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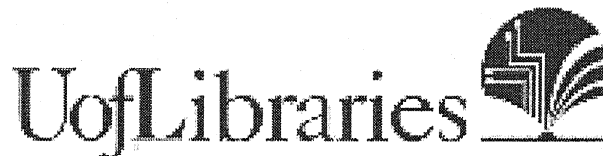
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Lateral arm composite tissue transfer to ipsilateral hand defects

Different applications in the use of the ipsilateral lateral arm free flap in 29 patients treated in our unit from November 1983 to December 1984 are described. The flap was used in both elective and emergency reconstruction with a success rate of 96.5%. This flap is elevated from the same limb as the injured hand, permitting the entire operative procedure to be performed with the patient under a single regional block anesthesia, both flap and recipient sites being prepared synchronously in a bloodless field. (*J HAND SURG* 1987;12A[2 Pt 1]:665-72.)

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The anatomy of the hand allows cover of small skin defects with a great variety of local pedicle and island flaps,¹⁻¹⁷ but for larger defects it is necessary that flaps from distant donor sites be used, either as pedicled^{14,18-20} or free flaps.²¹⁻²⁷

The advantages of free flaps over distant pedicled flaps in hand reconstruction are well documented. Free tissue transfer often requires only one operation and often allows all other reconstructive procedures to be done at a single stage. Free flaps bring new blood supply to the reconstructed area, in contrast to the distant pedicled flaps that become parasitic on the recipient site after division of the pedicle. Free flaps allow elevation of the hand and immediate motion. Physical therapy is started as soon as the patient recovers from anesthesia, and postoperative edema and stiffness are reduced. This is not possible when pedicled flaps are used—by their nature they restrict the mobility of the hand and also that of joints proximal to the site of injury.

There are many free flaps available for use in reconstruction of the hand.²¹⁻³² Choosing a flap with minimum

donor site morbidity is a primary consideration in reconstructive surgery. Fasciocutaneous flaps fulfill an important role in reconstructive surgery because an extensive area of vascularized tissue can be harvested with minimal donor site morbidity. These flaps have a particular place in reconstruction of the hand where thin skin with minimal subcutaneous tissue is required. For these reasons, in the past, the lateral aspect of the arm has been used as a pedicled flap for reconstruction of the contralateral hand.¹⁴ As a free flap these reconstructive advantages are augmented. At a single operation tissue of requisite thickness and near perfect color match, especially to the dorsum of the hand, can be transferred. The flap is potentially sensate.

Materials and methods

From November 1983 to December 1984, free lateral arm tissue transfer provided cover to ipsilateral hand defects in 28 of 29 cases.

The age range of the patients was from 5 to 67 years, with an average age of 35 years. There were 26 males and three females. Thirteen flaps were transferred in emergency operations. The remaining 16 cases were elective reconstructions of soft tissue loss and included cases of unstable skin graft after irradiation, exposed fixation plates, chronic ulceration secondary to thermal injury with no available local flaps, electrical burns needing release of the first web space, and one case of bleomycin extravasation with necrosis of most of the dorsal skin of the hand.

In the emergency cases the most common injury was tissue loss on the dorsum of the hand, exposing bone and/or opening the wrist joint. Most were the result of motor vehicle accidents. Defects on both surfaces of

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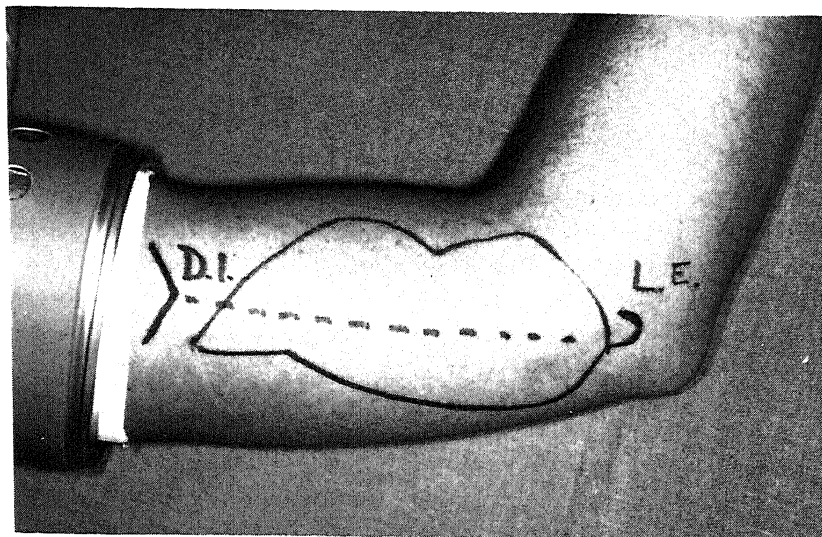


