

RESEARCH ARTICLE

Repair of Minor Tissue Defect in Hand by Transfer of Free Tissue Flap from the Toe

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Abstract

Background: To introduce our experience of using the free neurovascular flap from great and second toe.

Methods: Thirteen patients (fifteen fingers) sought surgical treatment for soft tissue defects of the hand at our medical institution between March 2006 and September 2009. In two patients, fibular side skin-nail flaps of great toe were applied to cover the dorsal defect of distal thumb. In twelve, the treatment was carried out for the pulp defect of finger with fibular side flap of great toe or tibial side flap of second toe. In one, the treatment was carried out for the defect of distal middle with composite flap with distal digital bone of second toe.

Results: All flaps survived. The average subjective satisfaction score was 8.08 (range 4-10). Nine patients (69%) experienced cold intolerance, and 2 patients (15%) dysesthesia. The Semmes-Weinstein sensitivity score was between 3.47 and 4.72 on the flap, and 0-4.18 on the donor site. The mean two-point discrimination was 6.8 mm (range 4-12). Grip strength was 10% less than in the unaffected hand. The proximal interphalangeal mobility loss was less than 15 degrees.

Conclusions: Our results indicated that these free flaps from toe are useful for patients with a small soft-tissue defect in hand.

Key words: Free neurovascular flap, Hand tissue defect, Toe

Introduction

The great mass of hand injuries result in moderate or severe skin loss as one of the injury components, which may frequently expose the bone, cartilage, tendon or nerve, or leave an open joint. To preserve hand functions and to protect its basic structures, multifarious types of skin flaps are used to cover these tissue defects, such as groin flap, random abdominal flap and local pedicled flaps, for reconstruction of the degloved fingers (1-4). Meanwhile, with the advent of microsurgery, fascial free flaps, fasciocutaneous sensitive flap, posterior interosseous free flaps, or even innervated arterialized venous flaps have been introduced for reconstruction (5-8). However, the results with insensibility, bulk, and poor blood supply from those options remained unsatisfactory with complications. Moreover, despite the fact that some free flaps could recover the sensibility, no finger nails and texture disparity still could embarrass

the patients (9). Therefore, it is an ideal options for reconstruction for tissue defect in hand according to various sizes, shapes, and the site.

However, soft tissue of hand is of anatomic advantages. First, volar side skin of the hand is thin, sensible, and glabrous for precise gripping. Second, to prevent shearing or slippage with gripping, the skin must be stabilized by the fibrous septum, which anchors the palmar fat pad before it tethers on to the deeper structures (10). Because the toe and its adjacent tissue are of anatomic similarity to the hand, the free flap from toe is especially useful in hand reconstruction where restoration of sensation is essential, and it can be harvested in a wide range of sizes that can be used in various types of hand defects (11). Previous studies showed that the first web space free flap were capable of providing an adequate amount of tissue for reconstruction of the skin defects, which reached up width of 7.5 cm by 14 cm length

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Table 1. Patient Characteristics

| Case | Sex | Age (yr) | Affected Finger | Pattern of Defect | Defect Size (mm) | Flap Type |
|------|-----|----------|-----------------------|---|------------------|--|
| 1 | M | 19 | Right thumb and index | Dorsal defect of distal thumb Vola-radialis defect of index | 13×15 12×20 | Fibular side skin-nail flap of great toe for thumb defect Tibial side flap of second toe for index defect |
| 2 | M | 24 | Right thumb | Pulp defect of thumb | 10×12 | Fibular side flap of great toe |
| 3 | F | 37 | Right thumb | Pulp defect of thumb | 12×15 | Fibular side flap of great toe |
| 4 | M | 32 | Left thumb | Pulp defect of thumb | 9×13 | Fibular side flap of great toe |
| 5 | M | 21 | Left thumb | Dorsal defect of distal thumb | 12×13 | Fibular side skin-nail flap of great toe |
| 6 | F | 29 | Right thumb | Pulp defect of thumb | 11×13 | Fibular side flap of great toe |
| 7 | M | 27 | Right thumb | dorsal-radialis defect of proximal thumb | 15×18 | Fibular side flap of great toe |
| 8 | M | 29 | Right middle and ring | Vola defect of distal middle and ring | 16×24 20×25 | Fibular side flap of bilateral great toe |
| 9 | F | 21 | Right thumb | Vola-ulnaris defect of proximal thumb | 10×15 | Fibular side flap of great toe |
| 10 | F | 22 | Right index | Pulp defect of index | 10×12 | Tibial side flap of second toe |
| 11 | M | 20 | Right middle | defect of distal middle | 13×11 | composite flap with distal digital bone of second toe |
| 12 | F | 23 | Right middle | Pulp defect of middle | 10×18 | Tibial side flap of second toe |
| 13 | M | 21 | Right ring | Pulp defect of ring | 11×16 | Tibial side flap of second toe |

