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COMPARISON FOR THE COMPLICATION RATE WITH THREE DIFFERENT MATERIALS USED IN FRONTAL SINUS OBLITERATION

Hesham Fattouh*

ABSTRACT

Aim: The aim of the current study was to evaluate the complications rate after frontal sinus obliteration following trauma with the use of each one of the following graft materials separately; abdominal fat, autogenic iliac bone, or hydroxyappaite cement.

Patients and Methods: This study included 11 patients who is indicated for FS obliteration after frontal bone trauma, patients were divided into three groups according to the intended material to be used in FS obliteration; group I (Autogenous fat group) included four patients where the FS is obliterated with freshly harvested autogenous abdominal fat, group II included four patients and the sinus is obliterated with autogenous bone (bone group), while group III (hydroxyapatite group) included three patients where FS obliteration done with hydroxyapatite (HA) cement.

Results: All the used materials for FS obliteration showed comparable results with high success rate and low rate of complications with no significant differences between them, most of the complications that happen were transient and were categorized as minimum to moderate.

Conclusion: Autogenous fat, HA cement and autogenous cancellous bone are perfect materials to obliterate the FS. The benefits of HA cement include the lack of donor site morbidity and the ability to reconstruct the anterior table, however with an additional cost compared with autogenous grafts.

KEYWORDS: Frontal sinus obliteration, Fat, Hydroxyapetite, Trauma, Complications.

* Associate Professor, Oral and Maxillofacial Surgery Department, Faculty of Oral and Dental Medicine, Cairo University.

INTRODUCTION

5–15% of all maxillofacial fractures are frontal sinus (FS) fractures, it is usually associated with physical attacks or motorcycle accidents where the force of the impact extends past the anterior table to affect the posterior table and also the frontal sinus. Involvement of the anterior and posterior tables, with or without the FS, are the most typical pattern of these fractures (67%) [1]. The FS being aerated region in the midline of the upper part of the facial skeleton, is considered as a "crumple zone", shielding the inner cranial components [2-3].

Options for management of FS fractures ranges from observation, open reduction and internal fixation for the fractured bone of the anterior table till FS obliteration and cranialization in severe cases[4]. Recognising the anticipated result for certain complication is crucial to determine the specific surgical indications [5]. Proper treatment depends on a precise diagnosis using physical examination, computed tomography (CT) and data obtained from intraoperative exploration, isolated anterior table fractures with no or little displacement (1-2 mm) are usually managed non surgically with local wound care and analgesics, as they hardly ever cause aesthetic or functional disability, on the other hand, surgery is necessary for displaced fractures that are more than 1-2 mm in size for isolation of intracranial contents, infection prevention, correction of cerebral spine fluid (CSF) leakage and restoration of facial aesthetics and contour[6], however; there are currently no conclusive studies on the most effective materials to use for FS obliteration, which is the topic of the most frequent debate related to FS trauma as it is challenging to obtain long-term follow-up on trauma in patients with FS fractures [7]. In general, autogenous bone, fat and various alloplastic materials are being used in FS obliteration [8-9].

FS obliteration with autogenous abdominal fat was first done by Bergara and Tato et al.[10], **Goodale and Montgomery** then made the osteoplastic flap technique in combination with fat obliteration as the standard method for managing difficult and challenging FS fractures. Montgomery stated that the complication rate in FS obliteration utilizing fat was 18%, including, morbidity of the donor site, wound complications, necrosis of fat, postoperative infections and chronic sinusitis [11].

Utilizing bone as a donor site in FS obliteration has the advantage of favourable aesthetic results. A study done on 11 patients who had FS obliteration with autogenous bone graft between 2005 and 2011, on outcome assessment, all patients showed improvement without any residual symptom [12].

The absence of donor site morbidity and time required to harvest the autograft are the primary benefits of employing synthetic materials in FS obliteration over autografts, a variety of materials can be used as; tricalcium phosphate, Glass ionomer cement and hydroxyapatite (HA) cement [13]. HA cement is easily mouldable and contourable with a favourable tissue interaction and rapid setting time in only fifteen minutes and hardens completely to solid HA in average four to six hours [14]. Dental augmentation, obliteration of the FS and reconstruction of other cranial abnormalities are among the reported uses of HA cement, which has been successfully utilised to contour and shape a variety of skull deformities, such as the fronto-facial skeleton reconstruction [15].

