



Free medialis pedis venous flap transfer for reconstruction of volar finger defects: Clinical application and esthetic evaluation[☆]



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KEYWORDS

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Summary Background: There have been many reports about venous flaps, which are often used for the reconstruction of soft tissue defects after finger injury because such flaps are simple to elevate. Recently, high viability rates and nearly normal histological findings were reported for venous flaps, although the mechanism of flap survival remains unclear. This study investigated the esthetic outcomes after the reconstruction of volar finger defects with free medialis pedis venous flaps, which are venous flaps that elevated between the submalleolar and medial plantar regions.

Materials and methods: Reconstruction of volar finger defects was performed in 6 patients. All flaps were arterialized flow-through flaps with the venous anastomosis as the outflow. All 6 patients were men, with a mean age of 32.0 years. The defect involved the finger shaft in 4 patients and the finger pulp in 2 patients, and the mean size of the venous flap was 16.7 mm (width) × 34.2 mm (length). Five plastic surgeons specializing in maxillofacial surgery evaluated the color match of the flaps at 6 months postoperatively by assigning a score (maximum: 5 points).

Results: The flap showed complete viability with little postoperative atrophy in all 6 patients. The mean color match score for the flaps was 3.7, and it decreased as the flaps were raised further from the medial plantar region.

Conclusion: Free medialis pedis venous flaps can be used for the reconstruction of volar soft tissue defects of the finger. Acceptable esthetic results can be obtained if flaps are harvested from an appropriate location in the medialis pedis region by a suitable method.

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Introduction

Venous flaps are often used for the reconstruction of soft tissue defects after finger injury because these flaps are easy to elevate.¹⁻⁶ Although, the mechanism by which venous flaps remain viable has been discussed, it is still unclear.^{7,8} According to a systematic review and meta-analysis of the clinical use of venous flaps, 92.2% show complete or nearly complete viability, but this is slightly lower than the viability rate of 95-100% reported for most conventional free flaps.⁹ Several authors have proposed that venous flaps should generally be small and relatively thin, with the number of veins anastomosed in the flap being increased or the inflow and outflow veins being selected from different layers if a flap is large.^{1,3,6,9} Regardless of such technical considerations, venous flaps have unique advantages that include ease of dissection, thinness, and pliability, and the potential to include other tissues as well as skin.^{3,9}

Venous flaps are often harvested from the forearm, but Yokoyama et al. reported^{4,14} the reconstruction of volar finger defects using free medial plantar venous flaps from the medial plantar region, which has the advantage of not requiring sacrifice of arteries at the donor site. However, it becomes more difficult to elevate a venous flap as the donor site moves closer to the medial plantar region compared with elevation at the submalleolar region, because the subcutaneous veins are narrower and communicating veins from the deep venous system run deeper.¹⁶ In addition, primary closure of the donor site becomes more difficult because of greater skin tension.

Therefore, this report focuses on patients who underwent reconstruction of volar finger defects by using medialis pedis venous flaps elevated from a wider region compared with medial plantar venous flaps, which are harvested between the submalleolar and medial plantar regions. To the author's knowledge, this is the first report on the clinical and esthetic outcomes of using free medialis pedis venous flaps for the reconstruction of volar finger defects.

Materials and methods

Reconstruction of volar finger defects using venous flaps was performed by the author in 6 patients from 1997 to 2012, and these patients were reviewed retrospectively. All flaps were elevated from the medialis pedis region, and were arterialized flow-through flaps with the venous anastomosis as the outflow (A-A-V flaps).⁶ The methods employed for elevation of the flaps and for reconstruction of the finger pulp or finger shaft are shown in Figures 1 and 2.

All 6 patients were men, with a mean age of 32.0 years (range: 25-50 years). Four patients had a defect of the finger shaft and 2 patients had a defect of the finger pulp. The mean size of the venous flap was 16.7 mm (width) × 34.2 mm (length) (range: 15 × 25 ~ 25 × 50 mm). The affected digits included 1 right index finger, 2 left middle fingers, and 3 right little fingers (Table 1).

