CASE REPORTS IN PLASTIC SURGERY AND HAND SURGERY, 2018
VOL. 5, NO. 1, 1–8
https://doi.org/10.1080/23320885.2017.1415760

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CASE REPORT

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Free serratus anterior fascial flap combined with vascularized scapular bone for reconstruction of dorsal hand and finger defects

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ABSTRACT
We present two cases of serratus anterior free fascial flap combined with vascularized scapular bone graft for reconstruction of traumatized dorsal hand and phalangeal bone defects. Composite flaps with single vascular pedicles allowed conservation of severely injured fingers and provided good functional and cosmetic outcomes.

ARTICLE HISTORY
Received 11 July 2017
Accepted 7 December 2017

KEYWORDS
Serratus fascia; scapular bone; free flap; finger reconstruction

Introduction

Tissue loss accompanied by bone defects of the finger presents a challenging problem for reconstruction. As skeletal reconstruction and soft-tissue coverage are mandatory to salvage the finger, primary skin resurfacing and staged bone graft are an option for treatment. However, such methods occasionally prolong the treatment period, and thus increase the risk of articular contracture. For the reconstruction of dorsal finger defects including phalangeal bone, well-vascularized bone and thin, pliable soft tissues are ideal materials from functional and cosmetic viewpoints. Osteocutaneous flaps can provide both elements at once, but sometimes require defatting procedures afterward. We present a combined flap comprising serratus anterior fascia and scapular bone fulfilling these demands with a single vascular pedicle and requires no additional surgery (Figure 1).

Operative procedure

The flap is harvested from the contralateral, uninjured side. The patient is placed in a semi-lateral position on the affected side with the uninvolved arm elevated and supported, and the injured hand is placed on the hand table. A lazy zigzag incision is made from the axillary fold to the level of the eighth or ninth rib and the lateral and anterior margins of the latissimus dorsi muscle are identified. The plane between the latissimus dorsi and serratus anterior muscles is developed to expose the vascular bundle and the long thoracic nerve running along the surface of the serratus anterior muscle. The areolar tissue must be kept with the serratus muscle, not with the latissimus muscle. Dissection of the thoracodorsal artery is continued in retrograde fashion to its origin at the subscapular bifurcation. The branch to the latissimus muscle is encountered and ligated, and the angular branch is dissected to the lateral border of the scapula, then preserved. After the vascular pedicle is mobilized to the required length, the serratus fascia and overlying areolar tissue of the required size are lifted off the muscle from ventrally to dorsally.

The long thoracic nerve is carefully separated from the fascia, but the branches to the lower three muscle strips are cut and elevated with fascia, because harvest of the lower three strips of the serratus as a muscle flap is allowed, to prevent scapular winging [1]. A segment of bone from the lateral border of the scapula, depending on the recipient-site requirements, is outlined on the attached subscapularis muscle. Following division of the muscle fibers along the marking in order to expose the bone surface, osteotomies are performed with an oscillating saw. Bone flap is harvested

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using a small muscle cuff containing the vasculature to the bone.

The pedicle of the flap is anastomosed to the radial artery in the region of the anatomical snuff box. The vascularized bone is placed in the phalangeal defect and fixed with surgical wire. The serratus fascia is placed to cover the exposed bone and joint. Split-thickness skin graft is performed simultaneously without tie-over fixation.

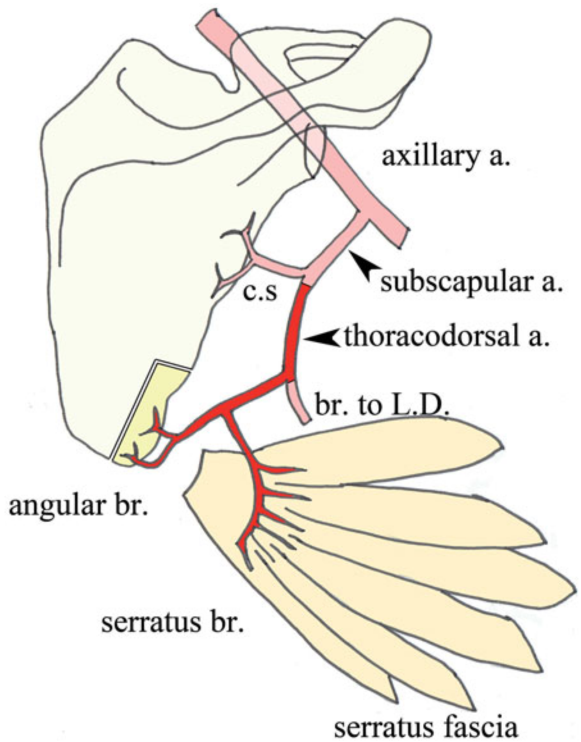


Figure 1. Schematic drawing of the flap.

