

Restoration of Bilateral Cranial Defects by Hybridization of Microvascular Free Flaps and Artificial Bones

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Summary: Although treatment methods for cranial reconstruction have significantly improved over the past decades, patients having potentially negative influences, such as a history of infection, epidural dead space, or inadequate scalp, remain at high risk of postoperative failure from implant infection and exposure necessitating removal. A 41-year-old male patient sustained severe craniofacial injuries in a traffic accident. Cranioplasty with titanium mesh implants failed due to implant infection, leading to implant removal and debridement. Following repeated local infections and a craniectomy, the patient developed large bilateral complex cranial defects. We then performed a multistage operation, consisting of vascularized free-flap transfers to cover the intracranial dead spaces, and bony reconstruction using hydroxyapatite implants, which achieved full restoration of the defects. We believe that this is the better operative plan for treatment of cranial defects in patients with high-risk factors. (*Plast Reconstr Surg Glob Open* 2019;7:e2428; doi: 10.1097/GOX.0000000000002428; Published online 30 September 2019.)

Cranioplasty is surgical intervention using a bony substitute to repair cranial defects resulting from trauma, tumors, congenital deformities, or postoperative defects. Methods used for cranial reconstruction, whether autoplasmic bone grafts or alloplastic implants, have significantly improved over the past decades; however, there is still no consensus on which method is better in difficult cases.¹ The one certain thing is that the patients with potentially negative influences, including (1) a history of infected, failed previous cranial reconstruction, (2) the presence of the intracranial, epidural dead space, (3) inadequate scalp or skin to cover the external surface, or (4) the presence of an avascular tissue posterior to the reconstructed cranium, are at higher risk of implant infection, exposure, or failure necessitating implant removal.^{2,3} In this article, we report on a case of large bilateral complex cranial defects which met all of the 4 risk factors but were successfully restored by 3-stage operations consisting of 2 free-flap transfers and biocompatible hydroxyapatite implants.

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CASE REPORT

A 41-year-old man sustained severe cranial bone fracture and acute subdural hematoma in a traffic accident. In the emergency room, a decompressive craniectomy, hematoma removal, and placement of a ventriculoperitoneal shunt were performed. Several days later, the neurosurgeons performed cranial reconstruction for bilateral cranial defects using titanium implants; however, epidural abscess following implant infection occurred weeks later and necessitated another debridement and craniectomy, creating large bilateral complex-shaped cranial defects. The patient was then introduced to our department of plastic surgery.

Computed tomography (CT) images clearly delineated enormous, bilaterally symmetric cranial defects (each approximately 9×8cm) and significant deformity of the cranium with only the cerebral falx and sagittal sinuses remaining (Fig. 1A). CT images also showed considerable exclusion of the frontal and temporal lobes with large epidural dead spaces exceeding 3cm on both sides, yet the patient presented neither communication problems nor acroparalysis. Severe depression deformities in the scalp contour were also noted. We thus conducted a 3-stage operation, consisting of 2 vascularized free-flap transfers into the intracranial dead spaces, followed by alloplastic hydroxyapatite implantation.

Surgical Procedure

Initially, we harvested and transferred free left latissimus dorsi flap with 2 vascularized ribs into the left intracranial

