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Pedicle Galeo-pericranial Flap Augmentation in Salvage Frontotemporal Cranioplasty: Additional 'Neurosurgeon-friendly' Reconstruction Technique of Aesthetic Neurosurgery in Superficial Temporal Artery Branch Compromised Host

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Abstract

This technical note aims to demonstrate the usefulness, indications and its limitations of augmentation technique by bipedicle galeo-pericranial rotation flap and by monopedicle galeo-pericranial flap, both in STA (superficial temporal artery) branch compromised hosts in salvage frontotemporal cranioplasty. Although these flaps are not always idealistically vascularized owing to accidental injuries to the STA branches during previous surgeries, they are properly augmenting after salvage frontotemporal craniotomy when infection is not active. The procedure is indicated for salvage frontotemporal craniotomy when vasculature is needed at the surgical site, such as beneath the skin incision line in a thin injured scalp, onto the titanium plates or beneath the fragile fibrous scar. We do not apply this technique by neurosurgeons alone where infection is active or if the host is irradiated. This technique is recommended as a reconstructive aesthetic neurosurgical procedure. It is a 'neurosurgeon-friendly' simple procedure, as it does not require any special tools or complicated techniques.

Key words: pedicle galeo-pericranial flap, salvage cranioplasty, aesthetic neurosurgery

Introduction

Aesthetic neurosurgery has been discussed extensively in the last decade,[1)] and this subspecialty field includes the art of post neurosurgical aesthetics as well as aesthetical trouble shooting issues and reconstruction.[2–6)] Cranial fixation techniques[7)] or reconstructive cranioplasty is one of the well-discussed issues in aesthetic neurosurgery, as salvage cranioplasty is a challenge in every situation. Salvage cranioplasty is subsequently performed after multiple procedures, followed by skull removal due to infection such as subdural empyema, or due to scalp trouble. For example, subdural empyema is a consequence when pus accumulates between the subdural spaces and paranasal sinuses or mastoid air cells, or between the layers of implanted cranium and dural substitution, regardless of preserved one or artificial one, respectively, due to lowered immunity. It is also a consequence of poor skin adaptation, sometimes. It usually leads to removal of the implanted skull, and further procedure of dura matter removal and exchange is necessary if it is contaminated. Another example to require salvage cranioplasty is a scalp

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ulceration. It is created in the middle of the scalp flap or along with the incision line. This may be caused by vasculature loss, which is sometimes enhanced by increased skin tension and local infection, and it also usually results in skull removal, regardless of whether it is an autograft or an artificial implant. Since salvage cranioplasty is usually performed after a number of neurosurgical procedures, it is usually complicated with shrinkage of the scalp, cicatrization with lost vasculature, tissue loss, injury to the superficial temporal artery (STA) branches and/or other arteries such as supratrochlear artery or supraorbital artery. This situation of poor host condition may also occur in tumor surgery with recurrences. Irradiation may add to the difficulties in achieving proper skin closure and wound healing.

Many techniques have been applied to overcome these disadvantages in salvage cranioplasty, including our partial cranioplasty technique (Catcher's mask cranioplasty),[2,4] the combination of rib grafts and calvarial grafts, which gives better aesthetic result in salvage cranioplasty after trauma surgery. The fundamental here is that cranial reconstruction in salvage cranioplasty should be performed with autologous bone graft. Another solution is a galea-calvarial flap technique,[3,5,6] which enables calvarial graft implantation with preserved blood supply from the pedicle galeal flap, and this galeal flap is simultaneously isolating the frontal sinuses. This cranial reconstruction technique of vascularized calvarial flap is implemented because the amount of cranial defect is not as big as the one in trauma surgery or even in aneurysmal surgery. Other techniques include vascularized composite allotransplantation, for example, with the antero-lateral thigh flap,[8,9] but the technique of vascularized free tissue implantation is rather concentrated in the scalp closure, not in the calvarial (skeletal) reconstruction. Varying from small manipulation to larger flaps, the surgical indication for each additional technique differs between cases to cases, depending on host circumstances, i.e., the size of defect and conditions of skin, muscles and blood vessels where cranioplasty was performed. The common issue here is a lack of appropriate amount of vascularized tissue and its function in those host circumstances.

