

# Outcome of free digital artery perforator flap transfer for reconstruction of fingertip defects

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## ABSTRACT

**Background:** Fingertip defect can be treated with many flaps such as random pattern abdominal flap, retrograde digital artery island flap, V-Y advancement flap, etc. However, swelling in the fingertip, dysfunction of sensation, flexion and extension contracture or injury in the hemi-artery of the finger usually occurs during the recovery phase. Recently, digital artery perforator flaps have been used for fingertip reconstructions. With the development of super microsurgery techniques, free flaps can be more effective for sensory recovery and durability of the fingertip.

**Materials and Methods:** Six cases (six fingers) of fingertip defects were treated with free digital artery perforator flaps of appropriate size and shape from the proximal phalanx. During surgery, the superficial veins at the edge of flap were used as reflux vessels and the branches of the intrinsic nerve and dorsal digital nerve toward the flap were used as sensory nerves. The proximal segment of the digital artery (cutaneous branches) towards the flap was cut off to form the pedicled free flap. The fingertips were reconstructed with the free flap by anastomosing the cutaneous branches of digital artery in the flap with the distal branch or trunk of the digital artery, the flap nerve with the nerve stump and the veins of the flap with the digital artery accompanying veins or the superficial veins in the recipient site.

**Results:** Six flaps survived with successful skin grafting. Patients were followed up for 6-9 months. The appearance and texture of the flaps was satisfactory. The feeling within the six fingers recovered to S4 level (BMRC scale) and the two point discrimination was 3-8 mm.

**Conclusion:** Free digital artery perforator flap is suitable for repairing fingertip defect, with good texture, fine fingertip sensation and without sacrificing the branch of the digital artery or nerve.

**Key words:** Fingertip defect, perforator flaps, reconstruction

**MeSH terms:** Surgery, plastic, surgical flaps, finger injuries

## INTRODUCTION

Fingertip defect, one of the most common injuries in the hand, is treated with various flaps such as random pattern abdominal flap and retrograde digital artery island flap.<sup>1-5</sup> However, swelling in the fingertip, dysfunction of sensation and scarring leads to restriction

of flexion and extension. Injury to the hemi-artery of the finger usually occurs during the recovery stage. Recently, digital artery perforator flaps have been used for fingertip reconstruction<sup>6,7</sup> and these can avoid most of the above described complications. In this study, we reported six cases of fingertip reconstruction using free digital artery perforator flaps.

## MATERIALS AND METHODS

Six patients with fingertip defects underwent repair with free digital artery perforator flaps between March 2009 and August 2012. They were all manual workers. The fingertip defects were caused by crush injury and incised wound, with bone and tendon exposure [Figure 1a]. All flaps survived. The size of the flap ranged from 1.0 cm × 1.4 cm to 1.3 cm × 2.8 cm. No patients had postoperative hypersensitivity of the repaired fingertips. This study was conducted with approval from the Ethics Committee of Qilu Hospital, Shandong, China. A written informed consent was obtained from patients or their families.

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## Operative procedure

Using brachial plexus block and pneumatic tourniquet, the surgery was performed under operating microscope. After thorough cleaning the skin edges of fingertips, the dorsal digital vein, bilateral digital artery stump and its branches and digital nerve stump or terminal branches were isolated and labeled. The flap was designed as a free style flap.<sup>8</sup> The digital artery perforator flaps were devised in the proximal local or neighbour finger according to the size of palmar defect [Figure 1b]. The back flowing veins of the flap to the dorsum of the finger were freed after removing the redundant subcutaneous fat. About 1cm of the freed veins cut, ligatured and labeled. After separation the edge of flaps, the digital arteries and accompanying veins were identified at the proximal and distal sides of the flap, followed by dissociation along the dorsal surrounding intervals of digital artery. The cutaneous branches of digital artery from proximal medium were protected according to anatomized rules. Then, the palmar branches of digital intrinsic nerves were labeled and cut, and the flaps were lifted up. After loosening the pneumatic tourniquet, the blood supply of the flap was observed. After supplying blood for 10 min, the digital arterial cutaneous branches (with the diameter of 0.2-0.3 mm) were severed on its original site and then the flap was freed completely. The flap was sutured with the injured digital distal skin using 6-0 polydioxanone suture (PDS)-II thread. The digital dorsal veins of the flap were anastomosed with the digital artery accompanying veins or the ending dorsal veins through subcutaneous tunnel using 12-0 noninvasive sutures. The diameter matching these veins was about 0.6-1.0 mm, suitable for vascular anastomosis. The bilateral digital arteries were freed carefully. The middle and larger branches of the arterial arch of one digital artery were chosen, with the diameter of 0.3-0.4 mm and then were clipped and anastomized with cutaneous branches of artery using 12-0 noninvasive sutures [Figure 2a]. It is very important to carefully and gently expose the tiny arteries. The labeled

