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Original Article

Using Free Chimeric Anterolateral Thigh Flap For Reconstruction Of Composite Dorsal Hand Defect

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ABSTRACT

Background: Simultaneous repair of the extensor tendons and soft tissues in hand injuries remains challenging. The free chimeric anterolateral thigh (ALT) flap with fascia lata (FL) flap represents an alternative for hand reconstruction. This report describes the reconstruction of the extensor tendon and skin defects using free chimeric ALT flaps with FL.

Methods: Eight patients (one female and seven male) underwent reconstruction of complex hand defects with free chimeric ALT and FL flaps. The defects were caused by crushing injuries, burns, snakebite scars, and animal bite wounds. The average skin defect was 116 cm^2. Perforators were selected for the skin paddle and the FL flap. The thinning procedure was performed microsurgically.

Results: The skin paddle size ranged from 12 to 23 cm in length and 6 to 11 cm in width, and the FL flaps ranged from 3 × 5 to 12 × 5 cm. The mean pedicle length was 7.88 cm. Nine extensor tendons were repaired with FL flaps. The flap thickness after thinning was only 3–6 mm. The donor site was closed primarily in six patients, and skin grafts were used in two cases. All flaps survived without complications. The follow-up period lasted from 17 to 80 months. Range of motion was achieved with satisfaction.

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Conclusion: The chimeric-thinned ALT and FL flap is a valuable material, and it should be considered a reconstructive option for hand soft tissue and extensor tendon reconstruction. This technique allows us to achieve a good appearance and extensor function without donor-site morbidity.

Introduction

Traumatic skin loss may be combined with extensor tendon injuries of the hand. These composite injuries often lead to substantial functional morbidity, and their treatment poses a challenge for hand reconstruction.[1] Traditionally, these injuries have been managed in a multiple-stage procedure.[2] But in turn, these techniques increase the risk of tendon adhesions and may present an extended rehabilitation period. As microsurgery evolved, both tendon and soft tissue defects can be reconstructed with a composite free flap in a single-stage procedure.[3,4] The advantages of using these flaps are rapid healing, early mobilization, potentially lower tendon adhesion incidence, and shorter patient reintegration process to normal life activities.[5,6] The composite anterolateral thigh (ALT) flap is commonly used for limb reconstruction, especially the hand, as it provides a large skin paddle with a fascial component.[7-10] However, an interesting anatomical feature of the ALT flap is that it can be harvested with many perforators. These separated flap components were used in a chimeric pattern. Furthermore, the ability to thin the flap to enhance aesthetic results has recently gained attention.[11,12] We have reported in a study using a chimeric-thinned ALT flap with fascia lata (FL) flap in the chimeric form to reconstruct overlying skin and Achilles tendon defects.[13] In this paper, we would like to report a technique for the repair of complex defects of the extensor tendon defect and soft tissue coverage of the hand using the chimeric ALT flap, consisting of a thinned skin paddle and a fascial flap supplied by independent perforating vessels.

Patients and Methods

From June 2012 to September 2021, eight patients underwent reconstruction of the extensor tendon and skin defects of the hand using the free chimeric ALT and FL flaps. There were seven male patients and one female with a mean age of 42.38 ± 14.6 years (range 26–63). Most patients presented to our hospital with severe impairment (7 cases), full-layer extensor tendon, and soft tissue defects. One patient was bitten by a cobra three years earlier, and a fifth finger deformity appeared after self-treatment. Four other patients with soft tissue necrosis were admitted to our department also after a snakebite. One patient suffered a tilapia fish injury with a complete laceration of the extensor tendon and dorsum of the left hand. There were no bone fractures or joint damage injuries in all the cases. Patients underwent debridement to remove necrosis and vacuum-assisted closure (VAC) wound management for 7 days before surgery. The length of the nine extensor tendon defects ranged from 3 to 9 cm. One patient had an extensor pollicis longus (EPL) injury; six patients presented with loss of extensor tendon to the index and middle finger; and one case had three tendon injuries in digits 2 to 4.

