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Original Article

Saving exposed titanium mesh cranioplasty using adipocutaneous anterolateral thigh flap: A case series

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ABSTRACT

Introduction: Scalp thinning and soft tissue atrophy are significant risk factors for prosthetic material exposure after cranioplasty surgery. Reconstruction of the forehead and scalp to ensure functional coverage and aesthetics continues to be challenging.

Patients and Methods: This prospective study assessed 15 patients with titanium mesh material exposure, scalp thinning, and soft tissue atrophy following cranioplasty from 2020 to 2023 to identify contributory factors. All patients underwent reconstruction with free adipocutaneous anterolateral thigh flap to cover skin defects and fill soft tissue. The results were evaluated based on flap survival, coverage, and symmetry after surgery.

Results: The average age in the study was 40.46 (range 11–68) years, and the male/female ratio was 9/6. From 2020 to 2023, 15 free adipocutaneous anterolateral thigh flaps were used for reconstruction. Complete flap survival was achieved in 93.3 % (14/15) patients with all titanium mesh implants retained. Symmetry and soft tissue hypoplasia correction was achieved in all 15 cases.

Abbreviations: ALT, Anterolateral thigh; LD, latissimus dorsi.

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Conclusion: Adipocutaneous anterior lateral thigh (ALT) flap is a versatile flap to treat complications following cranioplasty with titanium mesh. The ALT flap provides extensive coverage, reduce the risk of recurrent infections, and create an implant for soft tissue atrophy or skin thinning to restore the scalp's aesthetics

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Introduction

Cranioplasty with artificial materials is regularly performed to repair skull defect following decompressive craniectomy. A variety of artificial materials such as autologous bone, cement, C-PEEK, or titanium mesh have been used with titanium mesh gaining increasing popularity.^{1,2} Complications associated with cranioplasty using artificial materials are reported to range from 16.4 % to 36.5 %; among them, 76 % required the reoperation.^{3,4} Exposure of implant material has been historically considered a complete failure of cranioplasty and removal of the implant material is generally recommended. However, removal of the prosthetic material can significantly increase the risk of multiple cosmetic and functional complications for the patient.

Furthermore, scalp thinning and soft tissue atrophy have been shown as significant risk factors for the exposure of the prosthesis,^{1,5} little is reported about soft tissue atrophy following skull reconstruction using prosthetic materials.^{3,6} Although some authors have addressed this problem, their reports were primarily anecdotal and had short-term follow-ups. Several recent reports have recommended using in situ or microsurgical flaps to cover craniofacial materials following infection or exposure.^{7,8} Salvage surgery with reconstruction of scalp defect using local flaps has demonstrated positive results. However, this technique has failed in several cases and damaged the neighboring scalp, increasing the vulnerability to infections. The use of microsurgery flaps in head and neck has been reported in the literature; however, reconstruction of the forehead and scalp remains challenging owing to the need to ensure functional coverage and aesthetics. The leading cause of skin thinning and titanium mesh exposure is usually poor blood supply to the skin area. Therefore, using a microsurgery flap with a good blood supply is proposed as the best choice for appropriate coverage of exposed craniofacial material. In this report, we present the surgical outcomes of our patients who received adipocutaneous anterior lateral thigh (ALT) free flap for covering the exposed titanium mesh and repairing soft tissue atrophy. The work has been reported in line with the SCARE criteria.⁹

Patients and methods

Patients

This study included all patients who underwent free adipocutaneous ALT flap reconstruction to cover and preserve the exposed titanium mesh after cranioplasty from January 2020 to December 2023 at the Maxillofacial, Plastic and Aesthetic Surgery Department, Viet Duc University Hospital in Hanoi, Vietnam. Cumulatively, we performed 15 surgeries using free adipocutaneous ALT flap to cover and preserve titanium mesh after cranioplasty.

Data collection and follow-up

- Data regarding patient history, causes of cranioplasty, size of scalp defect, size of scalp atrophy, infection, and time from titanium mesh exposure to surgery were collected via clinical examination before surgery.