(12,13). Following, Woo *et al* reported the classification of the first web space flap and its various applications, and believed that the sensory restoration is excellent with minimal morbidity at the donor site because of the anatomic similarity in contour, thickness, texture, and nerve innervation with the hand (14).

Although its use seems to be widely spread among the surgeons involved in hand and finger reconstructive surgery, hand injuries incur minor skin loss under certain circumstance. Therefore, it is necessary to harvest the free flap from toe according to various sizes and shapes of defects in the hand and fingers. In the current paper, we propose and discuss the reconstruction of minor skin defect in hand by transfer of multiform free tissue flap from the toe in a series seen in an urban medical center in China during a span of 32 months and to document any complications with the flap or the donor site.

Materials and Methods

Over a period of 3 year and 6 months, from March 2006 to September 2009, 13 patients (15 fingers) of various tissue defect of the hand were treated using free tissue flap from the foot. All of the cases were performed consecutively without selection by the same senior hand surgeon. Eight patients were men and five were women. Their ages at surgery ranged from 19 to 37 years, with a mean of 25 years. Most of the injuries occurred with industrial activities. Eleven injuries occurred in the dominant hand. Of them, eight involved the thumb, two the index finger, three the long finger, two the ring

finger. All patients underwent emergency surgery, with a time delay after injury of 2 -15 hours. The minimum defects were 9x13 mm, and the maximum 20x25 mm. In two patients, fibular side skin-nail flaps of great toe were applied to cover the dorsal defect of distal thumb. In twelve, in the treatment of pulp defect of finger with fibular side flap of great toe or tibial side flap of second toe. In one, in the treatment of defect of distal middle with composite flap with distal digital bone of second toe. All flaps were transferred as free flaps. The details of patients are presented in Table 1. The length of the vascular pedicle ranged from 3 to 10 cm for all various flaps. The arterial diameter was approximately 1.0 mm.

Surgical procedure

Preoperatively, the Doppler study was used to trace out the course of the vessels in the hand and foot, which was then marked on the skin. Routine angiogram was not performed. The flap was designed according to the size of the defect. The 'S' shaped incision was made at the first web space, and the dorsal digital veins of first or second toe were dissected in adequate length. Through this, the first or second arteria digitalis are identified. Simultaneously, the toe nerve, which runs along the arteria digitalis, was dissected. From here, the distal margin of the flap at the first or second toe was incised, exposing the periosteum of the phalangeal bone. Also, when harvesting the fibular side pulp flap of second toe, the dissection was carried out at the second web space. When fibular side skin-nail flaps of great toe was

Table 2. Outcomes

| Case | Follow-up (mo) | Complications | SS Score | SW Flap | SW Donor | Two-point Discrimination | Cold Intolerance | Dysesthesia |
|------|----------------|------------------------------|----------|---------|----------|--------------------------|------------------|-------------|
| 1 | 24 | None | 8 | 4.26 | 3.36 | 4 | + | - |
| 2 | 26 | None | 9 | 3.47 | NS | 7 | + | - |
| 3 | 30 | None | 10 | 4.72 | NS | 4 | + | - |
| 4 | 36 | None | 6 | 4.26 | 4.18 | 7 | + | - |
| 5 | 27 | None | 9 | 3.47 | 3.24 | 5 | - | - |
| 6 | 31 | Partial flap necrosis (<10%) | 4 | 4.23 | 4.06 | 8 | - | - |
| 7 | 42 | None | 8 | 3.86 | 3.86 | 10 | + | + |
| 8 | 48 | None | 10 | 4.23 | 4.18 | 6 | + | - |
| 9 | 42 | None | 10 | 4.72 | NS | 8 | - | - |
| 10 | 24 | Partial flap necrosis (<10%) | 7 | 4.26 | 3.47 | 12 | + | + |
| 11 | 24 | None | 9 | 3.86 | 3.24 | 6 | + | - |
| 12 | 30 | None | 9 | 3.47 | 3.86 | 5 | + | - |
| 13 | 33 | Partial flap necrosis (<10%) | 6 | 4.26 | 4.18 | 6 | - | - |