Surgical Technique

We planned to use a chimeric ALT flap and FL flap to reconstruct extensor tendons and soft tissue defects simultaneously. We used a hand-held Doppler to locate and map the perforator on the skin. We designed an appropriate outline of the skin paddle for the skin defect. The incision started from

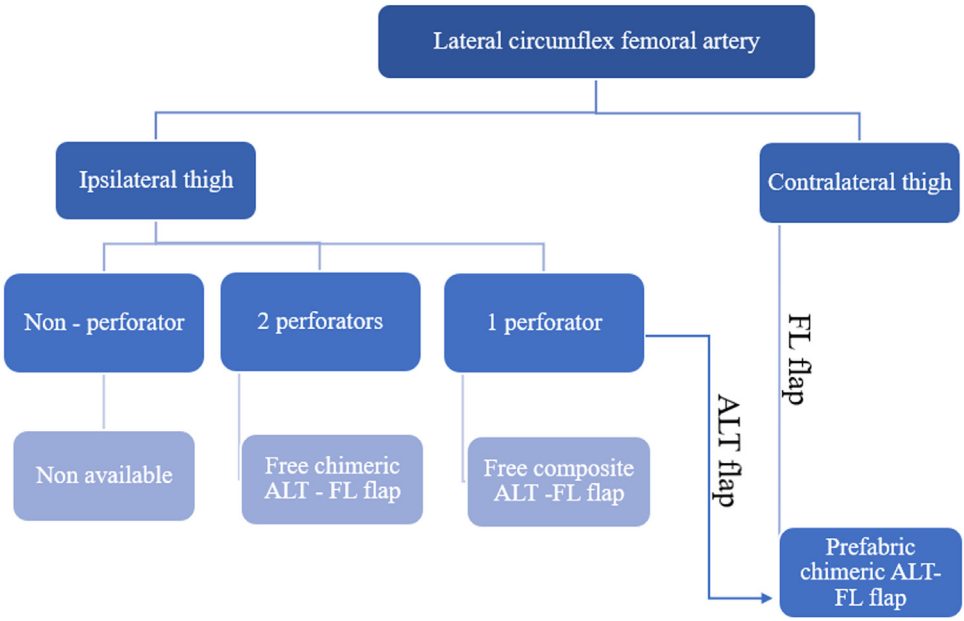

Figure 1. Illustration of the anatomical consideration in surgical techniques.

the medial border of the skin flap to the subfascial plane. Dissection continued in the subfascial plane until the descending branch of the lateral circumflex femoral artery (LCFA) and its perforators were found. We then selected two perforators for the chimeric flap from the descending branch, including the skin paddle and the FL flap (Figure 1). Based on the size of the skin defect, we harvested ALT and FL flaps with independent perforators. The skin flap was thinned under microscopy, and the fat above the superficial fascia was removed with blunt scissors, preserving the subdermal vessels. To reconstruct the extensor tendon effectively, harvested FL flaps were approximately 2 cm longer than the length of the tendon defect. After dissecting the recipient's vessels, an end-to-end or side-to-end anastomosis was performed to connect the vessels to the flap pedicle. Anastomosis was performed after molding the flap into the defect. The FL flaps were then folded two or three times to create a tendon-like structure, and then they were subsequently attached to the remnants of the tendon using 2–0 simple interrupted prolene sutures. After confirmation of blood perfusion, the skin defect was covered with a thinned skin paddle flap placed over a silicone drain. The donor sites were primarily closed or received skin grafts. Postoperatively, the hand was immobilized in an extensor aluminum splint for three days, and one week postoperatively, patients began passive movements of the finger joints. The active movements were initiated three weeks after reconstruction. This action gradually increased until maximum improvement was reached. Patients were followed on a six-month basis each year.

Results

Detailed information and reconstruction results are shown in Table 1. The average skin defect area was 116 ± 65.8 cm^2 (75–270) cm^2. The skin flap size ranged from 12 to 23 cm in length and 6 to 11 cm in width, whereas the FL flap size ranged from 5 × 3 to 12 × 5 cm. The skin flap area was 127.3 ± 60.8 (90–253) cm^2, of which five flaps were smaller than 100 cm^2, and two larger flaps were over 150 cm^2. The thickness of the original flaps ranged from 15 to 30 mm (average of 21.13 ± 5.36 mm). The flap pedicle length ranged from 7 to 9 cm (mean 7.88 ± 0.83 cm). After thinning, flap thickness was reduced to 3–6 mm (4.5 ± 0.92 mm), a decrease of 77.7% compared with the

Table 1
Patient data.