FS fractures are relatively uncommon among maxillofacial fractures, but due to their proximity to the brain and orbit, they may cause sinusitis, mucocele formation, forehead deformities, CSF leaking and intracranial abscess if inadequately managed [16-17]. This study aims to compare the complication rate in FS obliteration using 3 different obliterating material: autogenous fat, autogenous cancellous bone and hydroxy appetite cement.

PATIENTS AND METHODS

Patients were selected from Oral and Maxillofacial surgery department, Faculty of Dentistry, Cairo University, the population of this study included patients with FS fractures indicated for surgical intervention. Frontal bone fractures not near the FS and patients with incomplete follow-up periods were excluded, Patients demographic data were recorded including gender, age, aetiology and type of fracture and the presence of associated facial bone fractures or CSF leakage. Based on the intended material to be utilized in FS obliteration, patients were categorized into three groups: group I (Autogenous fat group) included four patients who had their FS obliterated using freshly harvested autogenous abdominal fat; group II (Bone group) included four patients who had their sinus obliterated using autogenous bone; and group III (HA group) included three patients who had their FS obliterated using HA cement.

Surgery for obliteration of the FS

All operations were carried out by the same surgical team, the favoured access in most cases was done by bicoronal flaps except for 2 patients with extensive facial laceration (one from the first and another from the third group), where fractures were approached through the wound **(Fig. 1)**. The bicoronal flap was performed using a standard skin flap, the flap was then dissected anteriorly in the sub-galeal plane till the level of the supraorbital rims to have a good exposure for the frontal bone while preserving both the supraorbital and supratrochlear nerves, the anterior table was then removed and preserved in normal saline using a high-speed oscillating saw. A diamond drill or cutting bur is used to thoroughly remove any remaining FS mucosa. After visualising the NFD, the duct was closed by the harvested fascia and fibrin glue was added to it ensuring its appropriate sealing. Patients with posterior fractures and severe cerebral injuries are excluded from the current study and any necessary dural tears are fixed.

Group I: (Autogenous fat group)

A 4 cm midline incision beneath the umbilicus is used to harvest abdominal fat (only the superficial fascia of the abdominal muscles was dissected), after packing the sinus with enough amount of fat, wound closure is done in layers (Fig. 2A).

Group II: (Bone group)

The anterior iliac crest was used to harvest the cancellous bone graft by a minimally invasive technique using a trephine; a hole is done through bone to penetrate the cortex and obtaining a core of cancellous bone graft used to obliterate the sinus while the harvest site wound is sutured in layers (Fig. 2B).

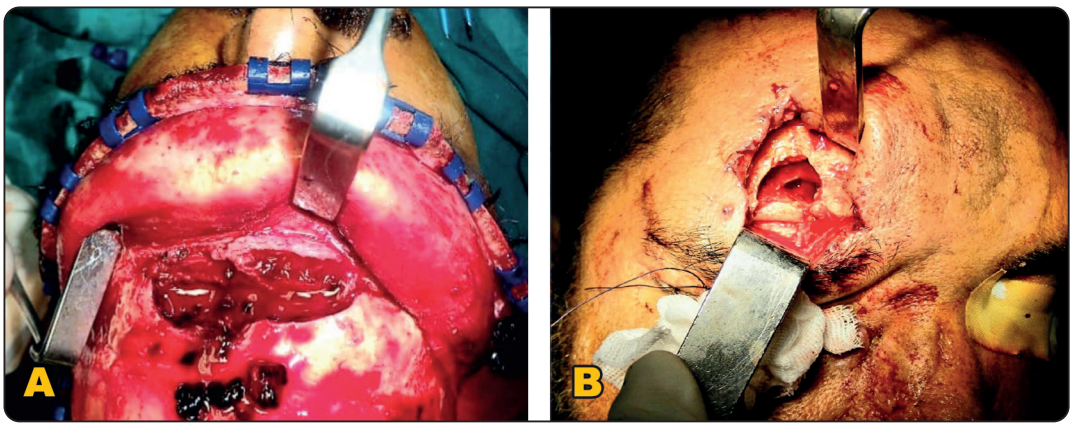

Fig. (1) Access for the frotal sinus through (A): Bicoronal flap (B): Wound laceration

