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Reconstruction of Failed Autogenous Calvarial Bone Graft in a Post Craniectomy Defect Using Precontoured Titanium Mesh- A Case Report

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ABSTRACT
Postcranioplsty infections have generally been treated by debridement of infected tissues, disposal of the bone flap, and delayed cranioplasty several months later to repair the resulting skull defect. Debridement followed by retention of the bone flap has also been advocated. Here we report a case of on patient presented with clinical and radiographic signs and symptoms of postcranioplasty infection, treated by debridement, bone flap disposal, and immediate titanium mesh revision cranioplasty. The patient was subsequently administered antibiotics, and her clinical courses were followed. The patient treated in this fashion did not have recurrence of their infections during 2-year follow-up periods. Surgical debridement, bone flap disposal, and immediate titanium mesh cranioplasty may be a suitable option for the treatment of postcranioplasty infections. This treatment strategy facilitates the eradication of infectious sources and obviates the risks and costs associated with a second surgical procedure.

Keywords: Growth Factors; Epithelial-Mesenchymal Interactions; Odontogenesis; FGF; EGFR

INTRODUCTION

Cranial trauma, intracranial haemorrhages and apoplectic insults create life threatening medical conditions. Decompressive craniectomy has become a critical and standard life-saving manoeuvre. Decompressive craniectomy is a neurosurgical procedure done in conditions of trauma or pathology where a part of skull is removed to allow the brain to expand and thus prevent damage to brain from getting pressurized. This procedure is ideal for management of refractory intracranial hypertension following head injury. Other indications for craniectomy are intracranial disorders caused by tumours, epileptic surgery or infections[1,2,3]. Provided the patient survives their decompressive procedure, replacing the bone flap is important for several reasons. Cranioplasty is the surgical correction of skull defects. All cases of decompressive craniectomy require cranioplasty to provide aesthetics as well as protection to the brain. Delayed cranioplasty is performed to reconstruct contour after the brain edema resolves[1,3]. The cranioplasty provides protection to the underlying brain, will cosmetically restore the cranial contour, and can improve neurological function by reestablishing cerebrospinal fluid dynamics and cerebral blood flow that is associated with the syndrome of the trephined.

When performing the decompressive craniectomy, there are specific issues regarding the anticipated future cranioplasty that need to be considered. The first concern that needs to be addressed is what to do with the bone flap once the decompressive craniectomy is performed. In the past and still at some institutions, cranial bone flaps were either implanted in the subcutaneous fat, usually on the abdominal wall, or were wrapped sterilely and stored in a freezer until the time of reimplantation. Both of

these storage techniques are associated with their own unique problems. Storage in the abdominal fat can lead to partial resorption of the flap depending on the length of time until the bone is reimplanted. Additional surgical procedure is required for placement and retrieval of the graft which increased the cost along with an unsightly scar and makes the storage uncomfortable for the patient. For those flaps stored in freezers or autoclaved, there is always the question of sterility because there is no good way to sterilize autogenous bone that does not predispose the flap to partial resorption. To avoid the concerns associated with autogenous bone flaps, there are several vendors that now produce cranial implants made of various materials such as poly methyl methacrylate (PMMA), hydroxyapatite, porous polyethylene, poly ether ether ketone (PEEK), and titanium processed by different manufacturing techniques such as high speed milling, selective laser sintering and casting[4].Computer aided design (CAD) and manufacturing (CAM) deliver individualized, highly precise patient specific implants (PSI).