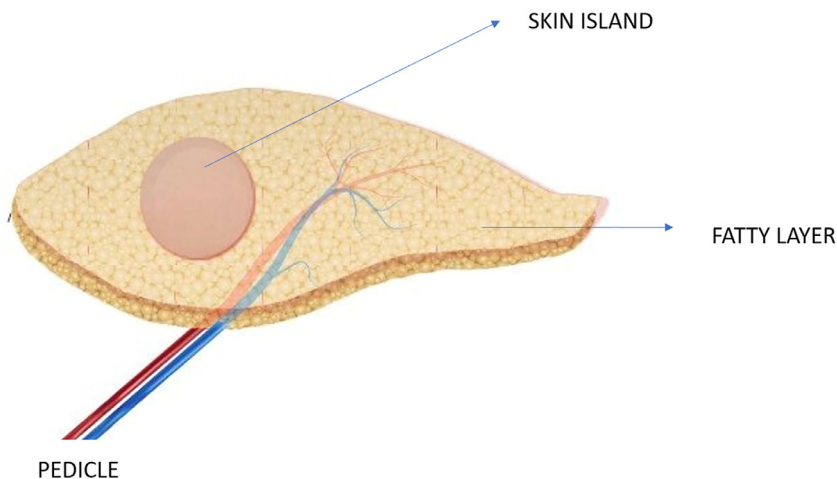


Figure 1. Diagram of adipocutaneous ALT flap with skin paddle.

- Surgical results were assessed by follow-up which was prospectively carried out via physical examination in the outpatient clinic at Viet Duc University Hospital. The timing of follow-up appointments depended on the patient condition evaluated at time of hospital discharge and prior appointment. The primary outcome of the study is survival of the flap.

Surgical techniques

Surgical harvesting technique of adipocutaneous ALT flap

- The patients were assessed for the size of the defect exposing the titanium mesh and extent of the associated skin atrophy. Three-dimensional (3D) titanium mesh panels were preserved and retained. The 3D titanium mesh was taken out, cleaned, and sterilized using the STERRAD system before being reinserted.
- The flap is harvested only from the skin with fatty tissue.
- The flap size is measured according to the skin atrophy area.
- The skin monitor pad is designed according to the size of the exposed titanium mesh. The epidermis from the rest of the flap is removed, leaving the fat layer of the flap to fill the soft skin atrophy defect (Figure 1).
- The pedicle recipient is commonly a superficial temporal fascia vessel.
- We evaluated the necrosis of the flap, wound infection, hematoma, aesthetics (covering defects, symmetry, and patient satisfaction) post-operatively.

The monitoring skin paddle of the flap covered the entire exposed area of titanium mesh. The epidermal layer was removed from the rest of the skin flap. The fat layer was preserved to fill the entire skin atrophy and soft tissue defect, especially in the temporal region, which achieved outstanding aesthetic results.

Results

Fifteen cases that were reconstructed using free adipocutaneous ALT flap to cover and preserve the titanium mesh after cranioplasty were reviewed. The clinical summary of the cases is shown in Table 1. The average age in the study was 40.46 (range 11–68) years, and the male/female ratio was 9/6. Cranioplasty was carried out after trauma from traffic accidents (13/15 patients) and after surgical resection of meningiomas with adjuvant radiation therapy (2/15 patients). Overall, 66.7 % of the patients had a history of infection. The 3D titanium mesh was designed for 10/15 patients. The titanium

Table 1
Patients data.

