Posttraumatic Frontal Bone Osteomyelitis

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ABSTRACT

We present the clinical case of a patient with open bilateral frontal sinus fractures who developed a frontal osteomyelitis. A review of the problem and management ascending to the different alternatives for central anterior skull base defects and fronto-orbital reconstruction is also presented. After extensive radical debridement of the necrotic bone, final reconstruction of the skull base was performed by using a rectus abdominis free flap. A custom-made hard tissue replacement implant was used for the fronto-orbital reconstruction. Extensive debridement is required for the treatment of frontal osteomyelitis. An appropriate isolation of the skull base from the upper aerodigestive system must be obtained to prevent continuous infectious complications. Free flaps are especially useful for skull base reconstruction when traditional methods are not available or have failed because of the lack of available tissue for vascularized reconstruction. Custom-made alloplastic implants are a good reconstructive option for large fronto-orbital defects once the infection is gone and vascularized tissue has been transferred.

KEYWORDS: Frontal sinus fracture, frontal osteomyelitis, skull base, free flap

Osteomyelitis of the frontal bone has been described after closed and open trauma of the frontobasilar system. It can also be a major complication after neurosurgical procedures.¹ However, since the introduction of antibiotics, it is less common as a posttraumatic sequela.

Reconstruction of skull base defects conceptually requires well-vascularized tissue to seal the area of the dura, to cover the bone, to fill dead space left by fractures, and sometimes to replace the skin.² With the advent of free tissue transfer, new possibilities have been introduced to reconstruct skull base defects refractory to treatment with traditional methods.

Regarding cranial bone reconstruction, an important recent advance is produced by computer-assisted surgery. Computed tomographic data allow three-dimensional visualization of the defect, volume calculation, and biomedical modeling by use of stereolithography or laser sintering. Computer-assisted design (CAD) and

computer-assisted manufacture (CAM) are technological advancements developed to fabricate custom implants.

We present the clinical case of a patient with a severe traumatic head injury and open bilateral frontal sinus fractures who developed an osteomyelitis of the frontal bone. We discuss the treatment, emphasizing the possibilities of anterior skull base and fronto-orbital bone reconstruction.

CASE REPORT

A 36-year-old male truck driver suffered a polytrauma in December 2003 as a result of a motor vehicle accident in a neighboring country. He suffered a severe head injury with penetrating comminuted bilateral frontal sinus fractures—affecting both anterior and posterior walls, with epidural hematoma, brain contusion, and cerebrospinal fluid (CSF) leak; other trauma included posterior arch fracture of C2 and C3; right comminuted fractured

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femur and abdominal trauma with hemoperitoneum, mesocolon tear, and pancreatic contusion. Reduction and osteosynthesis of the femur fracture, laparotomy and bifrontal craniotomy with hematoma evacuation, dural repair, frontal sinus cranialization, and a fat graft for the skull base defect were performed in a local hospital.

One month later, the patient was discharged and presented to our department, with bilateral frontal and orbital cellulitis, frontal osteomyelitis with bone sequestration, and an epidural abscess (Figs. 1 and 2). The initial surgical treatment included sequestrectomy and curettage of the infected bone. Nasoethmoidal-orbital fracture was stabilized with transnasal wiring, and the medial canthal tendons were repaired using bilateral transnasal canthopexy. Reconstruction with a temporalis muscle flap was initially performed to seal the anterior cranial fossa defect (Fig. 3). Galeal or galeal-pericranial flaps were not possible at that time because of the initial soft tissue damage and chronic infection. Frontal bone reconstruction was accomplished using bone fracture fragments with fixation utilizing the Synthes (Solothurn, Switzerland) 1.3-mm system of titanium miniplates and screws (Fig. 4).

Two months after the second surgery, the patient developed recurrent bilateral frontal osteomyelitis with fronto-orbital cellulitis. Cultures from the necrotic bone revealed the presence of *Pseudomonas aeruginosa*. Systemic antibiotic therapy and local debridement were not completely effective. Thus, a more extensive surgical debridement was performed. The bone from the initial bifrontal craniectomy and the fronto-orbital bar were removed.