No.	Sex/age (y)	Etiology	Injured structures	SD size (cm)	TD length (cm)	FL size (cm) Tendon repair	SF size (cm)	Thickness before/after thinning (mm)	Pedicle length (cm)	Type of anastomosis	Donor site	ROM	Follow-up (month)
1	M 26	Snakebite scar	EDC V Zone 5,6	12 × 7	5	8 × 3 EDC V	13 × 7 90 cm^2	15/3	7	UA Side-to-end	Direct. Closure	5th MP 0–85	80 Excellent
2	M 34	Burn	EDC II Zone 5,6	11 × 8	6	8 × 3 EDC II	12 × 8 95 cm^2	26/5	8	DBRA End-to-end	Direct. Closure	2nd MP 0–85	60 Excellent
3	F 29	Trauma	EPL I Zone 5	14 × 7	3	5 × 3 EPL	14 × 8 105 cm^2	30/4	8	RA Side-to-end	Direct. Closure	1st MP 0–85	58 Excellent
4	M 46	Snakebite	EDC II Zone 3,4	18 × 8	4	6 × 3 EDC II	19 × 10 190 cm^2	20/4	9	RA Side-to-end	Skin graft	2nd MP 0–80	19 Satisfactory
5	M 31	Snakebite	EDC II Zone 3,4,5	13 × 6	7	7 × 3 EDC II	14 × 7 95 cm^2	16/4	7	RA Side-to-end	Direct. Closure	2nd MP 0–75	19 Satisfactory
6	M 63	Snakebite	EDC II, Zone 4,5	13 × 7	6	8 × 3 EDC II	13 × 7 90 cm^2	20/5	7	RA Side-to-end	Direct. Closure	2nd MP 0–85	18 Excellent
7	M 48	Snakebite	EDC III Zone 2,3,4,5	15 × 5	8	10 × 3 EDC III	17 × 6 100 cm^2	25/5	8	DBRA End-to-end	Direct. Closure	3rd MP 0–70	18 Satisfactory
8	M 62	Snakebite	EDC II, III, IV Zone 3,4,5,6	27 × 10	9	12 × 5 EDC II, III	23 × 11 240 cm^2	17/6	9	RA Side-to-end	Skin graft	2nd MP 0–60 3rd MP 0–60	17 Good

M, Male; F, Female; EDC, Extensor digitorum comunis; EPL, Extensor pollicis longus; FL, Fascia lata; SD, Skin defect; TD, Tendon defect; SF, Skin flap; DBRA, Dorsal branch of the radial artery; RA, Radial artery; UA, Ulnar artery; ROM, Range of motion; MP, Metacarpophalangeal.

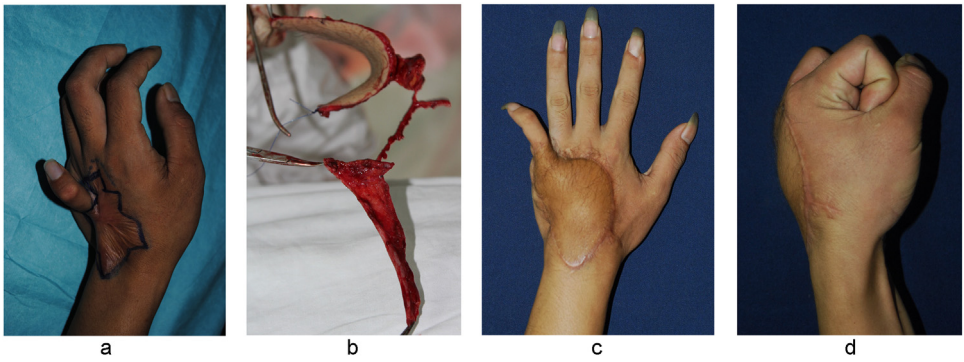

Figure 2. Case No. 1. (A) A 26-year-old male patient with severe hand dorsal contracture and deformity of the fifth finger caused by a snakebite 2 years earlier. (B) A Chimeric flap was harvested, including the skin flap of 13 × 7 cm with 3 mm thickness; a FL flap of 8 × 3 cm to reconstruct extensor tendons in zone 5,6 of the fifth finger. (C, D) At 12-month follow-up, the aesthetic and functional appearance of the hand was improved, and the fifth finger could return to full extension.
FL, fascia lata.

original. Nine extensor tendons (8 extensor digitorium communis and one extensor pollicis longus) were repaired by FL flap. Anastomosis of two flaps was performed end-to-end at the dorsal branch of the radial artery. One case was anastomosed side-to-end with the ulnar artery and five others with the radial artery. The donor site was closed primarily in six patients and with a skin graft in two cases. All flaps survived entirely without complications. After 17–80 (mean, 36.1) months of follow-up, all flaps were well vascularized, including reliable soft tissue and pleasing contour in the original defects. None of the patients required secondary flap defatting, and no donor-site complications were reported. The follow-up duration ranged from 17 to 80 months. Six months after injury, range of motion (ROM) with extension of 0° and flexion of 60° was achieved at the MP joint. However, in the case of No. 8, the ROM of MP joints was 30° due to the absence of physiotherapy. After one year, the functional assessment of the hand improved, as shown in Table 1. All patients were satisfied with the appearance after the reconstruction. The patient's surgical interventions are shown in Figures 2 and 3.

