Cranial Reconstruction in a Pediatric Patient Using a Tissue Expander and Custom-made Hydroxyapatite Implant

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A tissue expansion technique in conjunction with a custom-made artificial bone implant was effective for a large cranial reconstruction in a pediatric patient. The patient was an eight-year-old boy with cranial bone fracture, acute subdural hematoma in the left lobe, and acute epidural hematoma in the right lobe due to an accident. Wound dehiscence and artificial dura infection were observed as postoperative complications. Because of insufficiency of the skin flap caused by scar contracture, a scalp skin expansion using a tissue expander was necessary before reconstruction with the artificial bone implant. This combined procedure provided safe coverage of the implant and resulted in good wound healing. There are relatively few reports involving the use of tissue expanders for cranioplasty; furthermore, our search of the literature did not reveal any reports involving children. We believe that this procedure is safe and effective for early rehabilitation in pediatric patients.

Key words: Cranial reconstruction; Tissue expander; custom-made; pediatric

INTRODUCTION

After undergoing a neurosurgery for severe brain injuries, some patients are left with large cranial bone defects [1]. In addition to causing esthetic problems, these defects are associated with risk of causing contusion or penetrating injuries to the brain in daily life [1]. In cases in which extracranial decompression surgery is necessary, the size of bone defects are typically too large to be reconstructed by autologous bone graft. Recently, the number of articles reporting cranial reconstruction surgery using custom-made artificial bone implants is increasing [2–6]. These implants, composed of artificial materials of a relatively large size, tend to cause complications such as postoperative infection or exposure [4, 7–10]. To resolve these problems, some authors have reported cases of cranial skin flap expansion using tissue expanders before cranial reconstruction with artificial bone [4, 11]. Here we describe a case involving a pediatric cranial reconstruction using a tissue expander in conjunction with a custom-made artificial bone implant.

CASE REPORT

The patient was an eight-year-old boy. He was referred to the plastic surgery outpatient clinic by neurosurgeon. The patient's and his parents' chief complaint was his concaved cranial shape and large cranial bone defect. The patient suffered cranial bone fracture, acute subdural hematoma in the left lobe, and acute epidural hematoma in the right lobe in an accident, and underwent emergency brain surgery. On the 10th day after surgery, severe brain edema caused rupture of the dura suture and skin wound dehiscence, which led to cerebrospinal fluid leakage. A secondary surgery was performed, and the infected artificial dural membrane was replaced by an autologous fascia lata. Approximately one month after the secondary surgery, the patient was referred to the plastic surgery outpatient clinic because of delayed wound healing, although he had recovered from the cerebrospinal fluid leakage and dura mater infection.

Following wound closure with conservative medical management, he was discharged from hospital on postoperative day 53 with a large cranial bone defect and concave cranial deformity after external decompression. He was referred to the plastic surgery outpatient clinic again before cranial reconstruction.

Physical findings on the first visit to our department:

The scar on the patient's scalp was determined to be too thin and the blood circulation too poor for use in cranial reconstruction surgery **(Fig. 1a)**. The scalp skin flap covering the bone defect was flat, and the area was determined to be too small to cover the reconstructed cranial vault **(Fig. 1b)**. Computed tomography scanning of the skull revealed a bone defect in the left temporal area with a longitudinal diameter of 11 cm and transverse diameter of 9.5 cm **(Fig. 2)**. The bone defect was considered to be too large to be reconstructed by an autologous bone graft; therefore, a scalp skin