Fig. 1. The landmarks of the flap are the lateral epicondyle (*LE*) and the deltoid insertion (*DI*) being connected by a line that corresponds to the lateral intermuscular septum.

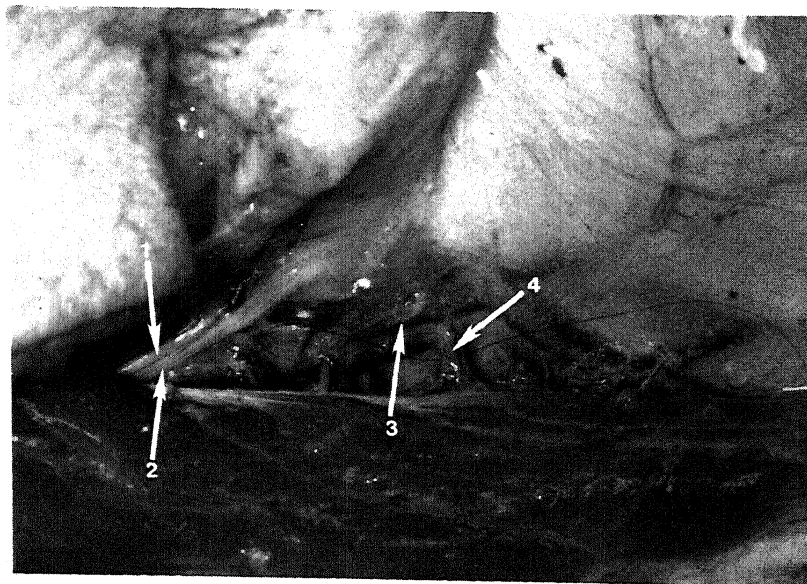


Fig. 2. Both the lower lateral cutaneous nerve of the arm (*1*) and the posterior cutaneous nerve of the forearm (*2*) run in close relationship to the vascular pedicle, (*3*) the posterior radial collateral artery and its venae comitantes. The muscular and periosteal branches (*4*) must be carefully ligated.

the hand were reconstructed with the lateral arm flap. Composite skin, fat, and fascia were used in 25 cases. Vascularized fascia along with split-skin graft cover was used in four cases.

In two cases, the flow-through possibility of the lateral arm flap was used as a conduit to revascularize nonviable digits distal to the soft tissue defect.

Anatomy of the flap

Donor site. The lateral arm flap consists of the skin and underlying soft tissue of the distal half of the lateral aspect of the arm and the proximal fifth of the forearm.

It is centered on a line running from the insertion of the deltoid to the lateral epicondyle of the humerus with the elbow extended (Fig. 1). The skin can be harvested to a width of 10 to 14 cm.^{23, 29, 31} Such a wide donor defect will require skin grafting with loss of padding and gliding over the lateral humeral epicondyle, and we restrict the width of the skin flap to 6 cm when possible, allowing primary closure of the donor defect. An area of fascia 20 × 14 cm and an area of skin 12 cm long by 6 cm wide may be harvested with primary closure of the defect.