Case reports

Case 1

A 53-year-old man had injured his right hand in a motor vehicle crash, sustaining a composite wound exclusively to the dorsal aspect of the distal hand and the middle and ring fingers. More specifically, he suffered a comminuted intra-articular fracture of the proximal phalanx of the ring finger with a 6×8-cm overlying soft-tissue defect that also included the distal hand and middle finger to the proximal interphalangeal (PIP) joint level. The extensor tendon of the ring finger was disrupted, but not lost (Figure 2). The volar surface of the right hand remained intact.

The wound was temporarily covered with artificial dermis and reconstruction was performed 14 days after injury. After surgical debridement, an 8×8-cm area of serratus fascia and a block of bone measuring $3 \times 1 \times 0.5$ cm from the scapula on the angular branch of the thoracodorsal artery were harvested concomitantly (Figure 3). The angular branch arose from the serratus anterior pedicle of the thoracodorsal artery and the length of the pedicle dissected to the bifurcation of the subscapular artery was 8 cm. After setting the harvested bone block in the defect and suturing the disrupted tendon, a fascial flap was placed over the wound. A split-thickness skin graft from the ipsilateral chest wall in the same operative field was grafted

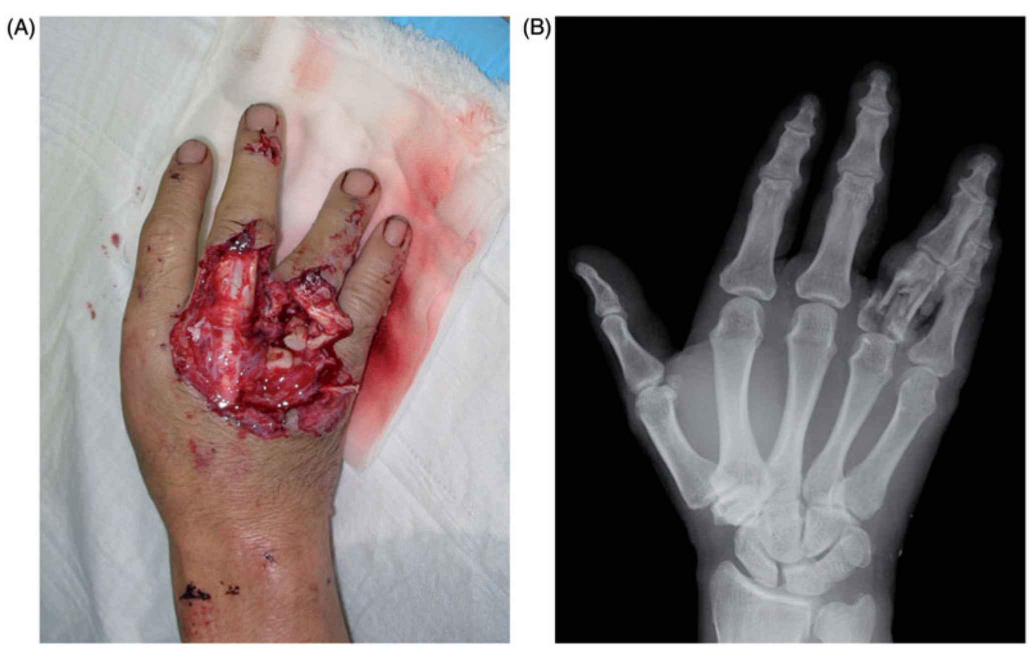


Figure 2. Case 1: right hand on initial presentation. (A) Dorsal view showing the skin defect. (B) X-ray revealing a comminuted fracture of the ring proximal phalanx.

on the fascial flap. In the anatomical snuff box, the artery of the flap was anastomosed to the radial artery and the vein of the flap was anastomosed to the cephalic vein in end-to-end fashion.