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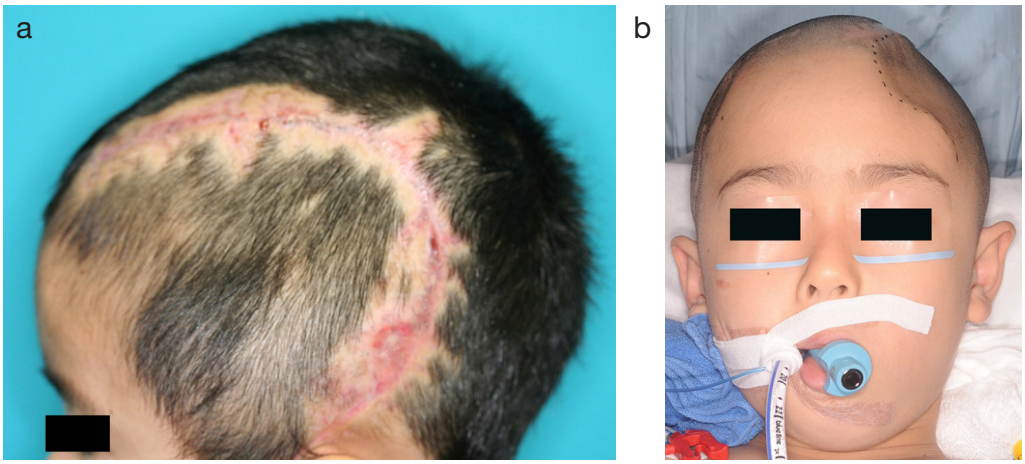

Fig. 1 a. Photograph taken after wound closure by epithelialization.
The scar on the patient's scalp was estimated to be too thin and the blood circulation too poor for use in cranial reconstruction surgery.
b. Photograph taken in the operation room before insertion of the implant.
The scalp skin flap covering the patient's bone defect was flat, and the area was determined to be too small to cover the reconstructed cranial vault.

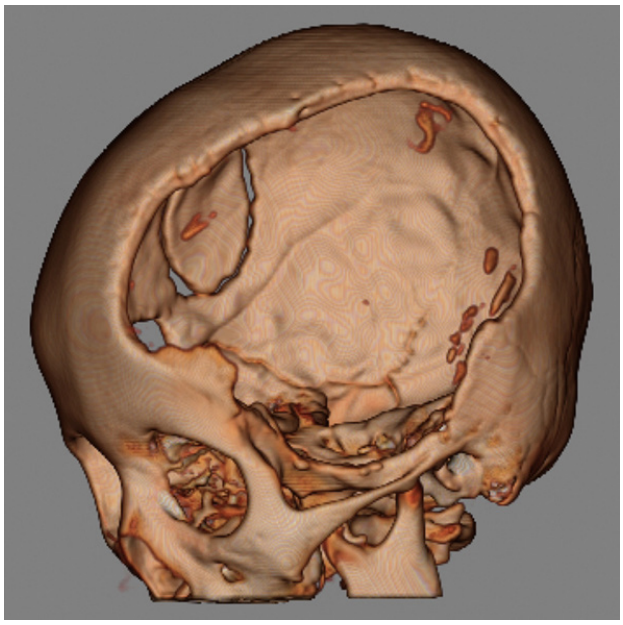

Fig. 2 Computed tomography scan of the skull showed a bone defect in the left temporal area; its longitudinal diameter was 11 cm and its transverse diameter was 9.5 cm.

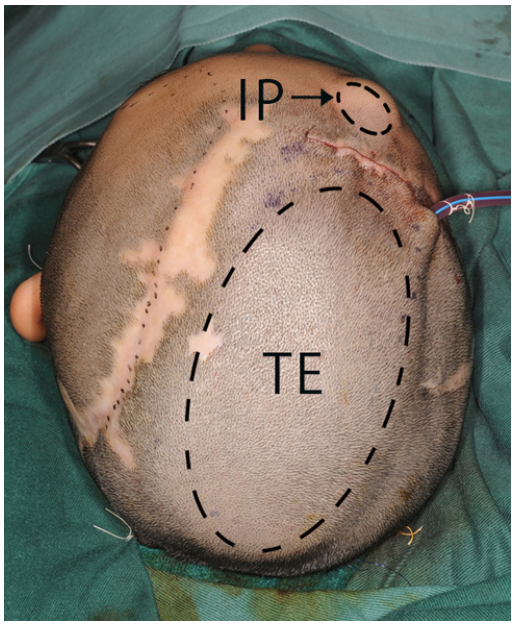

Fig. 3 Photograph taken at the first surgery. We used a rectangular tissue expander (60 mm × 120 mm; 290 mL). A skin incision was made on the frontal scar of the previous surgery, avoiding the area directly above the bone defect. The tissue expander was inserted under the galea of the parietal side of the defect.
TE: Tissue Expander, IP: Injection port

flap expansion using a tissue expander before insertion of an artificial bone was planned.

