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CASE REPORT
Reconstructive

# Accelerated Cranioplasty with Perforator-preserved Split Flap Sandwiched Plate for Treatment of Infected Cranial Defects

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**Summary:** Large cranial vault defects are challenging to manage due to the need to balance infection control, skin coverage, and restoration of the protective mechanical rigidity of the skull while also ensuring good head and neck aesthetic results. Conventional-staged treatment requires a long time period that includes debridement and scalp skin defect coverage with flaps as a first step, followed by definitive plate reconstruction 3–9 months later after infection control and flap atrophy resolution. We report a case of successful early cranioplasty in a factory worker who developed a large full-thickness cranial skull defect following artificial dura infection. Reconstruction was performed in two stages using an anterolateral thigh (ALT) flap. In the first stage, the scalp defect was covered with an ALT flap to close the skin following debridement. In the second stage performed 6 weeks later, the ALT flap was split into adiposal and adipocutaneous flaps to sandwich a computer-aided design custom-made titanium plate with an opening for the perforator to complete the cranioplasty. The patient successfully returned to work without recurrence of infection with 1-year follow-up. We report this case to demonstrate the utility of adipocutaneous flap plate sandwiching techniques in providing well-vascularized cover for early definitive cranial reconstruction and accelerated patient recovery. *(Plast Reconstr Surg Glob Open 2022;10:e4234; doi: 10.1097/GOX.0000000000004234; Published online 8 April 2022.)*

## INTRODUCTION

The cranium functions as an important rigid barrier protecting the brain from infection and mechanical trauma while giving the head its aesthetic form. Defects, particularly those arising from infection, are difficult to treat. Infection complicates 4%–11% of patients undergoing cranial surgery with use of artificial dura and nonvascularized skull bone grafts associated with increased risk.[1–3] Reconstruction of such defects presents a challenging balance in treatment between controlling infection and restoring the rigidity of the cranial vault for mechanical protection of the brain in the shortest possible time.[1,3–6]

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Conventional-staged treatment requires a long period of time. It involves debridement of the infected artificial dura, bone and skin, and flap coverage of the defect as a first stage, followed by definitive cranial vault reconstruction performed 3–9 months after the initial surgery because of the need to control infection and await the resolution of flap muscle atrophy.[3–8] This prolonged treatment is physically and psychologically distressing for patients and may also result in loss of employment and income.

To reduce the treatment period, we report successful cranioplasty of a defect complicated by artificial dura infection managed by sandwiching a mesh plate between the bilayers of an adipocutaneous anterolateral thigh (ALT) flap in 6 weeks.

## CASE REPORT

A 61-year-old male factory worker with history of cerebral aneurysm 10 years ago treated with artificial dura (GORE-TEX; W. L. Gore & Associates Inc., Newark, Del.)

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covered with orthotopic autologous skull bone graft presented with a 1-year history of an infected skin ulcer above the graft fixation plate. Following onset of the ulcer, the plates were removed, and multiple debridement procedures were performed. However, the infection did not subside, and the ulcer widened, forming a 3×2 cm scalp defect, exposing the cranial bones and artificial dura (Fig. 1).

To control infection and cover the scalp defect, we decided to use an ALT flap. Following admission, a two-stage reconstruction was planned jointly with the neurosurgeons. The first surgery was performed to remove necrotic tissue and provide soft tissue cover. Intraoperatively, necrotic bone was removed with the artificial dura. Beneath the artificial dura, a watertight membrane was found to have formed on the brain surface preventing CSF leakage. Therefore, dura reconstruction was considered unnecessary and only superficial debridement was performed.[5] The resulting extensive bone and soft tissue defect was covered with a 23 cm × 12 cm ALT flap from the left thigh including three perforators and without vastus muscle (Video) (**see Video [online]**, which shows the first stage and second stage of the cranioplasty reconstructive surgery and the postoperative CT angiography). End-to-end vascular anastomosis was performed to the left superficial temporal artery and vein. The flap was deepithelialized to fill the defect and artificial dermis (TERUDERMIS; Olympus Terumo Biomaterials Corp, Japan) applied to protect the anastomosis site. The postoperative course was uneventful. The patient desired to return to work as soon as possible so cranial vault reconstruction with mesh plate cranioplasty was planned at 6 weeks.

**Fig. 1.** Preoperative photograph showing the infected complex cranial defect on presentation. The defect included a 2×3 cm full-thickness scalp defect, extensively infected skull bones with chronic osteomyelitis and infected artificial dura shown at the base of the defect. All the infected tissue and necrotic bone was removed in the first stage operation.