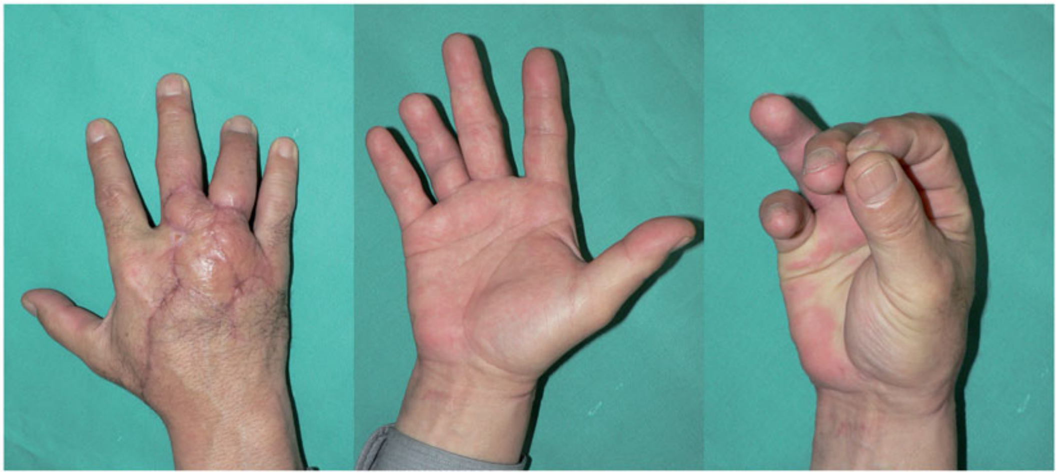
The defect was reconstructed with good contours, whereas the joints of the ring finger were stiff. Six months postoperatively, the metacarpophalangeal (MP) joint had stiffened in 40° of flexion, and the PIP and distal interphalangeal (DIP) joints had stiffened straight. Grip strength was 11 kg for the right hand and 53 kg for the left, unaffected hand. However, since the stiffened fingers did not impede pinching or grasping, the patient required no additional surgery to improve range of motion of the ring finger (Figure 4).

Case 2

A 36-year-old man had injured the left index finger in an industrial accident, resulting in a composite tissue problem. He suffered extensive comminution of the proximal and middle phalanges with bone loss and obliteration of the PIP joint. In addition, the overlying extensor mechanism and skin were not salvageable. Fortunately, the flexor tendons, neurovascular bundles and distal phalanx were relatively spared (Figure 5). K-wire interosseous pinning was performed to prevent shortening of the finger due to wound contraction, and the soft-tissue defect was temporarily replaced by artificial dermis the same day (Figure 6).

Figure 3. Intraoperative findings in case 1. (A) Harvested flap comprising serratus anterior fascia and scapular bone vascularized with thoracodorsal artery. White arrowhead indicates the fascial component, and black arrowhead indicates the bone segment. (B) Flap is set, with split-thickness skin graft performed simultaneously. (C) Immediate postoperative X-ray showing skeletal reconstruction of the ring finger.

(A)



(B)

Figure 4. Appearance of case 1 at 8 months postoperatively. (A) Dorsal and volar view of the right hand. (B) Bone union shown on X-ray. Frontal and lateral view.

Reconstructive surgery was performed 17 days after injury. Following removal of the artificial dermis, a 6×8-cm area of serratus fascia and scapular bone segment measuring $4 \times 1 \times 0.7$ cm was elevated with thoracodorsal artery. The angular branch arose from the serratus anterior muscle branch of the thoracodorsal artery. The bone block was interposed between remnant bone fragments of the proximal and middle phalanges, all of which were firmly fixed with K-wire and stainless-steel wire. Given the complexity of the injury, a single block of bone was utilized to provide a solid construct 1-cm shorter than the original length, to allow the patient to perform a tripod pinch. The exposed bones were covered with serratus fascia. The flap was revascularized by end-to-end anastomosis of the thoracodorsal artery to the radial artery, and the thoracodorsal vein to the cephalic vein in the anatomical snuff box. A split-thickness skin graft was concomitantly applied over the serratus fascia without any compression (Figure 7).

The postoperative course was uneventful. Although the reconstructed finger became thinner than we had expected and the PIP joint was lost, the patient obtained a range of motion of 0/65° for the MP joint (Figure 8). He returned to his original job 6 months postoperatively, without difficulty. He always attempted to use the salvaged finger in grasping or pinching, but sometimes chose not to use the index finger and substituted the middle finger instead out of habit.