Vascular system. This fasciocutaneous flap is based

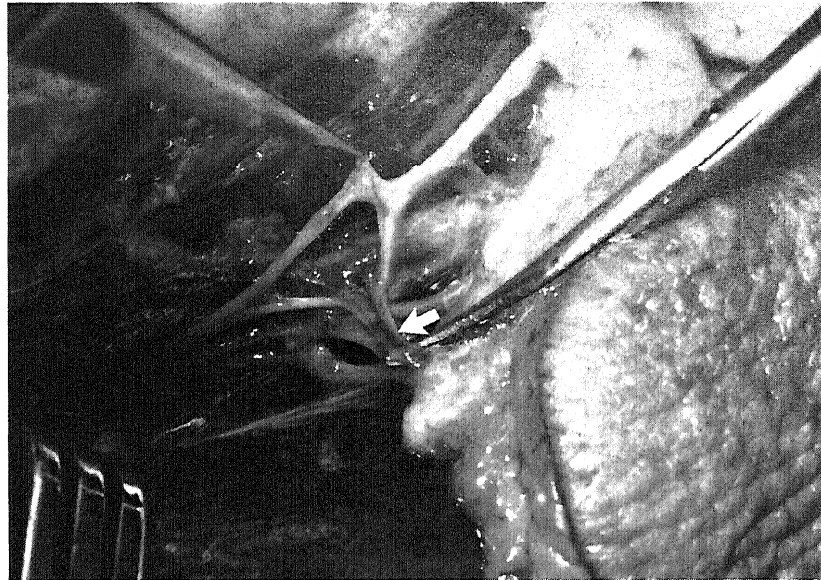


Fig. 3. The first major septal branch originating from the posterior radial collateral artery perforates the posterior cutaneous nerve of the forearm. Division of the inferior fascicles allowed dissection leaving the vascular pedicle intact. The fascicles were repaired under magnification reducing the area of anesthesia in the posterolateral aspect of the forearm.

on the profunda brachii artery, which is the first branch of the brachial artery. After giving origin to several muscular branches on the medial aspect of the arm, this artery accompanies the radial nerve around the spiral groove where it splits into two branches, the middle collateral and the radial collateral arteries. The middle collateral is usually the larger; it enters the substance of the long and medial heads of the triceps, descends along the posterior aspect of the humerus, and ramifies deep to the anconeus.

The radial collateral artery continues to the distal end of the groove. At this point it divides into two terminal branches, the anterior radial collateral and the posterior radial collateral arteries.

The anterior radial collateral runs between the brachialis and brachioradialis muscles alongside the radial nerve.

The posterior radial collateral artery enters the lateral intermuscular septum close to the distal insertion of the deltoid muscle (between the brachialis and brachioradialis muscles anteriorly and the triceps muscle posteriorly). It remains in the lateral intermuscular septum, close to the lateral border of the humerus giving off periosteal and muscular branches (Fig. 2). It passes distally toward the lateral humeral epicondyle then passes posterior to the epicondyle. At this point the caliber of the artery reduces markedly. In its course the posterior radial collateral artery gives origin to two or three major septal branches that pass to the deep fascia

and subsequently supply the skin. The most proximal branch is closely related to the posterior cutaneous nerve of the forearm.

The venous return of this flap is through two systems, the superficial veins, draining to the cephalic vein and the deep system of venae comitantes. Either system alone will provide satisfactory drainage of the flap, but we prefer to rely on the venae comitantes because they are conveniently placed adjacent to the arterial pedicle. The superficial system is useful as an interpositional conduit when revascularizing parts distal to the soft tissue defect being reconstructed with this flap.

The pedicle is constantly present. Its length varies according to the design of the flap, ranging from 4 to 8 cm. In our experience, the caliber of the artery has always been greater than 1.2 mm and the venae comitantes larger than 2.0 mm.

We encountered a variation in the arterial pattern in one case. This patient had two branches of the posterior radial collateral artery running in parallel within the lateral intermuscular septum. The deep branch supplied the distal end of the flap, overlying and distal to the lateral epicondyle, while the superficial branch supplied the proximal part of the flap. It was necessary to anastomose both arteries to achieve complete vascularization of the flap. This was done by anastomosing the superficial artery end to side to the deep artery and anastomosing this vessel end to side to the recipient radial artery.

