CASE REPORT

Two-stage cranial reconstruction with a custom-made titanium plate using a preliminary bipedicled scalp flap : A case report

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Abstract : A 75-year-old woman presented with scalp and cranial defects caused by implant exposure, infection, and cranial necrosis following multiple craniotomies. To reduce the risk of complications after cranioplasty, we planned a two-stage cranial reconstruction. A wide bipedicled scalp flap with a long longitudinal axis above the cranium covered the scalp defect after debridement, and skin grafting was performed on the periosteum after flap harvesting during the first surgery. A custom-made titanium plate was implanted under the bipedicled flap during the second cranioplasty 4 months after the initial surgery. The patient had no complications during the two surgeries, and her clinical course was uneventful for 6 months after the last surgery. Although a two-stage approach, our technique is relatively safe for patients who have previously undergone multiple surgeries and decreases the risk of postoperative complications due to the shorter exposure time of the titanium plate during the second surgery. J. Med. Invest. 72 : 185-188, February, 2025

Keywords **:** *Cranioplasty, Cranial Reconstruction, Custom-made titanium plate, Bipedicled Flap, Two-Stage Surgery*

INTRODUCTION

Patients undergoing craniotomy usually require cranioplasty for brain protection, improved neurological outcomes, and cosmetic reasons (1-3). However, cranioplasty after craniotomy increases the risk of postoperative complications (2). The most common complication is infection, which occurs in approximately 2–20% of patients (4, 5). Debridement followed by cranial and scalp reconstruction is occasionally performed ; however, these procedures may be challenging because of poor surgical conditions with marked scarring and fibrotic degeneration after multiple surgeries (6, 7). Herein, we present a case of two-stage cranial reconstruction with a custom-made titanium plate using a bipedicled scalp flap in a patient with surgical site infection after craniotomy.

CASE REPORT

A 75-year-old woman diagnosed with a malignant meningioma of the right limbus of the sphenoid underwent six Gamma Knife radiosurgeries and four craniotomies employing titanium plates and screws to address recurrent lesions within the past year. The patient had purulent discharge from the surgical scar at the lateral head 3 months after the last craniotomy. The amount of discharge was initially subtle, but gradually increased within a month. At her first visit to our hospital, we found a cutaneous fistula with exposed bone cement, and magnetic resonance imaging revealed a considerable abscess under the skin, which continued toward the dura (Figure 1). The pus was removed, the wound was irrigated with normal saline, and ceftriaxone 4 mg/day was administered intravenously. To prevent infection spread around the dura, emergency debridement was planned for the day after the patient's visit to our neurosurgery department. The patient's physical status based on the American Society of Anesthesiologists (ASA) physical status classification system was ASA 3. Accordingly, we decided to perform a two-stage cranioplasty in which a local flap is used to cover the defect after debridement and cranial reconstruction with a titanium plate is performed thereafter, considering the patient's poor physical status.

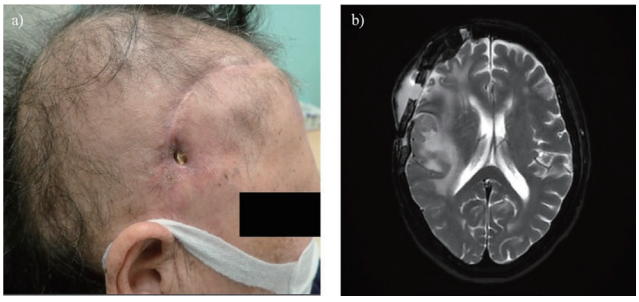

Figure 1. Patient images at the first visit.
a) A fistula with purulent discharge is found near the incision scar of the previous craniotomy.
b) An abscess collected under the skin by magnetic resonance imaging in the T2-weighted imaging sequence.

First, the patient underwent thorough debridement of the infection site, and all titanium plates and screws were removed. The entire erythematous skin and soft tissue affected by the subcutaneous infection were removed, and the abscess was thoroughly washed with copious amounts of normal saline. Because the remaining tissues were considered to be uninfected, and without necrosis and hypovascularities, a sodium hyaluronate-based bioresorbable membrane (SEPRAFILM®, Baxter

Received for publication June 26, 2024 ; accepted November 13, 2024.

