Cranioplasty with Split-thickness Calvarial Bone

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Abstract

Cranioplasty with autogenous split-thickness calvarial bone was performed in 10 patients. Follow-up for a mean of 19 months (range 2–43 mos) showed satisfactory protection of the brain and cosmetic reconstruction. No serious complication was seen except in one patient with postoperative epidural abscess. Split-thickness calvarial bone graft is recommended in patients with previous infection or high risk of infection, in poorly vascularized recipient sites resulting from multiple operations or irradiation, and in younger patients aged more than 7 years.

Key words: cranioplasty, calvarial bone splitting, bone graft

Introduction

Cranioplasty is a common but formidable surgical procedure for neurosurgeons. The greatest problem is selecting the optimum material for repair of the cranial defect. Materials for cranioplasty can be divided into alloplastic materials and autogenous bone. Alloplastic materials are most commonly used in neurosurgical practice because of their strength, easy manipulation, suitability for immediate use or prefabrication, and no size restriction.^{2,5,7,8,13)} However, such synthetic implants may result in complications such as infection or local fluid collection. Infection may occur years after the cranioplasty, especially in areas near the nasal cavity or paranasal sinuses.^{1,10)} Some workers believe that the timing of reconstruction and not the type of material is the crucial factor.⁷⁾ Once infection occurs removal of the implant is necessary. Accordingly, artificial materials cannot be used in high risk patients.

Autogenous bone graft is therefore used in patients with previous infections or exposure to paranasal sinuses, reconstructions involving poorly vascularized recipient sites such as in patients who have had infection, multiple previous operations, or radiation therapy, and in younger patients.^{6,11)}

Cranial bone grafting has become an increasingly

favoured method for the repair of large defects of frontal bone caused by craniofacial surgery.^{3,4,9,11,12)} We adopted the split-thickness calvarial bone for the repair.

Materials and Methods

Ten patients have received cranioplasty with autogenous split-thickness calvarial bone grafts since 1991, four males and six females, aged from 7 to 69 years (mean 42 yrs) (Table 1).

After exposure of the skull defect, a second scalp incision was made if necessary to harvest an adequate area of parietal bone (Fig. 1 *upper*). Bone from a single parietal craniotomy as large as the bone defect was harvested. The bone was cut through the diploe with an oscillating saw, and split into two layers (Fig. 1 *middle*). If more bone was necessary, the contralateral parietal bone could also be harvested. The cutting surface was incessantly cooled with physiological saline solution to avoid heat damage during the harvesting procedure. The inner cranial bone layer was trimmed and applied to the cranial defect, and fixed with miniplates and screws. The outer cranial bone layer was returned to the donor site (Fig. 1 *lower*).

Four patients (Cases 1–4) were treated for epidural abscess due to infectious bone flap and/or resin plates from previous surgery. The period between the previous surgery and occurrence of the epidural

Table 1 Summary of patients

Case No.	Age/ Sex	Clinical diagnosis	Recipient site/ size (cm)	Donor site/ size (cm)	Dural plasty	Complica- tion	Follow-up period (mos)
1	59/F	epidural abscess, SAH postop	bifrontal/ 6 × 14	bil parietal/ 10 × 9, 8 × 7	galeal flap	none	22
2	65/F	epidural abscess, ASDH postop	lt frontoparietal/ 11 × 14	rt parietal/ 10 × 14	none	none	14
3	69/M	epidural abscess, SAH postop	bifrontal/ 13 × 8	bil parietal/ 7 × 10, 6 × 10	none	none	13
4	27/M	epidural abscess, open DF postop	lt frontal/ 9 × 7	lt parietal/ 10 × 6	galeal flap	none	2
5	33/F	open DF, cerebral contusion	lt frontal/ 11 × 10	lt parietal/ 11 × 5	galeal flap	none	21
6	49/M	open DF, cerebral contusion	rt frontotemporal/ 9 × 14	rt parietal/ 6 × 8	galeal flap	epidural abscess	17
7	59/M	pterional meningioma	rt pterion/ 8 × 7	residual bone/ 8 × 7	temporal fascia	none	36
8	42/F	frontal epidermoid cyst	lt frontal/ 5 × 8	lt parietal/ 7 × 10	galeal flap	none	11
9	7/F	skull and scalp defect, PNET postop	rt occipitoparietal/ 10 × 10	biparietal/ 12 × 11	none	none	43
10	9/F	cleidocranial dysostosis	bifrontal/ 5 × 5	rt parietal/ 5 × 5	none	none	10