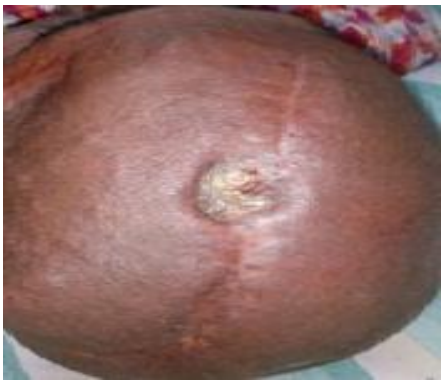
The autogenous bone is still considered to be the gold standard in the reconstruction of cranial defects. Reimplantation of autogenous bone specimen can result in infection or resorption leading to further interventions[5]. Cranioplasty infections represent a dreaded complication in patients who have already experienced a serious, usually traumatic event. Postcranioplasty infections are relatively infrequent[12]. When they occur, they can manifest as superficial scalp infections or deeper infections, including osteomyelitis, epidural abscesses, subdural empyemas, meningitis, and/or intradural abscesses.

Historically, the management of postcranioplasty infections has involved debridement of the operative cavity and removal of the bone flap, with delayed cranioplasty performed several months later. If the bone flap is of a significant size, this strategy has several significant drawbacks, including a cosmetic defect that can be disfiguring, increased susceptibility to brain injury requiring use of a protective helmet, and an additional surgery for a delayed cranioplasty[13].

In cases where an infected bone flap has been removed and a subsequent cranioplasty is necessitated, there are a number of cranioplasty materials available. Polymethylmethacrylate is an acrylic resin that can be molded and when cured, offers strength and protection similar to that of native skull[14] Polymethylmethacrylate, however, is associated with infection rates similar to that of autogenous/autoclaved bone cranioplasty[14]. Hydroxyapatite, a calcium-based bone cement that offers benefits of increased osteoconduction and osteointegration, is also an option. It too, however, can become infected and has also been described to cause an intense foreign body inflammatory reaction and extrusion[14]. Another alternative, dynamic titanium mesh, has the favorable qualities of high tensile strength and biologic inertness. Multiple studies have demonstrated lower rates of infection in titanium mesh cranioplasties[14].

CASE REPORT

A 52-year-old woman underwent a left temporoparietal craniectomy for acute left temperoparietral subdural haematoma following RTA. 3 months postoperatively, she presented with dehiscence and purulent discharge from her incision. CT and Magnetic resonance imaging revealed subgaleal and epidural fluid and tissue collections.



Postcranioplasty infection

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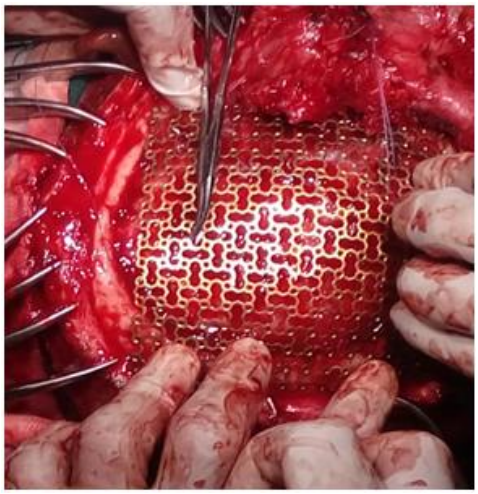
Following clinical and radiographic diagnoses of postcranioplasty infection, patient was taken to the operating room for debridement and irrigation of infected tissues as well as removal of the bone flap.

Infected autologous bone graft

A single piece of titanium mesh was fashioned such that it mimicked the curvature of the original flap, completely covered the craniectomy defect, and also radially overlapped the surrounding bone edge by approximately 5 mm. Different thicknesses of mesh (0.4 or 0.6 mm) can be used depending on the size of the defect and larger defects over a rounded part of the skull can be covered with a double layer of mesh if there is concern about possible later flattening of the implant curvature. The cut edges of the mesh were carefully turned down toward the bone so as not to project into the overlying scalp. Titanium microscrews were inserted through the mesh and into the underlying bone circumferentially to secure the mesh



Defect covered using Ti mesh

The wound was closed in layers. Patient was administered broad-spectrum antibiotics that were later tailored based on the results of intraoperative cultures. She had no evidence of recurrent infection at last follow-up of 2 years.