First surgery

A rectangular tissue expander (60 mm × 120 mm; 290 mL) was used (PMT Corporation, Minnesota, U. S. A.). An incision was made on the frontal scar from the previous surgery, avoiding the area directly above the bone defect. The tissue expander was inserted under the galea, on the parietal side of the defect **(Fig. 3)**. After the patient was discharged from hospital, the tissue expander was expanded gradually once per week by injection of normal saline through the injection port at the outpatient clinic.

Second surgery

Four months after the first surgery, the tissue expander was at full expansion. A cranioplasty was performed using a custom-made artificial bone consisting of hydroxyapatite (NGK Co. Ltd., Aichi, Japan). The implant was fixed to the cranial bone using a titanium plate and screws at three points **(Fig. 4a, b)**. The scalp skin was expanded to a size that was sufficient to cover the convex artificial bone implant and was sutured

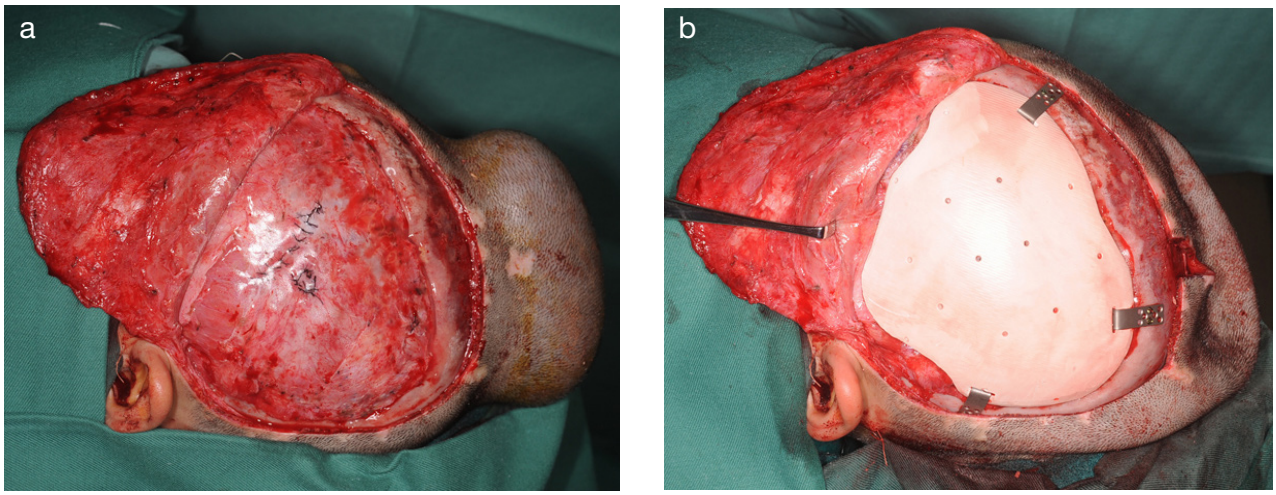

Fig. 4 a. Photograph taken at the second surgery (four months after the first surgery). The skin flap was elevated above the galea reconstructed by the autologous fascia lata. It is clear that the scalp skin flap is fully expanded.
b. Cranioplasty was performed using a custom-made artificial bone made of hydroxyapatite (NGK Co. Ltd., Aichi, Japan). The implant was fixed to the cranial bone using a titanium plate and screws at three points. The expanded scalp skin is now draped on the cranium, and is large enough to cover the convexed artificial bone implant.