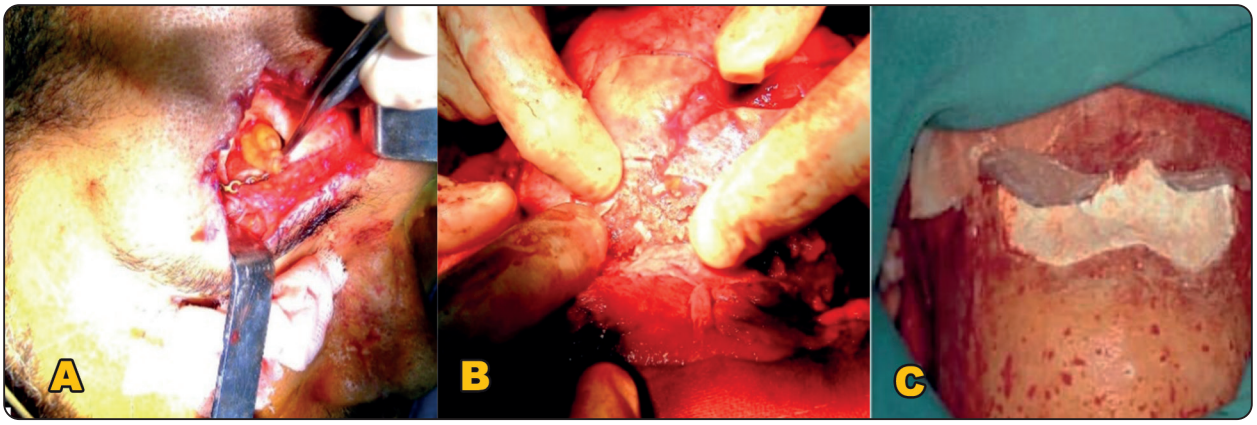

Fig. (2) Frontal sinus obliteration by: (A): Fat (B) Cancellous bone (C): HA cement

Group III: (HA group)

The HA cement * was obtained via mixing the sterile hydroxyapetite powder with approximately 0.4 ml of sterile water per gram of the powder to create a paste like consistency, to keep the cavity dry after receiving the cement, dry gauze was placed into the sinus. Cut sheets of silicone were placed in opposition to the periorbita to allow for the correct contour of the orbital roof by offering an even surface and preventing cement adhesion to the eye, which could later result in fibrosis. The empty frontal sinuses were gradually filled and the cement is left to dry for 10 to 15 minutes (Fig. 2C).

The anterior table was reconstructed and rigidly fixed as ideal as possible with miniplates and screws when it was appropriate, and contoured with either titanium mesh in groups I and II or the HA cement itself in group III when it is insufficient or missing (Fig. 2C). After periosteal suturing, the coronal flap was replaced, and suction drains were placed for 1 day. After 10–14 days, skin sutures and staples were removed.

Outcome Measurement

Both clinical and radiographic postoperative evaluation were carried out; the clinical evaluation monitored the healing process and wound infection at both the donor and the recipient site, any associated complications as chronic pain /headache, abscess or mucocoele formation, hypoesthesia or anaesthesia at the frontal region, inappropriate correction for the clinical deformity and sinusitis, data were collected at 1 week, 2 weeks, 1, 3, 6 and 12 months following the procedure. At one week, six months and one year following the surgery, radiographic evaluations utilising CT were performed.

Statistical analysis of the data was done using SAS (SAS Institute Inc, Cary, NC) software. Quantitative information is presented as percentages and figures. The mean standard deviation is shown for quantitative data with a normally distributed distribution. Clinical significance is indicated by a P-value of less than 0.05 for a t-test.

RESULTS

3 female (27%) and 8 male (73%) patients suffered mainly from traffic accidents (55%) followed by sports accidents (27%) and finally interpersonal violence (18%) were enrolled in this study. The mean age was 47.3 years for women and 40.7 years for men. Regarding patient sex or age, no significant difference in treatment decision was made in this study. One patient from the fat group, another from the HA group, and two patients from the bone group all had NFD injuries. Except for one patient in each group who experienced severe

* Stryker Biotech, Bone Source group Montreux, Switzerland.

displacement with a dislocation of more than 5mm, patients in all groups had moderate displacement of the anterior table with average dislocations between 2mm and 5mm.

The primary outcome measurements were the presence of an aerated frontal sinus and the correction of forehead contour deformities; while our late outcomes were the absence of any sequelae related to frontal sinus fracture, such as mucocele or sinusitis. Early complications, defined as those that occur within six months following surgery, and late complications, defined as those that occur more than six months after surgery. The majority of surgical complications were transient, with most patients experiencing just mild discomfort and edoema. Three patients, two from the bone group and one from the HA group had postoperative forehead paraesthesia; they were all treated conservatively with neurotonic and anti-inflammatory medications. All the patient's paraesthesia was reversible and went away three months postoperatively.