Those complicated technique of reconstruction procedure is technically not easy to be performed only by the neurosurgeons, and in most cases, it is performed by the plastic reconstructive surgeons or by the aesthetic neurosurgery teams which is organized with the participation of both neurosurgeons and plastic surgeons. Because a well-trained plastic reconstructive surgeons are not always working closely together with neurosurgeons, development of a 'neurosurgeon-friendly' technique of salvage cranioplasty is in demand.

We hypothesized, in salvage cranioplasty, an implant will be successfully applied together with tissue augmentation even if this tissue is not perfectly well vascularized, provided that host is not actively or severely compromised. Here, we demonstrate the technique of augmentation by pedicle galeo-pericranial flap in salvage cranioplasty.

Case Report

Technical points

Salvage cranioplasty was performed with ceramic implants (Mizuho Ikakogyo Co. Ltd., Tokyo, Japan), with minimized convexity contour, compared with the other side of the skull, to lower scalp tension. Once the ceramic implant was in place, an additional 6-cm perpendicular skin incision was placed at the middle of the original incision posteriorly (Fig. 1a), to expose the superficial layer of the galea (Fig. 1b). The original skin incision to expose the skull defect was used to harvest frontal longitudinal edge of the galeal flap, and the other posterior side of the longitudinal edge is made by incising 5 cm parallel to it (Fig. 2a). A 5 × 25-cm bipedicle galeo-pericranial rotation flap was harvested by removing the pericranial side of the flap from the skull, and trans-positioned anteriorly (Figs. 1c and 2b), to

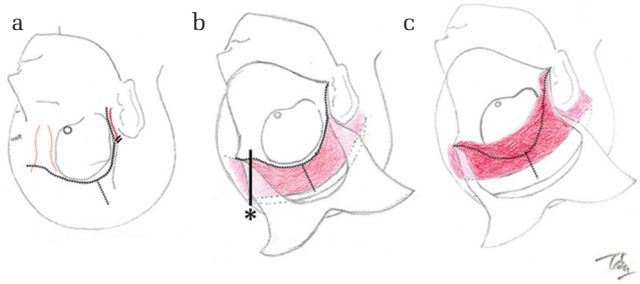

Fig. 1 Schematic drawing of the pedicle flap in frontotemporal craniotomy. (a) Additional skin incision is posteriorly placed onto the original skin incision perpendicularly. STA is usually compromised in this salvage cranioplasty. (b) Scalp is separated from the galeal layer. Bi-pedicle galeo-pericranial rotation flap (shown in a *red bundle*) is harvested and anteriorly mobilized when the pericranium is detached from the skull with both short margins left attached to the skull. Mono-pedicle galeal flap is harvested when the medial short attachment is incised (*), for the better mobilization of the flap. Note that most part of the anterior margin of the pedicle flap is adjacent to the edge of the craniotomy. (c) The anteriorly rotated flap is covering the original skin incision line. In order to expose this flap, the scalp layer is widely dispatched from the galeal layer, which also contributes to the following skin closure in a tension free manner.