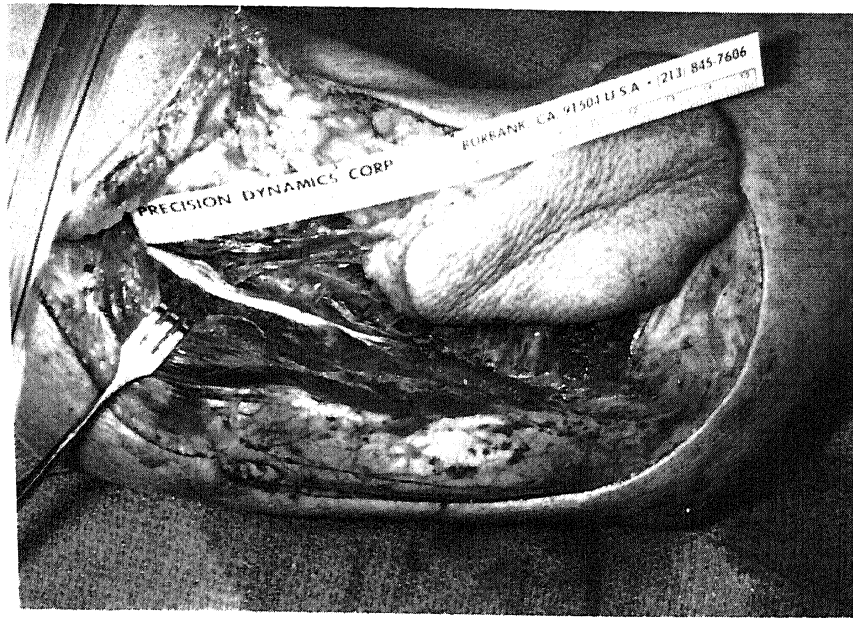


Fig. 4. The length of the vascular pedicle will depend on the design and positioning of the skin island.

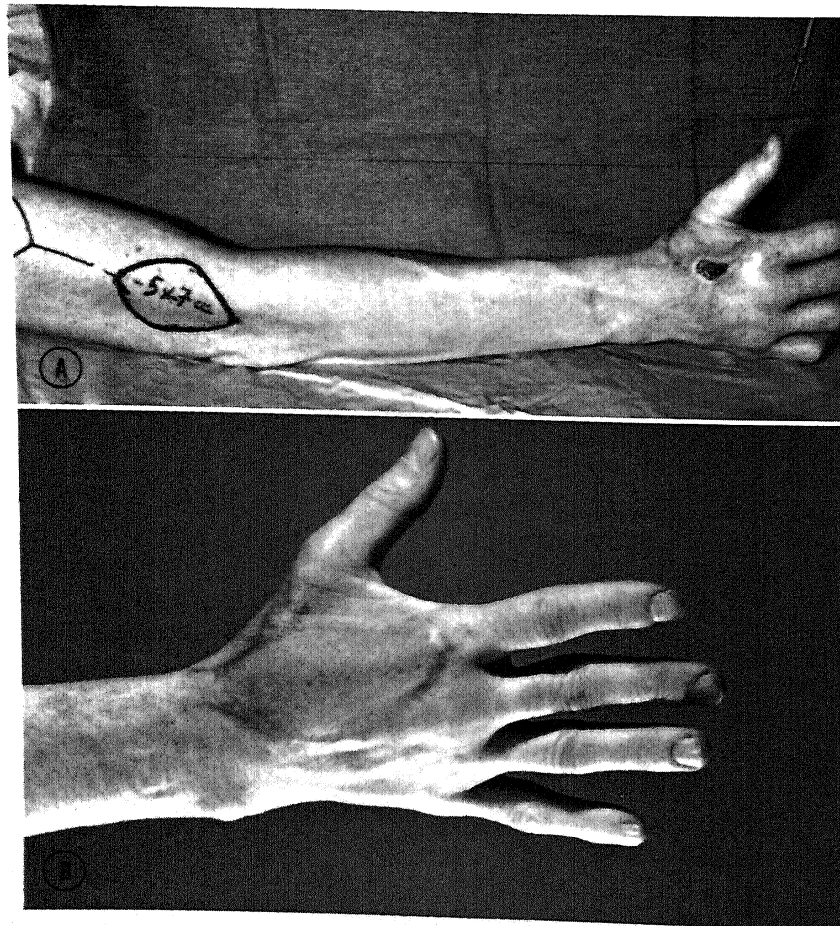


Fig. 5. A, Case 1. Breakdown of scar after secondary bone graft of the second metacarpal and exposure of fracture fixation plate. Scarring on the dorsum of the hand precluded the elevation of a local rotational or transposition flap. A lateral arm flap adequately closed the defect. **B,** Three months postoperatively the flap bends favorably with the skin on the dorsum of the hand.