SS: subjective satisfaction; SW: Semmes-Weinstein NS: no sensation

needed, the matrix unguis was peel from the periosteum of the phalangeal bone with the nail root. To minimize the incision scar at the recipient site, the closest vessel (which in most cases is the ulnar digital artery and dorsal digital vein) was used for anastomosis. If the defect left at the donor site was small enough, it was covered with the plantar skin. A split-thickness skin graft from the lateral thigh or a full-thickness graft from the groin was used for a large donor-site defect. Avoidance of tissue desiccation and meticulous hemostasis during the operation were essential to prevent problems at the donor site. Unlike the ordinary skin graft, undue compression of the skin graft should be avoided. Immobilization with foot elevation and daily dressing change with removal of hematoma in the first week can ensure the complete taking of the flap. The leg should be elevated for 2 weeks postoperatively, and normal daily activities can be resumed starting in the third week.

Results

All flaps survived. One patient developed venous thrombosis at the site of vascular anastomosis after 29 hours postoperatively. Removal of the thrombus and reanastomosis resulted in complete survival of the flap. Heparin was used systemically after the salvage procedure. Three patients experienced partial flap necrosis (<10%). The average subjective satisfaction score was 8.08 (range 4-10). Nine patients (69%) experienced cold intolerance, and 2 patients (15%) dysesthesia. The Semmes-Weinstein sensitivity score was between 3.47 and 4.72 on the flap, and 0-4.18 on the donor site. The mean two-point discrimination was 6.8 mm (range 4-12) (Table 2). Grip strength was 10% less than in the unaffected hand (hand dominance was not taken into consideration). Since almost all the patients were living in another area, their rehabilitation was irregular. The proximal interphalangeal mobility loss was less than 15 degrees. All patients return to their jobs. The skin defect at the donor site was closed

primarily in one patients. Other patients needed a full-thickness skin graft to cover the skin defect at the donor site. No patients had postoperative complications at the donor sites.

Case Reports

Case 1

Left hand of a 21-year-old man was crushed. The soft-tissue defect of distal thumb was 12×13mm². The tendons and bone on the palmar aspect were exposed. The defects were repaired by transfer fibular side skin-nail flap of great toe. The length of vascular pedicle was 4 cm. The donor site was closed full-thickness skin graft. The first dorsal metatarsal artery was anastomosed to the radial arteria digitalis, and the vein was anastomosed to the basilic vein branch at dorsal finger. The nerve was sutured to the dorsal branch of finger. The flap survived completely and adapted well in appearance and function (Figure 1).

Case 2

A 20-year-old man sustained a crush injury to the right middle and ring finger while working. The skin defect of distal middle was 11×13mm². The distal phalanx was hypophalangism and exposed. The skin defect of distal ring 0.6×0.4mm². The defects of middle were repaired by transfer composite flap with distal digital bone of second toe. The length of vascular pedicle was 6 cm. The donor site was closed primarily. The first dorsal metatarsal artery was anastomosed to the radial arteria digitalis, and the vein was anastomosed to the dorsal digital vein. The nerve was sutured to the radial digital nerve. The flap survived completely and adapted well in appearance and function (Figure 2).

Discussion

Skin defects in hands may be covered by local, distant, or free flaps depending on the conditions of the local wound, adjacent area and donor site, and the general



Figure 1. The patient in case 1. A: Preoperative view of soft-tissue defect of distal thumb. B: Design of fibular side skin-nail flap of great toe. C: Elevation of the skin-nail flap. D: Immediate postoperative view: the defect reconstructed. E: Appearance of the hand at 27 months after surgery. F: Appearance of the donor site at 27 months after surgery.

condition of the patient. The most ideal innervated flap used in hand reconstruction should have similar thickness as the hand and also appropriate vessels for anastomosis. In addition, it should have nerve fascicles responsible for the sensation with similar number and quality as that of the recipient site, and the nerve

should run parallel to the vascular pedicle (15). After the harvest of the flap, it should leave a minimal and acceptable disfigurement and dysfunction at the donor site. Considering these major factors makes the toe and its adjacent tissue one of the best donor sites for the soft-tissue reconstruction of the hand.

