over the pericranial flap. The sinus was obliterated by tucking-in cancellous bone as obliterating material. Patients received antibiotics according to culture and sensitivity results that were done for the debrided tissues.

Mucoceole/mucopyoceole with involved posterior table:

Cranialization of the frontal sinus was done in three cases. The whole mucoceole was removed through intracranial approach. The inner aspect of the anterior wall was curetted with small size burr, the posterior wall was removed and the nasofrontal duct was occluded with bone. The dural integrity was confirmed by the neurosurgery team. Any defects of the anterior table were corrected by bone grafting. Patients received antibiotics according to the results of culture and sensitivity that was done for the debrided tissues.

Group C: (Combined aesthetic and functional problems):

In the absence of frank signs of infection, the osteomyelitic bone was debrided with removal of any hardware, along with occlusion of the duct and cranialization followed by cranioplasty at the same setting. In cases with signs of acute infection with or without discharging sinuses; two-staged procedure was planned. The first stage included;

removal of infected hardware, debridement of the osteomyelitic bone, and occlusion of nasofrontal duct opening with bone and pericranial flap. Patient was followed-up for 6 months and may use antibiotics for a long period. The second stage included cranioplasty to correct contour deformities.

Follow-up: Patients were followed-up with a minimum of twelve months. Patient satisfaction as regards resolution of symptoms and correction of contour deformities was measured by using a scale from [1 to 4] being [4] highly satisfied, [3] moderately satisfied, [2] mildly satisfied and [1] dissatisfied.

RESULTS*Contour deformities:*

All contour deformities were camouflaged with minimal asymmetry that was highly accepted by all patients. Improvement of cosmetic appearance occurred in all 6 patients. All patients gave score [4] denoting high satisfaction. Fig. (2) shows improvement of contour deformities using fat graft. Fig. (3) shows improvement of contour deformities using rib with attached costochondral graft. Fig. (4) shows improvement of contour deformities using bone substitute.

Chronic sinusitis/chronic headache:

Chronic sinusitis patients (n=2) showed transient improvement on medical treatment, which dictated prescription of actual anti-migraine medications for longer periods. One patient was moderately satisfied while the other one was mildly satisfied.

Mucoceoles/mucopyoceoles:

All patients with mucoceole or mucopyoceole showed dramatic improvement of pressure symptoms after sinus obliteration or cranialization. Fig. (5) shows one patient with mucoceole that eroded into the orbital roof causing left-sided proptosis and pressure effect disrupting the visual field. Removal of mucoceole that was attached to the left periorbita and dura at one part was carried out through an intracranial approach. Reconstruction of orbital roof was done by split calvarial bone graft along with elimination of the sinus and obliteration of the NFOT. Two weeks following surgery, the degree of proptosis was almost negligible. The visual field was restored almost completely in one month. Mucopyoceole needed longer duration of antibiotics administration after culture and sensitivity. Six patients were highly satisfied and one patient was moderately satisfied.

Combined contour deformities with frontal bone osteomyelitis:

Patients had removal of all pathologic tissues with sinus obliteration. The aesthetic deformity was corrected with cranioplasty procedure in the same session in one patient Fig. (6). This patient was highly satisfied. Another patient presented with acute suppurative skin sinuses; debridement and cranialization were done as a first stage. This is followed by cranioplasty procedure 6 months later. This patient was moderately satisfied.

There were no major postoperative complications for patients in all groups. Also, there was no recurrence of mucocele or mucopyocele. Postoperative CT in cases with cranialization showed that the brain is replacing the frontal sinus with no complications. Overall satisfaction was high as;

13 patients were highly satisfied, 3 moderately satisfied and only one patient was mildly satisfied.

Table (1): Incidence of aetiology of FSFs.

No. of patients	Aetiology
10 (58.8%)	RTA
3 (17.6%)	Assault
2 (11.7%)	Fall from height
1 (5.8%)	Explosions
1 (5.8%)	Industrial accidents

Table (2): Patients' descriptive data.

No. patients (%)	Affected table
8 (47%)	Anterior table fractures
9 (53%)	Both anterior and posterior table fractures.

Table (3): Management of patients in different groups.