Using photographs of the reconstructed fingers obtained with a camera or digital camera at 6 months postoperatively, the color match of the flaps was evaluated by 5 plastic surgeons specializing in maxillofacial surgery. They

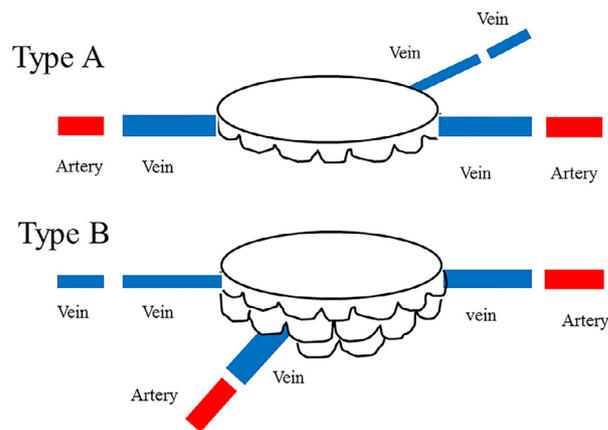


Figure 1 Types of A-A-V venous flaps.

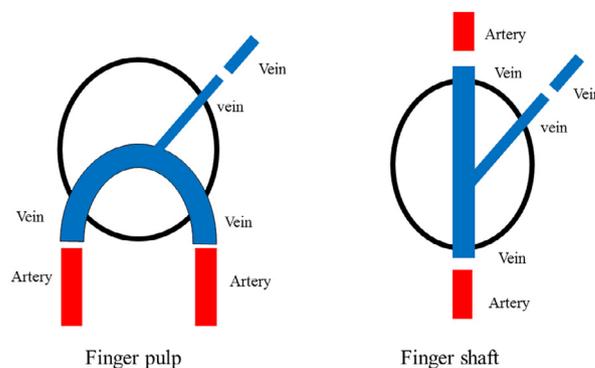


Figure 2 Diagram showing reconstruction of a soft tissue defect and digital artery by using an A-A-V venous flap.

assigned a color match score with a maximum of 5 points based on their initial impressions.

Surgical procedure

Before the operation, visible veins are marked in the medialis pedis region with or without the use of a tourniquet. Then the size of volar skin defect is measured and the digital artery is identified, after which the medialis pedis venous flap is designed using the marked veins. The flap elevation method is similar to that reported previously.^{3,6,17} Elevation is performed carefully under local anesthesia (1% lidocaine with epinephrine), lumbar anesthesia, or general anesthesia. A Type A venous flap only contains subcutaneous veins, while a Type B venous flap has both subcutaneous veins and a communicating vein (Figure 1). While communicating veins are not visible preoperatively, a communicating vein branching from a subcutaneous vein can almost always be identified by searching carefully. It is often difficult to select a vein that matches the diameter of the digital artery, especially the distal stump. While the author has not measured the exact diameters of the veins in each flap, Yokoyama et al. reported that subcutaneous veins at the medial plantar region have a diameter of 0.4-0.6 mm and communicating veins at the this region have a diameter

Table 1 Summary of the patients and average color match scores assigned by the 5 plastic surgeons.

| Case | Age/sex | Finger | Diagnosis | Flap size (mm) (width × length) | Location of volar defect | Type of venous flap | Color match score |
|------|---------|--------------|---|------------------------------------|-----------------------------|------------------------|----------------------|
| 1 | 27/M | Right little | Scar contracture after fracture with severe soft tissue damage | 15 × 25 | Finger shaft | Type A | 4 |
| 2 | 39/M | Left middle | Scar contracture after severe soft tissue damage with digital nerve and artery defect | 15 × 30 | Finger shaft | Type B | 3.2 |
| 3 | 19/M | Right little | Scar and joint contracture after incomplete amputation with severe soft tissue damage | 15 × 50 | Finger shaft | Type A | 5 |
| 4 | 56/M | Left middle | Scar and joint contracture after severe soft tissue damage | 25 × 50 | Finger shaft | Type A | 2 |
| 5 | 17/M | Right little | Ectopic nail | 15 × 25 | Finger pulp | Type B | 4 |
| 6 | 34/M | Right index | Painful scar contracture after severe soft tissue damage | 15 × 25 | Finger pulp | Type B | 4 |



Figure 3 Case 3: (A) A 19-year-old man had scarring and joint contracture after incomplete amputation of the right little finger with severe soft tissue damage. (B) A 15 × 50 mm Type A venous flap was designed at a site near the medial plantar region. (C) The flap veins were anastomosed to the digital artery and to the dorsal subcutaneous vein of the digit. (D) At 6 months after the surgery, the flap was not bulky and was almost the same color as the surrounding skin. The color match score was 5.