No.	Age, years/sex	Cause of cranioplasty	Infection history	Time from titanium mesh exposure to covering with ALT flap (months)	Exposed titanium mesh location/Size	Size of soft tissue atrophy	Flap survival
1	59/M	Traffic accident	N	2	Temporal/ 7 cm × 4 cm	22 cm × 10 cm	Complete
2	45/F	Traffic accident	Y	4	Temporal, vertex/ 4 cm × 5 cm, 6 cm × 7 cm	20 cm × 12 cm	Complete
3	63/F	Traffic accident	N	3	Temporal/ 8 cm × 4 cm	24 cm × 12 cm	Complete
4	68/F	Traffic accident	N	3	Frontal/ 6 cm × 4 cm	20 cm × 10 cm	Complete
5	26/M	Post radiation therapy	Y	6	Vertex/ 12 cm × 8 cm	None	Complete
6	52/F	Traffic accident	Y	20	Vertex/10 cm × 8 cm	20 cm × 8 cm	Partial Necrosis
7	30/F	Traffic accident	Y	4	Temporal- Frontal/10 cm × 8 cm	16 cm × 8 cm	Complete
8	29/M	Traffic accident	Y	24	Frontal-Vortex/ 6 cm × 8 cm – 4 × 5 cm	20 cm × 8 cm	Complete
9	40/M	Traffic accident	Y	9	Frontal/ 8 cm × 4 cm	25 × 10 cm	Complete
10	30/M	Traffic accident	Y	6	Frontal/8 cm × 6 cm	20 cm × 8 cm	Complete
11	32/F	Traffic accident	N	3	Frontal/8 cm × 8 cm	18 cm × 8 cm	Complete
12	52/M	Traffic accident	N	3	Temporal/15 cm × 7 cm	20 cm × 8 cm	Complete
13	11/M	Traffic accident	Y	4	Frontal/10 cm × 6 cm	20 cm × 7 cm	Complete
14	20/M	Traffic accident	Y	4	Frontal-Temporal/ 6 cm x 8 cm	22 cm × 8 cm	Complete
15	50/M	Post radiation therapy	Y	3	Frontal-Vortex 20 cm × 12 cm	25 cm × 12 cm	Complete

Abbreviation: ALT = anterior lateral thigh.

mesh was exposed in the forehead area (2/4 patients) and temporal region (2/4 patients). The feeding vessel of donor area were superficial temporal or facial artery.

- The patient's postoperative follow-up period was over 6 months.

The average age in the study was 40.46 (range 11–68) years, and the male/female ratio was 9/6. From 2020 to 2023, 15 free adipocutaneous ALT flaps were used for reconstruction. Complete survival of the flap was achieved in 93.3 % (14/15) of the patients and all titanium mesh implants were retained. Shaping and repairing the atrophied skin areas were effectively carried out in all patients.

Presentation of case 1

A 59-year-old woman underwent cranioplasty after a traffic accident with a 3D titanium mesh one year ago. After cranioplasty, the patient experienced thinning of the skin and holes under the skin. The atrophy of the temporal muscle caused the loss of aesthetic appearance. The thinning skin area appeared to tear and exposed the titanium mesh, which progressively widened in the temporal region until flap surgery was carried out 2 months later (Figure 2A, B). The 3D titanium mesh was cleaned and preserved (Figure 2C). Preoperatively, we measured the size of skin defects and soft tissue atrophy in preparation for the flap. The adipocutaneous ALT flap was designed and harvested with dimensions of 22 cm × 10 cm. Skin monitoring with paddle size of 8 cm × 5 cm was used to cover the exposed titanium mesh area (Figure 2D). The rest of the flap without the epidermis was used to repair soft skin atrophy. The vascular pedicle of flap was supplied by the facial artery and superficial jugular vein (Figure 2E). The flap ultimately survived. The outcomes including coverage and aesthetics were good, significantly restoring the temporal symmetry while preserving the skin of the forehead and temporal regions (Figure 2G, H).



Figure 2. (A, B) Scalp area with the exposed 3D mesh titanium is situated around thinning skin and atrophy temporal zone. (C) Preserved 3D titanium mesh; (D) De-epithelialized adipocutaneous ALT flap with skin paddle (E); Pedicle anastomose (G, H) Post-operative 6 months follow up.

Presentation of case 2

A 69-year-old woman underwent cranioplasty with a 3D titanium mesh after a traffic accident 2 years ago. The atrophy of the frontal muscle caused loss of aesthetic appearance. The thinning skin area appeared to tear and exposed the titanium mesh, which gradually widened in the frontal region until the flap surgery after 3 months (Figure 3A). The 3D titanium mesh was cleaned and preserved. Preoperatively, we measured the size of skin defects and soft tissue atrophy in preparation for the flap. The adipocutaneous ALT flap was designed and harvested with dimensions of 24 cm × 12 cm (Figure 3B). Skin monitoring paddle size was 8 cm × 5 cm to cover the exposed area of the titanium mesh. The flap ultimately survived. The outcomes of the coverage 4 months post-operatively were good, restoring the frontal symmetry significantly while preserving the forehead skin (Figure 3C-F).