After surgery, one patient in the bone group had ongoing discomfort in the frontal region that was caused by the miniplates utilised to stabilise the anterior table rather than the obliteration procedure, the condition subsides after removing the plates. In one patient from the fat group, there were complications with the abdominal wound that required wet-to-dry dressing changes to resolve the infection. Only one patient in the HA group had a postoperative hematoma that was successfully treated conservatively and without surgery. One patient in the bone group experienced postoperative osteomyelitis and a forehead fistula; the patient underwent recurrent debridement and bone sequestrate removal until full resolution was obtained after 3 months from doing the surgery, scar formation developed in 2 cases (1 patient from each of the fat and HA group), both patients had severe lacerations preoperatively and the surgical access was done through the existing lacerations, sinusitis in 3 cases was observed and resolved in the 3 months follow-up, forehead asymmetry also was found in 2 cases with no relation to the used obliterating material. There were no noticeable symptoms other than the mentioned complications at the end of the follow-up period; none of the patients experienced persistent pain or neuralgia, no hair loss or persistent CSF leak was recorded at the 12-month recall follow-up. Only one patient in the bone group had insufficient FS obliteration, FS re-obliteration was carried out for this patient (Table 1).

The radiologic CT assessment performed at 1 week, 6 and 12 months postoperatively recorded the FS obliterations and ventilation as well as the rate of bone replacement for the used obliterating materials over time in all patients (Fig. 3). The degree of postoperative complications (either early or late) that took place in the 3 groups was quite comparable, and there was no statistically significant difference between the 3 groups ($P = 0.7236$ and 0.628 for the early and the late complications respectively).

TABLE (1) Demonstrates early & late complications with number of patients in each group

Complications / Group	**Group I: (Fat group)**	**Group II: (Bone group)**	**Group III: (HA group)**
Early complications (With number of patients)	• Abdominal wound complications (1) • Sinusitis (2)	• Forehead paraesthesia (2) • Forehead osteomyelitis & fistula (1) • Persistent discomfort (1) • Incomplete bone obliteration (1)	• Forehead paraesthesia (1) • Postoperative hematoma (1) • Sinusitis (1)
Late complications (With number of patients)	• Persistent scar (1) • Forehead asymmetry (1)	• Forehead asymmetry (1)	• Persistent scar (1)

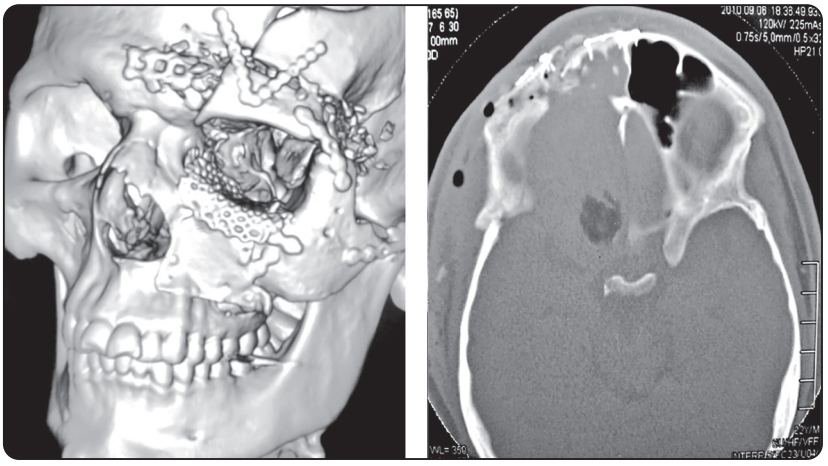

Fig. (3) 1-week postoperative CT after FS obliteration & anterior table reconstruction

DISCUSSION

There are few studies that discuss specific complications in relation to certain therapeutic options or specific material utilised in FS obliteration, most studies grouped all side effects before providing a summary of frontal sinus fractures, in general, according to medical studies; 10% to 17% of patients with frontal sinus fractures experience complications either early or late, the most common complications were headache and chronic pain in the area that had been injured, other complications like frontal sinusitis, mucocele, mucopyocele, CSF leakage, contour deformity, hardware and wound infection, haematoma under the coronal flap and brain abscess were less frequently to occur [18-19].