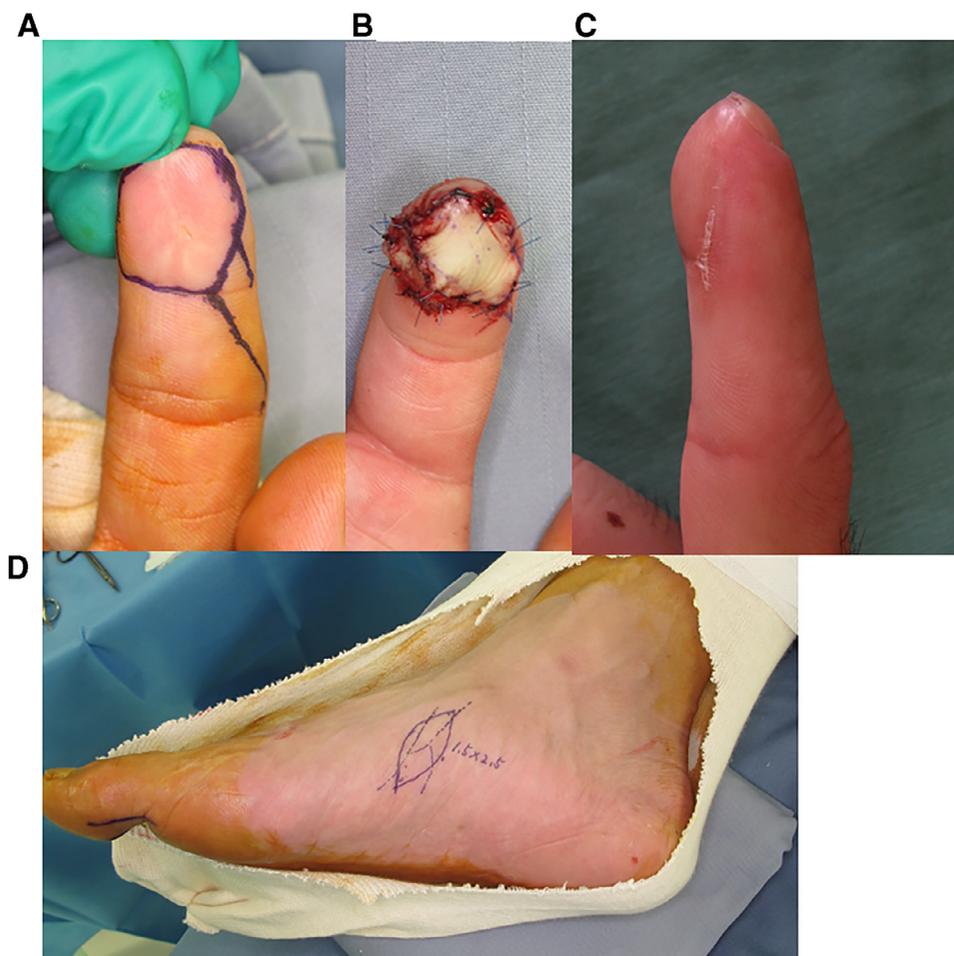


Figure 4 Case 6: (A) A 34-year-old man had painful scar contracture after severe soft tissue damage. (B) A 15 × 25 mm Type B venous flap was designed slightly away from the medial plantar region. (C) The flap veins were anastomosed to the digital artery and to the dorsal subcutaneous vein of the digit after resection of a scar. (D) At 6 months after the surgery, the flap was similar to the normal fingers and the pulp was well-shaped with little postoperative atrophy. The color match score was 4.

of 0.8 mm.¹⁷ In addition, it seems that subcutaneous veins become larger at sites further from the medial plantar region and communicating veins become larger as they get deeper below the subcutaneous layer. Accordingly, it may be important to preoperatively investigate the flap veins in the medialis pedis region by ultrasound,¹⁷ as it is done for the small arteries of perforator flaps. The author has not encountered any technical difficulty with vascular anastomosis. After confirmation of good blood flow through the reconstructed digital artery by the patency test, the other proximal subcutaneous vein of each flap is anastomosed to the dorsal subcutaneous vein of the digit (Figure 2). Donor sites are closed primarily without using a skin graft.