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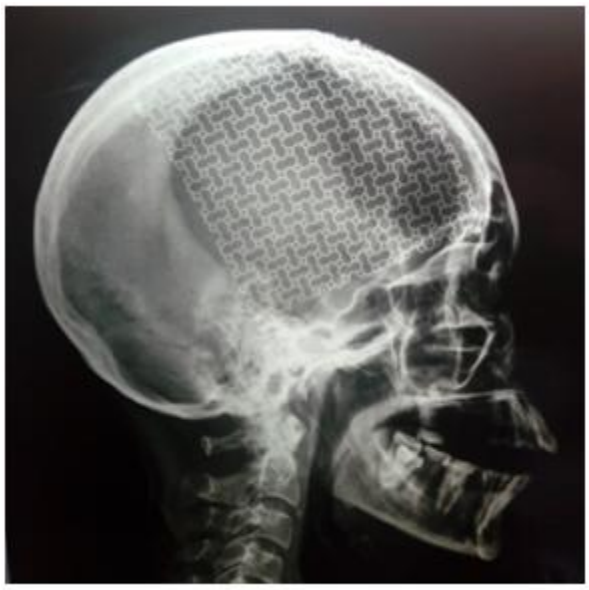
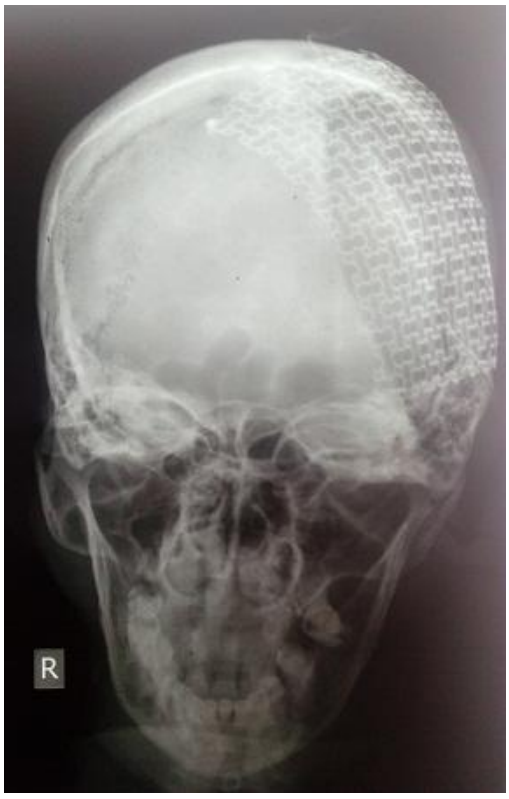


Postoperative view (Lateral)



Postoperative view (PA view)

DISCUSSION

Autogenous skull bone plates preserved, lyophilized or implanted in the abdominal wall are common options for reconstruction[1,5]. However, both clinical procedures have clear disadvantages. Most important is the fact that the re-implanted bone material will change its form and biological characteristics during storage. Autosensitisation, the loss of vitality due to loss of perfusion and changes in the three-dimensional structure of the bone plate are the most well-known biological reactions and risks. Auto-allergic reactions after re-implantation of lyophilized

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bone specimen will inevitably induce resorption[5]. From the biological standpoint the reintegrated skull bone is an osteoconductive, non-perfused implant which will be remodelled by the surrounding tissues[6].

There are specific complications that can result after surgery, namely seizures, subdural effusion, resorption of the autogenous flap, cerebral swelling, and infection requiring bone flap removal with later replacement. Unlike standard clean neurosurgical cranial procedures, in which the rate of infection can be as low as 0.8% [7], the rate of cranioplasty infection is significantly higher, with a rate as high as 26% recently reported[8]. Explanations that have been provided to explain the high incidence of cranioplasty infection have included the colonization of the skin that occurs with hospitalization and the immunocompromise that is associated with trauma and reoperation[8].

