Cranioplasty

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KEYWORDS

- Cranioplasty • Autologous cranioplasty • Synthetic cranioplasty • Skull reconstruction
- Cranial defect • Methyl methacrylate

KEY POINTS

- Cranioplasty restores the normal cranial architecture and protective functions of the skull and may play a role in normalizing cerebrospinal fluid dynamics in patients undergoing large craniectomies for trauma.
- The ideal material for cranioplasty is lightweight, durable, easily fixable to the skull, osteoconductive, and malleable.
- Separation of the scalp flap and temporalis muscle from the underlying dura or dural substitute is critical for a good outcome.
- Cranioplasty, like any neurosurgical procedure, has specific complications with which neurosurgeons must be familiar.

INTRODUCTION

Skull defects and craniofacial bone abnormalities that require reconstruction are common in a variety of neurosurgical procedures. From the patient's perspective, the primary reason for repair of these defects may be cosmetic. However, cranial bone provides important support and restores normal cerebrospinal fluid (CSF) flow dynamics, reducing the formation of pseudomeningoceles and protecting vital structures. Craniofacial reconstruction and cranioplasty have a long history, but new surgical techniques and a multitude of material options have recently fueled advancement in this area. This article describes the clinical indications for cranioplasty, preoperative management and timing of reconstruction, materials, and operative techniques.

CLINICAL INDICATIONS FOR CRANIOPLASTY

Although largely an elective procedure, cranioplasty has several important indications and can improve quality of life for postcraniectomy patients. Following craniectomy, patients can develop skin depression and a sunken flap that can lead to an asymmetric appearance of the head. Although seemingly innocuous, this abnormal appearance can have major negative implications on the psychological well-being of the patient as well as how the patient is perceived by other people. Restoring the normal architecture of the skull can have significant psychosocial benefits to the patient as well as reestablishing the protective barrier of the skull.

Craniectomy essentially nullifies the Monroe-Kellie doctrine that governs intracranial pressure, CSF dynamics, and ultimately cerebral blood flow and can give rise to several complications, including extra-axial fluid collections; hydrocephalus; and sunken flap syndrome, also known as syndrome of the trephined. Sunken flap syndrome results from a combination of receding brain as swelling resolves, disturbances in CSF dynamics, and effects of atmospheric pressure.

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Miscellaneous neurologic symptoms are attributed to the hemispheric collapse and include headache, dizziness, fatigue, and psychiatric changes.[1] Replacement of bone flap has been shown to lead to neurologic improvement, mostly in motor function, in small case series.[2] Transcranial Doppler ultrasonography has shown improvement in cerebral blood flow following cranioplasty.[3] Larger, controlled studies are needed to better understand the relationship between cranioplasty, cerebral hemodynamics, and clinical outcome.

TIMING OF CRANIOPLASTY

Timing of cranioplasty depends largely on the indication for craniectomy. Immediate cranioplasty has rare indications and may be performed for craniectomy for neoplastic invasion of cranium. Delayed cranioplasty is usually indicated for removal of bone flap for intracranial infection or medically refractory intracranial hypertension.

In cases of intracranial infection with suspected involvement and devitalization of bone, craniectomy is commonly performed. Although recent, small case series have shown the feasibility and safety of immediate titanium cranioplasty after bone flap infection,[4] usually time intervals between craniectomy and cranioplasty between 6 weeks and 1 year have been identified.[5] Ultimately the timing of cranioplasty is patient tailored and sufficient time must pass for adequate treatment and clearance of cranial (as well as any systemic) infection. The previous incision must be well healed and surrounding tissues must be vascularized. Inflammatory markers, such as C-reactive protein and erythrocyte sedimentation rate, as well as serial imaging, may assist in the determination of cranioplasty timing.

In patients who undergo decompressive craniectomy for intracranial hypertension (Fig. 1) in the setting of traumatic brain injury or stroke, the patient's neurologic status and intracranial pressure must have stabilized and the patient should be free of both systemic and cranial infection. As in cases of cranioplasty after intracranial infection, the patient's incision should be healed completely. Traditionally, cranioplasty after decompressive craniectomy is performed at approximately 3 months, allowing sufficient time for neurologic and medical recovery, but the optimal timing remains controversial. Some practitioners have argued that early cranioplasty may improve CSF dynamics and lead to better neurologic recovery, although conflicting data in the literature suggest that larger prospective studies of the relationship between timing of cranioplasty and neurologic outcome are needed.[6–9]

On a technical note, early cranioplasty after 5 to 8 weeks may allow easier discrimination of the various tissue layers when the skin flap is reflected. However, onlay synthetic dural substitutes, if used, may not have formed an adherence to the underlying native dura and are often inadvertently reflected with the skin flap.

PREOPERATIVE MANAGEMENT

Once the decision to perform cranioplasty is made, important preoperative studies include computed tomography with bone windows; three-dimensional reconstruction may further guide operative management. MRI is occasionally useful if there is a question about the relation of soft tissue structures, such as scalp or dura, to the skull defect. In addition, preoperative management must include a thorough investigation of the patient's underlying health status and search for

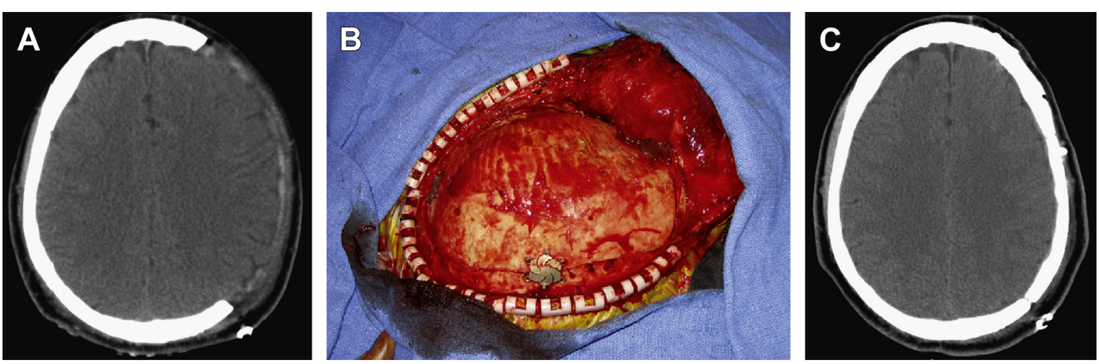

Fig. 1. Cranioplasty after left decompressive hemicraniectomy for intractable intracranial hypertension. (*A*) Preoperative computed tomographic scan showing left skull defect. (*B*) Intraoperative view of autologous bone flap secured to native skull with plating system. (*C*) Postoperative computed tomographic scan showing cranioplasty. (*From* Piazza M, Sean Grady M. Cranioplasty. In: Winn HR, ed. Youmans and Winn neurologic surgery. 7th edition. Philadelphia: Elsevier, 2017; with permission.)