Results

All flaps survived with little postoperative atrophy. Visual observation was conducted by the author for part of the flap, and results showed that each part remained completely viable in each patient without obvious congestive or ischemic changes throughout the postoperative period. There was a good cosmetic outcome with 3 Type A flaps used

to reconstruct finger shaft defects (Figure 3) and 2 Type B flaps used to reconstruct finger pulp defects (Figure 4), but 1 Type B flap used to reconstruct a finger shaft defect required defatting (Figure 5). The mean color match score of the flaps was 3.7 (range: 2-5) (Table 1). Color match became worse as the flaps were raised further from the medial plantar region (Figure 6). The location of each donor site in the medialis pedis region is shown by the case numbers in Figure 7. In 5/6 patients, the author performed surgery alone at both the recipient and donor sites. The mean operating time was 5.3 h in 3 patients without additional procedures, such as corrective osteotomy, nerve graft, or arthroplasty.

Cases

Case 3

A 19-year-old man sustained incomplete amputation of the right little finger with severe soft tissue damage when his fingers were caught in a press. The radial digital artery and nerve were intact, but the ulnar digital artery and



Figure 5 Case 2: A 39-year-old man had scar contracture of the left middle finger after severe soft tissue damage. A 25×50 mm Type B venous flap was designed for reconstruction of the volar skin defect and digital artery. The flap remained completely viable with minimal postoperative atrophy and thus was too bulky for reconstruction of the finger shaft defect. Accordingly, defatting was performed. The color match score was 3.2 (Power Shot S21S, Canon, Japan).

nerve were crushed. On the day of the accident, emergency repair was performed under axillary block. The finger injury was treated by primary closure and suturing of the ulnar digital nerve. After he received conservative therapy for >3 months, scarring and joint contracture were noted (Figure 3(A)) Revision surgery with medialis pedis venous flap transfer was scheduled. Before the operation, visible subcutaneous veins were marked in the medialis pedis region. Surgery was performed under axillary block (recipient site) and local anesthesia (donor site). After the joint contracture was released, a 15×50 mm Type A venous flap based on the subcutaneous veins (Figure 3(B)) was elevated at a site near the medial plantar region to reconstruct the volar finger skin defect and the ulnar digital artery. The

vein at the distal border of the flap was anastomosed to the proximal stump of the digital artery, while the veins at the proximal border of the flap were anastomosed to the distal stump of the digital artery and the dorsal subcutaneous vein of the finger (Figure 3(C)). The flap remained completely viable. At 6 months after surgery, the flap was not bulky and was almost the same color as the surrounding skin (Figure 3(D)). An image of the reconstructed finger was obtained with a camera ($\alpha 7700i$, Minolta, Japan). The color match score was 5.

Case 6

A 34-year-old man sustained severe injury to the pulp of the right index finger. Painful scarring with contracture persisted after conservative therapy for >5 months, so surgery with medialis pedis venous flap transfer was scheduled. Before the operation, visible subcutaneous veins were marked at the medialis pedis region. Surgery was performed under general anesthesia to allow finger pulp reconstruction. Scar tissue was resected from the finger pulp (Figure 4(A)). Then a 15×25 mm Type B venous flap (based on both the subcutaneous veins and the communicating vein) was elevated at a site slightly away from the medial plantar region (Figure 4(B)) to reconstruct the volar finger skin defect and the digital artery. The communicating vein at the distal border of the flap was anastomosed to the ulnar digital artery, while the subcutaneous veins at the proximal border of the flap were anastomosed to the radial digital artery and the dorsal subcutaneous vein of the finger (Figure 4(C)). The flap remained completely viable. At 6 months after surgery, the flap was similar to that of normal finger skin and the pulp was well-shaped with little atrophy (Figure 4(D)). An image of the reconstructed fingers was captured with a digital camera (Power Shot S21S, Canon, Japan). The color match score was 4.