Discussion

The leading cause of skin thinning and titanium mesh exposure is usually poor blood supply to the skin area. Therefore, a microsurgery flap with a good blood supply is the best choice for covering exposed craniofacial material.

The free flaps used in covering craniofacial materials are diverse including the latissimus dorsi flap (LD), ALT, or Juri flap.^{5,7,8} ALT flaps are used commonly used because of relatively constant flaps, long pedicles, extensive coverage capacity, and of patient positions that allows 2 surgical teams to operate simultaneously.¹⁰ In this report, we used free ALT flaps. However, our flap technique is different, only adipocutaneous flap and it uses only adipocutaneous flap. Not harvesting the fascia lata with the flap has several advantages, such as increased coverage and thin flaps. In addition, de-epithelialization combined with the skin paddle creates an implant and improves the soft tissue quality of the skin. This serves aesthetics purposes such as restoration of volume and retention of the skin in the forehead or temporal region. A study by Uzun showed that patients with the fasciocutaneous flap had shorter hospital stay and less blood loss than those with myocutaneous flap in the reconstruction of scalp defects.¹¹ Yoshioka's report on 12 patients with LD flaps suggested that LD flaps with skin grafts would create better scalp flatness than ALT skin flaps owing to the fat layer thicker than the scalp that caused flap bulging.⁷ However, fat flaps provided satisfactory cosmetic results in our patient group (Figures 2G, H, 3E, F).



Figure 3. A: Scalp area with 3D mesh titanium exposed is situated around thinning skin and atrophy frontal zone. B, D: De-epithelialized adipocutaneous ALT flap with skin paddle; C: Preserving 3D titanium mesh; E, F: Follow-up 4 months results.

Using an expansion flap is also one of the options for scalp reconstruction. However, in our group of patients, most had cranioplasty with wide skin incisions such as bi-coronal or question marks, which will increase the risk of expansion flap failure. In addition, the expansion flap does not repair the soft tissue hypoplasia of the skin covering the titanium mesh. Hilaire described using the ALT fat flap simultaneously with cranioplasty with titanium mesh in 10 cases with satisfactory results.¹² Our patients underwent reoperation after cranioplasty with titanium mesh due to complications such as mesh exposure and extensive skin hypoplasia; moreover, the patient had undergone several previous surgeries. However, we found that the results of 15 patients were positive regarding coverage and aesthetics while preserving the titanium mesh (Figures 4, 5).

Several studies suggest that all foreign materials, including metal implants, allografts, and non-vascular autografts, can reduce the effectiveness of antibiotics by increasing bacterial adhesion and biofilm formation. In reality, antibiotics, phagocytes, and various humoral immune reactants cannot reach the bacteria through the biofilm. According to some reports, *Staphylococcus epidermidis* adheres to stainless steel more readily than titanium.^{13,14} Therefore, the titanium alloy surface is considered to minimize bacterial adhesion and reduce infection rates. Reconstruction of the skull with titanium mesh prevents post-operative skull defects while minimizing the risks and costs associated with subsequent surgical procedures. Some authors believe that it is necessary to remove the exposed mesh and create a cover using flaps.^{15,16} Although the 3D titanium mesh was exposed for more than 2 months in our 4 of our patients, all surgeons, after discussing with the neurosurgeons, decided to preserve and cover the titanium mesh using the microsurgery flap. At the six-month follow-up after surgery, no case of recurrent infection were recorded. However, owing to the small sample size, we only hypothesized this result: (1) Titanium is an inert material that facilitates little adhesion to bacteria; (2) When covered with a microsurgical skin flap with good blood supply, it resists the invasion of bacteria and increases the vitality of the surrounding tissues.