In preparation for the second-stage operation, computer tomography angiography (CTA) and 3-dimentional rotational angiography were performed to confirm the anatomical course of the three perforators in the flap and to establish the dimensions of the defect. Utilizing computer-aided design, a corresponding custom titanium mesh plate was constructed (BONEMASTER; PIOLAX Medical Devices, Japan) to match the defect with an opening designed for the superficial layer perforators within the flap identified on CTA (**see Video [online]**).

The second operation was performed 6 weeks later as planned. Under the microscope, the ALT flap was split horizontally through the superficial fascia, forming a superficial adipocutaneous flap based on the two perforators passing through the opening designed on the plate and a deep adiposal flap based on one perforator and the main flap pedicle. The vascularity of the two newly separated parts of the flap were confirmed by indocyanine green near-infrared fluorescence angiography and the customized plate was inserted between the layers and fixed to the cranial bone (Fig. 2A and B) (**see Video [online]**). The ventricular shunt tube was then removed, and the skin wounds closed.

The patient was discharged 9 days after surgery and returned to work. CTA 6 months later confirmed that the branches of the perforator vessels were preserved in both layers of the flap sandwiching the mesh plate (**see Video [online]**). He could retain his job with no complications. Total follow-up duration was 1 year and the patient was satisfied with the aesthetic result (Fig. 3).[9] [**See table, Supplemental Digital Content 1**, which shows five questions asked to assess aesthetic outcomes following cranioplasty (proposed by Fischer et al.), **http://links.lww.com/PRSGO/B990**.]

## DISCUSSION

Generally, there are two main contrasting opinions regarding the optimal period to perform cranial vault reconstruction for treatment of infected complex cranial defects that include both bone and scalp defects.[3,7] The first considers early cranioplasty a potential risk for recurrent infection of the implant and therefore advocates for cranioplasty to be delayed for at least 6–9 months after confirming the adherence of the transplanted flap and the completion of flap atrophy.[3] The second advocates for early cranial reconstruction to reduce the risk of complications associated with the syndrome of the trephined and recommends an interval of approximately 3 months.[7] In both cases, the resulting overall duration of treatment of an infected cranial vault defect requires a period of 3–9 months.