Discussion

Among free flow-through venous flaps,² arterialized flow-through venous flaps (A-A flaps) are useful for repairing a volar soft tissue defect of the finger and the digital artery at the same time,⁵ but the circulation of these flaps may be inadequate because only a single flow-through vein is anastomosed to the artery at the distal and proximal sides of the flap.⁷ We have previously reported A-A-V flap to solve this problem, and the cutaneous architecture of flaps showed nearly normal without degeneration of the appendages or subcutaneous fat.⁶ In the present series, Type A or Type B venous flaps (Figure 1) remained completely viable with almost no postoperative atrophy. These flaps were designed as thin or thick A-A-V venous flaps and were modifications of the arteriovenous flow-through flaps (A-V flaps) reported by Nakazawa et al.³ or Yokoyama et al.¹⁴ Therefore, Type A flaps achieved an adequate cosmetic outcome when used for the reconstruction of finger shaft defects, as did Type B flaps when used for finger pulp defects.

It is important to perform reconstruction with a skin flap that is similar to the skin at the recipient site as possible. Interestingly, this study showed that venous flaps elevated

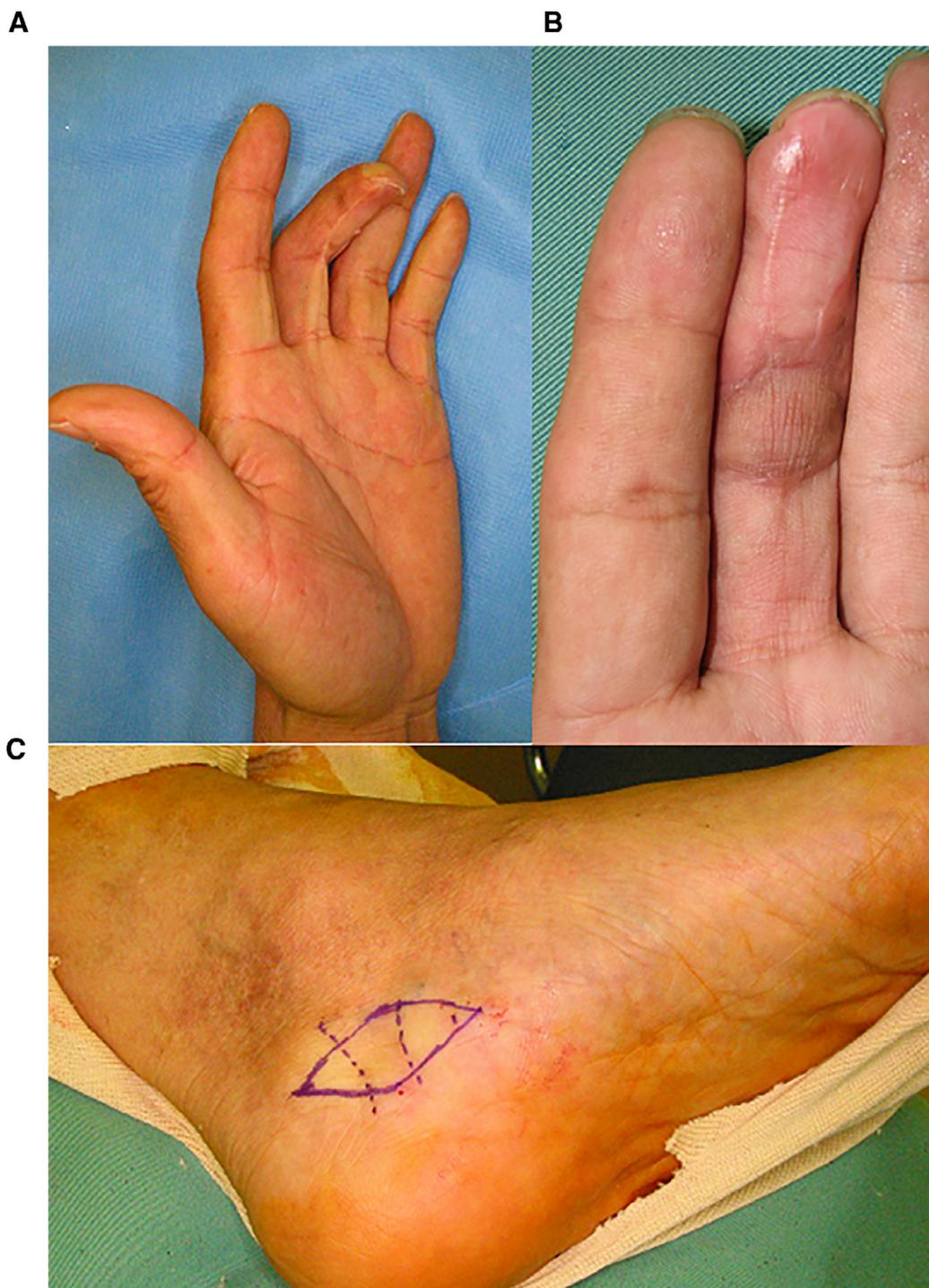