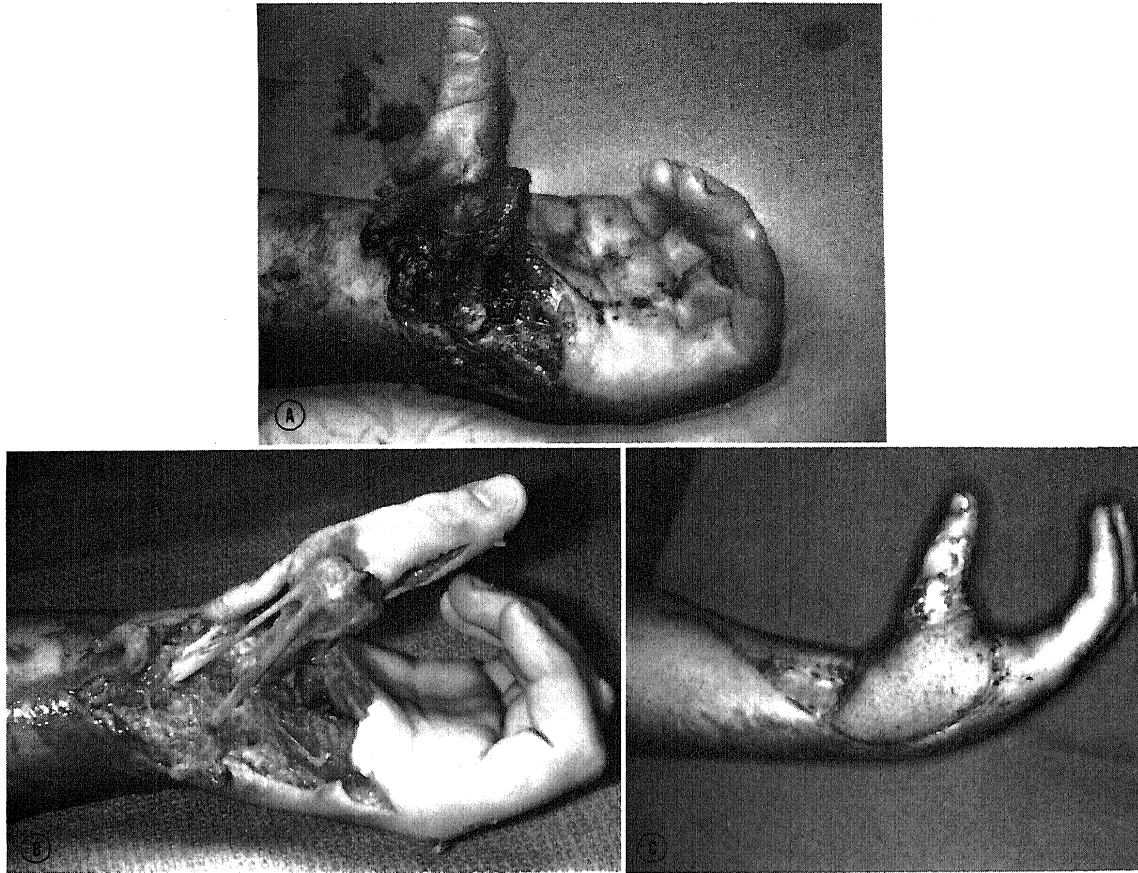


Fig. 6. **A**, Case 2. Motor vehicle accident in which the right hand was pinned between the car and the pavement. Devascularized thumb with destroyed intrinsic muscles leaving a lax, open carpal metacarpal joint. The long tendons of the thumb were in continuity as were the digital nerves. **B**, The carpal metacarpal joint was pinned in palmar abduction. A lateral arm flap was used as a flow-through flap to revascularize the thumb and to provide coverage of the large tissue defect. **C**, Ten days postoperative after removal of sutures. There is no sign of infection. No other operative procedures were required for useful function of the thumb.

Nerves. The lower lateral cutaneous nerve of the arm innervates the skin of this flap, allowing it to be used as a sensate flap. The posterior cutaneous nerve of the forearm runs with the posterior radial collateral artery (Fig. 3) and has to be sacrificed in most cases. It could be used as a vascularized nerve graft within the flap to bridge nerve defects in the recipient hand.

Elevating the flap

This flap is among the simplest of the available free tissue transfers to elevate for the following reasons: (1) tourniquet control allows a bloodless operative field; (2) observation of the vital structures is facilitated by shoulder mobility; and (3) the central axis of the flap, a line connecting the deltoid insertion and the lateral humeral epicondyle, is easily identified even in the obese patient.