Despite receiving treatment after a traumatic brain injury, posttraumatic headaches can persist in more than 50% of patients [20]. In this study, the incidence of postoperative complications was 18.6% which is roughly in line with other studies reports; Gossman et al. [21] reported that 48 patients had their frontal sinus fractures surgically repaired, having an 11% total complication rate. Their outcomes included several complications that our patients had, the most common of which was headache or persistent pain around the area of injury., Chen et al. [22] had a complication rate of 16.7%, which is near to what we recorded in our study. However, in contrast to our findings, neither persistent pain nor headache were on their list of complications.

The best graft material to fill the FS fractures is still debatable in literature [23-24], since it was first described by Bergara and Itoiz in the 1950s, abdominal fat is regarded as the gold standard for obliteration techniques [25-26]. Our findings confirm that FS with abdominal fat obliteration has a high rate of success and a low rate of complications. Similar findings of a low rate of complications following fat obliteration to the FS were reported by Calcaterra and Strahan [27]; they reported that 23 of 24 patients with fat obliteration were cured of chronic sinusitis with no documented cases of recurrence following the removal of mucosa from the sinus and closing the NF duct with fascia.

Like what we had, after employing fat in FS obliteration surgery, Hardy and Montgomery [28] experienced a reduced postoperative complication rate: 208 patients needed to have their FS obliterated with abdominal fat, only 13 (6.3%) had abdominal wound complications (abscess, seroma and hematoma) and 5 patients (2.4%) experienced acute FS wound infection in addition to fat necrosis. In contrast to our findings, and as measured by magnetic resonance imaging, R. Weber et al. [29] had clinical failure rates of up to 10% and long-term rates of resorption of up to 80%, indicating poor results with the fat obliteration of the FS.

The anterior iliac crest is the «gold standard» source for cancellous autogenous bone grafts because of its regeneration properties, which reflect the presence of osteoblasts in the trabecular bone, and the relatively large volume of bone that can be harvested from the pelvis [30], our study found comparable complications of about 21.3 % to other used materials in this study including fat and alloplasts, having a nearby values of other trials who used the iliac crest as the FS obliterating material [31].

The most used alloplastic obliterating material for the FS is undoubtedly the hydroxyapatite cement; In cases of severe comminution, the cement has an advantage over other grafting materials in that it may be moulded to produce a new anterior table. Additionally, the majority of patients who had frontal sinus obliteration with the HA cement showed full osseointegration with minor problems[32-33]. In an experimental model, Costantino et al.[34] initially described using HA cement for obliteration of the FS, these studies showed its osteoconductive properties and the progressive replacement by local bone without a reduction in the HA cement volume, the information gained during this experimental study served as the basis for later clinical studies on humans that demonstrated the effectiveness and safety of this substance [34]. The HA cement has the advantage of being perfect when there are deficits from serious injury, unlike autologous materials, which require an intact FS table[35]; When the anterior table was considered inadequate, we replaced it with HA cement, and the patient's postoperative frontal cosmetic features were noted to be satisfactory. Agreeing with the perfect results and low complication rate we obtained with the HA cement, Costantino and Friedman [34] utilised six cats and surgically inflicted minute cerebral lesions and then filled up these holes with HA cement, at 6 and 12 months the cats were sacrificed and fresh bone ingrowth with an average depth of 7.3 and 10.8 mm respectively was recorded without any sign of infection.

However, reports of the use of HA cement in transtemporal surgery and suboccipital craniotomy repair have shown resorption, leading to failure in healing bone defects, in contrast to the results we observed [36], this was corelated with the development of hematomas; subsequent research of 21 patients who underwent cranial defect repair and had postoperative drains and even when the cement was in close contact with a CSF, there were no adverse consequences from HA cement resorption [37]. HA cement is effective for obliterating FS, nevertheless the cost of using this chemical cannot be ignored. Fattahi et al. [38] published a paper criticising the cement›s cost-effectiveness in FS obliteration compared to fat, but one would assume that the price of HA cement would drop as more bioengineering technology becomes available.

LIMITATION

The relative rarity of FS fractures presented a challenge, forcing us to conduct this research on a limited population with unequal groups. Also in the current study, the follow-up time was only 12 months postoperatively, frontal fracture issues have reportedly been linked to a longer interval of time. Consequently, additional studies with a longer follow-up period and more cases are required.

CONCLUSION

Abdominal fat, autogenous iliac crest and HA are good successful materials for FS obliteration with a comparable outcome regarding the complication rate. HA cement yet with great postoperative forehead aesthetics, shorter procedure times and minimal morbidity. However, compared to HA cement, autogenous iliac bone and abdominal fat seem to be more cost-effective.

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