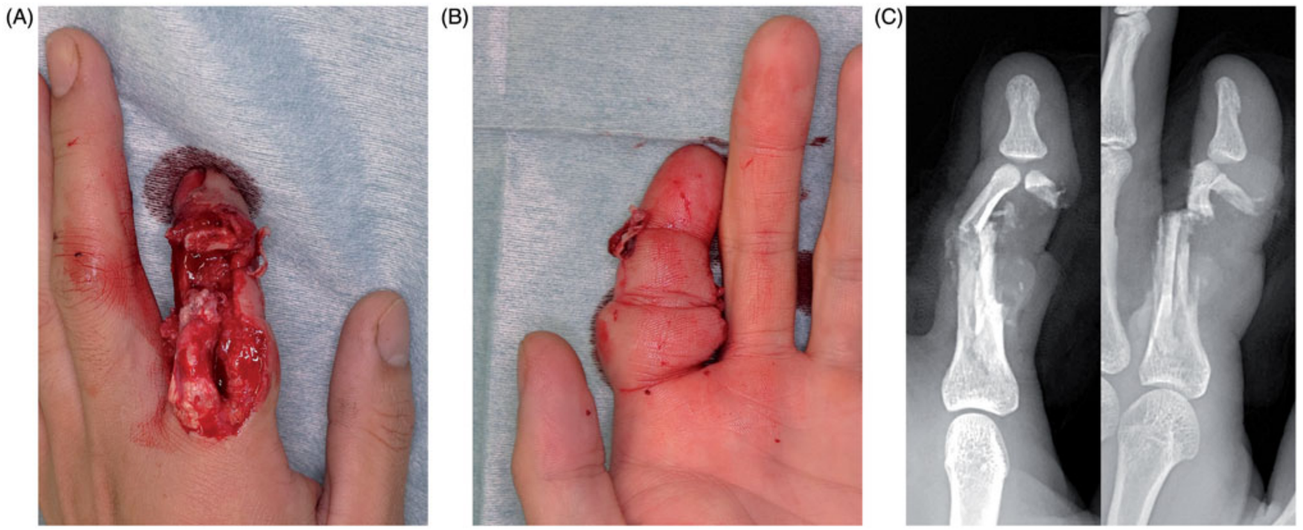


Figure 5. Case 2: left index finger on initial presentation. (A) Dorsal view showing skin defect and open fracture. (B) Volar site of the finger remains intact. (C) X-ray depicting comminuted fracture. Frontal and lateral view.

Discussion

As our two cases presented with segmental defects of the phalangeal bone and overlying dorsal skin, skeletal support and soft tissue for resurfacing were mandatory to preserve the affected fingers. For bony reconstruction, vascularized bone graft was preferable to non-vascularized bone graft for maintaining finger length and strength, because of the high infection-resisting capability resulting from the intrinsic blood supply [2], and bone resorption was expected to be minimized. Soft-tissue coverage over the bone graft must be thin and pliable for cosmetic and functional reasons.

Osteocutaneous flaps offer a useful reconstructive tool, such as free fibular osteocutaneous flap, scapular or parascapular osteocutaneous flap, and lateral arm osteocutaneous flap [3]. The wounds we treated did not require long bone grafts and were not of a length requiring fibular flap, and the lower legs of the two patients were quite hairy, and not optimal for dorsal skin resurfacing. In general, the skin paddle of the scapular or parascapular flap is too thick for the dorsal surfaces of fingers, and lateral arm flaps leave unsightly scars on the upper arm that are readily visible when wearing a short-sleeved shirt. Moreover, according to a retrospective review by Parrett et al. [4], a fascial flap with skin graft is better than fasciocutaneous flap or muscle flap with skin graft in terms of esthetic outcomes for dorsal hand reconstruction. Referring to that study, we sought to identify the optimum fascial flap that could be harvested in combination with vascularized bone.

In the category of fascial flaps, the temporoparietal fascial flap offers the benefit of being a good tendon gliding material while also providing dorsal hand coverage [5,6], and can potentially form an osteofascial flap when accompanied with calvarial bone [7]. However, harvesting the temporoparietal flap leaves an unconcealable scar in some short-haired patients.

