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DISTAL RADIAL AND ULNAR ARTERIES PERFORATOR-BASED ADIPOFASCIAL FLAPS FOR COVERING HAND TRAUMATIC DEFECTS

AQ1 IOANNIS A. IGNATIADIS,* SPYRIDON F. XEINIS, VASSILIKI A. TSIAMBA, CHRISTOS K. YIANNAKOPOULOS, GEORGE N. NOMIKOS, and NIKOLAOS E. GEROSTATHOPOULOS

Aim: The clinical value of adipofascial flaps based on distal ulnar or radial-artery perforators is demonstrated in a series of 14 patients with severe hand injuries and significant soft tissue defects requiring coverage. *Material and methods:* There were 10 male and 4 female patients, aged between 23 and 72 years. The defects were 7 dorsal, 4 palmar, 1 combined dorsal–palmar, and 2 with thumb or total digit amputation. In the patients with a dorsal defect, the extensor tendons were intact in 2 cases, reconstructed in 2 cases, and reconstructed in 3 cases using silicon rods. Following debridement, a fascial flap based on a distal ulnar (12) or radial (4, 2 primarily and 2 secondarily) artery perforator was fashioned and used to cover the defect. A split thickness skin graft was used to cover the defect and the hand was immobilized for 2 weeks. *Results:* All cases were followed up for at least 6 months. The donor and recipient sites healed uneventfully, and the functional result was very good in terms of wrist and hand joint range of motion, which approximated the normal rates. The extension or flexion deficit was less than 25 degrees. The esthetic result was satisfactory. Two ulnar flap partial (involving ~35% of the area) necroses have been treated using reversed radial–distal perforator flaps. *Conclusion:* The described fascial flaps offer several advantages over other local flaps, and are rather easy to perform and cover effectively both dorsal and palmar hand defects without causing significant functional deficits to the upper limb. © 2007 Wiley-Liss, Inc. Microsurgery 00:000–000, 2007.

The use of reversed flow forearm fascial flaps based on distal perforators of the ulnar or radial arteries gained popularity and is one of the dominant types of flap used in the last decade to cover hand and wrist defects without AQ2 sacrificing major arteries or inducing an unacceptable esthetic result at the donor site. There is no need preoperatively to perform additional investigations such as angiography, Doppler, or triplex ultrasounds or the Allen test.

The reversed ulnar forearm flap described by Lovie is a septocutaneous flap[1–5] based on the septocutaneous perforators of the ulnar artery, but it can also be harvested as a fascial flap.[2] The use of the fascial flap is indicated in patients with soft tissue defects of the hand.

The ulnar forearm flap has the advantage of involving a thin, elastic fascia, and it can be harvested with bone, muscle, and sensory or motor nerves.[1] With the advent of perforator flap surgery reduction of donor site morbidity has been made possible, improving the functional and esthetic result of the coverage operation.[6–8] The vascular supply[2,3] of the flap arises from the ulnar artery. The main trunk of the pedicle is called ulnodorsal artery, arising from the ulnar artery 3–5 cm proximal to the pisiform. The artery passes beneath the flexor carpi ulnaris and divides into three branches: a) the proximal branch supplies the distal part of flexor carpi ulnaris, b) the middle branch supplies the skin and divides into two thin arterial branches piercing the fascia; the ascending branch passes between the ulna and the flexor carpi ulnaris, supplying the skin of the medial aspect of the distal forearm, while the descending branch accompanies the sensory dorsal branch of the ulnar nerve supplying the skin, and c) the distal branch, which supplies the pisiform.

The distally based radial forearm perforator flap[9–12] is based on the tiny perforators around the radial-styloid process and the longitudinal chain-linked vascular plexuses and was described in the past decade. Since then, it has become a very popular locoregional flap in hand reconstructive surgery. Using these flaps instead, the traditional Chinese flap achieved the two major disadvantages of the Chinese donor site area have been overcome the sacrifice of a major artery and the presence of a displeasing donor site appearance secondary to the use of a split-skin graft for coverage.