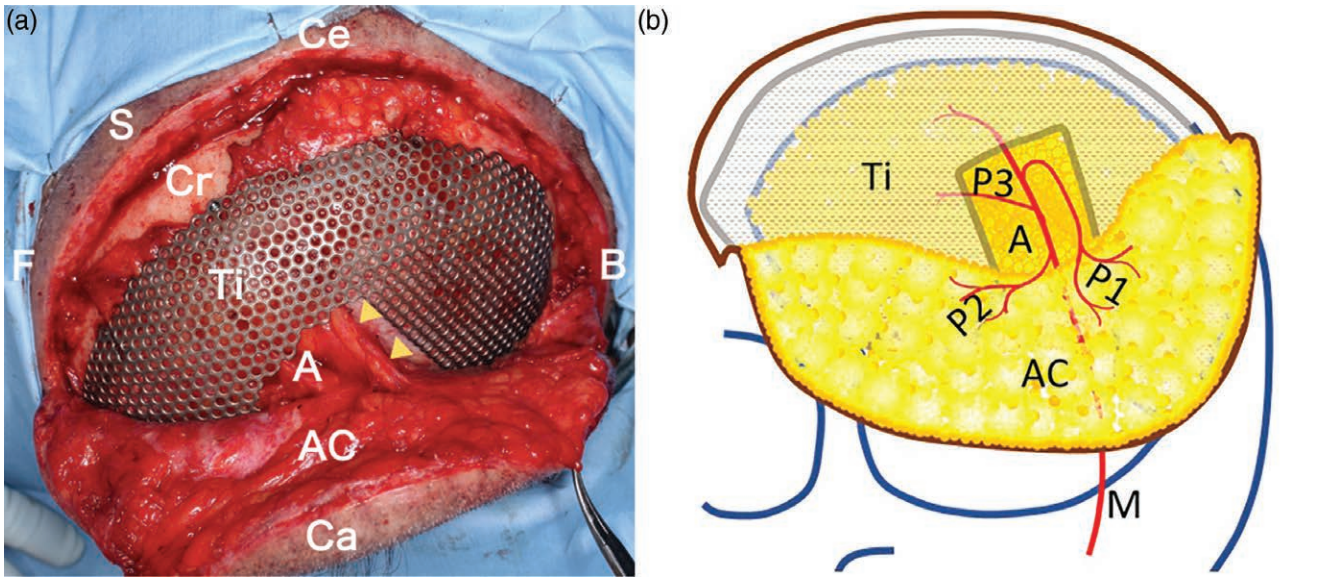


**Fig. 2.** Perforator-preserved split ALT flap for sandwiching plate. A, A, Intraoperative photograph of the second-stage operation insertion of the custom computer-aided design titanium mesh plate (Ti) sandwiched between the adiposal flap (A) below and adipocutaneous flap (AC) above. The perforator (yellow arrow) supplying the adipo- cutaneous flap is show passing from the main ALT flap pedicle in the adiposal flap laterally through the designed opening in the plate to the adipocutaneous flap (see B marked P1, P2). The vascularity of both of the newly separated flaps was confirmed using ICG near-infrared angiography and CTangiography. B, Illustration of the second-stage operation. The perforators (P1, P2) supplying the adipocutaneous flap (AC) are shown passing from the main ALT flap pedicle (M) in the adiposal flap (A) laterally through the designed opening in the plate (Ti) to the adipocutaneous flap. The perforator supplying the deep adiposal flap layer is marked P3. Orientation; B, back; Ca, caudal side; Ce, cephalic side; Cr, cranium; F, front; s, skin.

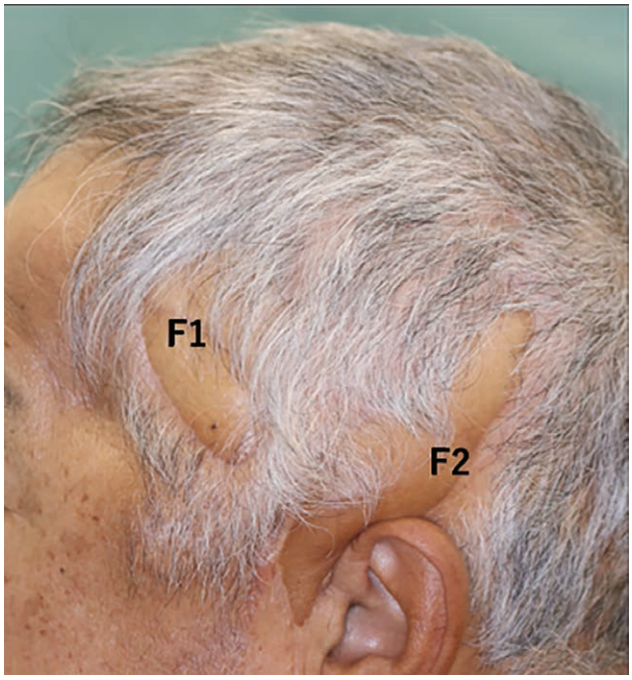


**Fig. 3.** Postoperative photograph showing the postoperative result. Most of the flap skin was deepithelialized, leaving two areas with skin marked F1 to cover the original scalp defect and F2 overlying the flap pedicle anastomosis to the superior temporal artery and vein.

To achieve the shorter period of treatment of 6 weeks in our case, we considered two key factors; First, to reduce the risk of recurrent infection, a well-vascularized adipocutaneous flap was used as two layers sandwiching the mesh plate. Traditional flap dissection for plate insertion is often performed between the flap and the newly formed dura membrane, or between adiposal and muscle layers of myocutaneous flaps.[3–7] The former method results in dead space, leading to infectious fluid collection, whereas in the latter method, it is difficult to precisely adjust the volume of muscle in anticipation of the inevitable muscle flap atrophy due to muscle denervation. Therefore, we elevated the flap without muscle to avoid atrophic volume changes. A retrospective case series by Hong et al[8] showed adipocutaneous flaps were as effective as myocutaneous flaps in the treatment of osteomyelitis. By leaving a deep adiposal layer below the mesh plate, we eliminated the dead space between the plate and the dura membrane while ensuring the membrane-like dura remained covered with well-vascularized tissue to reduce the risk of re-infection. Second, to preserve the perforating branches and the vascularity of the flap layers, we designed a dedicated slit opening in the prefabricated plate for the adipocutaneous pedicle. Despite this, the strength of the plate was still maintained.[10]

The main limitation of this technique is the potential weakening of the plate if excessive modifications are made. Further studies with more cases are needed to establish the clinical efficacy and application of this technique.

## CONCLUSION

Plate sandwiching with perforator-preserved split adipocutaneous flaps provides well-vascularized coverage for early cranial reconstruction and may accelerate patient recovery.

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