The serratus fascial flap was first described as a tendon gliding material for coverage of exposed flexor tendons at the forearm or wrist level by Wintsch and Helaly [8]. This flap has since seen frequent application to dorsal hand coverage together with skin grafts because of its thinness, long and constant vascular pedicle, and low donor-site morbidity [9–14]. The angular branch that nourishes the lower part of the scapula in the present two cases arose from the serratus anterior branch of the thoracodorsal artery. According to Seneviratne et al. [15], the same branching pattern was observed in only 25% of dissections. Branching from the latissimus dorsi muscle pedicle was seen in more than half of their specimens. However, Seitz et al. [16] noted that the angular branch mostly arose from the serratus branch (48.5% of their cadaver dissections). Either way, the independence of pedicles between fascia and bone facilitates flap positioning.

As several authors have mentioned, meticulous hemostasis is necessary when elevating the fascia from the muscle because of the numerous arterial and venous branches entering the serratus muscle [9,11–14]. Seitz et al. [17] recommended using an ultrasonic blade instead of bipolar coagulator in harvesting serratus fascial flap. We used a Harmonic SYNERGY curved blade (Ethicon Endo-Surgery, Cincinnati, OH) and confirmed its utility.

One drawback of the serratus fascial flap is the absence of a monitoring skin paddle. The blood supply