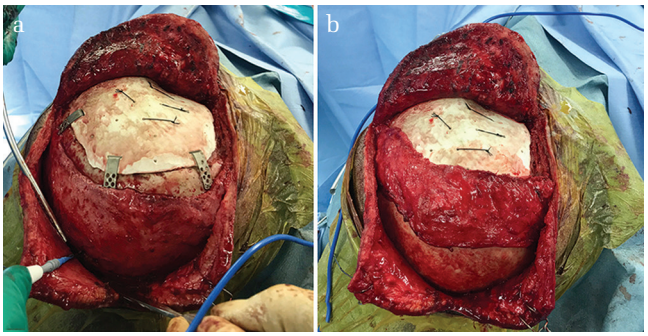

Fig. 2 (a) Electrocautery is incising the posterior longitudinal margin of the pedicle flap. (b) Bipedicle galeo-pericranial flap is mobilized anteriorly to make a rotation flap.

undercover the original skin incision and to cover titanium plates. Eventually, this procedure dispersed scalp tension by dissecting the scalp skin from the galeal tissue to implement skin closure in a tension free manner.

A 5 × 25-cm monopedicle galeo-pericranial flap was harvested by cutting the front end of the flap (Fig. 1b). This monopedicle flap is applied where increasing mobility of the flap is in demand.

Case presentations

Three candidates (two men and one woman; mean age, 38.3 years; range 22–47 years) for salvage cranioplasty were referred to the first author (I.T.) between July 2013 and December 2015. All patients have undergone frontotemporal craniotomy due trauma surgery or aneurysmal surgery, with a mean number of 4 (range, 3–5) surgical procedures. Both frontal and parietal branch of the STA of the craniotomy side were compromised in all cases.

Two patients underwent bipedicle galeo-pericranial rotation flap augmentation and the other one patient underwent monopedicle galeo-pericranial flap augmentation in salvage frontotemporal cranioplasty in a scalp tension free manner. The period between the last surgery and the salvage cranioplasty ranged from 21 to 31 months.

Case 1: Bipedicle galeo-pericranial rotation flap

A 46-year-old man was admitted due to the head trauma. Because of cerebral contusion and subdural hematoma, the patient underwent external decompression on July 2014, and GoreTex was used for dural plasty. He underwent cranioplasty on August 2014 with cryopreserved autograft, but he developed subdural empyema on September 2014. The autograft and GoreTex was removed, and dural plasty using free fascia lata was performed 20 days after the cranioplasty.

Salvage frontotemporal cranioplasty was performed on February 2017 with bipedicle galeo-pericranial rotation flap augmentation (Figs. 3a and 3b) in a tension free scalp closure manner. This procedure was done by co-authoring young neurosurgeon (KH) under the supervision by the first author (IT). For this patient, bipedicle rotation flap was chosen to add the more vasculature.

Case 2: Bipedicle galeo-pericranial rotation flap

A 18-year-old man was admitted due to the head trauma. Because of cerebral contusion and subdural hematoma, the patient underwent external decompression on November 2014. He underwent cranioplasty on December 2014 with ceramic, but he developed subdural empyema in two weeks, resulting ceramic and the GoreTex removal, and free fascia lata graft was applied for dural substitution. On May 2015, cranioplasty was performed with ceramic, but the implant had to be removed because of the pus discharge in three weeks.

Salvage frontotemporal cranioplasty was performed on February 2018 with bipedicle galeo-pericranial rotation flap augmentation (Fig. 2a and 2b) in a tension free scalp closure manner. Bipedicle rotation flap was chosen for this patient to add the more vasculature.

Case 3: Monopedicle galeo-pericranial flap

A 46-year-old woman was admitted to due to subarachnoid hemorrhage secondary to ruptured right middle cerebral artery aneurysm on September 2011.

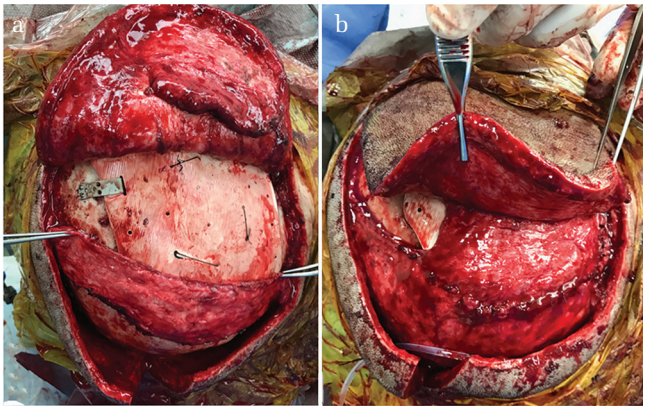

Fig. 3 (a) Harvested 5 × 25-cm bipedicle galeo-pericranial rotation flap. (b) Bipedicle flap is applied to undercover the skin incision and cover the titanium plate. It is sutured to the temporal fascial. Eventually, this flap has vascular supply from ipsilateral supratrochlear artery and supraorbital artery.