Chang et al.[9] attempted in 1988 to raise at the radial side of the forearm a reverse island fasciocutaneous flap that did not include the radial artery itself. In their report, this procedure was successful in all 10 cases of hand reconstruction. The flap was a mixture of fasciocutaneous and venocutaneous muscle, and the deep fascia and especially the cephalic vein in the pedicle played an important, beneficial role in flap survival. To elucidate the vascular basis of this new flap, Chang and Chen[13,14] performed an anatomic study in 1990 in 14 fresh cadaveric forearms and designed a distally based, radial forearm fascial flap for hand reconstruction. In this study, they found about 10 small branches (ranging from 0.3 to 0.8 mm in diameter) extending from 1.5 cm above the radial-styloid process to the bifurcation of the radial artery. These perforators pass through the septum, fan out on

Hand Surgery and Microsurgery Department, KAT Hospital, Athens, Greece
*Correspondence to: Ioannis A. Ignatiadis, Hand Surgery and Microsurgery Department, KAT Hospital, 14561 Kifissia, Athens, Greece.
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both surfaces of the deep fascia, and form a rich, chain-linked longitudinal plexus of the integument along the course of the main artery, the septum, the fiber of the deep fascia, and the superficial vein. The venous system of the deep fascia drains to the *profunda venae comitantes* and directly through the concomitant perforating veins. The pivot point of the pedicle is located 1.0–1.5 cm proximal to the radial-styloid process. Chang et al.[15] also demonstrated that the large, superficial, cephalic vein has no positive role in flap survival and it cannot help venous drainage by reverse flow through its valves, but it does transfer venous blood from the hand to the flap, causing congestion, and swelling endangering flap viability. In 1992, Goffin et al.[16,17] performed an anatomic study of the perforators of the distal-radial artery; an island distally based flap was designed. The authors emphasized that the pedicle should be located 2 cm above the tip of the radial-styloid process to include all the peristyloid perforators. In 1993 and 1994, many authors[18–25] performed studies dealing with neurocutaneous, neurofascioseptocutaneous, or tubed vascularized flaps, using the distal-radial perforators. In 1994, Weinzweig et al.[26] reported their anatomic study and clinical experience on the use of the distally based radial forearm fasciosubcutaneous flap nourished by perforators situated 5–8 cm above the radial-styloid process. The anatomic study by Rambe and Pho[27] in 1995 showed a similar result. Also, in 1995, Koshima et al.[28] introduced a distally based adipofascial flap for coverage dorsal hand defects. This flap is supplied by a lateral intertendinous perforator of the radial artery located 10 cm proximal to the radial-styloid process. Braun et al.[29] reported a distally based radial forearm fascia-fat flap supplied by distal perforators 5–8 cm above the wrist crease. They used this flap to pad and protect the median nerve, to provide a gliding surface for tendon transfer, and to separate the fresh-cut surfaces of and ulna-radius synostosis. In 1997, El-Khatib and Zeidan[30] published a study citing their experience on eight cases using an island adipofascial flap based on distal perforators of the radial artery located 2–7 cm from the radial-styloid process. In 1998, Jeng and Wei[31] reported their experience on 12 cases using the distally based radial forearm flap for hand reconstruction. The pivot point of the adipofascial pedicle was about 2–4 cm above the radial-styloid process.

In 2000, Georgescu and Ivan[10] described an extended alternative of the above-mentioned flap, which reaches up to 20 cm in length. This flap has almost the same capability with the traditional Chinese flap to cover a distal hand defect.

The purpose of this article was to describe the use of a fascial flap based on distal ulnar or radial-artery perforators to cover skin defects. The indications and advantages of this flap are presented.

