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Reverse Dorsolateral Proximal Phalangeal Island Flap: A Modified Technique for Reconstruction of Finger Defect

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Abstract

Soft tissue defects of the fingertip are the very common after hand injuries. Nevertheless, they still represent a challenging issue for hand surgeons. This article aims to report a modified reverse dorsolateral homo digital island flap for reconstruction of finger tip and pulp defect. We performed 13 reconstructive procedures in 11 patients with the reverse dorsolateral proximal phalangeal island flap for fingertip amputations or finger pulp defects. After the surgical procedures, no flap ischemia was found by us. However, five flaps displayed mild venous congestion 2 days later, which were improved by removing compression on the pedicle. At final follow-up 4 weeks post surgery all flaps and donor side grafted skins survived. No wound infection was observed. The reconstructive finger got a satisfied appearance. Our results demonstrate that the reverse dorsolateral proximal phalangeal island flap is a useful and reliable option for reconstruction of finger tip and pulp defect.

Introduction

Several options are available for the reconstruction of finger tip and pulp, which largely depends on the size and location of the defect, as well as the experience and personal preference of the surgeon [1]. The reverse digital artery island flap was a classic technique for finger soft tissue defect. But it was no so popular now for damage of an important artery. The reverse dorsal homo digital island flap reported by Oberlin et al. [2] receives blood supply from dorsal branch of the digital artery which avoids sacrificing an important artery, becoming popular these years. However, because of short blood pedicle and small donor site the flap is only suitable for small and special location of soft tissue defect of the finger [3-13]. In this study, we introduced a modified reverse homo digital island flap, that is, reverse dorsolateral proximal phalangeal island flap, a versatile technique to reconstruct fingertip and pulp defects.

Materials and Methods

From October 2015 to September 2016, we performed 13 reconstructive procedures in 11 patients (9 men and 2 women) with the reverse dorsolateral proximal phalangeal island flap for fingertip amputations or finger pulp defects. The ages of patients ranged from 26 to 65 years, mean age was 42.6 years. The causes of injury were: crush, amputation and avulsion. Involved finger were: Middle finger (6), Index finger (3), Ring finger (2), Little finger (2). Flap sizes ranged between 2 cm × 1.5 cm and 3 cm × 2.5 cm. We used a recently proposed fingertip wound classification in our patients [1]: the types of fingertip defects were either B or E, and extended to zone 1A or the distal part of the zone 1B, but none to zone 1C. The patient demographics are shown in Table 1. Patients were excluded and chose other operations when they had any of the following: (1) a finger pulp defect was larger than the whole finger pulp; (2) the donor site of the flap was injured; or (3) the digital artery on the donor site or its dorsal branch in the middle of the middle phalanx was injured. (4) The patient did not wish to keep the length of the injured finger. This study was approved by the institutional review board and informed consent was obtained from each patient.

Surgical technique

The operations were performed under axillary block with the aid of tourniquet control and loupe magnification. After a thorough debridement of the wound, reverse dorsolateral proximal phalangeal island flap was designed at the dorsolateral area on the proximal phalange of the injured finger according to the location of the defect, such that the required flap size was slightly bigger than the defect size. If possible the donor site is always located in the concealed area-i.e., the ulnar aspect of the index, middle and ring fingers-for aesthetic reasons. We chose the nearest uninjured

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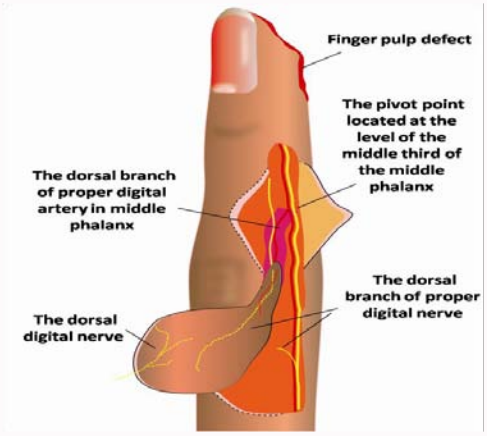

Figure 1: Operation schematic diagram of reverse dorsolateral proximal phalangeal island flap.