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International Inc., U.S.A.) was inserted onto the exposed dura following the removal of the titanium plate to prevent adhesion between the subcutaneous tissue and the remaining dura in the second cranioplasty surgery (Figure 2a). Subsequently, a bipedicled scalp flap with a long longitudinal axis and width, including the occipital and supratrochlear arteries, was designed posteriorly to cover the skin defect, advancing sufficient tissue to fill the dead space on the cranial defect after the removal of the titanium plates and screws. The flap was elevated above the cranium to avoid vascular impairment in the subcutaneous tissue around the previous scars. Moreover, we left some areas of the periosteum posteriorly under the flap in case of further advancement of the flap in the second cranioplasty (Figure 2b). A split-thickness skin graft was applied to the preserved periosteum after advancing the bipedicled flap (Figure 2c). Ceftriaxone 4 mg/day was administered for 10 days after the surgery.

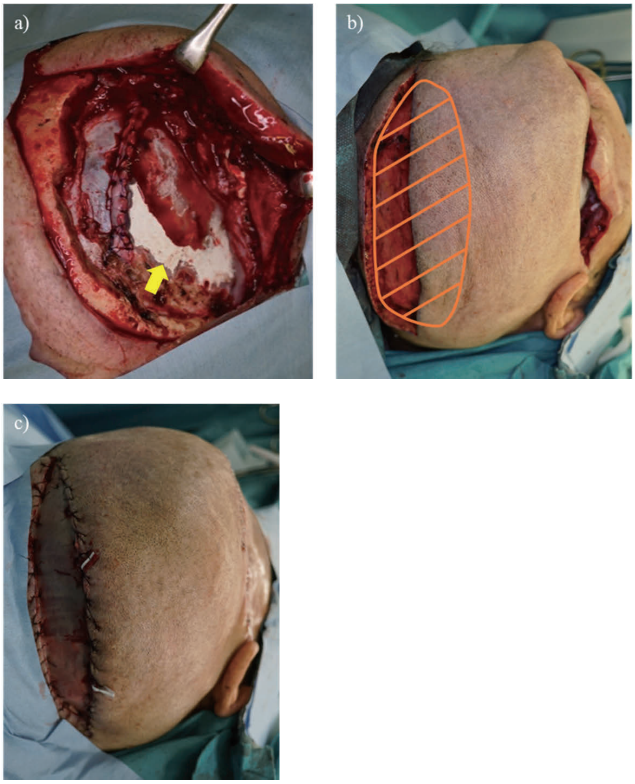

Figure 2. Debridement and a bipedicled flap advancement in the initial surgery.
a) All implanted titanium plates and screws are removed. The fistula is excised, and the abscess is thoroughly washed. A sodium hyaluronate-based bioresorbable membrane (yellow arrow) is inserted onto the exposed dura following the removal of the titanium plate.
b) A bipedicled scalp flap, including the occipital and supratrochlear arteries, is advanced towards the cranial defect. The area of the oblique orange lines shows the periosteum left under the flap.
c) Split-thickness skin grafting is applied to the remaining periosteum.

The postoperative course was uneventful without clinical infection, and a second cranioplasty involving implantation of a custom-made titanium plate (Atsurae Ti, HOYA Technosurgical Co., Japan) was performed 4 months later. An incision was made at the anterior border of the bipedicled flap, and the titanium plate could be inserted without strong tension on the surrounding tissue because of the supple condition of the initial bipedicled flap. Completing primary closure without advancing the flap further shortened the operative time (Figure 3).

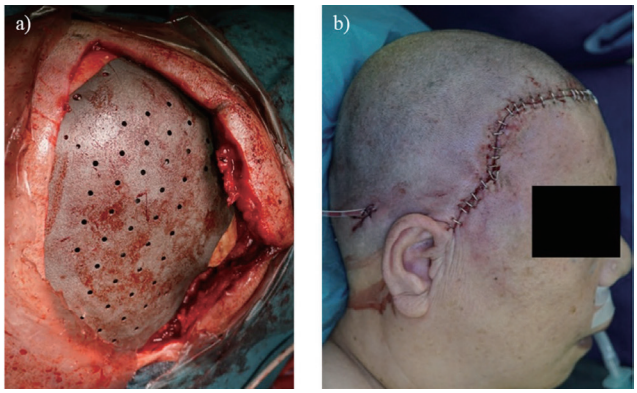

Figure 3. Second surgery with cranioplasty using a custom-made titanium plate.
a) An incision is made at the anterior border of the bipedicled flap, and the custom-made titanium plate can be inserted without strong tension on the surrounding tissue because of the supple condition of the initial bipedicled flap.
b) Primary closure shortened the operative time.