In determining whether the cranioplasty is infected or not, there are several clinical findings that may be present, such as redness of the scalp, fever, scalp tenderness, drainage from the incision, swelling over the implant, and headache. The laboratory investigations that should be utilized to determine whether a cranioplasty infection is present should include a white blood cell count with differential, erythrocyte sedimentation rate, and C-reactive protein. Although only one third of patients in the present study demonstrated an elevated C-reactive protein, that marker is extremely sensitive and is almost uniformly elevated in the presence of any type of infection.

Computed tomography or magnetic resonance imaging studies will invariably show a fluid collection in potentially more than one location. The purulent collection can be in a subgaleal location, the epidural compartment, or in the subdural space. Depending on where the infected fluid is located, it also can be associated with additional serious secondary infections such as osteomyelitis of the skull, encephalitis, and brain abscess formation.

As with any neurosurgical implant, the most common causative bacteria are those that comprise normal skin flora and include Staphylococcus epidermidis, Staphylococcus aureus, and Propionibacterium acnes. The more virulent the infectious organism, such as with S. aureus, the more likely that the inflammatory markers will be elevated.

Various factors have been attributed to cause cranioplasty infection, that include the timing of the cranioplasty after the decompression craniectomy, the size of the cranioplasty, the material used for cranioplasty, the bacterial types causing the infection, which inflammatory markers are elevated with an infection, when the cranioplasty became infected after implantation, whether the cranioplasty was autologous or synthetic, and the length of time to perform the cranioplasty.

Regarding the timing of performing the cranioplasty, there is no specific consensus opinion. Traditional teaching has suggested that the cranial flap should be replaced between 3 and 6 months, with early replacement now being considered any time before 3 months[9]. A recent systematic review of 18 articles concluded that early replacement versus delayed implantation did not influence the complication rates for cranioplasty including infection development[9]. The type of material of the cranioplasty did not influence cranioplasty infection rates, nor did the method of autograft storage (subcutaneous implantation or extracorporeal storage) in literature studies[9].

Factors that were found to influence autograft cranioplasty infection were the number of operations, the length of the operation, and whether the patient had diabetes mellitus[10]. The infection rate was 20% when surgery lasted more than 200 minutes. In a large series of 134 cranioplasties performed over a 10-year period, cranioplasty material and timing of the surgery did not influence the development of infection; however, poor neurological condition of the patient at the time of cranioplasty was associated with an increased infection rate[11]. The size of the cranioplasty also has been associated with an increased rate of infection, as was seen in a recent large series of 127 titanium cranioplasties[8].

There are limited guidelines in the neurosurgical literature regarding the management of bone flaps in the setting of postcranioplasty infections[13]. Most authors recommend disposal of bone flaps in anything more serious than a very superficial wound infection. This recommendation is particularly strong when there is evidence of cranial bone osteomyelitis[15]. Removal and disposal of the bone flap, without immediate cranioplasty, is associated

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with drawbacks, namely, an increased risk for trauma-related brain injury and a cosmetic deformity.

Titanium mesh reconstruction at the time of bone flap removal avoids the creation of a postoperative skull defect as well as the need for a subsequent operation to repair the defect. This is particularly important in patients who may become lost to follow-up. Immediate titanium mesh cranioplasty also avoids the risks and costs associated with a second surgical procedure that is typically performed under general anesthesia.

CONCLUSION

The early diagnosis and treatment of cranioplasty infection hopefully will reduce the neurological morbidity that can already be present in this impaired patient population. The prevention of secondary insults to an already traumatized brain is essential to ensure the best chance for a meaningful recovery for these unfortunate patients. The optimum method of cranioplasty remains unproven. Titanium has clear advantages over other biomaterials and titanium remains a tried and tested solution for full-thickness calvarial defects.

Bone flap removal and immediate titanium mesh cranioplasty should be evaluated in a larger number of patients to better determine its utility. We believe it to be a cost-effective operative strategy that maximizes the chances of eradicating a postcranioplasty infection and minimizes the risks of having a skull defect. It is also a preferred strategy for patients who are at risk for becoming lost to follow-up

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