Figure 1 Clinical photograph demonstrating frontal and orbital cellulitis with cutaneous fistulization and posttraumatic orbital hypertelorism.

The defect was first sealed with a rectus abdominis free flap (Fig. 5). Anastomoses were performed to the external carotid artery and thyrolingual trunk. Frontal bone reconstruction was performed in a second stage 1 year later using a custom-made hard tissue replacement (HTR) alloplastic implant (Biomet, Warsaw, Indiana) designed from computerized reconstruction (Fig. 6).

No other complications were observed during a further 3-year follow-up period (Figs. 7 and 8).

Figure 2 CT scans showing bilateral nasoethmoid orbital fractures and a frontal pneumoencephalus related to the frontal bone fracture.

Figure 3 Intraoperative view; patient supine and images taken from a cranial perspective. (A) Exposure of frontal bone after elevation of the cutaneous flap (*, nasal bones). (B) Epidural abscess and frontonasothmoid suppuration (*, nasal bones). (C) Stabilization of the nasoethmoid orbital complex with the transnasal wire technique. (D) Temporalis muscle flap obliterating the anterior cranial fossa (T, temporalis muscle).

DISCUSSION

Frontal sinus fractures are usually caused by high-velocity impact because of the strength of the bone. Inappropriate or inadequate management may lead to serious complications, even many years after the trauma. Frontal sinus fracture treatment is controversial, as there is no single therapeutic algorithm. Although treatment

must be tailored for each individual patient, objectives when planning should include appropriate isolation of the anterior cranial fossa, repair of any CSF fistula, and prevention of any possible complications of an infectious nature. According to the majority of authors, when a

Figure 4 Frontal bone reconstruction (T, temporalis muscle).

Figure 5 Rectus abdominis free flap obliterating the anterior cranial fossa.

Figure 6 (A) Deformity caused by the frontal bone defect. (B) Customized HTR implant. (C) Intraoperative view of the frontal bone defect and the rectus abdominis free flap. (D) HTR fixation with titanium miniplates. (E) Postoperative appearance.

frontal sinus fracture affects both the anterior and posterior walls resulting in gross displacement and comminution, the sinus ideally should be cranialized. Defects of the dura should be repaired (by means of direct suturing or dural patch), and the nasofrontal ducts should then be obliterated and the anterior cranial fossa sealed with a pericranial flap, if available. Bone obliteration of the frontal sinus defect with cancellous bone is preferred. Frontal osteomyelitis in this patient probably developed because of the severely comminuted open frontal sinus fracture itself and insufficient initial isolation of the central anterior cranial base from the upper aerodigestive system at the first operation.

An antibiotic treatment in frontal osteitis is seldom not effective because of the lack of blood supply or penetration in the necrotic bone or bone sequestra. Thus, the first surgery performed at our institution attempted to achieve debridement of dead bone and effective isolation of the anterior cranial fossa by the interposition of a temporalis muscle flap. A pedicled temporalis muscle myofascial flap has been demonstrated to be a

very useful and safe weapon in craniofacial reconstruction and for cranial base defects,³ predominately laterally and anterolaterally located, although it can be mobilized even across the midline to the contralateral side, eliminating existing dead spaces. Compared with microvascular free flaps, local flaps have less donor-site morbidity, easier surgical transfer, and shorter surgical time. However, when one considers the needs of an anatomic, aesthetic, and functional reconstruction of the fronto-basilar region, the quantity and versatility of tissues that can be provided by local flaps is inferior compared with that of microvascular free flaps. In the current case, frontal bone osteomyelitis recurred, probably related to persistent bone infection and insufficient isolation of the anterior cranial fossa from the upper aerodigestive system despite use of the temporalis muscle flap. In the article by Boeckx et al,¹ the authors present five patients with persistent frontal osteomyelitis after neurosurgical procedures. A constant finding was the irregular bone edges and even the nonabsorbable sutures, which were the main locations for

Figure 7 Postoperative CT scans.

bacterial adherence. In these recurrent cases, radical debridement was crucial. In such cases, a latissimus dorsi muscle flap covered with split skin grafts provides ample tissue to seal and close (reconstruct) the defect, eliminating all dead space.

Figure 8 Late postoperative frontal view.

