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Frontal Sinus Obliteration Using a Laterally Based Pedicled Pericranial Flap

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Objective: **Fractures of the frontal sinus represent one of the more uncommon injuries of the maxillofacial skeleton. In an effort to avoid potential mucocele formation, frontal sinus obliteration has been put forward as the treatment of choice when there has been significant disruption of normal frontal sinus drainage. Traditionally, sinus obliteration has been accomplished with nonvascularized free adipose tissue or bone grafts and a variety of alloplastic materials. We developed a laterally based pedicled pericranial flap to accomplish frontal sinus obliteration.** ***Study Design/Methods:*** **A total of 10 consecutive patients underwent obliteration of the frontal sinus with a vascularized, pedicled, laterally based pericranial flap. The patients were clinically followed prospectively to ascertain whether any adverse effects could be detected.** ***Results:*** **With a follow-up ranging from 6 months to 2 years, we have observed no adverse effects in any of the patients in whom this procedure was performed.** ***Conclusions:*** **Based on our preliminary results, we believe that the laterally based pedicled pericranial flap appears to provide readily available vascularized tissue, with no distant donor morbidity. It represents an inexpensive, safe, and effective modality that should be considered when treating this type of injury.**

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INTRODUCTION

Frontal sinus fractures comprise only 5% to 12% of all fractures of the maxillofacial skeleton.[1] Most often, they result from a high-energy impact to the upper third of the face. In fact, the amount of force required to elicit a fracture of the frontal sinus is more than two times that required to fracture the mandible and more than five times that required to elicit a fracture of the maxilla.[2] This relative resistance to fracture arises as a consequence of the buttressing effects of its pneumatization interposed between a sturdy anterior and thinner posterior plate of bone. Even though a variety of associated intracranial and/or cervical spine injuries may arise in the setting of the acute injury, potentially serious complications may also be noted years after traumatic sinus disruption.

Under normal circumstances the frontal sinus is lined with a ciliated, pseudostratified columnar epithelium that is continuous with the nasal lining. This ciliated epithelium propels the bilaminar mucous blanket toward the nasofrontal duct at a mean rate of 1 cm per minute.[3] It is well recognized that when two different mucosal layers come into direct contact, subsequent disruption of the mucociliary clearance system resulting in stasis of secretions will become evident. Under normal circumstances, both the nasofrontal duct and frontal recess are widely patent. Following traumatic disruption of this area, even partial obstruction of the nasofrontal duct often results in stasis of frontal sinus secretions, increasing the risk of acute and delayed frontal sinus infectious complications. In addition, the foramina of Breschet represent areas where frontal sinus mucosa is tethered deeply within the osseous portions, in particular, of the posterior and superior frontal sinus walls. These two characteristics of the frontal sinus lead to the unique propensity of its mucociliary drainage system to form mucoceles when exposed to trauma.[4]

A wide variety of materials has been used successfully in the past to accomplish obliteration of the frontal sinus. These materials have variably included adipose tissue, fascia, free bone grafts and, most recently, hydroxyapatite cement or similar biomaterials.[5–9] The senior author (Y.D.) has also used omentum with good success for patients undergoing concomitant laparotomy for other injuries. The success achieved with such a wide variety of materials points to the fact that no one ideal method of obliteration of the frontal sinus has yet been achieved.

In this report we present our favorable experience using a pedicled, laterally based pericranial flap for posttraumatic obliteration of the frontal sinus.

MATERIALS AND METHODS

Ten patients (all males) ranging from 16 to 50 years of age presented to the senior author (Y.D.) with fractures of the frontal sinus. Based on preoperative clinical evaluation and intraoperative exploration, all were thought to require obliteration of the

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frontal sinus. All patients underwent obliteration of the sinus with a laterally based pedicled pericranial flap.