Clipping surgery was performed without application of bone graft for external decompression. She underwent dural plasty 14 days after clipping because of cerebrospinal fluid leakage. The patient had an excellent clinical course without any neurological deficit, and cranioplasty was performed on October 2012 using autograft cryopreserved at −80°C. However, a skin ulcer developed on the scalp flap (Fig. 4a), and the autograft was removed on July 2013, with debridement and primary suturing of the skin ulcer. Up until the salvage cranioplasty, no artificial implant for dural substitution was used in this patient, and the healed skin ulcer was still thin and fragile to make fibrous scar.

Salvage frontotemporal cranioplasty was performed on April 2015 augmented with monopedicle galeo-pericranial flap (Figs. 4b and 4c). The monopedicle flap was chosen for this case because flap mobility was required in order to undercover the scalp flap at the site of the fibrous scar (where the vasculature was lost due to the skin ulcer), to undercover the skin incision, and to cover the titanium plate, followed in the tension free manner of scalp closure. This patient has no sign of recurrent scalp problem in the following 33-month observation period.

Discussion

Vascularization of the bipedicle galeo-pericranial rotation flap, when it is not compromised, is supplied by the ipsilateral STA, ipsilateral supraorbital artery, and ipsilateral supratrochlear artery.[10] The use of perfectly vascularized flap is idealistic to increase neo-vascularity, immunity, and the isolation and protection of the intracranial space from contaminated spaces such as the paranasal sinuses or air cells. This technique is used in many occasions including face[11] and neck[12] reconstruction, paranasal sinuses reconstruction,[13] anterior skull base reconstruction,[14,15] with endoscopic procedures,[16] one-stage reconstruction of chronic dermal ulcer after cranioplasty,[17] or in a secondary cranial reconstruction in a multi-disciplinary approach.[18]

But perfect vascularization is not always the case in a salvage cranioplasty surgery. Like in our case series, the STA branches may be accidentally injured during previous surgeries. In this situation of STA branch compromising, the blood supply of the lateral side of the pedicle galeo-pericranial flap is considered to be less than with the STA branch preservation. Eventually, the blood supply of a bipedicle galeo-pericranial rotation flap is richer than a monopedicle galeo-pericranial flap, as the former one could also be supplied from the ipsilateral supraorbital artery and supratrochlear artery. We tried to indicate bipedicle flap in all cases, but mono-pedicle flap was chosen to add the more mobility to the flap in our case 3. This 'less vascularity' is also discussed in the breast reconstruction.[19] We certainly are aware of this disadvantage, but mono-pedicle galeo-pericranial flap augmentation is far better than the application of free tissues such as free temporal fascia, free fascia lata or free fatty tissue for augmentation.

We consider this procedure is suitable in salvage frontotemporal cranioplasty, as the donor site of the flap is always adjacent posteriorly to the craniotomies to make a sufficient longitudinal margin of the flap. We indicated this technique where the wound is already healed but fragile tissues, to add vasculature in order to promote wound healing, and to enable