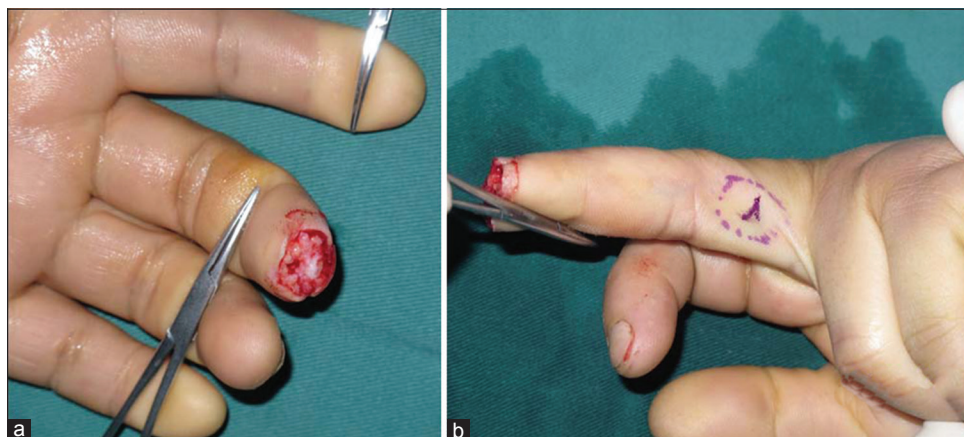
palmar cutaneous branches were sutured with the ending branches of digital nerves. After the flap was re-perfused, the careful attention was paid to confirm if there was leakage on the anastomising site of the artery or vein. Good venous backflow and blood supply of the flap should be reassured. The donor site was repaired with full thickness skin graft from the groin. The finger was wrapped up with sterilized dressing and externally fixed with plaster.

## Postoperative treatment

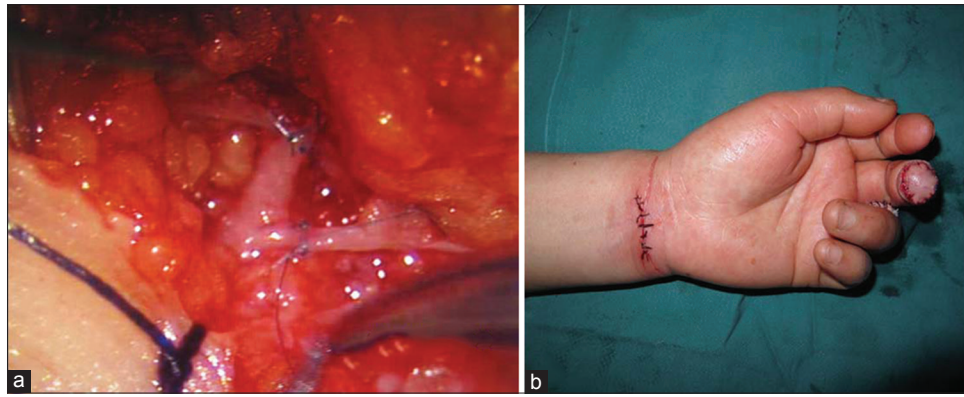
The antibiotic and anticoagulant drugs were used routinely in postoperative treatment and the blood coagulation function was supervised at regular intervals to keep the activated partial thromboplastin time (APTT) as no more than 1.5 times of the normal level. After 8 days, the compression on the grafted skin was removed. When the grafted skin survived well, the silica gel was used to relieve the scar hyperplasia. The plaster was removed after 10 days. The active and passive ROM training was performed on the patient. 1 month postoperatively, the sensation training of the flaps was started.