A few of studies have suggested that the first web space free flap can be used to reconstruct the defects in the hand with excellent function and cosmetic appearance (16-18). Hahn *et al* reported a series of cases of finger reconstruction with a free neurovascular wrap-around flap from the great toe with satisfactory results (4). It was believed that this procedure provided length, stability, and adequate sensibility for a functional pinch and grasp and also the donor site was acceptable, both esthetically and functionally. In Wei's report with reconstruction of finger avulsion injury using the second toe wrap-around flaps (19). Rapid and adequate functional recovery as well as satisfactory esthetic appearance in all patients was achieved. Doi performed the free wrap-around flap from the big toe with a free autologous iliac bone graft to reconstruct amputated thumb, and showed that the sensibility was superior and the functional result was excellent (20). However, hand injuries incur small skin loss under certain circumstance. Therefore, the closure of small defects requires small flaps. Deglise *et al* present the results of 8 posttraumatic fingertip reconstruction with free toe pulp neurovascular flap and demonstrate the successful restoration of a well-padded and sensitive fingertip with a follow-up of up to 20 months (21). After that, the free toe neurovascular flap has not been



Figure 2. The patient in case 2. A: Preoperative view of the right middle and ring finger injury. B: Elevation of composite flap with distal digital bone of second toe. C: Immediate postoperative view: the defect reconstructed. D: Appearance of the hand at 24 months after surgery.

frequently reported.

In our study, the free flap from toe restores sensation and volume with a similar texture of skin. The average subjective satisfaction score was 8.08 (range 4-10). Nine patients (69%) experienced cold intolerance, and 2 patients (15%) dysesthesia. The Semmes-Weinstein sensitivity score was between 3.47 and 4.72 on the flap, and 0-4.18 on the donor site.

The static 2-point discrimination in the lateral side of the great toe was, on average, 11.3 mm and that of second toe was 16.4 mm.^{3,5} In the current group of patients after the flap transfer and anastomosis of all the respective nerves, the average 2-point discrimination of 4 mm to 12 mm (mean 6.8mm) was obtained, which implies that the recovered sensation was more precise than at the donor site. Although several possible explanations exist, this phenomenon is probably best explained by cortical reeducation and adaptation with continuous, repetitive use postoperatively. Needless to say, an aggressive rehabilitative program is essential for sensory restoration.

Another advantage of the free flap is that it has a long neurovascular pedicle from which two anatomically different dorsal and plantar tissues can be harvested to be used in the reconstruction of defects in both the dorsum and palm of the hand. In addition to this, early exercise of finger joints is possible from the 7th day after operation, and the hand does not have to be attached to the body as is done in the distant flap. The results show that grip strength was 10% less than in the unaffected hand (hand dominance was not taken into consideration). The proximal interphalangeal mobility loss was less than 15 degrees. All patients return to their jobs. Furthermore, a secondary defatting procedure is rarely needed.

Although recent advances in microsurgical technique have allowed to anastomosis minute vessel, some difficulties can be encountered in the vessel dissection and anastomosis. In this study, one patient developed venous thrombosis at the site of vascular anastomosis after 29 hours postoperatively. Removal of the thrombus

and reanastomosis resulted in complete survival of the flap. Three patients experienced partial flap necrosis (<10%). The possible reasons are anatomic variations of vessel and excessive compression dressing.

Although the post-skin graft scar at the donor site was somewhat conspicuous, there were no specific problems with other types of flaps once the donor site wound healed completely. Numerous minor complications at the donor site such as poor hygiene, cold intolerance, minor pain, and hyperkeratosis all resolved spontaneously without special treatment and did not interfere with normal daily life activities.

Therefore, The free tissue flap from the toe is a valuable alternative for the reconstruction of small soft-tissue defect in hand with satisfactory results both functionally and cosmetically. The donor site morbidity is minimal if the wound treated with skin grafting is meticulously managed.

Disclosures

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