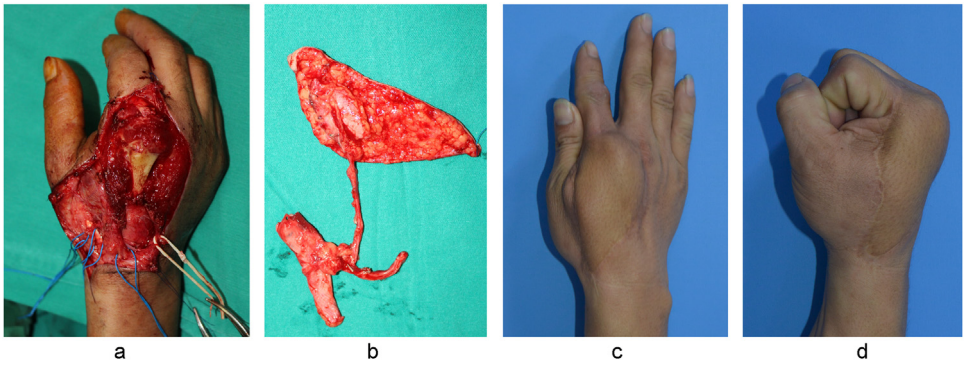

Figure 3. Case No. 2. (A) A 34-year-old male patient suffered a high-voltage electric burn 2 years earlier—total necrosis of the hand dorsal skin and loss of part of the extensor tendon to the index finger. (B) Chimeric ALT and FL flaps with 2 perforators, 1 for the skin paddle of 12 × 8 cm with 5 mm thickness and another for the FL flap measuring 8 × 3 cm, reconstructed for EDC II in zone 5,6. (C, D) The result after 38 months.
ALT, anterolateral; FL, fascia lata; EDC, extensor digitorum communis.

Discussion

The hand dorsal part is characterized by thin skin coverage, extensor tendons, muscle, and bone. Injuries of the dorsal part usually include skin coverage defects associated with extensor tendon loss, underlying fractures, and joint capsule injuries. They are especially common after trauma, oncologic resection, burn scars, or animal bites followed by infection.[1,14,15] Surgical treatments for this complex injury include reconstruction of both soft tissue and extensor tendon defects. The goals are to restore stable soft tissue coverage and achieve free gliding of the solid tendons and normal extensor function. The typical approach to this kind of injury is a multiple-staged procedure. The first stage aims at wound debridement and fracture union, and then the next step is to reconstruct the defect and the missing components. The selection of local or regional flaps is limited for reconstructing complex dorsal hand deformities. Tendon reconstruction is performed as a second-stage procedure.[2] However, the more extensive the procedure required, the more limited the functional and aesthetic outcomes and the greater the risk to the patient.[3] Due to advances in microsurgery, the free tissue transfer in single-stage and various types of free composite flaps have attracted attention for reconstructing these complex injuries of the dorsal hand, including temporal fascial flap, serratus fascia flap, dorsalis pedis flap, palmaris longus-venous flap.[16–18] The benefits of vascularized tendon transplantation are a faster healing process and improved tendon repair strength, decreased adhesion formation, more excellent resistance to infection, and better gliding. Single-stage reconstruction with composite flaps with vascularized fascia can offer several advantages, such as significantly fewer reoperations, reduced hospital stay, earlier hand rehabilitation, and the patient can return to normal activities sooner, with lower social and health care costs.

From the literature to the clinical, ALT flap with vascularization source from perforators of the descending branch of the lateral circumflex femoral artery (LCFA) has become favorable, with many components (skin, fascia, adipose, muscle) that can be well used for reconstruction. The composite ALT and FL flap is a good alternative for reconstructing complex injuries in the extremities. Some reports have introduced composite ALT with FL as a one-stage functional reconstruction of complex defects around the knee.[7–10] Several authors have suggested the application of a free composite ALT flap with the FL to reconstruct complicated Achilles tendon and skin defects.[19,20] However, there was little research on using these flaps to reconstruct complex hand injuries. The drawbacks of these composite flaps are the pedicle instability and flap thickness, which may affect the hand movement and aesthetic outcomes.