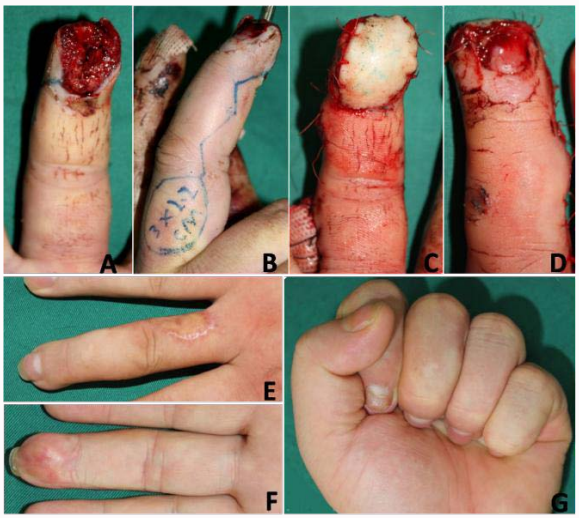

Figure 2: Case 2. A 27 years old man suffered from a crash injury of right middle finger repaired with reverse dorsolateral proximal phalangeal island flap. (A) Loss of soft tissue from the digital pulp of the right middle finger. (B) Reverse dorsolateral proximal phalangeal island flap was designed on the dorsoulnar side of the middle finger. (C) Flap covered soft tissue defect of middle finger. (D) Appearance of the dorsum of the reconstructive finger. (E,F) Appearance of the reconstructive finger 5 months post surgery. (G) The motion of the injured hand recovered.

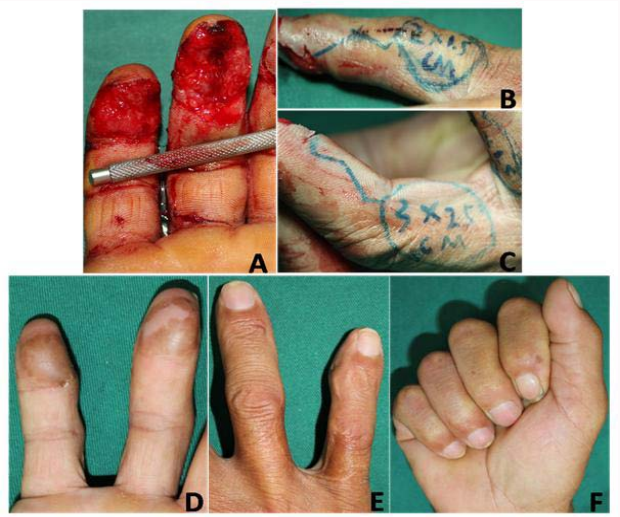

Figure 3: Case 3. A 61 years old man suffered from a crash injury of right ring and little finger both repaired with reverse dorsolateral proximal phalangeal island flap. (A) Loss of soft tissue from the digital pulp of the right ring and little finger. (B,C) Flaps were designed: ring finger on dorsoulnar side and little finger on dorsoradial side. (D,E) Appearance of the reconstructive finger 7 months post surgery. (F) The motion of the injured hand recovered.