Group	Problem	Management	Patients no
A [6 patients]	• Contour deformity	• Fat grafting • Subcision and dermofat • On lay bone graft • Bone substitutes	3 1 1 1
B [9 patients]	• Mucocele and mucopyocele • Chronis sinusitis/chronic headache	• Obliteration • Cranialization • Medical treatment	4 3 2
C [2 patients]	• Frontal bone osteomyelitis and contour deformity	• Debridement, obliteration of nasofrontal duct opening and cranioplasty	2

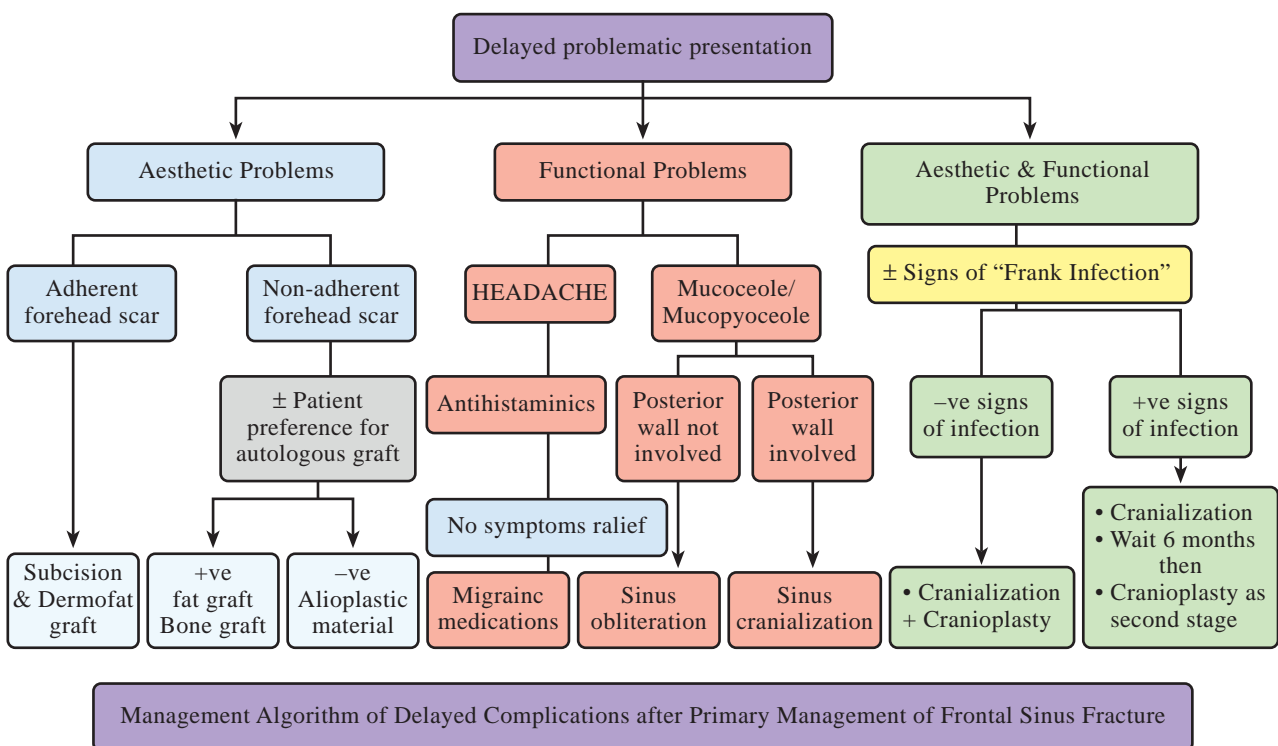
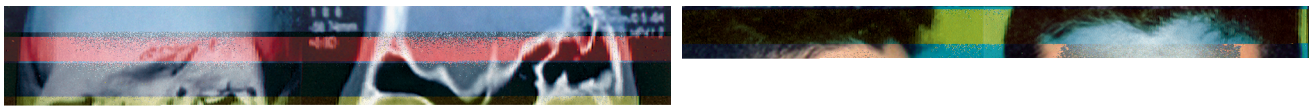
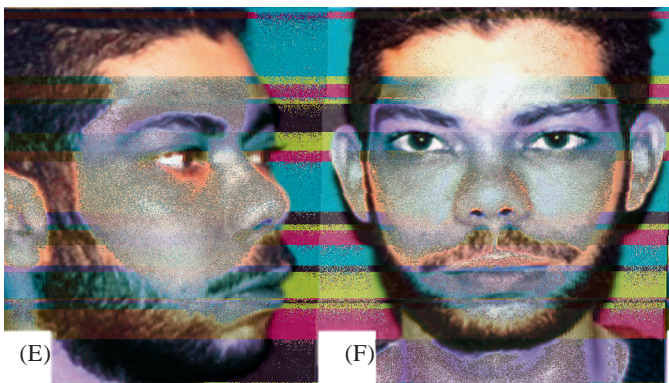


Fig. (1): Algorithm of management for delayed complications of frontal sinus fractures (FSFRs).