The patient was discharged uneventfully, and there were no clinical complications, such as infection, fluid collection around the implants, or scalp atrophy, 6 months after surgery (Figure 4).

Figure 4. Postoperative images.
a) Superior contour of the reconstructed cranium.
b) There were no clinical symptoms of infection or fluid collection around the advanced flap.
c) Remarkable alopecia due to the skin graft in the occipital region.

DISCUSSION

Cranioplasty involves substantial postoperative risks, such as infection, implant exposure, wound dehiscence, and flap breakdown (7, 8). The revision rate is as high as 23% and requires debridement, implant removal, and additional reconstruction (7). Traditionally, reconstruction procedures for cranial and scalp defects in unsuccessful cranioplasty cases involve local flaps, free flaps, and hard materials. In previous studies, these techniques were chosen based on the individual patient's condition, conforming to the principles of the "reconstructive ladder" and the replacement of "like with like" (7, 9). However, these reconstructions are often complicated by excessive tissue loss, multiple scars, and hypovascularized atrophy caused by previous surgeries (6, 10). Moreover, cranial reconstruction using free tissue transfer is a considerable burden to patients due to prolonged general anesthesia and increased surgical stress (11).

Multiple risk factors, such as diabetes mellitus, renal failure, peripheral vascular disease, preoperative radiotherapy, prolonged operative time, and prolonged general anesthesia, are associated with free flap failure (12-14). Furthermore, ASA classification is a predictor of complications after free flap transfer, with higher ASA scores associated with an increased risk of postoperative complications. ASA 2 suggests 2.2-times higher odds of postoperative complications than ASA 1 ; moreover, ASA 3 suggests 2.6-times higher odds than ASA 1 (15). In this case, we avoided single cranial reconstruction using free flap transfer. We decided to perform two-stage cranioplasty because of the patient's preoperative ASA 3 status and previous history of multiple craniotomies and combined radiosurgeries, which lead to a higher risk of complications after surgery.

A scalp flap is often elevated on the loose areolar layer between the galea aponeurotica and pericranium to increase flap mobility (16). However, fibrotic scarring and granulation tissue proliferation in the subcutaneous tissue due to previous infection or surgical debridement can occasionally limit flap mobility (6). To reduce these impairments, we designed a wide and long bipedicled scalp flap and elevated it above the cranium to avoid subgaleal scarring, which resulted in a shortened operative time and increased flap mobility. Moreover, we left some areas of the periosteum under the flap posteriorly in the initial surgery, considering the possibility of further requirement for an additional skin graft after advancing the bipedicled flap in the second surgery. If the periosteum was resected during flap harvesting in the initial surgery, additional coverage using vascularized flaps would have been required, resulting in an increased operative time. Using a bipedicle scalp flap is a feasible and reliable technique for cranial reconstruction, especially in patients with frailty (11, 17).

In the present case, a sodium hyaluronate-based bioresorbable membrane was placed on the exposed dura after debridement. Multiple studies have reported that its anti-adhesive and biodegradable features significantly decrease complications and adhesions to the surrounding tissues postoperatively in gastrointestinal surgery (18, 19) ; this contributes to its effectivity as a dural substitute for two-stage craniotomy (20). In contrast, using artificial foreign substances in infected surgical sites may cause severe infection, and autologous tissue such as fascia lata may be a beneficial alternative for dural reconstruction (21). In this case, we thoroughly removed the infected tissues, including the erythematous skin and soft tissue around the fistula, for infection control, despite the use of an artificial membrane.

This study had some limitations. Because this is a case report, the full implications may not have been captured, as numerous techniques for cranioplasty have been published. Moreover, our procedure resulted in decreased cosmetic satisfaction owing to the requirement for skin grafting after advancement of the bipedicled flap. However, we believe that this surgical approach can be considered relatively safe for patients who have undergone multiple surgeries. Moreover, this approach decreases the risk of postoperative complications owing to the shorter exposure time of the titanium plate during the second surgery.

CONFLICTS OF INTEREST

The authors declare that there are no relevant conflicts of interest.

ACKNOWLEDGEMENTS

None

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