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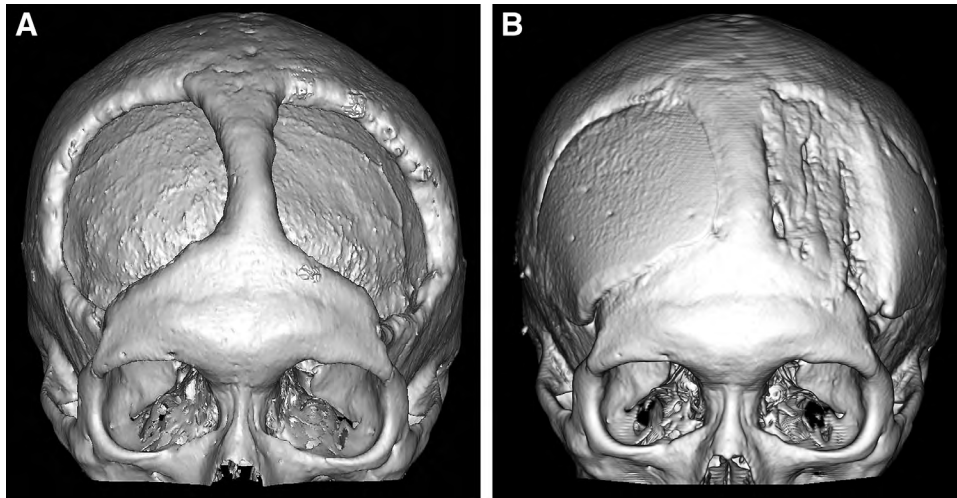


Fig. 1. Analytic 3D image reconstruction. A, Preoperative 3D CT scan. Large bilateral cranial defects of approximately 9×8 cm each and significant deformity of the cranium were delineated though the cerebral falx and sagittal sinuses remained intact. B, A follow-up 3D CT scan 6 years after the last operation. The esthetics of bilateral craniums were successfully restored and well-maintained without any complications. 3D, 3-dimensional.

defect. The left thoracodorsal vessels were anastomosed to the left temporal vessels, and the 2 vascularized ribs were fixed as cranial struts with titanium plate-screw fixation (Walter Lorenz Surgical, Jacksonville, Fla.). In the second operation, a free deep inferior epigastric perforator flap was transferred into the right cranial defect, as a right latissimus dorsi flap could not be harvested due to the presence of the ventriculoperitoneal shunt. The left deep inferior epigastric vessels were anastomosed to the right temporal vessels.

Three months postoperatively, CT images showed that the 2 flaps had survived and successfully filled the intracranial dead spaces (Fig. 2). Subsequently, the third operation was carried out. The scalp flap was elevated to expose the intracranial free flaps and transplanted ribs with sufficient blood flow, even though we split them into upper and lower parts and flipped them laterally to cover the adjacent bony defects (Fig. 3). Finally, custom-made hydroxyapatite implants (Apaceram; Pentax, Tokyo, Japan) were placed over the flaps to cover the remaining bony defects, ensuring a good fit at the peripheral edge. The implants and previously transplanted ribs were all fixed with poly-L-lactic and polyglycolic acid plates and screws (Lactosorb; Walter Lorenz Surgical, Jacksonville, Fla.). Six years postoperatively, the reconstructed cranium has developed no complications, and good cranial contouring was confirmed by CT scan (Fig. 1B).

DISCUSSION

Cranial reconstruction is required to compensate not only esthetic disfigurement but also mechanical vulnerability of the brain and transmission of vibrations of the brain that may cause disconcerting sensations to the patients. Many techniques and different materials for cranioplasty have been developed over the past decades; however, a therapeutic strategy for complicated cases remains to be established. In newly occurred cases, even when severe depres-