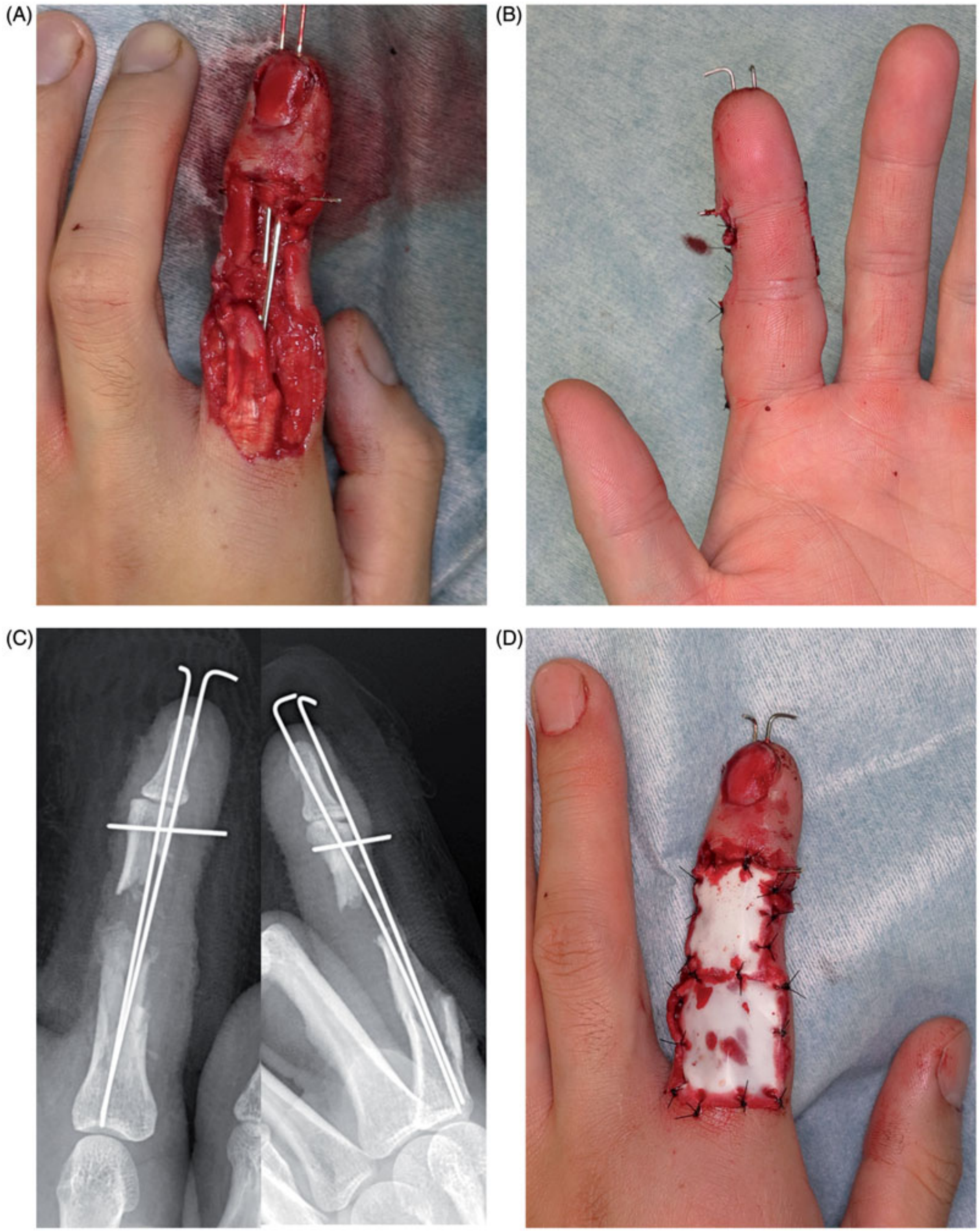


Figure 6. First operation in case 2. (A) Wire fixation of the remnant bone pieces. Defect of the expansion hood is apparent. (B) Original length of the index finger is preserved by wire fixation. (C) X-ray depicting bone defect. (D) Artificial dermis temporarily applied to cover the wound.

to the skin overlying the serratus is provided by inconsistent perforators of the muscle, and more predominantly by perforators of the lateral cutaneous branch of the posterior sixth and seventh intercostal vessels [18]. We could not find any perforators from the serratus to the overlying chest skin intraoperatively and realized that attachment of a skin paddle to the fascia was not feasible as a monitoring flap. Flap harvesting with a small muscle cuff as a monitoring tissue might have been a good choice.

We expected the serratus fascia to have played a role as a gliding surface of the extensor in case 1, but could not confirm this, because the function of the involved joints was lost. However, a sufficiently thin appearance of the finger was obtained without any need for flap debulking.

Considering functional outcomes of the hand, preservation of a single impaired finger when the other fingers are intact may be controversial. However, one study concluded that revision amputation does not

