

Salvage of Complete Degloved Digits With Reversed Vascularized Pedicled Forearm Flap: A New Technique

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Complete ring avulsion injury necessitates a difficult choice between microvascular repair and revision amputation. Microvascular repair is technically difficult and amputation may leave an unsatisfactory result. We describe an alternative method whereby a reverse radial forearm flap is wrapped around the complete degloved digit. This provides good quality cover to the whole volar, dorsum, and both sides of the finger. We performed 26 pedicle radial forearm flaps for 26 patients in the Hand and Reconstructive Microsurgery Unit, Sohag University Hospital, from 2001 to 2009. Indications included soft tissue coverage of the thumb (n = 8), ring finger (n = 11), index finger (n = 4), middle finger (n = 2), and little finger (n = 1). Finger salvage was successful in 96% of patients. There was complete loss of 1 flap and partial flap loss of a second. Finger range of motion was excellent in 18 fingers, good in 7, and fair in 1. Two donor sites were closed primarily; the rest were closed with split-thickness skin grafts. There were no reports of cold intolerance of the hand or dysesthesias in the superficial radial nerve or lateral antebrachial nerve distribution. (*J Hand Surg* 2012;37A:832–836. Copyright © 2012 by the American Society for Surgery of the Hand. All rights reserved.)

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DEGLOVING OF DIGITS (class III and IV ring avulsion)¹ is an extremely challenging injury. Replantation can result in good function and appearance in selected patients^{1–7}; otherwise, revision amputation is usually considered.^{1–4,6,8–10} Occasionally, patients will insist on reconstruction rather than amputation despite careful counseling. The radial forearm fasciocutaneous flap was described initially as a free flap by Yang et al² in 1981 and only later as a retrograde-flow pedicled flap for hand reconstruction by Lu et al^{3,11} in 1982. Recognition of the potential for retrograde flow in distally pedicled radial forearm flaps was a notable contribution to hand surgery because large areas of relatively thin skin and fascia

with a robust blood supply could be harvested from the same surgical field and transferred without the need for microvascular anastomosis.^{12,13}

PATIENTS

We performed 26 pedicle radial forearm flaps for 26 patients in our hand and reconstructive microsurgery unit from 2001 to 2009. The average age was 19.5 years (range, 16–33 y). All patients were male. Indications were digits that had circumferential degloving injuries of skin and subcutaneous tissue. The level of injury was at the proximal phalanx. Both flexor and extensor tendons were intact. Fracture of the proximal phalanx occurred in 8 fingers. We performed this procedure to save the following injured fingers: thumb (n = 8), ring finger (n = 11), index finger (n = 5), little finger (n = 1), and middle finger (n = 2).

SURGICAL TECHNIQUE

The procedure is performed under general anesthesia. The involved upper limb is prepared in a sterile manner and the arm is draped and freely mobilized on a side table. The contralateral lower limb is also prepared and draped for a partial-thickness skin graft taken from the

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FIGURE 1: **A** Totally amputated thumb with skin loss over first metacarpal caused by a motor vehicle accident. **B** X-ray of the amputated thumb. **C, D** After debridement and Kirschner wire fixation. **E** Flap elevation. **F** After wrapping of the flap around the degloved thumb and coverage of donor site with full thickness skin graft.

thigh. Debridement of the involved finger is the first step (Fig. 1A), followed by Kirschner wire fixation if there is a fracture (Fig. 1B–D). The flap axis is selected by a straight line placed slightly ulnar to the radial artery. The flap is outlined to include the template size. Before inflating the tourniquet, the Allen test is performed. Use of a reversed radial forearm flap is contraindicated if the ulnar artery alone fails to perfuse the hand. Cutaneous forearm veins are evaluated with a proximal venous tourniquet. One must ensure that there has been no venous injury through previous trauma or venipuncture. The course of the radial artery and also of the superficial veins is outlined. The outlined flap is incised down to fascia and then carried through the underlying antebrachial fascia and the flap is raised subfascially. The radial and ulnar sides of the flap are dissected toward the fascial septum, leaving a bed of muscle proximally and tendons with intact paratenon

distally. When approaching the space between the flexor carpi radialis and the brachioradialis, retract these 2 muscles. Dissection is carried out deeply, hugging the muscle bellies, keeping the dissection between the muscle and the intermuscular fascia. In this way, one retains a longitudinal curtain of fascia between the 2 muscles, connecting the skin to the radial artery.

Unlike simple dorsal hand coverage, when a reversed radial forearm pedicle flap is used for more distal reach in to the digits, a more proximal forearm flap design is required. To include the fascial septum, these dissection details need to be heeded. Observe the artery in the depth of the fascial curtain and the superficial branch of the radial nerve lying under the brachioradialis. The network of cubital veins in the cubital fossa is retracted to reach the radial artery. Identify the bifurcation of the brachial artery and the course of the ulnar artery before ligating the radial artery and its venae