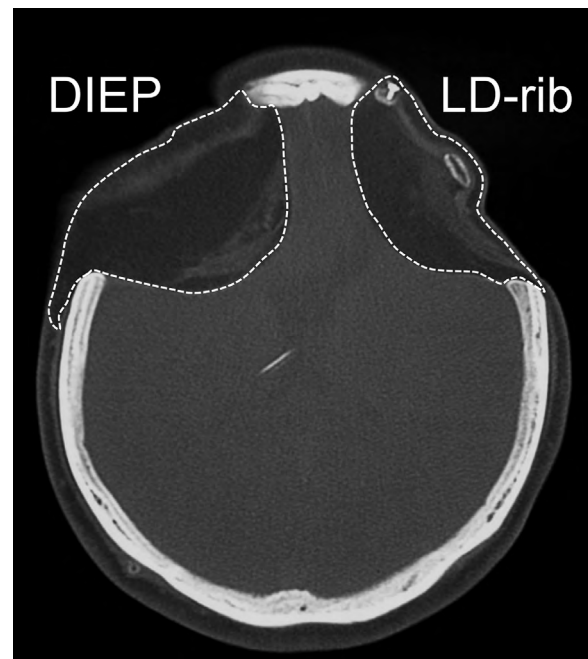


Fig. 2. Axial CT scan 3 months after the second-phase surgery (before bony reconstruction with hydroxyapatite implant). Two previously transferred flaps completely survived and successfully filled the intracranial epidural dead spaces. DIEP, deep inferior epigastric artery perforator flap; LD-rib, latissimus dorsi and rib composite flap.

sion deformity accompanies, spontaneous expansion of the brain, subdural space, and cerebrospinal fluid space can be expected after a rigid skull is reconstructed.⁴ However, in older cases, dura matter becomes scarred after a prolonged course, and such spontaneous expansion does not occur, leaving epidural dead space entailing risks for hematoma,

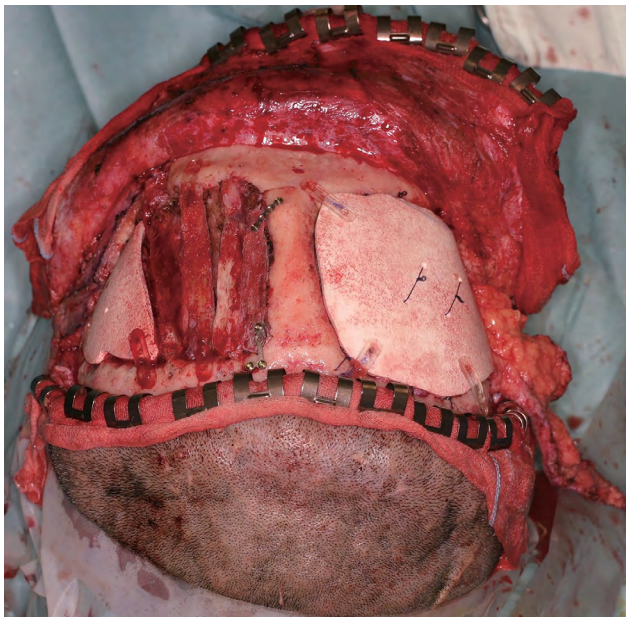


Fig. 3. Intraoperative findings of cranial reconstruction using hydroxyapatite implants. The transplanted ribs were split into upper and lower parts and flipped laterally to cover the adjacent bone defects. Bone gaps were filled with hydroxyapatite cement.

infection, and implant exposure. Thus, regardless of autoplasmic or alloplastic source, bony substitutes alone are not sufficient to restore cranial defects in such cases.

In our case, previous cranial reconstruction performed by neurosurgeons using only titanium implants failed, leading to implant exposure and epidural abscess, eventually requiring implant removal and further debridement. A history of repeated infection and operations, the presence of epidural dead spaces with large bilateral cranial defects, and scarring (avascularity) of surrounding tissues are thought to be detrimental to the outcome of cranioplasty. We thus planned a combined use of vascularized free flaps and hydroxyapatite implant, which has 2 significant advantages: (1) soft tissue interposition obliterates

epidural dead space⁵ and (2) vascularized flaps posterior to the implant reduce infection and facilitate wound healing. The transplanted and hinged ribs in the left cranial defect, which were vascularized through intercostal perforators, served to reduce the area of artificial material application. We believe that biocompatible artificial materials (such as hydroxyapatite) are better than nonbiocompatible ones (such as titanium), although this premise requires further study.

Our method led to a successful reconstruction of large complex bilateral cranial defects. This method embodies hybridization of two 20th century breakthroughs in plastic surgery, namely microsurgery and craniofacial surgery, and appears to be a safe and viable operative plan for the treatment of large cranial defects in patients with high-risk factors.

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