(A) (B) (C) (D)



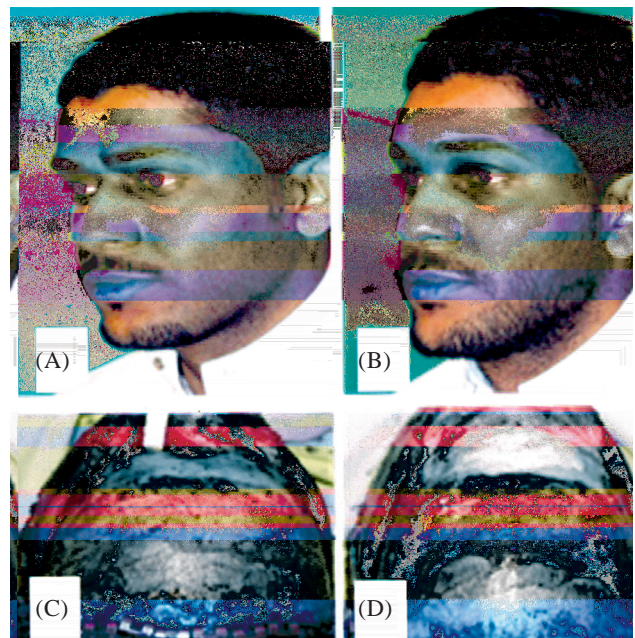
(E) (F)

Fig. (2): 26-year-old male with old fractures of the frontal sinus involving only the anterior table and left-sided NOE whom refused any major surgery and was camouflaged by lipoinjection. (A) Preoperative 3-D CT demonstrating the bony deformity. (B) Coronal cut CT demonstrating a well aerated & functioning sinus. (C,D). Preoperative photos showing obvious deformity seen on oblique lateral and frontal views respectively (E) Oblique lateral view showing the corrected depressed glabellar region following properly executed lipofilling. (F) Frontal view following lipofilling camouflaging of the underlying bony deformity, asymmetry and apparent left-sided telecanthus.



(A) (B) (C) (D)

Fig. (3): 19-year-old male with old fractures of the frontal sinus involving only the anterior table was camouflaged by rib graft with the attached costal cartilage. (A) Preoperative photo showing obvious deformity seen on frontal view. (B) Postoperative frontal view following bone graft camouflaging the underlying bony deformity. (C) Preoperative 3-D CT scan showing the frontal bone depression. (D) The rib graft with attached and costal cartilage sculptured for proper correction of the depressed glabellar region with the adjoining nasal dorsum.



(A) (B) (C) (D)

Fig. (4): (A) Patient with contour deformity as a delayed complication of frontal sinus fracture (B) Postoperative corrected deformity. (C,D) Intraoperative application of bone substitute.

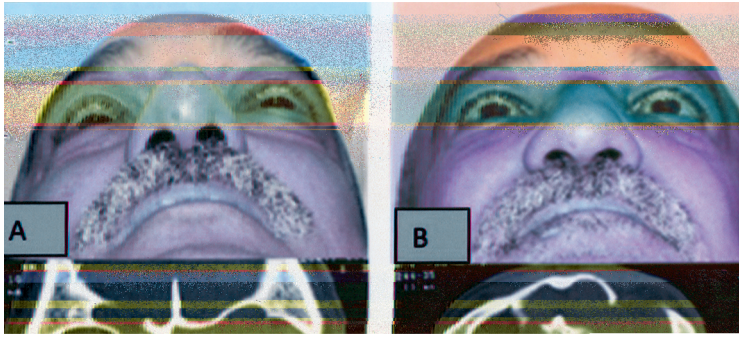


Fig. (5): 54-year-old patient with mucocoele following old frontal sinus fracture that was treated conservatively and underwent twice unsuccessful endoscopic frontal sinusotomy to drain it a few years later. (A) Preoperative worm's eye view demonstrating left sided proptosis. (B) Post-operative worm's eye view demonstrating correction of left eye proptosis. (C,D) CT coronal and axial cuts showing destruction of the frontal sinus walls and intra-orbital extension of the mucocoele (E,F,G) show steps of sinus duct obliteration. (H) The wall of mucocoele being peeled of the inner walls of the sinus that are seen eroded. (I) final result after recapping and fixation of the cranial vault.