## RESULTS

The average age of six patients was 33 years (range 23-49 years) and there were 4 males and 2 females. 2, 3 and 1 cases were with defect in the index finger, middle finger and ring finger, respectively. The size of the flaps was from 1.2 cm × 1.5 cm to 1.5 cm × 2.9 cm. The successful anastomosis was conducted on all cutaneous branches. After surgery, all six flaps survived, with good blood perfusion [Figure 2b]. In the followup of 6-9 months, the flaps had normal color and soft texture. The outlooks of the injured fingers were similar to normal, with well shaped pulps but without swelling. The scar contraction and hyperpigmentation were not obvious and the active and passive activities of fingers were similar to normal. The patients could outstretch the fingers [Figure 3a] and



**Figure 1:** Clinical photograph showing (a) Finger tip defect (b) Flap design

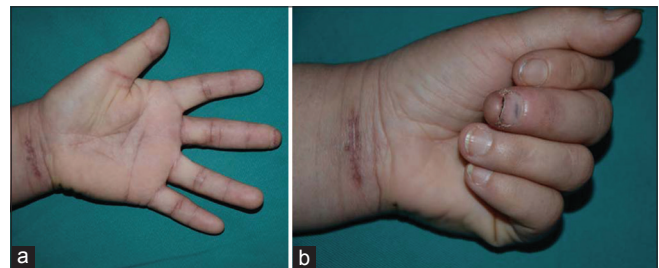


**Figure 2:** (a) Intraoperative photograph showing artery anastomosis (magnified view) (b) Clinical photograph after surgery showing the flap had good blood perfusion

clench the fist [Figure 3b]. The sensation of finger tips was evaluated according to the upper limb section functional evaluation standard of Chinese Medical Association Hand Surgery Master.<sup>9</sup> Results showed that, the feelings of 6 fingers recovered to S4 level (British Medical Research Council (BMRC) scale) and the two-point discrimination was 3-8 mm. The grafted skin at the donor site completely survived. The Doppler ultrasound indicated normal blood supply of the injured and supplied fingers.

## DISCUSSION

There are various methods of repairing defect of fingertip, including using the random pattern abdominal flap and retrograde digital artery island flap.<sup>1,3-5</sup> The large shortage of these surgical methods is the injury of unilateral artery and the postoperative complications such as atrophy and sensation of chill. In addition, in these surgeries the accompanying veins of digital arteries are susceptible to injury, which will lead to venous back flowing dysfunction of the flaps, hyper pigmentation, and even atrophy or necrosis of flaps.<sup>10</sup> V-Y advanced flap may be a quick and reliable choice for fingertip defect repair, but the uncomfortable distal palmar scar and finger hypoesthesia may prevent handworkers from going back to previous job. Previous studies<sup>2,7,11-13</sup> find that, the cutaneous branches of digital arteries are close to the proper palmar digital nerves, so the free digital artery perforator flaps are designed to repair defect of finger tips. In this study, the branches from digital intrinsic nerves and dorsal part of digital nerves to flaps are used in flaps as sensory nerves. The therapeutic outcomes of the six patients are found to be satisfactory. The microsurgical anastomosis of vessels is considered to be the bottleneck of free flap transplantation. With the development of microsurgical technique, the anastomosis of vessels with a diameter of 0.2-0.3 mm is no longer a problem nowadays. After intensive training, the average time of anastomosis can be controlled within 5-10 min. If the anastomosis is successfully performed, the free flap



**Figure 3:** Clinical photographs (a) after 6 months from surgery showing (a) the patient could normally extend the fingers (b) the patient could normally clench the fist

transplantation can be easily achieved. The whole surgical duration is 2-3 h. Therefore, the free flap transplantation is no longer a long and complex surgical procedure now. In addition, there is little scar after free flap transplantation, especially without a long strip of Z-shaped scar at finger side. This is conducive to the recovery of finger function.