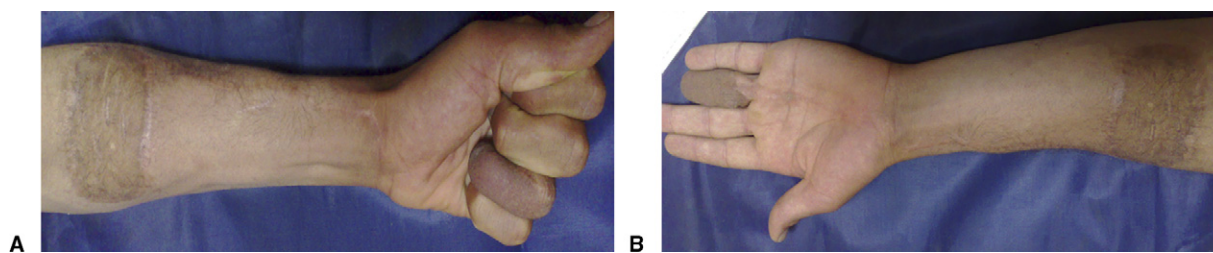


FIGURE 2: Two-year postoperative follow-up: **A** donor site with good cosmesis and good finger flexion; **B** finger extension.

comitants. Raise the skin flap with the underlying fascia and the septum hugging the radial artery and the venae comitants from proximal to distal. Hemoclips are used to ligate the small muscular branches. Dissection continues to the anatomic snuffbox to provide adequate pedicled length and avoid kinking the pedicle. The flap and its pedicle have to be passed under a skin tunnel over the anatomic snuffbox to reach the involved finger. Perfusion of the flap should be evaluated after releasing the tourniquet. The flap is wrapped around the finger (Fig. 1E). Closure of the donor defect can be performed either primarily or using skin graft, depending on the size of the defect (Fig. 1F). No formal nerve repair is performed.

A below-elbow splint is placed for 3 weeks. Skin stitches are removed after 2 weeks. Home physiotherapy is carried out after removal of the splint. This includes active flexion and extension of the wrist and finger joints. A therapy program continues for at least 6 weeks postoperatively. Kirschner wires are removed either after 6 weeks or after bone union.

RESULTS

We assessed both objective (tendon function) and subjective (sensation) measurements clinically every month. We assessed tendon function as excellent for 85% of full active range of motion, or finger flexion to 1 cm or less from the distal palmar crease, good (70% to 84% of normal range of motion or 2 cm from the distal palmar crease), fair (50% to 69% of normal range of motion), or poor (fixed contractures or adhesions). We assessed sensory recovery in 3 groups according to static 2-point discrimination: less than 10 mm (16 patients, 61%), greater than 10 mm (8 patients, 30%), and totally insensate (2 patients, 9%).¹⁴

Finger range of motion was excellent in 18 fingers (Fig. 2A, B), good in 7 (Fig. 3), and fair in 1. Finger salvage was successful in 24 (96%) patients. There was complete loss of 1 flap and partial loss of a second. All the donor sites were covered with split-thickness skin grafts, except 2 that were closed primarily. There were

no reports of cold intolerance of the hand or dysesthesias in the superficial radial nerve or lateral antebrachial nerve distribution, even though we performed no formal nerve repairs. All patients have returned to their original work and none has requested amputation of the reconstructed digit. The patients also did not seem to bypass that digit.

No patient who has had vascularized pedicled radial forearm flap for salvage of finger has requested amputation because of appearance. There was no evidence of painful neuromas, stiffness, or cold intolerance.

DISCUSSION

Treatment of ring avulsion injuries is a difficult reconstructive problem. Controversy exists regarding whether replantation or revision amputation should be performed. The digital vessels of the degloved digit should be evaluated carefully under the microscope before making the surgical decision. This may reveal irreversible damage to distal vessels, and amputation becomes obvious. Commonly, patients arrive with the avulsed part missing, destroyed, or not a candidate for replantation. Ray amputation is then usually considered.^{15–17}

Amputation of a digit is not uniformly accepted by all patients, and not in all ages. Thus, some patients will insist on reconstruction despite careful counseling.¹⁸ Implantation into the abdomen and tubed flaps usually result in an unacceptable outcome. They require more than 1 operation, are usually bulky, and fail to develop adequate sensibility.^{19–21} The cross-finger flap and reverse dorsolateral phalangeal island flap are reported to salvage similar digits.²² They offer less matching tissue in terms of color and hair-bearing characteristics, especially in men and dark-skinned patients. The use of heterodigital flaps and full-thickness skin graft is also reported.¹⁷ It is applicable for class III ring avulsion injuries. Some authors recommend the use of long vein grafts to restore either the arterial flow or the venous flow.^{23,24} However, this technique requires multiple anastomoses, increases microsurgical risks, and extends



FIGURE 3: Degloved ring finger caused by catching on a ring. **A, B** Debridement. **C** Flap elevation. **D** Flap passed under the skin bridge. **E, F** Flap wrapped over the ring finger. **G** Donor site immediately after operation. **H** Four-month follow-up with incomplete finger extension. **I** Final flexion and appearance of the donor site.

the length of the operation.²⁵ An alternative method to vein grafting is to transfer an artery or vein from the middle finger. This method is well known in thumb replantation and has been reported in the management of ring avulsion injuries as well. It is technically easy to perform the vessel transfer and end-to-end anastomosis. The vessels are out of the injured zone and are of similar diameter. However, the distal end of the avulsed vessel may be unsuitable because of intimal disruption. To shorten operative length and reduce the need for microanastomosis, we provide an alternative surgical technique, using a vascularized pedicle forearm flap to salvage complete ring avulsion injuries.

Pedicle radial forearm flap is a useful solution to save avulsed finger injuries and avoid amputation. This flap provides adequate soft tissue and good functional outcome compared with other salvage procedures.

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