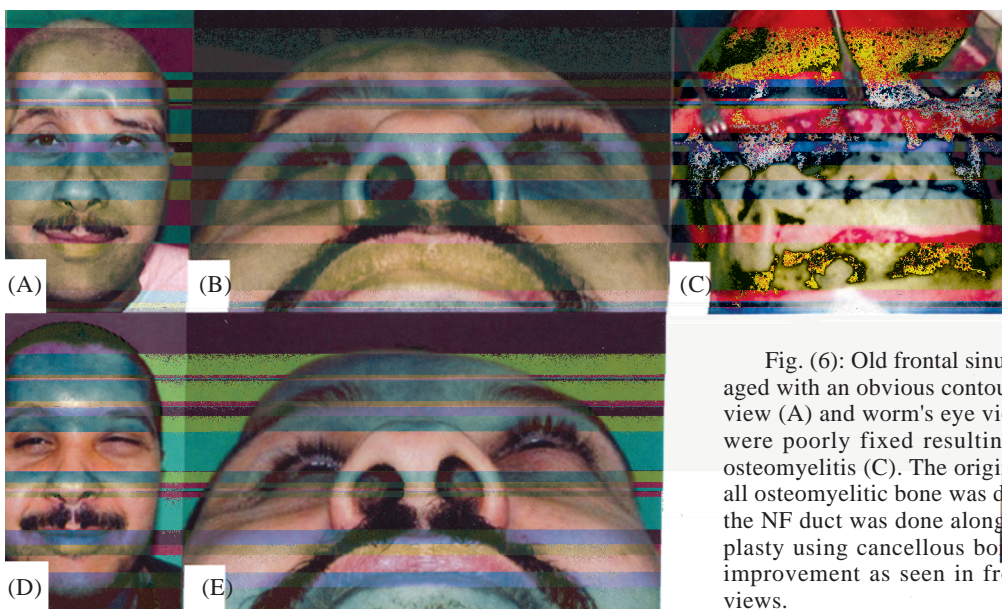


Fig. (6): Old frontal sinus fracture that was mismanaged with an obvious contour deformity seen on frontal view (A) and worm's eye view (B). The bone segments were poorly fixed resulting in loss, irregularities & osteomyelitis (C). The original hardware was removed, all osteomyelitic bone was debrided, and obliteration of the NF duct was done along with simultaneous cranioplasty using cancellous bone grafts resulting in great improvement as seen in front (D) & worm's eye (E) views.

DISCUSSION

Early complications of FSFr s are treated during the definitive management period and include CSF leak, traumatic brain injury, meningitis, pneumocephalus that result from the primary injury [12,13]. On the other hand, delayed complications of FSFr occur few months later and may lead to devastating consequences or even life threatening conditions. They are mostly due to mismanagement of the primary injury. Prevention of delayed complications is achieved by the proper and sound primary management as it is considered the first defending line against the occurrence of such problems. There was no definite algorithm for management of delayed complications yet.

Primary FSFr surgery depends on the presence of Nasofrontal Outflow Tract (NFOT) involvement. Determination of NFOT obstruction remains the cornerstone of management. If there is strong suspicion of NFOT involvement; exploration and sinus obliteration are highly recommended. Most craniofacial surgeons consider frontal sinus obliteration as the procedure of choice and as a long term safer approach in management of FSFr with NFOT involvement [7,16-21].

A recent concept of frontal sinus preservation aims at keeping a normally ventilated sinus cavity as one of the primary goals in frontal sinus injury management; in addition to restoration of facial aesthetics, and prevention of delayed complications. Smith and colleagues (2002) criticized sinus obliteration and claimed that patients may suffer from chronic forehead pain and difficult sinus radiographic evaluation. They stated that radiography in post-obliterated sinus; may fail to differentiate between fat remodelling and occurrence of mucocele and/or chronic sinusitis [22].