The insertion of the deltoid and the lateral epicondyle are outlined. A line joining these two landmarks is extended on to the forearm. The pattern of the defect is centered on the line corresponding to the lateral intermuscular septum. The tourniquet is placed as high as possible on the arm. The skin is incised posteriorly and distally, continuing from the back of the flap forward because there are no triceps muscle fibers taking origin from the posterior aspect of the lateral intermuscular septum while fibers of the brachioradialis take origin from its anterior aspect.

Dissection is commenced perpendicular to the skin until the deep fascia is encountered, including an extra 2 cm of fascia from the skin marking of the flap, and continued in a subfascial plane toward the lateral intermuscular septum. The plane between the lateral intermuscular septum anteriorly and the triceps posteri-

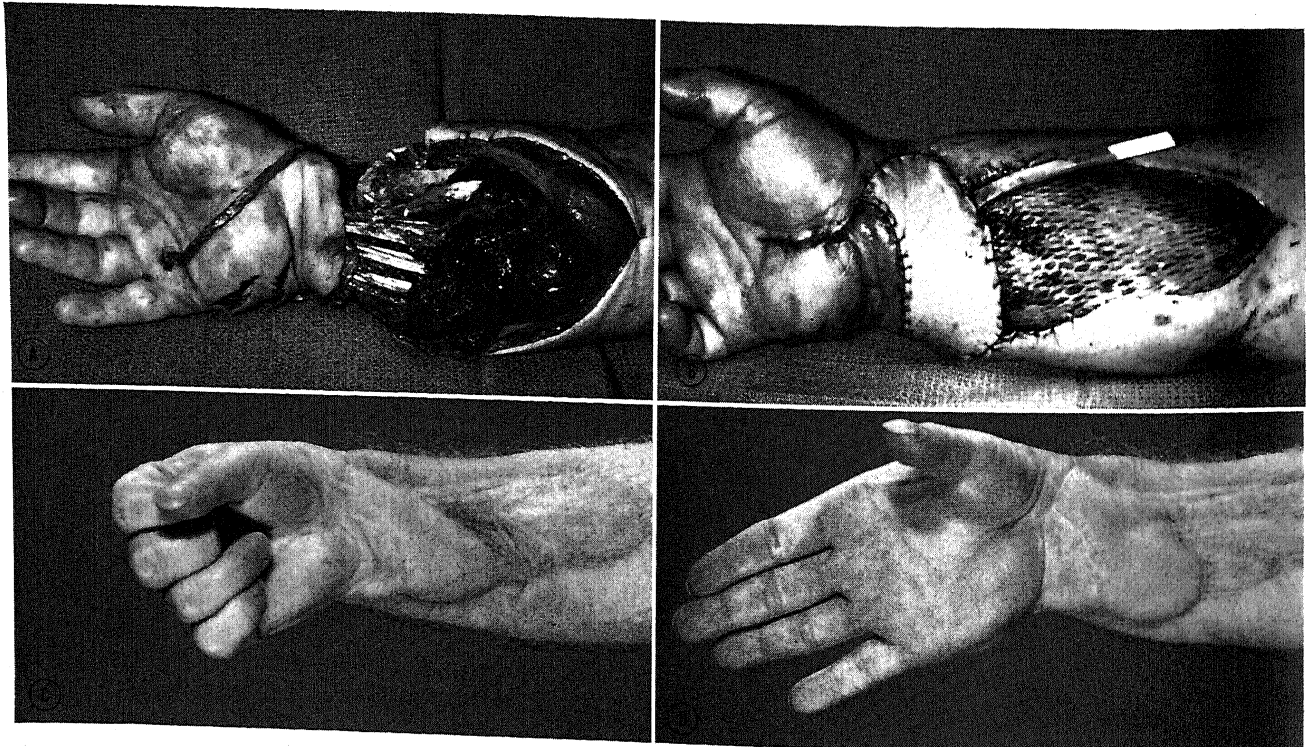


Fig. 7. A, Case 3. Heavy coal mine machinery fell on this patient's right forearm. The circumferential injury resulted in disruption of venous return, the radial artery, and of the superficialis and flexor carpi radialis tendons. The other flexor tendons were intact. The ulnar artery, and median and ulnar nerves were in continuity. Extension of the palmar wound reveals damage to the flexor muscles. B, The median nerve and tendons were covered with a lateral arm flap. The muscle bellies were covered with a mesh skin graft. C and D, One year later. The patient regained good motion and sensibility in the hand.