TECHNIQUE

General approaches to the frontal sinus include the coronal flap, midforehead incision, or butterfly-type transglabellar incision. Unless a preexisting significant local laceration may be easily extended into a natural rhytid, we generally prefer the use of a standard coronal flap. We find this to be a reliable, esthetically favorable approach that provides excellent access to the frontonasal area, as well as potential donor sites (temporalis fascia, pericranial flap/free graft, calvarial bone graft). The coronal incision is made 2 to 3 cm posterior to the anterior hairline. Dissection may proceed in a subpericranial or suprapericranial fashion to the level of the supraorbital rims. We prefer the former technique. Should further lateral exposure be required, dissection should proceed superficial to the deep temporal fascia, down to the temporal line of fusion between the superficial and deep layers of the deep temporal fascia. Incision of the fascia at this level with subsequent dissection superficial to the superficial layer of the deep temporal fascia allows reflection of the flap down to the level of the zygomatic arch, safely preserving the frontal branch of the facial nerve. Release of the supraorbital nerves from their foramina using a 3-mm osteotome allows for extended inferior reflection of the medial portion of the coronal flap.

Once the anterior frontal sinus wall has been adequately exposed, we transfer template markings of the sinus onto the patient. The template consists of a cutout of the frontal sinus obtained preoperatively from a standard 6-foot Caldwell radiograph. This affords the surgeon an outstanding perspective relating to the extent of sinus pneumatization, which varies widely between individuals and is frequently noted to be asymmetric. Access to the sinus interior is subsequently gained either with the use of an osteoplastic flap or through preexisting anterior table fracture segments which are sequentially removed (for later replacement). In the case of an osteoplastic flap, the periosteum should be left attached to the anterior wall of the frontal sinus. Subsequent design of the pericranial flap will be in a more superior position. Should there be obstruction, either osseous or mucosal, of the nasofrontal ducts bilaterally, obliteration of the frontal sinus should be undertaken (Fig. 1). The mucosal lining is completely exenterated with a periosteal elevator. A medium-sized round burr is next used to sequentially remove approximately 1 mm of osseous lining from the interior of the sinus, as well as from the undersurface of the osteoplastic flap or anterior table fragments. The mucosa at the introitus of the nasofrontal ducts is then inverted on itself and a plug (2 × 2 cm) of temporalis fascia placed on the frontal sinus aspect of the inverted mucosa. A laterally based pedicled pericranial flap is designed and lifted from the undersurface of the coronal flap with scissor dissection. The width of the base of the flap varies according to the size of the sinus being obliterated (generally 5–8 cm in width) (Fig. 2). Bilateral flaps may been used in the case of highly pneumatized frontal sinuses. Before flap insertion the lateral aspect of the ipsilateral frontal bone located adjacent to the removed or reflected anterior sinus wall is drilled for a distance of 0.5 cm to prevent flap compression. The pericranial flap is then folded on itself like an accordion, filling and obliterating the sinus cavity (Fig. 3). The osteoplastic flap or anterior wall fragments are rigidly fixated to the surrounding bone with a series of 1.2 mm miniplates (Fig. 4). The coronal flap is closed over suction drainage, which is generally removed on the first postoperative day, prior to the patient's discharge.

RESULTS

A pericranial flap adequate enough to accomplish obliteration of the frontal sinus was developed in each case. With follow-up ranging from 6 months to 2 years (mean duration, 1 y) we have encountered no complications or adverse effects in any of our patients. Follow-up computed tomography (CT) scans have verified complete

Fig. 1. Coronal computed tomography (CT) scan of a 19-year-old man with self-inflicted gunshot injury to the frontal sinus. Entrance wound was noted in the submental region.

Fig. 2. Laterally based pedicled pericranial flap. A flap width of only 5 cm was required in this patient because of the limited amount of pneumatization noted in the frontal sinus.