Similar to Manson, we do not fully agree with the concept of sinus preservation and believe that it is a bad idea, which might have a very limited application during the primary management of FSFr [23]. Our priorities of surgical intervention are; first to prevent delayed complications, second to restore facial aesthetics and the least is to preserve sinus function. Sinus preservation should be discouraged, with possible risks of delayed complications such as mucocele or pyocele. It also needs a longer period of follow up with frequent CT images to check sinus ventilation and detect complications. Endoscopic intervention has been advocated with incomplete ventilation [11,22,24].

One of the patients in this series underwent endoscopic frontal sinusotomy twice to drain a

frontal sinus mucocele and preserve the sinus. His symptoms persisted and the mucocele recurred. Endoscopic frontal sinusotomy was described in sinus surgery literature [25,26]. However, we do not agree with authors who considered frontal sinusotomy to be the first line of management and as an effective technique to drain mucoceles [27-33]. Recurrence is a worrisome risk. Endoscopy needs; compliant patient, longer duration of medications and follow-up with multiple visits and frequent radiological and endoscopic evaluation. In our study, one patient refused third session of frontal sinusotomy; in spite being less invasive than surgery. So, obliteration was the treatment of choice after failed endoscopy. Biglioli et al., treated severe combined cases using free flaps to reconstruct anterior skull base after recurrent mucocele [34]. More studies are needed to standardize protocol of management for recurrent cases; but paucity in number of cases may be an obstacle.

Surgical management of mucoceles and pyoceles was recommended to be either obliteration or cranialization to decrease incidence of recurrence. Obliteration of the sinus with preservation of the posterior wall should be done after meticulous removal of the sinus mucosa and permanent closure of the frontonasal ostium. The obliterating material varied between natural and synthetic materials [35-38].

Similar to previous studies [7,16-21], sinus obliteration was done in this study for cases of mucocele/pyocele without involvement of posterior wall. A percranial flap was used to separate the nasal cavity from the frontal sinus cavity and bone chips were used for plugging of nasofrontal ostium and cavity filling. In case of injured frontal pericranium; bone chips were used for plugging and filling over a percranial graft. Sinus cranialization was done in cases of mucocele/pyocele with involved posterior wall. The posterior wall was removed and separation of the nasal cavity and the paranasal sinuses from the brain with a vascularized percranial flap. It is not expected to preserve sinus function in both techniques.

Patients presenting with aesthetic problems/ contour deformities were offered camouflage procedure provided they had a functioning and well-aerated sinus and agreed to be followed up annually for life. Their fracture displacement was more than 4mm upon reviewing their original CTs taken at time of primary injury, which was consistent with study done by Kim et al., [39]. Several materials were used in this study for camouflage. Choice of the used material for camouflage depends on the deformity and patient's preferences. Subcision and

dermofat graft is ideal in the presence of an adherent scar and the patient was not concerned about the scar of the dermofat graft donor site. The only female patient in this study preferred fat grafting. Slim patients especially males might not be the ideal candidates for fat grafting. Other options were proposed for these patients including bone graft. Bone substitutes were chosen when the patient refused donor site morbidity and they had the advantage of less operative time.

In combined cases with aesthetic and functional problems; surgical plan depends on presence or absence of signs of infection. Sinus cranialization and immediate cranioplasty was done when there are no signs of frank infection. Late cranioplasty was postponed for six months in infected cases. Similar to previous studies; patients' satisfaction was also delayed until they gain accepted cosmetic outcome [40,41].

All patients were highly satisfied of the surgical outcome. During our study period no recurrences were encountered other than that patient. However, it is recommended that the algorithm expands to include recurrent mucocele cases. We do not interfere surgically with chronic headache caused by chronic sinusitis. The two cases were referred to ENT specialist who prescribed analgesics, steroids, and anti-histaminics.

Conclusion:

Effective primary management of FSFr is a key in avoiding the occurrence of serious delayed complications. Evolution of sinus preservation might increase risk of such complications. The literature discussed the delayed complications individually. In this study we present an algorithm for management of delayed complications of FSFr. Eradication of pathology is crucial to treat mucocele, pyocele, and osteomyelitis. Camouflage is applied only to correct contour deformities in the presence of a functioning and well-aerated frontal sinus.

Disclosure:

There is no conflict of interest.

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