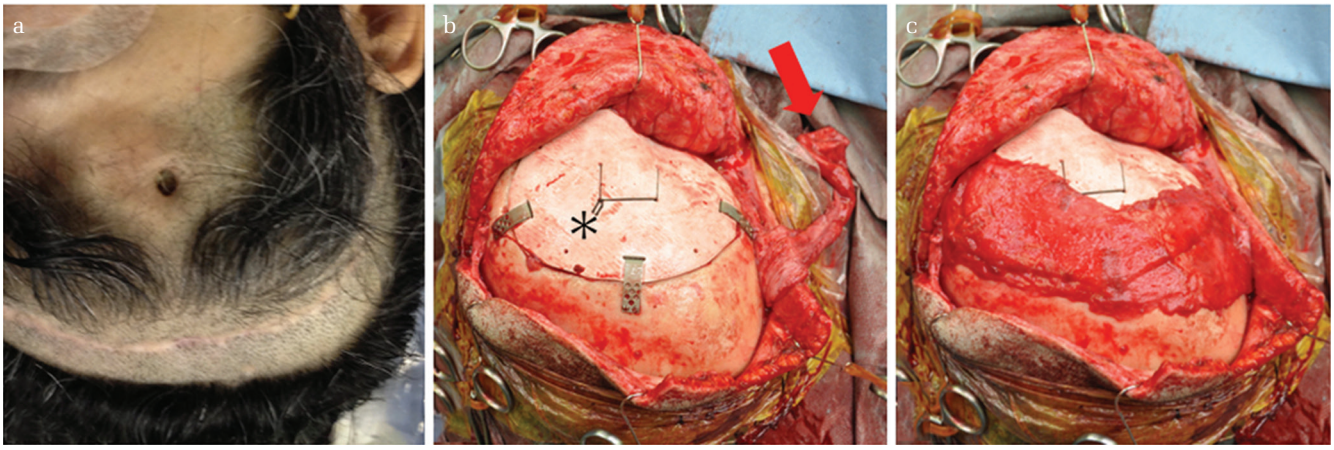

Fig. 4 (a) Skin ulcer is prominent at the middle of the scalp flap. (b) Harvested 5 × 25-cm monopedicle galeo-pericranial flap (*yellow arrow*). *Green asterisk* shows the location of the old skin ulcer at the flap. (c) Monopedicle galeo-pericranial flap is applied to undercover old skin ulcer, original skin incision line and the titanium plate. This flap has the advantage of increased mobility.

another surgical procedure. The augmentation covers on the titanium plates, beneath the fibrous scar due to the skin ulcer or beneath the skin closure line. The dissection of the scalp skin layer from the galeal layer at the donor site leads to the dispersion of scalp tension, leading to easier skin closure in a tension free manner, which is another advantage of this technique.

Like in our case 1, a neurosurgeon in training can easily perform this procedure. It is recommended as a reconstructive aesthetic neurosurgical technique. It is a 'neurosurgeon-friendly' technique, as this does not require any special tools or complicated techniques, and this could be performed without well-trained plastic surgeon in the team or even without senior neurosurgeon if the operating young neurosurgeon is experienced with this procedure.

These pedicle galeo-pericranial flap augmentation is indicated in stepwise reconstructions, not in a one-time reconstruction where infection is active. We also do not perform this technique when the host is irradiated, or if these flap could be used as bedding for skin graft is further to be determined. In these poor conditions of host, 'richly' vascularized flaps[17] or the vascularized composite allotransplantation[20] should be considered, which may require vast amount of medical resources and well organized team of reconstructive plastic surgery.

Our pedicle galeo-pericranial flap augmentation in salvage cranioplasty is indicated in patients with fragile skin due to the previous surgeries, those with foreseen higher skin tension, those with old skin ulcer at the flap, those without active infection, and those without previous history of irradiation.

In conclusion, pedicle galeo-pericranial flap augmentation is a useful technique in salvage frontotemporal cranioplasty in STA branch compromised hosts, as it adds vasculature, provided that the wound has already healed at the time of salvage cranioplasty. It is a 'neurosurgeon-friendly' technique of reconstructive aesthetic neurosurgery.

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Conflicts of Interest Disclosure

All authors have no conflict of interest.

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