Figure 6 Case 4: (A) A 56-year-old man had scar contracture of the left middle finger after severe soft tissue damage. (B) A 25 × 50 mm Type A venous flap was designed at a site far from the medial plantar region. (C) The flap remained completely viable. At 6 months after the surgery, the flap was not bulky, but showed stronger pigmentation than the surrounding skin. The color match score was 2 (Power Shot G15, Canon, Japan).

from the medialis pedis region were superior to previously reported venous flaps from the forearm region⁶ with respect to both color and texture match, and that color match improved as the medialis pedis flap was elevated closer to the medial plantar region. The submalleolar skin is quite different from the skin of the sole and the border with the sole skin is located at a point 20-25% of the intermalleolar dis-

tance from the medial malleolus, so it is better to harvest grafts for the volar region of the finger from sites closer to the medial plantar region.¹⁵

For the reconstruction of volar finger shaft defects, the author employs either a full thickness skin graft from the medialis pedis region or a venous flap from the forearm or medialis pedis region. Harvesting a skin graft is a simple

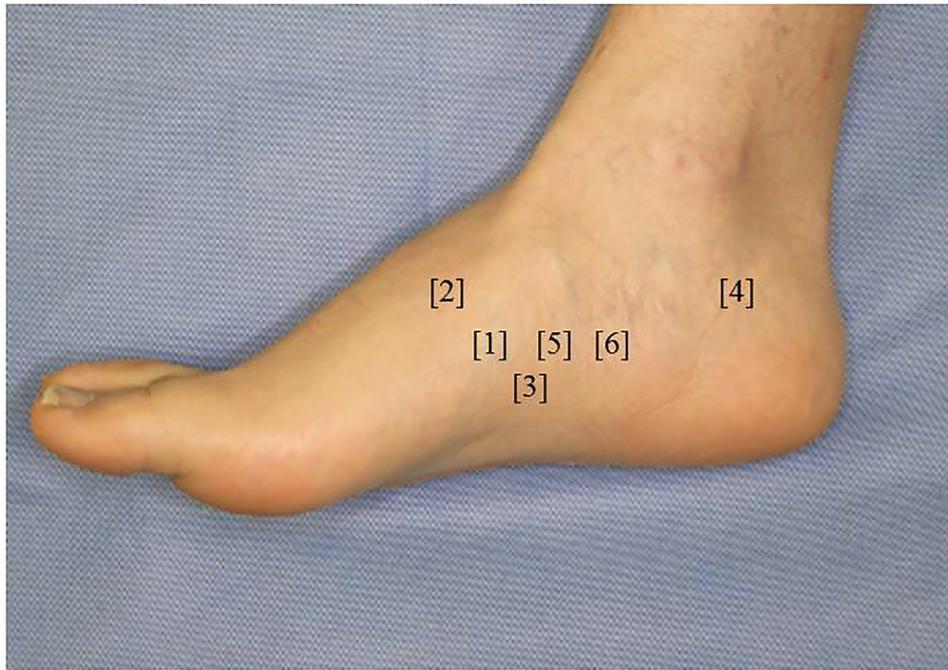


Figure 7 The case numbers indicate the location of each donor site in the medialis pedis region (photograph of the author's foot).