The main advantages of the ALT flap are that it matches the color and texture of the skin and long pedicle, and it may be harvested with more than one perforator. The chimeric skin flap is considered an alternative to improving the shortcomings of a combined free ALT flap, and it was used to reconstruct hand and limb defects.[11,21,22] There has been very little research on applying chimeric ALT flap and the FL for complex Achilles tendon defects.[13,23] In all of our cases, at least two perforators derived from the descending branch of LCFA were found to vascularize the skin paddle and FL flap. The perforators that supply two separate components must be at least 4 cm apart to not affect the FL flap's separation from the skin paddle. We chose the larger perforator for the skin paddle, which is not necessarily located in the center of the flap, even if the flap is more extensive than 150 cm^2. The other perforator to the FL was designed to be in the middle of the fascia. The tendon could be easily reconstructed with the chimeric type, as the FL did not adhere to the skin paddle. In the case of single tendon reconstruction only, the FL used needs to be 3–4 cm wide, and then the tendon is rolled like an extensor tendon structure. Its length depends on the defect. If two tendon reconstructions are required, the width of the FL is larger, 6–8 cm and the tendon is split into two parts at the distal end, corresponding to the number of missing tendons. Each of them is rolled up to the tendon structure. The FL proximal end is rolled and connected to the remaining original tendons. The chimeric-free ALT flaps have several advantages over composite ALT: a well-vascularized fascial flap, separated reconstructed tendons, less operation time, and improved functional outcomes; and the separated FL helps to enhance the gliding surface for tendon movement. Finally, the chimeric ALT flap with the FL is easy to thin without damaging the blood supply to the skin paddle.

Reconstructive material for the dorsal hand defect must be thin, pliable, and similar in texture, a requirement for the gliding of the underlying tendons. The main advantage of the ALT flap is the soft,

smooth texture of the skin. However, it still has some main drawbacks, such as the excessive thickness of the subcutaneous layer, especially in women. The average ALT flap thickness is 2–4 cm; hence, these bulky flaps can lead to ineffective outcomes and poor function. Liposuction may solve this problem, but excessive debulking can further impair mobility and perfusion of the flap. Secondary thinning is likely to create adhesions of the overlying skin. In 2001, Kimura et al. introduced the thinning technique in the ALT flap by either a primary or a microdissection procedure so that the flap could be thinned to 3–4 mm.[24] It was consensus that ALT flaps could tolerate defatting at the time of flap inset if they are designed for minor, thin defects, such as those of the dorsal hand.[25,26] The thinned ALT flap is valuable and reliable. It has been proven in the reconstructive procedures for coverage of various defects in the body, including the face, hand, limb, and penis. Few reports of the thinned ALT flap have focused on the reconstruction of the extremities and even less so on complex hand defects. There has been no conclusion regarding whether the incidence of flap necrosis is related to residual fat around the perforating vessel. Our studies show that the pattern of the perforator that runs through the superficial fascia is crucial for choosing the thinning method. We only perform microdissected thinning when the perforator penetrates the superficial fascia and then branches perpendicularly below the fascia. In all our patients, these types of perforators were present. In these cases, the superficial subcutaneous fat layer with the entire fascia layer was removed by blunt scissors; under the microscope, the fatty tissue around the perforator was surgically removed without damaging vessels supplying the subdermal plexus. The thickness of the flaps after thinning is, on average, 4.5 mm (range from 3–6 mm), which means it is reduced by approximately 80%. The average size of the skin flap is 127.3 cm^2 (range 90–253), including two flaps larger than 150 cm^2. Usually, with a free flap, there is no recommended thin flap if its size is over 150 cm^2. However, two extensive flaps from 190 cm^2 and 253 cm^2 were thinned without necrosis in our studies. The whole flap was well vascularized and showed no sign of necrosis.

The limitations of this report are related to the number of perforators obtained during dissection. The unfavorable variations of perforator supply to the ALT flap are that perforator absence is about 0.89%–5.4%, and only 45%–100% of the perforating branches originate from the descending branch.[27,28] Therefore, in some patients, it is impossible to have more than two perforators arise from the descending branch; thus, no chimeric ALT and FL flaps can be created.

Conclusion

The chimeric-thinned ALT and the FL flap are excellent, reliable, and valuable materials for soft tissue reconstruction, especially when the treatment approach requires combined extensor tendon reconstruction of the hand dorsum. This novel technique offered a favorable appearance and good extensor function; no donor-site morbidity exists.

Declaration of Competing Interest

There are no conflicts of interest to declare.

Ethical Approval

All procedures performed in studies involving human participants were following the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Our institutional research committee of Hanoi Medical University (136/QĐ-ĐHYHN).

Declaration of Patient Consent

All participants provided written informed consent before enrollment in the study. We adhered to the privacy and confidentiality terms of patient records while managing the clinical information during this research.

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