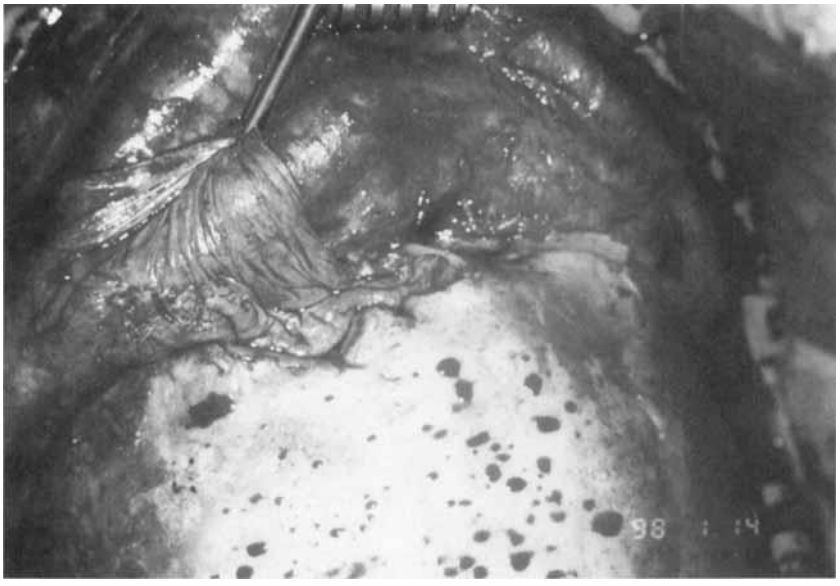

Fig. 3. Flap is inset within the frontal sinus in a tension-free manner.

sinus obliteration with no significant air space remaining within the frontal sinus (Figs. 5 and 6).

DISCUSSION

The optimal material for obliteration of frontal sinus fractures has not yet been delineated. We have used adipose tissue most frequently and, less often, free bone grafts and hydroxyapatite cement. The risk of late mucocele formation after adequate frontal sinus obliteration is small.[10,11] Thus, although small, there may exist a potential need for reexploration of these injuries at a later date. We have noted substantial difficulty in accomplishing safe revision obliteration in cases that were obliterated with bone grafts in the past, because of the inherent problems of separating and distinguishing healed graft material from normal frontal sinus wall. Presumably, the same scenario would be encountered should there be a need for reexploration following obliteration with hydroxyapatite cement. For this reason, we have preferred the use of soft tissue materials for the treatment of these injuries.

The use of adipose tissue grafts has been associated with excellent long-term outcomes. However, the use of such grafts is not without both theoretical and practical concerns. Excluding the fact that a second distant surgical site and surgical tray setup are required, there exists the potential for significant donor site morbidity, including risks of seroma or hematoma formation, and adverse scarring. Furthermore, we have encountered a number of young male patients with traumatic injury in whom it was exceedingly difficult, if not impossible, to identify enough subcutaneous fat in their abdomen, thighs, or buttocks to allow for adequate sinus obliteration. Further, the placement of large amounts of nonvascularized adipose tissue within the confines of an acutely traumatized, recently

Fig. 4. Anterior table fragments reconstituted with miniplate fixation. The junction of the ipsilateral frontal bone and anterior wall of frontal sinus has been opened for a width of 0.5 cm to prevent flap compression.

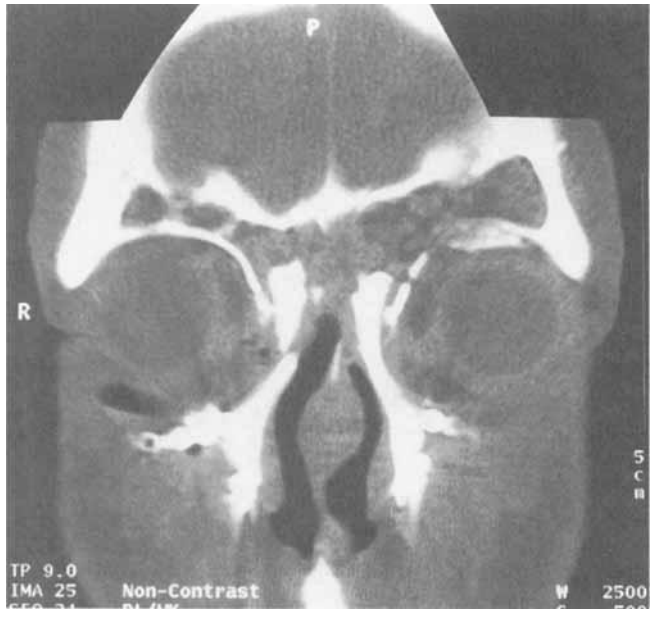

Fig. 5. Coronal CT scan through anterior frontal sinus following obliteration with pedicled pericranial flap.