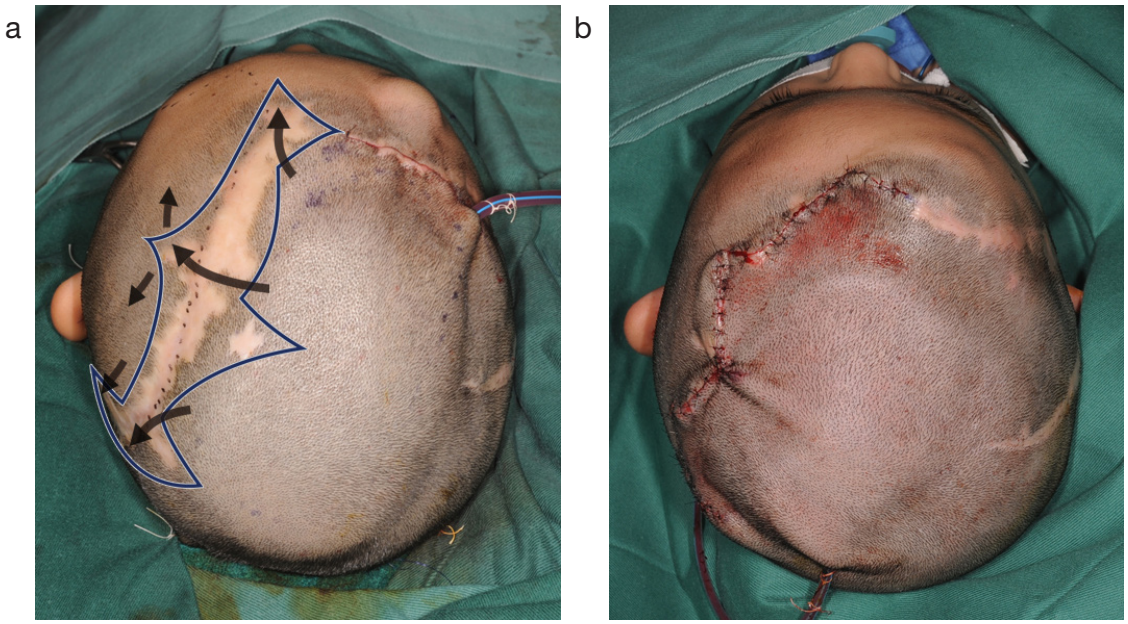

Fig. 5 a. Intraoperative design is drawn. Arrows indicate the direction of the flap rotation. The blue solid line in the photograph shows incision line to excise large scar. The expanded scalp skin flap was cut and divided to advance the peripheral margin of the flap over the skin defect.
b. The scalp skin could be sutured without any tension, although a thin and hairless scar was excised.

without any tension, although the thin and hairless scar was excised **(Fig. 5a, b)**.

Postoperative progress

4 years 2 months have passed after surgery without complications such as infection or implant exposure. Good cranial shape is maintained, and the scar resulting from the surgery is not conspicuous **(Fig. 6)**. Computed tomography scanning revealed no damage (such as cracks and breakage) to the implant.

DISCUSSION

Use of a tissue expander

When the surgery comprises implantation or grafting of artificial material, wound dehiscence leads to direct implant exposure and indicates failure of the surgery. For good wound healing, it is necessary that no excess tension be applied to the suture. In addition, the artificial material must be covered by a well-vascularized flap [4]. Therefore, in this case, we planned to use a tissue expander to decrease the skin tension applied to the scalp skin flap which reduced the flap blood flow. In cases without complications after emergency brain surgery, the scalp flap is well preserved and can be safely used for cranial reconstruction surgery without supplementation with soft tissue [4]. In cases involving wound dehiscence, artificial dura infection or fistula formation, scar contracture along the