only is easily developed but careful coagulation of small blood vessels is essential to avoid hematoma in the donor site and bleeding of the flap when circulation is reestablished. The pedicle is visualized close to the insertion of the lateral intermuscular septum into the humerus. It is exposed along its entire length from the insertion of the deltoid to the lateral epicondyle. The skin is then incised along the anterior border, again an extra 2 cm of deep fascia included. Here sharp dissection is necessary to divide the brachioradialis fibers that gain origin from the lateral intermuscular septum. When the vascular pedicle is seen in its entirety from the anterior aspect, the septum can be separated safely from the lateral border of the humerus, starting from the distal end. Periosteal branches will require coagulation. Up to this point dissection can be done in a bloodless field and will provide a satisfactory length of pedicle for most reconstructions, division of the artery being just distal to the bifurcation of the radial collateral artery where it emerges from the spiral groove (Fig. 4).

At the recipient site, the radial artery and the cephalic vein in the anatomical snuff box are favored as recipient

vessels, the artery being anastomosed end to side and the vein either end to end or end to side.

Case reports

Case 1. This patient sustained a gun shot wound of his right hand, with loss of the proximal two thirds of the second metacarpal bone. A silicone block with the shape of the missing bone was placed to preserve the space for later reconstruction. After the injured area settled an iliac bone graft was used to bridge the gap and fixed with a bone plate (Fig. 5). The skin over the injured area necrosed, and the fixation plate became exposed.

An ipsilateral lateral arm flap measuring 7 cm × 5 cm provided skin cover to the exposed bone graft and fixation plate. This procedure was done by two surgeons within a tourniquet time of less than 2 hours.

Case 2. A 19-year-old woman was involved in a traffic accident in which her right hand was caught between the car and the pavement. She sustained a severe injury to the first web space and thenar eminence (Fig. 6, A). The carpal metacarpal joint of the thumb was open and unstable, and the thumb was devascularized. The intrinsic muscles of the thumb were destroyed. The skin defect of the first web and

base of the thumb was 6×13 cm. The flexor pollicis longus and extensor tendons were in continuity, and the digital nerves were bruised but not divided.

After thorough debridement, the CMC joint of the thumb was fixed with a Kirschner wire in palmar abduction and opposition (Fig. 6, B). The ulnar digital artery was prepared for anastomosis. A lateral arm flap provided soft tissue cover of the thenar eminence and first web space and allowed revascularization of the thumb using its flow-through to the distal end of the pedicle, which was anastomosed end to end to the ulnar digital artery. Venous return of the digit was achieved by anastomosing the dorsal veins to the distal vein of the flap (Fig. 6, C).

Case 3. A 34-year-old guitar player had a severe crushing injury when heavy coal mine machinery fell on his right dominant upper extremity producing a circumferential laceration proximal to the wrist crease with compound fractures of the distal third of the radius and ulna. The flexor muscles were severely traumatized at the musculotendinous junction. The radial artery was divided. The median nerve was traumatized but in continuity. The ulnar nerve and artery were intact (Fig. 7, A).

After debridement of nonviable muscle, bone ends were shortened, and the fractures plated. Those flexor tendons without corresponding muscle attachment were sutured side to side to the adjacent intact musculotendinous units. Three major veins were anastomosed, and the dorsal wound was closed primarily.

On the palmar aspect extension of the wound revealed that the median nerve, wrist, and superficialis flexor tendons were exposed. A 12×6 cm ipsilateral lateral arm flap was required to cover the exposed structures at the distal end on the flexor aspect of the forearm (Fig. 7, B). This patient regained enough movement to allow him to play the guitar again (Fig. 7, C and D).

Results

The flap survival rate in this series was 96.5%. The only failure was in a patient who had had several previous operations for the same defect with late failure after each procedure. His elective free flap failed on the fifth postoperative day as he was preparing for discharge from hospital.