Once the osteomyelitis recurred in our patient, an extensive wound debridement was performed to remove all dead tissues until bleeding, healthy tissue was reached in all directions. Reconstruction with a free flap was planned to provide a good seal of the anterior cranial base, adequate volume to fill the dead space, and also provide the beneficial effect of an enhanced blood supply to eradicate the infection and promote rapid wound healing and scalp revascularization. Various free flaps have been proposed for skull base reconstruction.⁴ The choice of the most appropriate free flap depends on various factors: size of the defect, pedicle length needed, type of tissue and proportion needed, and preferences of the surgeon. A rectus abdominis free flap has been our mainstay for skull base reconstruction because it provides a large amount of vascularized tissue with a long pedicle.⁵⁻⁷ At our institution, this flap has been our first choice in patients with extensive cranial base defects. In the past 10 years, we have performed 41 free flaps for skull base reconstruction and 20 rectus abdominis and 12 fasciocutaneous free flaps (9 anterolateral thigh and 3 radial forearm free flaps) (unpublished data). Nowadays, if the skull base defect is not too large, we rather choose fasciocutaneous free flaps because they may be used in these cases with minimal complications. The anterolateral thigh free flap significantly decreases donor-site morbidity. When the defect is too big and more pliability is required, an omentum free flap may be needed to obliterate the dead space, and of course the latissimus dorsi is an option.

Cranial reconstruction is performed to protect the brain against trauma and to correct aesthetic

deformities.⁸ Traditionally, defects bigger than 16 cm² are always significant enough to deserve reconstruction. In the fronto-orbital region, even smaller defects need to be reconstructed to achieve a good cosmetic result. Different materials can be safely used for this purpose. The ideal biomaterial should be biocompatible, nonresorbable, easy to use during the surgical procedure, and should allow good image control. Autologous bone grafts may be useful for small-size defects. Fasciocutaneous flaps or osteocutaneous flaps combined with bone grafts have been used to reconstruct larger-size scalp defects.^{9,10} On the other hand, cranioplasty can be done using synthetic biomaterials such as methacrylate implants, but their main disadvantage is that they cannot promote osseous regeneration. A noninfected recipient bed and adequate isolation from the upper aerodigestive tract are known to be crucial for a successful frontal cranioplasty.¹¹ Hydroxylapatite-derived biomaterials can be also used, either as ceramic or cement. Hydroxylapatite cement is especially valuable as bone graft substitute for non-stress-bearing applications and can be combined with titanium cranial meshes to add structural support, but there have been problems with its use in greater than 5-cm depths. However, there is no histologic evidence of implant resorption nor significant bone regeneration during a 3-year follow-up.¹² HTR implants are fabricated from a porous hydrophilic polymer; and they can be preoperatively designed based on the CT scan data, facilitating the surgical procedure. Nowadays, there are on the market a series of alternative CAD-CAM products manufactured with low-molecular-weight polymers and that have good bioperformance. Titanium meshes and prostheses are of course always an option for these complex defects.

New technologies are offering alternatives to traditional nonbiodegradable prostheses: tissue engineering and osteoinductive strategies are being applied for the design and fabrication of customized calvarial cell-biomaterial implants, a combination of cells and scaffolds.¹³ Many of these technologies have yet to be developed, and their use currently is theoretical.

Simultaneous primary cranioplasty together with the microsurgical reconstruction of calvarial and skull base defects can be done if dural tears are repaired and the upper aerodigestive system is well isolated. Contact with the upper aerodigestive tract as well as local cutaneous infection greatly increases the risk of implant infection. In the current case, reconstruction was planned in two stages because of the frontal osteomyelitis to decrease the risk of implant infection.

CONCLUSION

Appropriate isolation of the anterior cranial fossa from the upper aerodigestive system is needed to prevent complications such as infection and CSF leak in central anterior cranial base defects. Frontal osteomyelitis or osteitis requires extensive surgical debridement. Muscle and fasciocutaneous free flaps are valuable to reconstruct the anterior cranial fossa when local flaps are not available or not enough for the type of defect. New techniques such as CAD-CAM cranioplasty implants, tissue engineering, and osteoinductive strategies are promising.

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