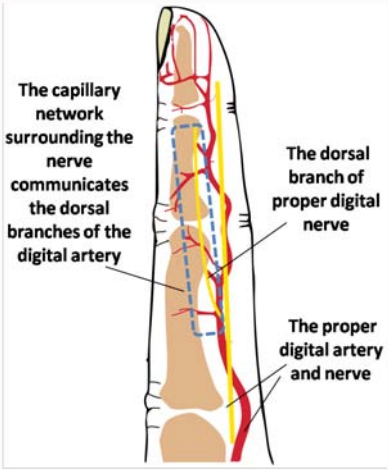

Figure 4: Schematic diagram of the blood supply for the flap. The capillary network surrounding the dorsal branch of proper digital nerve communicates the dorsal branches of the digital artery, which constitutes the blood supply and drainage system of the flap.

dorsal branch of the proper digital artery as the vascular pedicle of the flap, located at the level of the middle of the middle phalanx, where the pivot point was marked. The pedicle was designed along the dorsal branch of the digital artery in middle phalanx and extended to the proximal phalanx along the dorsal branch of the digital nerve. The flap was harvested proximal to distal with preservation of the tenosynovium. A lazy-Z incision stretched across the PIP joint from the distal end of the flap to the pivot point. The pedicle was raised from the paratenons of the extensor sheet with width of 8 mm at least, which included the dorsal branch of the digital nerve and dorsal branch of the digital artery located at the middle phalanx. After the whole flap was elevated and rotated, the tourniquet was released to confirm the circulation of the flap. After that, the flap was turned 180° and inserted into the defect area with several tension-free stitches. The dorsal digital nerve can also be contained in the flap, and two nerves were sutured to the ends of proper digital nerves in the defect area. Donor site was covered with a full-thickness skin graft harvested from the inner aspect of the upper arm. Figure 1 is operation schematic diagram.

Level of expertise of surgeons

All 11 cases were operated by surgeons of expertise level 3 without other levels [14,15].

Postoperative treatment

After operation, the injured hand was placed above the heart level to reduce venous congestion of the flap for one or two days. The color and capillary refilling were checked carefully until the flap reached a steady state. Active and passive rehabilitation exercises were encouraged thereafter. Usually patients stayed in hospital for about 7 days. The final follow-up was performed 4 weeks post surgery by 2 surgeons who did not participate in the operations.

Table 1: Demographics of Patients.

Case	Sex	Finger	Age (years)	Type of Injury	Fingertip Wound Classification	Size (cm × cm)
1	M	L. Middle	45	avulsion	Zone 0B-B	2.5 × 2.2
2	M	R. Middle	27	crush	Zone 0B-B	3 × 2.2
3	M	R. Ring and Little	61	crush	Zone 0A-B	3 × 2.5, 2 × 1.5
4	M	R. Middle	28	avulsion	Zone 0B-B	3 × 2.5
5	M	L. Index	26	amputation	Zone 1A-E	3 × 2.5
6	M	L. Index	45	amputation	Zone 1A-E	3 × 2
7	M	L. Little	55	crush	Zone 0A-E	2.5 × 2
8	F	R. Middle	35	crush	Zone 0A-E	2.2 × 1.8
9	F	R. Middle	65	crush	Zone 0B-B	3 × 2
10	M	L. Middle and Ring	37	crush	Zone 1B-B	2.8 × 2.5, 2.5 × 2
11	M	R. Index	45	avulsion	Zone 0A-E	3 × 2
Mean			42.6			2.9 × 2.1

Results

Flap ischemia was not observed post operation. Five flaps displayed mild venous congestion 2 days later, which were improved by removing compression on the pedicle. At final follow-up 4 weeks post surgery all flaps and donor side grafted skins survived. No wound infection was observed. The reconstructive finger got a satisfied appearance. Figures 2 and 3 present the operation and follow-up results of case 2 and 3.

Discussion

The fingertip pulp plays an indispensable role in pinching because of its specialized covering [19]. It is sometimes difficult, however, to resurface the fingertip with a good quality, pliable and sensate skin coverage and achieve cosmetically and functionally good results [20-22]. Various reconstruction techniques for fingertip repair have been reported, use of the V-Y advancement flap results in good fingertip and pulp sensation. It is, however, not suitable for defects larger than 1.5 cm [23]. Cross-finger and thenar flaps provide stable pulp padding but require a two-stage procedure [24]. Takeishi et al. utilized verse; dorsal, digital island flap for homo digital tip defect coverage obtaining good sensory recovery but it was at the cost of sacrificing a proper digital artery [25]. Free partial toe flap has been reported with good cosmetic sensibility recovery but it requires microsurgical vessel anastomosis with a longer operating time as well as higher risks of operation failure [26].