ASDH: acute subdural hematoma, DF: depressed fracture, PNET: primitive neuroectodermal tumor, SAH: subarachnoid hemorrhage.

abscess ranged from 1 month to 11 years. The origin of infection was the paranasal sinuses in three cases, and unknown in the other case.

Two patients (Cases 5 and 6) had frontal bone defects exposed to the paranasal sinuses due to open depressed fractures in the forehead. After subsidence of the brain swelling, cranioplasties were performed with dural plasties of vascularized expanded galeal flap.

Two patients (Cases 7 and 8) had bone defects created during removal of tumors invading the skull. The bone defects were exposed to the paranasal sinuses, and were repaired with split-thickness calvarial bone.

A 7-year-old girl (Case 9) had undergone multiple operations to treat primitive neuroectodermal tumor. She was referred to us for reconstruction of scalp necrosis and occipitoparietal bone defect. She underwent cranioplasty with split-thickness calvarial bone and reconstruction of the scalp with a free latissimus dorsi musculocutaneous flap.

A 9-year-old girl (Case 10) had a congenital bone defect at the area of the anterior fontanelle, diagnosed as cleidocranial dysostosis. She received cranioplasty to avoid developmental disturbances.

Results

All patients have had a very satisfactory postoperative course during follow-up periods from 2 to 43 months (mean 19 mos). No serious complication was seen except in one patient who had postoperative epidural abscess which was cured with only chemotherapy. No widespread resorption of the graft was seen. One patient fell and hit his forehead on the floor. He had a scalp laceration, but his graft was not fractured or deformed. No developmental disturbance was observed in the two children. Osteogenesis was induced under the repaired area in one child.

Discussion

Cranial bone grafting has the following advantages: low rate of infection, good survival rate even in poorly vascular recipient sites, adequate size, good esthetic contour, easily accessible within the same operative site, minimal pain and postoperative morbidity, hidden in the hairline, no growth disturbance, and the possibility of osteogenesis.^{3,11,12)}

The disadvantages resulting from the splitting of the calvarial bone are bone resorption, weakness to impact, and difficulty in harvesting. Membranous cranial bone grafts are less likely to resorb than

Fig. 1 Operative technique. *upper*: Scalp is reflected. The design of the craniotomy is drawn. *middle*: The harvested calvarial bone is split. *lower*: The inner layer of the split calvarial bone is fixed with miniplates and screws. The outer layer is returned to the donor site.

grafts of enchondral origin.^{3,12)} Widespread bone resorption was not observed in our patients. The immobilization of the implants, fixed tightly with miniplates and screws, may decrease bone resorption. The strength of reconstructed bone has never been assessed, although one patient happened to hit his head at the repaired area, but without resultant fracture in the graft. This incidental episode proved the resistance of the graft to quite a strong impact. Splitting of the bone requires experience, and sometimes the bone is cracked into several pieces. However, the pieces of bone can easily be fixed with miniplates and screws. Therefore, splitting of the complete bone is not necessary. Some workers consider that cranial bone grafting cannot easily replace a large-sized bone defect.⁶⁾ In our series, the largest implant was 10 by 14 cm from a single donor site, and bilateral harvesting was performed in three patients. By planning the bone harvest, a quite large bone defect can be covered. The diploe does not develop until the age of 7 years, so this procedure is not possible in younger patients. In our 7- and 9-year-old patients, there was no difficulty in harvesting and splitting of bone.

The choice of cranial vault reconstruction material should depend on the location of the bone defect and the history of the patient. Autogenous split-thickness calvarial bone is useful to prevent foreign body reaction and developmental disturbance, and may result in osteogenesis.

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