Bone Resorption of Autologous Cranioplasty Following Decompressive Craniectomy in Children
- Case Report -

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Objective: In pediatric patients, autologous-bone assisted cranioplasty is preferred because the child’s original skull material will become reintegrated. Unfortunately, the replaced bone flap sometimes undergoes bone resorption, which results in structural breakdown necessitating reoperation. We report two children who underwent failure of autologous cranioplasty following decompressive craniectomy. Methods: An 11-year-old girl visited our emergency department with the chief complaint of stuporous mental change. Radiologic evaluations identified intracranial hemorrhage with arteriovenous malformation (AVM) in left fronto-parietal lobe. Decompressive craniectomy and clipping of nidus of AVM was performed on the day on admission. After 1 month later, the autologous-bone assisted cranioplasty was performed. An 11-year-old boy visited our emergency department after trauma. The computed tomography (CT) scan revealed acute subdural hematoma in left cerebral convexity. Decompressive craniectomy was performed immediately. After 3 months later, the autologous-bone assisted cranioplasty was performed. Results: One year, and 2 months respectively after cranioplasty, they revisited outpatient service center with the chief complaint of breakdown of skull contour. The three dimensional CT scan revealed resorption of autologous bone graft. Repair was performed using porous polyethylene implant (Medpor®, Porex Surgical, Inc, Newnan, GA, USA) and absorbable microplates. Conclusion: The use of autologous bone flap for delayed cranioplasty following decompressive craniectomy should be reconsidered in light of the resorption in pediatric population.

KEY WORDS: Autologous cranioplasty · Craniectomy · Children.

Introduction

In many hospitals, decompressive craniectomy is undertaken for treating severe cerebral swelling due to spontaneous intracranial hemorrhage (ICH) or trauma. Delayed cranioplasty is then performed to reconstruct skull contour after the brain edema has resolved.

Numerous techniques and alloplastic materials have been developed to alternate autologous bone and to reduce complications after cranioplasty. However, in pediatric patients, placement of original bone flap which is removed in craniectomy is preferred because the potentiality of reintegra-tion with resident bone as he or she grows up.

Unfortunately, the replaced bone flap sometimes undergoes bone resorption, which results in structural breakdown necessitating reoperation. We present two cases which of failure of autologous bone assisted cranioplasty following decompressive craniectomy in children.

Case Report

Case I

An 11-year-old girl was referred to our emergency department with stuporous mentality. She had a Glasgow Coma Score (GCS) of 7 (eye opening 1, verbal response 1 and motor response 5) points with right side motor weakness.

A head computed tomography (CT) scan confirmed the ICH in left fronto-parietal lobe with severe brain parenchymal edema. An enhanced CT was subsequently perform-
ed, which demonstrated an arteriovenous malformation (AVM) nidus in ICH region.

Shortly after the CT study, decompressive craniectomy, direct evacuation of hematoma and removal of AVM nidus was performed. The size of skull defect area was about 98.5 cm² and the thickness of bone flap was 3.0 mm (Figure 1).

The bone flap was irrigated and debrided with normal saline, dried, wrapped in a sterile gauze and glove, and covered with sterile cotton. Then the bone temperature was reduced quickly and suddenly to ~70 to ~80°C and then stored in laboratory refrigerator.

One month after craniectomy, cerebral swelling was resolved and autologous-bone assisted cranioplasty was performed (Figure 2). Before one day of the operation, the

FIGURE 1. Images of pre- and post-craniectomy. A: Enhanced brain computed tomography (CT) revealed intracranial hemorrhage with AVM nidus in left frontoparietal lobe. B–D: Skull X-rays and CT showed left craniectomy state. AVM: arteriovenous malformation.

FIGURE 2. Images of autologous cranioplasty. A: Skull X-rays. B: CT.

bone flap was transferred to operation room, irrigated with normal saline and sterilized with Ethylen Oxide in autoclave for 12 hours. The bone was fixed using absorbable microplate and microscrews, and the scalp was closed layer by layer using absorbable vicryl galeal sutures and nylon skin sutures. Post-operative antibiotic therapy was continued for 7 days.

After 1 year after carnioplasty, she revisited outpatient service center with the chief complaint of breakdown of skull contour. The three dimensional CT scan revealed resorption of autogenous bone graft (Figure 3). Repair was performed using porous polyethylene implant (Medpor®, Porex Surgical, Inc, Newnan, GA, USA), absorbable microplates and microscrews (Figure 4). At the time of cranioplasty revision, there was no infection sign, and the loose bone pieces were removed totally and irrigated massively.

She has been followed up with no complication during 6 months after second cranioplasty.

Case II

An 11-year-old boy was referred to our emergency department with stuporous mentality after violence. A CT scan revealed the acute subdural hematoma (SDH) in left cerebral convexity with midline shifting.

