TECHNICAL REPORT

Reconstructing Complex Cranial Defects with a Preformed Cranial Prosthesis

T.C. Oritano, M.D., Ph.D., Ricardo Izquierdo, M.D.,
and Louis B. Scannicchio, D.D.S.

Abstract—Large cranial defects (70 cm² or more) of complex geometric shapes (bifrontal or involving supraorbital ridges) that are associated with significant cutaneous contracture or soft tissue loss are challenging to reconstruct. We have treated 10 patients with complex cranial defects through a staged approach. Reconstructing the defect involved several steps. Before each surgery, we constructed a craniofacial prosthesis from polymethyl methacrylate to fit the patient's individual defect. When indicated, adjacent skin was expanded with a subcutaneous tissue expander. Finally, we carried out a cranioplasty and placed the prosthesis. Operative closure of the defect was facilitated by microplate and screw fixation with minimal prosthesis contouring. Secure, vital, nontension skin closure was performed with the delayed, expanded local flap. Exposure to free polymer and exothermic reaction was avoided. Cosmetic results in these patients with high-volume, geometrically complex defects were excellent. No complications occurred, and the overall operative time was shortened. (*Skull Base Surgery*, 5(2):109–116, 1995)

The closure of cranial defects has a long and colorful history^{1–3}: multiple autologous bone, metal, and polymer-based implants have been used. In the past, the impetus for development has generally been injuries related to war. Today, an increase in the use and caliber of civilian weapons, the increased frequency of reoperation for pathologic intracranial processes (especially after radiation therapy), and the improved survival of patients with traumatic head injuries provide new and more complex needs for this procedure.

The goals of cranioplasty are to restore cosmetic aesthetics, protect the underlying brain, and restore intracranial pressure relationships. As the size and geometric complexity of the defect increases, the ability to meet these goals decreases. The loss of overlying soft tissue (muscle) and contracture or skin necessary for closure are often associated with large cranial defects. This can be of special concern when old skin edges must be debrided. We have utilized a combined, staged approach to close cranial defects that are large and geometrically complex.

PATIENTS

Ten patients (six men and four women; ages 18 to 65 years) with large cranial defects (mean, 105 cm²) were treated with a combined staged cranioplasty of preformed polymethyl methacrylate (Fig. 1; Table 1). Figure 2 shows typical preoperative patients presenting with large defects.

TECHNIQUE

Initially, the patient must be examined for construction of a cranial prosthesis.^{4–8} Zero magnification x-rays in both posteroanterior and lateral views are obtained to allow for accurate sizing and identification of bony irregularities. A moulage of the defect is made with alginate. From this, a reverse model is made of hydrocol-105 stone, which serves as the working cast for the maxillofacial

Figure 1. Cranial defects.

Table 1. Complex Cranioplasty Cases

Case	Sex	Age	Defect (cm ²)	Pathology*
1	F	30	100	Post-operative osteomyelitis (redo craniotomy for meningioma) [†]
2	M	37	105	Motorcycle trauma
3	M	35	125	Recreational rocket injury
4	M	45	75	Motor vehicle accident
5	F	50	50	Post-operative osteomyelitis (cerebral aneurysm)
6	M	22	120	Gunshot wound
7	F	65	95	Previous cranioplasty with intra-operative abscess [‡] ; (multiple reoperations for recurrent meningioma)
8	M	32	100	Post-radiation osteonecrosis [†] (malignant astrocytoma)
9	M	18	100	Gunshot wound
10	F	56	60	Post-operative wound infection [†] (cerebral aneurysm)

*Primary pathology resulting in bone loss

† Primary pathology for which craniotomy performed

[‡]Referred chronic defect > 1 year old

Figure 2. A: Preoperative defect, including the right frontal-parietal-temporal region and bilateral supraorbital ridges (case 7). B: Preoperative defect, including the bifrontal region with severe skin contracture from loss of volume (case 3).

prosthodontist. A wax model is then constructed (Fig. 3A). The wax imprint is tailored and contoured and the patient has a final fitting. The methylmethacrylate prosthesis is generated from the final stone cast (Fig. 3B) and this is delivered to the operating room in a gas sterilized package (Fig. 3C).

In 5 of the 10 patients, the skin available for closure was deemed unsatisfactory and required cutaneous tissue expansion before the cranioplasty. Indications for tissue expansion included severe contracture associated with cutaneous changes induced by radiation, prolonged volume loss (Fig. 2B), or large eschar at the suture line requiring debridement to viable tissue. A Silastic subcutaneous tissue expander^{4,9,10} (Fig. 4A) was placed under normal tissues adjacent to the cranial defect over the bone and under the galea. The tissue expands over 4 to 6 weeks. Once each week, saline was injected into a remote port according to the patient's ability to tolerate pain. The patient was scheduled for definitive cranioplasty when tissue expansion was sufficient for closure (Fig. 4B to D).

The actual cranioplasty was straightforward. The cranial incision was opened and the tissue expander removed. Any eschar was debrided if necessary, and the prosthesis was laid in position. Final tailoring was done away from the operating table, thereby eliminating poten-

tial contamination at the implant site. The plate was approximated with sutures, wire, or microplate. Our preference for the microplate is based on the rapid and rigid fixation of the prosthesis (Fig. 5). Surgical time was about 1 hour per patient. Postoperatively, excellent cosmesis was obtained (Fig. 6). No complications were encountered with a mean follow-up of more than 1 year.

CONCLUSIONS

The use of a combined staged cranioplasty for patients with large, geometrically complex defects allows for definitive, safe reconstruction that fulfills the goals of cranioplasty. This technique is especially useful for patients with anatomically complex defects in cosmetically challenging areas, such as the supraorbital rims, and where soft tissue defects lead to volume loss. The use of subcutaneous tissue expanders allows for adequate, viable, full-thickness skin closure, which is critical when covering foreign bodies in previously injured, radiated, or infected areas. Form-fitting the prosthesis to the defect shortens the operating time. Processing the acrylic moultage before surgery eliminates the need to expose underlying tissue (dura, brain) to the exothermic reaction and

Figure 3. A: The wax pattern model of prosthesis. B: The wax pattern processed in clear polymethyl methacrylate prosthesis inserted into the cast. C: The completed prosthesis, gas sterilized, and ready for implantation.

A

B

C

Figure 4. A: The subcutaneous tissue expander. B,C: The tissue expander fully expanded in place (case 7). Note expander just behind the cranial defect. (Figure continued on the next page.)

D

Figure 4. (Continued). D: Case 3 with a fully expanded subcutaneous tissue expander. The remote injection site can be seen as a frontal bubble.

A

Figure 5. Prosthesis in place fixated with microplates: A: Case 7. (Figure continued on the next page.)

Figure 5. (Continued). B: case 3.

Figure 6. A: Early postoperative results (case 7). B: Late postoperative (1 year postoperative) results (case 3).

absorption of chemical radicals into surrounding soft tissue. Volumetric reconstruction of the cranial defect and overlying soft tissue enhances the symmetry of the reconstruction, ensuring a cosmetically pleasing result.

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