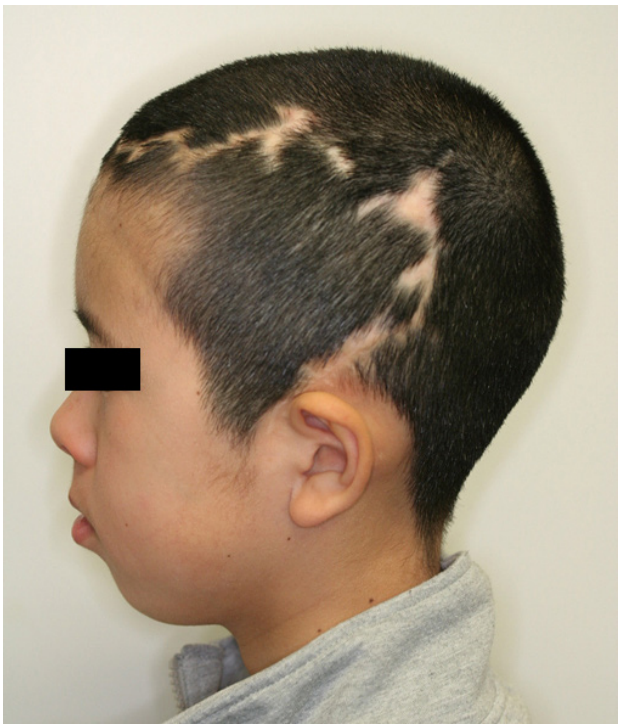

Fig. 6 Photograph taken after the surgery. Complications (such as infection or implant exposure) were not observed. Good cranial shape has been maintained.

site of infection and thin scars formed by granulation and epithelialization at the site of the fistula can cause skin flap insufficiency [4]. Many authors have reported implant exposure in cases with complications after the primary surgery [7–11].

The application of tissue expanders for the reconstruction of skin and soft tissue has already been well established in plastic surgery [12–14]. However, to date, there are relatively few reports involving the use of tissue expanders for cranioplasty [4, 11]; in particular, our search of the literature did not reveal any reports involving children. We believe that the use of a tissue expander with reconstructive surgery is effective for surgeries in cases similar to that reported here.

Use of a custom-made artificial bone implant

Custom-made artificial bone implants are often chosen for cranioplasty in adult patients. When the implantation of artificial material is considered for children, it is necessary to consider the cranial growth [15]. The space between the artificial implant and surrounding bone will usually be filled by newly formed bone; however, in children, it has been observed that implants sink into the calvarial bone during cranial growth and often expose the inside of the cranium, referred to as the "sinking phenomenon" [16]. Therefore, in our case, it was likely that the implants would need to be changed, according to the cranial growth. In cases when the defect is relatively small, we consider reconstruction surgery using autologous tissue is desirable for growing children. There are some reports regarding a combined procedure that involves absorbable material that acts as a scaffold, in combination with regenerative tissue engineering. Although this method would be ideal for growing children, the procedure is still being studied [17, 18]. On the other hand, a potential resolution to such situations is to delay the surgery until the child's growth is completed. However, many educational institutions are proposing a requirement that patients attend school without large cranial hard tissue defects. This situation makes it more difficult for schoolchildren to return to school.

Consequently, because of physical and anatomical limitations as well as social needs, reconstructive surgeries have been performed using artificial bones in many cases [15, 19–21]. We also used custom-made artificial bone in this case. In our case, the patient is now 12-year old, and his cranium is estimated to have already achieved a remarkable growth. We expect that he will be unlikely to require an implant change in the future.

CONCLUSION

A tissue-expansion technique in conjunction with a custom-made artificial bone implant was effective for a large cranial reconstruction in pediatric patient. In cases involving wound dehiscence, artificial dura infection or implant infection after a primary emergency brain surgery, this combined procedure provides safe coverage of the implant and good wound healing.

CONFLICT OF INTEREST

All authors declare no conflict of interest.

ETHICAL STANDARDS

All procedures performed in this article were in accordance with the ethical standards of the institutional ethical board of Tokai University School of Medicine and with the 1964 Declaration of Helsinki and its later amendments.

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