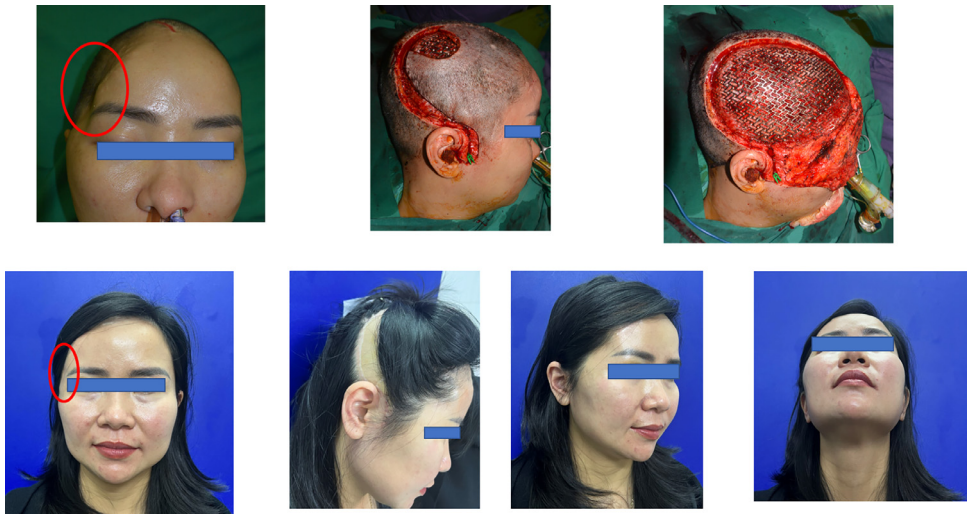


Figure 4. Patient with exposed temporal-parietal titanium mesh with hypoplasia of the proper temporal-frontal soft tissue. Results after 3 years of surgery.

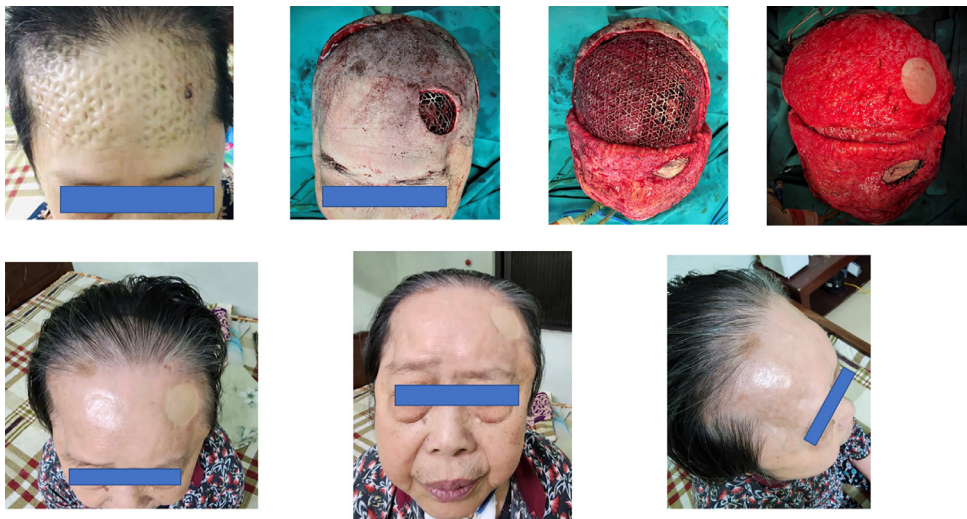


Figure 5. Patient No. 2, results of follow-up after 3 years.

Conclusion

Adipocutaneous ALT flap is a versatile flap used to treat complications after cranioplasty with mesh titanium. The ALT flap provides wide coverage, reduces the risk of recurrent infection, and creates an implant to help repair soft tissue atrophy or skin thinning and restore the aesthetics of the scalp.

Conflict of interest

None.

Source of funding

This research did not receive any specific grant(s) from funding agencies in the public, commercial, or not-for-profit sectors.

Ethical approval

The study was approved by the Research Ethics Committee of Hanoi Medical University. The procedures used in this study adhere to the tenets of the Declarations of Helsinki.

Consent

Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

Research registry

Not applicable – this is a single case report, not a systematic review or meta-analysis. Moreover, we attest that it is not a “first in man” study, either.

Acknowledgments

Nothing to declare.

Provenance and peer review

Not commissioned, externally peer-reviewed.

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