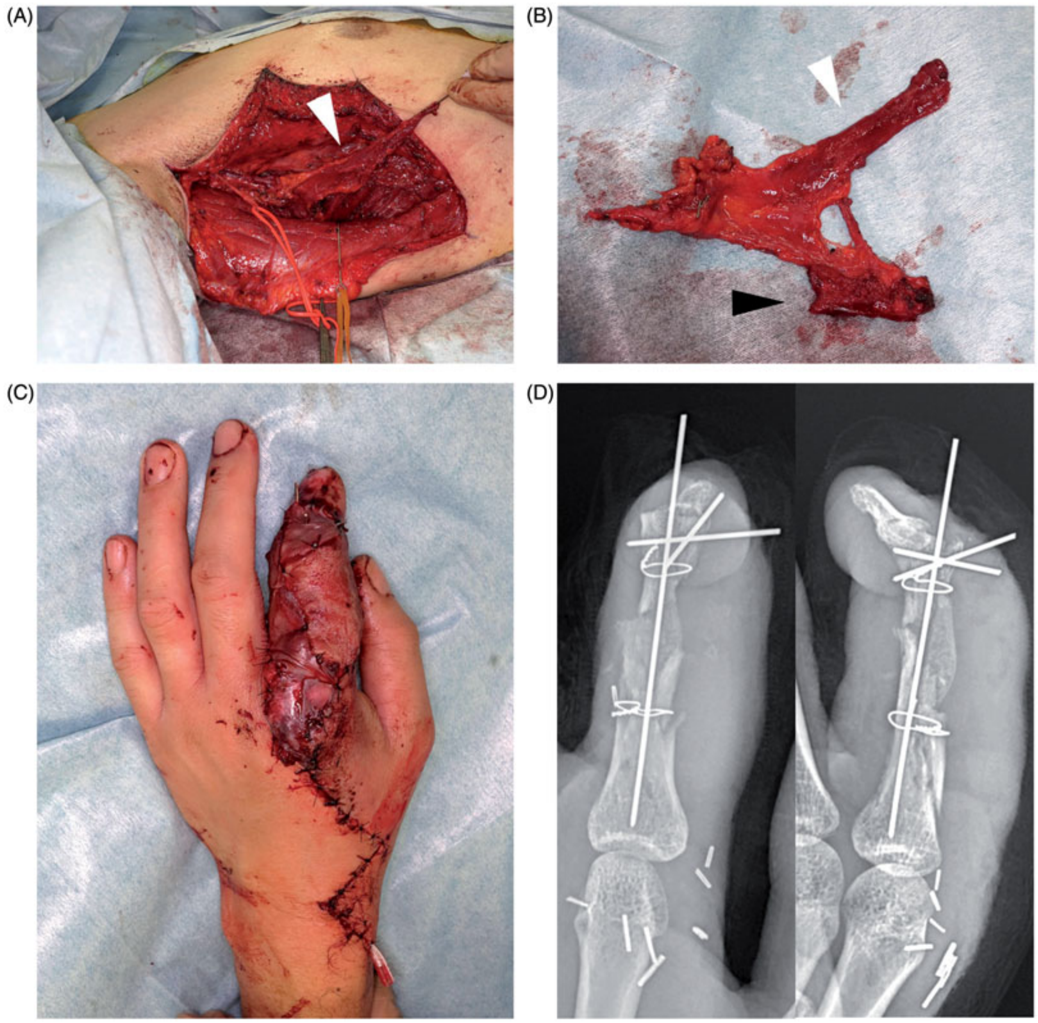


Figure 7. Second operation in case 2. (A) Intraoperative view of flap-harvesting procedure. White arrowhead indicates the fascial flap. (B) General view of the flap. White arrowhead indicates the fascial component, and black arrowhead indicates the bone segment. (C) Transferred flap after microsurgery with immediate split-thickness skin grafting. (D) X-ray showing skeletal reconstruction of the index finger with vascularized bone grafting fixed with surgical wire.

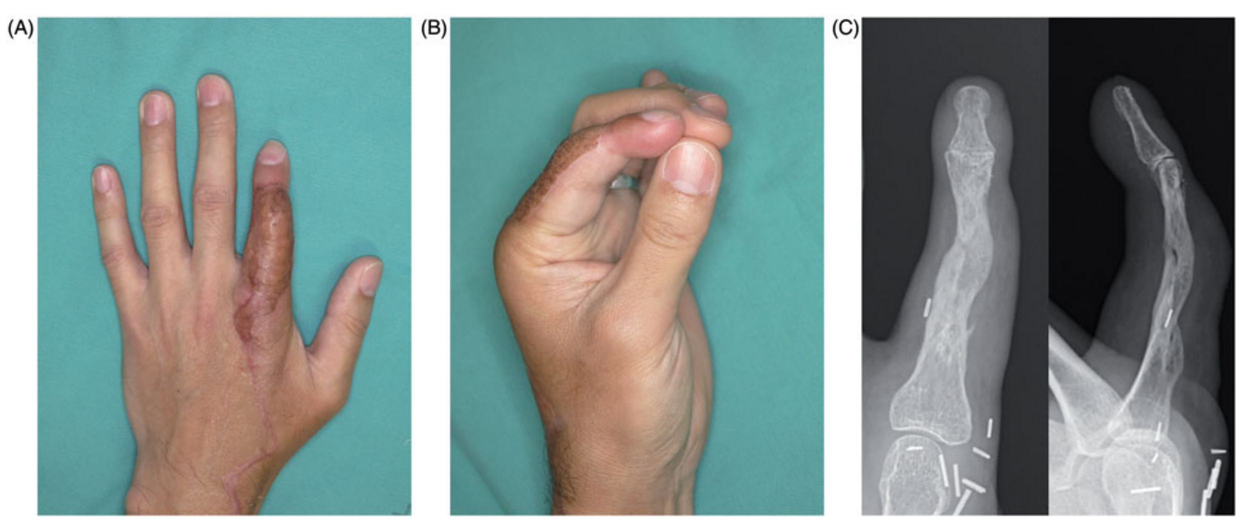


Figure 8. Appearance of case 2 at 7 months postoperatively. (A) General view of the left hand. The reconstructed finger has atrophied. (B) Shortening of the index finger allows tripod pinch. (C) X-ray revealing union of grafted bone.

confer better functional results when compared to replantation in single-digit flexor zone 2 amputation [19]. In the present cases, rescue of the severely damaged finger did not allow for full recovery of hand function, but the restored hands proved useful in daily living. The patients reported overall satisfaction with both functional and cosmetic outcomes.

Disclosure statement

The authors report no conflicts of interest.

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