Immediately after the CT scan, decompressive craniectomy and removal of hematoma was performed. The size of skull defect area was about 105.2 cm² and the thickness of bone flap was about 3.5 mm (Figure 5). The bone flap was preserved in the same way, as mentioned above, until the child would be ready for cranioplasty.

Three months after craniectomy, the autologous-bone assisted cranioplasty was performed (Figure 6). The operation technique and post-operative care was same with previous case.

After 2 months after cranioplasty, he revisited outpatient service center with the chief complaint of breakdown of skull contour. The three dimensional CT scan revealed resorption of autogenous bone graft (Figure 7). In the operation room, the fragile and dried bone pieces were removed, and then porous polyethylene implant (Medpor®) was fixed by absorbable microplates and microscrews (Figure 8).

The pathologic finding was broad necrosis with dystro-
phic calcification and chronic inflammation with fibrosis and foreign body reaction (Figure 9).

He has been followed up with no complication during 5 months after second cranioplasty.

**Discussion**

In pediatric patients, delayed cranioplasty presents a dilemma: should the surgeon use autologous bone or one of
Sorbed. Osteoconduction is the process whereby osteoprogenitor cells from the surrounding tissue migrate into the transplant bed from surrounding bone diploe, dura and scalp infiltrate the revascularization, osteoconduction, osteoinduction, and osteogenesis. During the first week after grafting, capillaries regenerate, and new bone formation is initiated. During the second week, fibrous granulation tissue proliferates and osteoplastic activity occurs. Primitive mesenchymal cells differentiate into osteoprogenitor cells, a process nowadays termed osteogenesis. It is now understood that auto- and allo-grafts have relied on osteoconduction as the main principle of cranioplasty. It is also understood that, by contrast, in osteoinduction, cells do not have to migrate from the surrounding tissues but, probably with the help of bone morphogenetic proteins, can be produced in situ. Osteogenesis involves new bone formation by surviving preosteoblasts within the graft. As the healing progresses, the bone graft is remodeled through bone resorption and new bone formation. The duration (between failure and replacement) and method of bone flap preservation have previously been suggested to lead to breakdown of the bone flap. Autoclaving of the bone flap has been shown to denature bone protein and impair vascularization and resorption, and therefore, is not routinely performed. In a recent study, investigators reevaluated the use of fresh-frozen autologous bone flaps in patients undergoing delayed cranioplasty: they reported bone resorption in only one (4%) of 49 cases 15 months following cranioplasty. Other authors have suggested that patients retain an increased propensity for skull healing when cranioplasty is performed prior to puberty. Grant et al. reported that symptomatic bone resorption subsequently occurred in 20 children (50%) in all of 40 children. The incidence of bone resorption significantly correlated with an increased skull thickness. No significant correlation was found with age, sex, or anatomical location of the skull defect, number of fractured bone fragments, presence of a shunt, cause for decompressive craniectomy, method of duraplasty, or interval between the craniectomy and the cranioplasty. In our 2 cases, the duration between failure and first replacement was not long. Patients’ age might not be risk factor of resorption because they were prior to puberty. Autoclaving of bone might be included to risk factor, but not reasonable. Because, in 100 cases of adult cranioplasty, there were no cases of resorption in the same technique of bone preservation in our hospital.

We hypothesize that these 2 cases of resorptions in children were due to the thickness (3.0 and 3.5 mm) of the calvaria and large defect area (98.5 and 105.2 cm²). Loder reported that the left postero-lateral skull thickness of children was 2.4–4.8 mm (average 3.6). The skull thickness of our children was absolutely thinner than that of adults, and relatively thinner than that of other children. Gerant et al. reported that defects greater than 75 cm² had a failure rate greater than 60% whereas those smaller than 75 cm² were associated with no failures. Although autologous bone graft has been the preferred material, the associated rate of failure and high rates of re-operation in patients with large defects and thinness suggest that alternative solutions might be considered at the time of initial cranioplasty.

Figure 9. Photomicrograph of resorbed bone flap (×400) showed extensive necrosis and chronic inflammation with fibrosis and foreign body reaction.
On the other hand, several techniques are known to be available for preventing autologous bone resorption. At the time of cranioplasty, drilling down the edges of both the donor and recipient bones and overlap the edges as much as possible using a tongue-and-groove technique to maximize bone-bone contact and promote osteoblastic ingrowth. 5) Some studies involving nonvascularized autologous bone grafts have shown that rigid fixation of the graft is critical to minimize graft resorption and facilitate osteoconduction. 4) The normal microenvironment of the cranium is not sufficient to promote osteogenesis and may require the addition of growth factors to recruit cells and stimulate bone repair. 5) Researchers have studied the use of bone growth factors including insulinlike growth factor-I, transforming growth factor-β1, and other growth factors can be helpful to osteogenesis. 2)

**Conclusion**

We have described two patients who suffered resorption after autologous bone assisted cranioplasty in children. The use of autologous bone flap for delayed cranioplasty following decompressive craniectomy should be reconsidered in light of the resorption in pediatric population.

**REFERENCES**