procedure that takes less than half of the time compared with venous flap transfer, does not require postoperative hospitalization, and achieves good cosmetic results. However, it is not suitable for secondary reconstruction of a finger defect with poor blood supply to the graft bed after debridement, and is also unsuitable for covering an exposed tendon or when a nerve graft is required.⁴ Venous flap transfer requires hospitalization of the patient because vascular anastomosis is performed, but a wider defect can be reconstructed in comparison to local flap transfer without skin grafting, and simultaneous reconstruction of both a volar finger skin defect and the digital artery is possible.^{5,6} In addition, a finger reconstructed by using a venous flap is softer and moves more smoothly (as after reconstruction with other local flaps) than a finger reconstructed using a full thickness skin graft, especially in the early postoperative period.⁴ When reconstruction of both a volar finger skin defect and digital artery are required, a perforator flap may also be useful.¹⁰⁻¹² These are superior to venous flaps because the digital artery is reconstructed by using the flap artery and the resulting circulation is more physiological, but are more troublesome than venous flaps because careful microsurgical techniques are required to detect, preserve, and anastomose small perforators. In addition, most perforator flaps are bulky and defatting is often needed, especially at the flap pedicle. Recently, the use of a super-thin perforator flap for hand and finger reconstruction was reported,¹³ but the color and texture are unsuitable for volar finger defects, as has been found with venous flaps elevated from the forearm region. For reconstruction of volar finger pulp defects, the author has mainly employed a V-Y advancement flap, thenar flap, or reverse digital artery flap. However, it is difficult to properly reconstruct the shape of the finger pulp with a V-Y advancement flap, while a

thenar flap requires two operations and a reverse digital artery flap involves the sacrifice of one digital artery. On the other hand, although venous flap transfer has achieved a good outcome when employed for reconstruction of volar finger shaft defects, the author was concerned about the risk of postoperative flap atrophy rather than congestion. However, our previous study showed that A-A-V venous flaps survived with little postoperative atrophy and maintained nearly normal cutaneous architecture.⁶ Accordingly, the author has performed medialis pedis venous flap transfer in patients who did not want hemi-pulp flap transfer because sacrifice of a toe was required. While the pioneers in this field developed various free flaps for the reconstruction of volar soft tissue defects of the fingers, the next generation of surgeons not only need to improve flap survival rates, but also have to consider how to perform finger reconstruction with flaps that are minimally invasive and provide excellent texture and color match.

Finally, the Vancouver scar scale (VSS) designed by Sullivan et al.¹⁸ is one of the methods for the evaluation of the esthetic outcome. Fujiwara et al. applied the VSS for the esthetic evaluation of scarring and skin grafts after surgery to release finger contractures caused by burns.¹⁹ The VSS assesses four parameters, which are pigmentation, pliability, height, and vascularity. Both pliability and vascularity are almost normal when a venous flap is raised by our method,⁶ while height can be modified by postoperative defatting of the flap. Although pigmentation is esthetically important, it is only assessed by three categories in the VSS (normal, hypopigmentation, or hyperpigmentation), and it is difficult to evaluate precisely. Therefore, the VSS was not employed for evaluation of the flaps in the present study. Instead, photographs obtained 6 months postoperatively were assessed by a panel of plastic surgeons specializing in maxillofacial

surgery, and evaluation was based on their first impressions. Although the objectivity of this method may be low because photographs obtained with different cameras were employed, the surgeons compared the reconstructed finger with the other healthy fingers to improve objectivity.

Conclusion

Free medialis pedis venous flaps can be used for the reconstruction of volar soft tissue defects of the finger. Acceptable esthetic results can be obtained if flaps are harvested from an appropriate location in the medialis pedis region by a suitable method.

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Conflicts of interest

None declared.

Ethical approval

Not required.

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