The operative time ranged from 2 to 8 hours. This was related to the extent of injury and reconstruction needed before flap cover and not to the free flap procedure itself, which may be done routinely in less than 3 hours. There were no major infections. In cases in which fascia alone was transferred, minor skin losses were encountered when the split-skin graft was applied immediately. No such loss of skin graft occurred when the skin was applied after a delay of 24 hours or when the fascia was turned over and grafted on its deep aspect. The hospital stay ranged from 3 to 7 days.

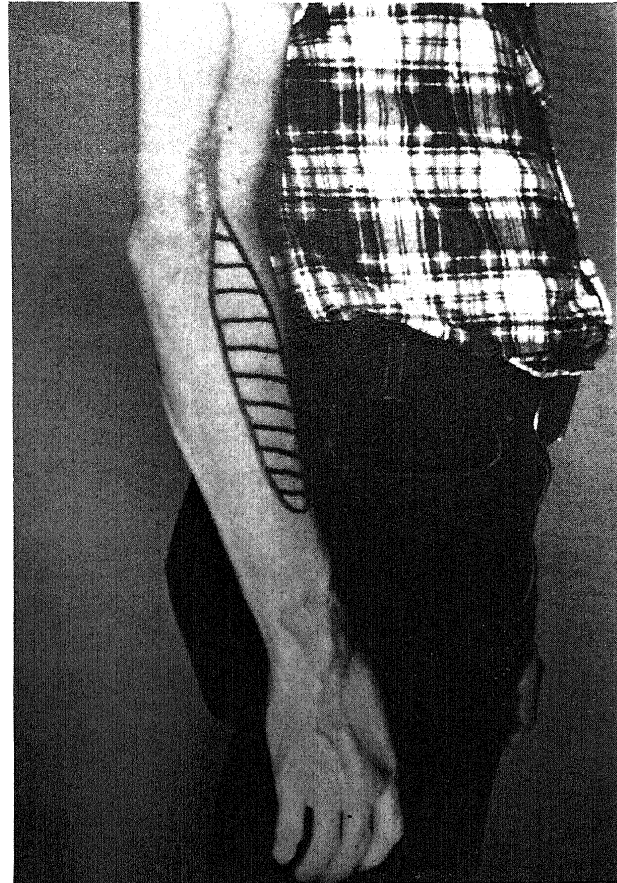


Fig. 8. The area of anesthesia (*marked*) tends to decrease from the size shown to a small area about 5 cm in diameter within 2 years.

Discussion

With the current profusion of free flaps, it is now possible to tailor flap cover in the upper extremity to the needs of the recipient site—matching soft tissue and skin thickness, texture and color. In the hand, use of the free flap must be weighed against the use of a distally based radial forearm flap,³³ which provides an excellent skin and soft tissue match while avoiding microsurgery; however, this flap suffers the theoretical disadvantage of removing one of the major arterial inputs to the hand, and the more real disadvantages of an obvious donor site, tethering of the flexor tendons to the skin graft at the donor site and, of most importance, the limitation of its use to cases in which the palmar arterial arch system is intact.

The lateral arm free flap is a good alternative. It also allows reconstruction at a single stage with a nonparasitic flap. It is a fasciocutaneous flap of similar qualities to the radial flap. When raised, with the patient under regional anesthesia, both flap and recipient site

may be prepared simultaneously in a bloodless field by two surgeons, compensating at least in part, for the time necessary to complete the two microvascular anastomoses.

The benefit of restricting donor site morbidity to a single extremity is maintained. A flap of up to 6 cm wide may be taken with the advantage of primary closure of the donor defect. The donor site has only proved a problem in those cases in which skin grafting was necessary. Apart from the more obvious cosmetic defect, tenderness of the lateral epicondyle may occur if the flap is not designed so that this bony prominence remains covered with full-thickness skin. Loss of the lateral cutaneous nerve of the forearm inevitably results in a small area of anesthesia on the extensor aspect of the forearm just distal to the elbow (Fig. 8). Like the radial arm flap, this flap suffers the theoretical disadvantage of transferring hair to the palmar surface of the hand in certain persons. This has not proved a serious defect and is likely to occur with most donor sites in such patients. Both flaps tend to be bulky in females because of the natural distribution of fat.

From our experience we would commend the use of the lateral arm flap for soft tissue loss in the hand when replacement by local skin is not possible.

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