The advantages of using free digital artery perforator flaps in repairing defect of the fingertip are as follows: (1) Satisfactory appearance. The free digital artery perforator flaps are designed according to the size of skin defect in palmar side of the fingertip and are cut according to the shadowing features of skin in palmar. If a defect in palmar skin is large, the flap is harvested near finger palmar. The round needles and monofilament suture are used during suturing, to avoid the scar of fingertip effectively and reconstruct the palmar dermatoglyph. The Doppler ultrasound can be used to identify the digital artery and the dorsal perforators.<sup>14</sup> During operation, if the cutaneous branches of digital arteries are found, the surrounding lipochondrion can be cleaned undoubtedly, which can relieve the volume of adipose tissue in the flap. So the size of flap can well match with the defect of fingertip, to avoid the mushroom head appearance. (2) Favorable function of fingers. The traditional reversal island flaps of digital artery are required to be cut in Z shape on the sideward of finger, which often leaves scar. The contraction and hyperplasia of the scar



may cause dysfunction in flexion and extension. In this study, after surgery only the round scars on pulp and linear scars on finger tips are left, with no sideward scar in fingers which may influence the flexion and extension of fingers.<sup>15</sup> The active and passive activity of injured fingers are not significantly different with the uninjured ones. (3) Good blood supply in injured fingers and satisfactory recovered sensation. The free digital artery perforator flaps causes less injury to the digital arteries of fingers, and the bilateral digital arteries can be reserved. So the blood supply of the injured fingers is abundant, which can avoid the operative complications such as atrophy of injured fingers and sensation of chill.<sup>16-19</sup> During surgery, the cutaneous branches of digital arteries are excised directly, without picking redundant adipose tissues and more fascia or thin adipose covering intrinsic nerves of fingers which are beneficial for skin grafting survival. When the dimension of donor site is minor, it can be sutured directly. The digital nerve is repaired and the sensation of fingertip is recovered satisfactorily. The terminal branches of digital nerves and cutaneous branches of digital nerves from dorsum of the finger to the flap match well. The normal sensation can be recovered in the fingertip without injuring the dorsal branches of digital nerves while reserving the dorsal cutaneous sensation in medium deep joint of injured fingers.

For reconstruction of fingertip using free digital artery perforator flap, the surgical technique and key points of postoperative management are as follows: (1) Meticulous operation. The debridement is done under microscope to avoid iatrogenic injury of digital arterial terminal branches. The vessels should be protected carefully during the debridement, ligature and marking branches of digital arteries. Each hemorrhagic spot is scorched with ophthalmology hemostat to avoid the hematoma and swelling of flap and further crisis of blood circulation.<sup>20</sup> During lifting up the flap, the dorsal digital veins are separated to enough length according to the vein condition, with sharply removing the tissues along the digital arteries. The pulling of cutaneous branches of the digital artery should be prevented. In the reperfusion the flap, the vasospasm often occurs due to little soft tissue surrounding the vessel pedicle. This can be timely released by local hydropathic compressing with warm salt water and gentle hydraulic pressuring and extending with microinstrument.<sup>21</sup> (2) Reasonable application of anticoagulant. 500 ml low molecular dextran is given by intravenous drip 30 min before vascular anastomosis. Heparin is pumped in at 0.1 mg/(kg/h) after the reperfusion of flap for 7 days with keeping APTT level less than 1.5 times to normal.

For prevention of the complications, the following points should be taken into account: (1) Before performing vascular anastomosis, the blood ejection of the proximal blood vessel

side should be carefully observed. If there is vasospasm, the causative factors should be excluded first. The dressing should be timely changed to avoid the compression of vessel. When the arterial crisis occurs, the blood flow status should be timely adjusted, with local hydropathic compression with warm salt water and massage of the digital artery. When the venous crisis occurs, the part of suture should be removed, with a small incision bleeding drainage along the skin edge to keep good blood circulation of the flap. (2) Scar contraction. The invasive manipulation like clamping and gripping should be avoided. The skin is sutured loosely with 6-0 round needle and monofilament suture to avoid the disturbance on the blood supply of skin edges.<sup>22</sup> In this study, there was no scar contracture at the donor site. The reason may be that, the donor site area is very small and is covered by the full-thickness skin from groin. Full thickness skin is not susceptible to contracture. In addition, the silica gel dressing can relieve the scar hyperplasia.