The reverse digital artery island flap based on the proper digital artery was first described by Weeks and Wray [16]. Given the rich blood supply, considerable size of donor site and easy harvested nerve, coverage of a large finger defect with innervated reverse digital artery flap is feasible. It became a classic operation for finger tip reconstruction. But several articles have reported the disadvantage of sacrificing an important artery of a finger and the long scar along the lateral aspect of finger through joint [22,23]. Our previous work found that no obvious loss of motion in the injured finger, but cold intolerance of the flap was prone to occur in the fingers in which the dominant artery was sacrificed [24,25].

To avoid the complications occurred after sacrificing an important proper digital artery, there are many other operations. Local advancement flaps can only cover small-size defects [26]. Cross-finger and thenar flaps provide stable pulp padding, but require a two-stage procedure [27]. The direct island flap without cutting off the proper digital artery resulted in motion loss in both articulations of the finger but with better discriminatory sensation in comparison with the reverse flap [28]. In another comparative study of the oblique triangular neurovascular advancement flap and the reverse digital artery island flap there was no significant difference in the motion and sensation results 12 months after surgery [29].

As described in a series of anatomical studies the dorsal branches of the digital artery is relatively constant [2,30,31]. Based on these dorsal branches of the digital artery located on different levels of phalanx the reverse dorsal homo digital island flaps were designed for various reconstructive requirements. Previous studies have reported that the flap can cover 2/3 the entire finger pulp at most [9]; hence, it is only suitable for small and moderate soft tissue defects of the finger [13]. Our previous study found that some patients with a reverse dorsal homo digital island flap had very obvious donor site scaring and skin sinking which affected the appearance of the reconstructive finger [24]. To avoid the problem the donor site of the modified flap is always located at the lateral proximal finger. Otherwise we chose concealed donor side for different finger i.e., the ulnar aspect of the index, middle and ring fingers. The donor side can also be extended to the dorsum of proximal phalanx if a larger flap was needed.

We chose the dorsal branch of the proper digital artery located at the level of the middle of the middle phalanx to be the vascular pedicle of the flap, so that the pedicle can have enough length to cover the finger pulp. As we know the dorsal branches of the proper digital artery nourish different regions of the dorsal skin of finger independently, but they nourish the dorsal branch of the proper digital nerve collaboratively. The capillary network surrounding the nerve communicates the dorsal branches of the digital artery (Figure 4). So the pedicle contained the dorsal branch of the proper digital nerve can supply the blood for the flap. All the 13 flaps survived without necrosis. The incidence of venous congestion was 38%, higher than other reports [9,13]. We speculate that it is due to the long pedicle or compression on the pedicle, which may be solved by enlarging the pedicle width and small skin graft on the pedicle pivot.

Flap sensation may be improved by neurorrhaphy, but the reported S-2PD varies considerably [6,9,11,13,24]. Recently, the innervated reverse dorsal homo digital island flap has been reported to have better sensation than the non-innervated flap, and double

neurorrhaphies is suggested [13]. The dorsal branch of proper digital nerve and dorsal digital nerve from one side of the finger can all be contained in the modified flap to reconstruct sensation of finger pulp. The donor nerves from one side may minimize the influence on the sensation over the dorsum of the injured finger.

Compared with reverse dorsal homo digital island flap, reverse dorsolateral proximal phalangeal island flap can provides longer blood pedicle and larger stable skin coverage, so it can be used to reconstruct almost the whole finger pulp. It is a reliable choice for coverage of finger defects. In this study we did not have long time follow-up results to evaluate the sensation recovery of the flap and the motion of the injured finger, which will be completed in the future.

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