infected frontal sinus may delay orderly healing. In two patients, we have in fact removed infected adipose grafts placed at an initial surgery and replaced them with a pedicled vascularized pericranial flap. No further problems have been noted in either of these two patients (mean follow-up, 1.2 y).

The pericranium represents the well-vascularized covering of calvarial bone. The blood supply to the pericranium anterior to the vertex is derived from anastomosing branches of the superficial temporal, occipital, greater auricular, supratrochlear, and supraorbital arteries.[12,13] Anteriorly based pericranial flaps have been used with great success to allow for separation of the intracranial from extracranial spaces following surgery of the anterior cranial base.[14–16] Thaller and Donald[17] have reported the use of an anteriorly based pericranial flap for frontal sinus obliteration. We have found it difficult to accurately maintain the position of an anteriorly based flap within the frontal sinus while applying rigid fixation to the outer table. Theoretically, there also exists the potential for decreased flap vascularity arising as a consequence of the acute angle it is required to make at its entry point into the osseous portion of the frontal sinus. A laterally based pericranial flap has avoided these difficulties. Free bleeding was noted from the distal edge of each of the flaps before and after insertion into the sinus. Further, application of miniplates to reconstitute the anterior wall of the frontal sinus was easily accomplished in each case. We have observed no adverse effects in follow-up of our patients. Permanent frontal hypesthesia has not been noted. Although long-term follow-up is necessary with any new treatment modality presented for the treatment of frontal sinus fractures, we believe that the laterally based pedicled pericranial flap represents an excellent alternative that should be considered in the routine treatment of these injuries. There is no need for a second (donor) surgical site to be violated, and the theoretical advantages arising from this flap's excellent vascularity may decrease the risk of perioperative or delayed infectious complications.

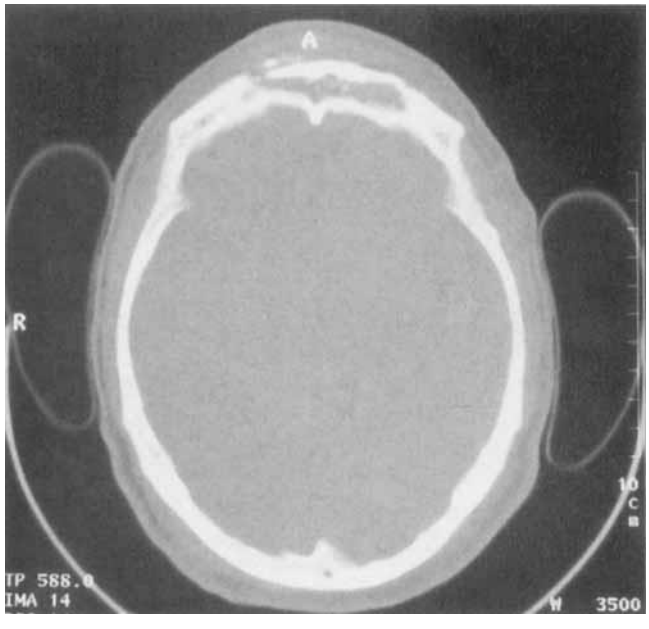

Fig. 6. Axial CT scan through frontal sinus following obliteration with pedicled pericranial flap. Access portal for flap on right anterolateral aspect of frontal sinus is evident.

CONCLUSION

The laterally based pedicled pericranial flap appears to represent a safe, locally available, effective treatment modality that should be considered in the treatment of frontal sinus fractures requiring obliteration. Although long-term follow-up is required, we have encountered no adverse effects in any of the patients treated in this way. We have found it to be simple and rapid to harvest and inset the flap.

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