## REFERENCES

- Lai CS, Lin SD, Yang CC. The reverse digital artery flap for fingertip reconstruction. *Ann Plast Surg* 1989;22:495-500.
- Panse N, Sahasrabudhe P. The ulnar digital artery perforator flap: A new flap for little finger reconstruction-A preliminary report. *Indian J Plast Surg* 2010;43:190-4.
- Sungur N, Kankaya Y, Yıldız K, Dölen UC, Koçer U. Bilateral V-Y rotation advancement flap for fingertip amputations. *Hand (N Y)* 2012;7:79-85.
- Suzuki S, Koshima I. Digital artery perforator flap for reconstruction of fingertip after resection of melanoma *in situ*. *Hand Surg* 2011;16:395-8.
- Yu YD, Zhang YZ, Bi WD, Wu T. Functional sensory function recovery of random-pattern abdominal skin flap in the repair of fingertip skin defects. *Exp Ther Med* 2013;5:830-4.
- Koshima I, Urushibara K, Fukuda N, Ohkochi M, Nagase T, Gonda K, et al. Digital artery perforator flaps for fingertip reconstructions. *Plast Reconstr Surg* 2006;118:1579-84.
- Liu G, Xi Z, Wang C, Zhu X, Liu Z, Wang F. Reverse island flap of digital artery parallel for repairing degloved injuries of fingertip. *Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi* 2011;25:1030-2.
- Wei FC, Mardini S. Free-style free flaps. *Plast Reconstr Surg* 2004;114:910-6.
- Pan DD, Gu YD, Shi D. The upper limb section functional evaluation tentative standard of chinese medical association hand surgery master. *Chin J Hand Surg* 2000;16:130-5.
- Bene MD, Petrolati M, Raimondi P, Tremolada C, Muset A. Reverse dorsal digital island flap. *Plast Reconstr Surg* 1994;93:552-7.
- Kawakatsu M, Ishikawa K. Dorsal digital perforator flap for reconstruction of distal dorsal finger defects. *J Plast Reconstr Aesthet Surg* 2010;63:e46-50.
- Li GS, Wang ZT, Zhu L, Liang Y, Li CH, Hao LW. The relationship between cutaneous branches of digital arteries and proper palmar digital nerves and its clinical significance. *Chin J Clin Anat* 2008;26:25-8.
- Mitsunaga N, Mihara M, Koshima I, Gonda K, Takuya I, Kato H, et al. Digital artery perforator (DAP) flaps: Modifications for

- fingertip and finger stump reconstruction. *J Plast Reconstr Aesthet Surg* 2010;63:1312-7.
14. Khan UD, Miller JG. Reliability of handheld Doppler in planning local perforator-based flaps for extremities. *Aesthetic Plast Surg* 2007;31:521-5.
  15. Lim GJ, Yam AK, Lee JY, Lam-Chuan T. The spiral flap for fingertip resurfacing: Short-term and long term results. *J Hand Surg Am* 2008;33:340-7.
  16. Gu JH, Jeong SH. Radical resection of a venous malformation in middle finger and immediate reconstruction using medial plantar artery perforator flap: A case report. *Microsurgery* 2012;32:148-52.
  17. Huang SH, Wu SH, Lai CH, Chang CH, Wangchen H, Lai CS, *et al.* Free medial plantar artery perforator flap for finger pulp reconstruction: Report of a series of 10 cases. *Microsurgery* 2010;30:118-24.
  18. Ozcanli H, Coskunfirat OK, Bektas G, Cavit A. Innervated digital artery perforator flap. *J Hand Surg Am* 2013;38:350-6.
  19. Turner A, Ragowanski R, Hanna J, Teo TC, Blair JW, Pickford MA. Microvascular soft tissue reconstruction of the digits. *J Plast Reconstr Aesthet Surg* 2006;59:441-50.
  20. Hill RA, Pho RW, Kumar VP. Resection of vascular malformations. *J Hand Surg Br* 1993;18:17-21.
  21. Kim KS, Yoo SI, Kim DY, Lee SY, Cho BH. Fingertip reconstruction using a volar flap based on the transverse palmar branch of the digital artery. *Ann Plast Surg* 2001;47:263-8.
  22. Kishibe M, Nishio A, Morita R, Kawakami S. Aggressive remodelling with pedicled skin flaps of the volar surface for the release of contractures of the fingers. *J Plast Surg Hand Surg* 2012;46:272-5.

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