PATIENTS AND METHODS

Between 2001 and 2003, 14 patients with a posttraumatic soft tissue defect were operated (Table 1, Figs. 1a, 2a, 3a, and 4a). There were 10 men and 4 women, aged between 23 and 72 years. The defect was dorsal in 7 cases, palmar in 4 cases, involved the total hand area (transcarpal amputation and thumb amputation) in 2 cases, and radial in another 1 case. All dorsal defects were accompanied with fractures. The associated fractures were located at the metacarpals (4 cases); in 1 case, the metacarpal fracture was associated with a Galeazzi fracture, and in other case, there was a radius and ulna fracture. All fractures were stabilized at the index operation, using Kirschner wires or plates. In six cases, extensor tendon laceration was present. The extensor tendon injury was reconstructed primarily in 2 cases and secondarily in 3 cases, using silicon rods in 2 cases and tendon transfer in 1 case. All patients were operated within 2 and 4 weeks after the initial trauma, except for 1 patient with a gunshot hand injury and a metacarpal bone defect, who was operated after 7 months. The cases with a dorsal defect were initially treated with direct wound closure (2 cases) or split thickness skin grafting (3 cases) or full thickness skin grafting (1 case). The patient with a radial side hand injury suffered a diaphyseal defect of the first metacarpal, EPL tendon defect, and massive skin and soft tissue loss.

T1,F1–F3 F4

Regarding the palmar defects, necrosis occurred in the first case 2 weeks following a transpalmar replantation and in the second case necrosis of the hypothenar area occurred within 2 weeks after a compound injury with ulnar nerve transaction and subsequent repair. In the first case, following meticulous debridement, the median nerve was left uncovered, while in the second case, a group fascicular repair of the motor branch of the ulnar nerve and neurotube interposition for bridging the two sensory branches was carried out.

In all cases, the defect area was debrided and its size was assessed before harvesting the graft. Twelve ulnar and two radial distally perforator based flaps have been performed. Another two radial perforator flaps have been performed after partial necrosis of the ulnar flaps.

In the ulnar perforator flaps, the incision site was outlined on the ulnar side of the wrist and forearm overlying the tendon of flexor carpi ulnaris muscle. The pisiform was identified and the pedicle was located emerging between 2 and 5 cm from it. Subdermal dissection allowed exposure of the fascia and the subcutaneous tissue was preserved. The flap was released on its radial side and retracted progressively until the underlying flexor carpi ulnaris muscle was revealed. The pedicle can be seen in the distal third of the flap. After locating the pedicle the ulnar side of the flap was released, maintaining a distal

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Table 1. Presentation of Our Patients with Palmar and Dorsal Hand Defects Covered with an Ulnar Artery Perforator Based Fascial Flap

Case	Age	Sex	Defect ocation	Extensor tendon injury	Fractures	Operation timing after injury	Cause of injury	Initial treatment	Final result
1	38	M	Dorsal	No	Metacarpals	3 weeks	Work	Direct closure	Good
2	23	M	Dorsal	Yes	Metacarpals–Galeazzi	2 weeks	MVA	Split thickness skin graft	Satisfactory
3	25	M	Palmar	Yes-repair	No	21/2 weeks	Work	Transpalmar replantation	Good
4	40	M	Dorsal	Yes – Silicon Rods	Radius-Ulna	4 weeks	MVA	Split thickness skin graft	Good
5	42	M	Palmar	No	No	3 weeks	Work	Ulnar nerve repair	Satisfactory
6	35	F	Radial	EPL-yes-tendon-transfer	1st Metacarpal	In emergency UF-partial necrosis-secondarily RF	Work	Split thickness skin graft	Satisfactory
7	67	F	Dorsal	No	Metacarpals	2.5 weeks	Work	Direct closure	Good
8	54	M	Both	–	Transcarpal amputation skin necrosis	2 weeks	MVA	Amputation skin closure	Satisfactory
9	33	M	Dorsal	Yes-silicon rods	Metacarpals	7 months	Gunshot	Full thickness skin graft	Good
10	24	F	Ulnar side	Yes-repair	IV, V-Finger amputation-	2 weeks UF	Work	Split thickness skin graft	Good
11	72	M	Dorsal	–	Scaphoid-trapezium	2 weeks RF-fasciocutaneous	Work	Fascio-cutaneous	Good
12	22	M	Dorsal	Tendon transfer	1st metacarpal	RF	Work	Full thickness skin graft	Good
13	52	M	Palmar	Silicon rods	3rd metacarpal-digit-Ray amputation	4 weeks-infection-RF	MVA	Split thickness graft and reversed kite flap	Good
14	40	F	Dorsal	Silicon rods	Wrist-distal radius-bone lost	Emergency flap -UF-postoperational necrosis-second. RF	MVA	Split thickness skin graft	Good

AQ9

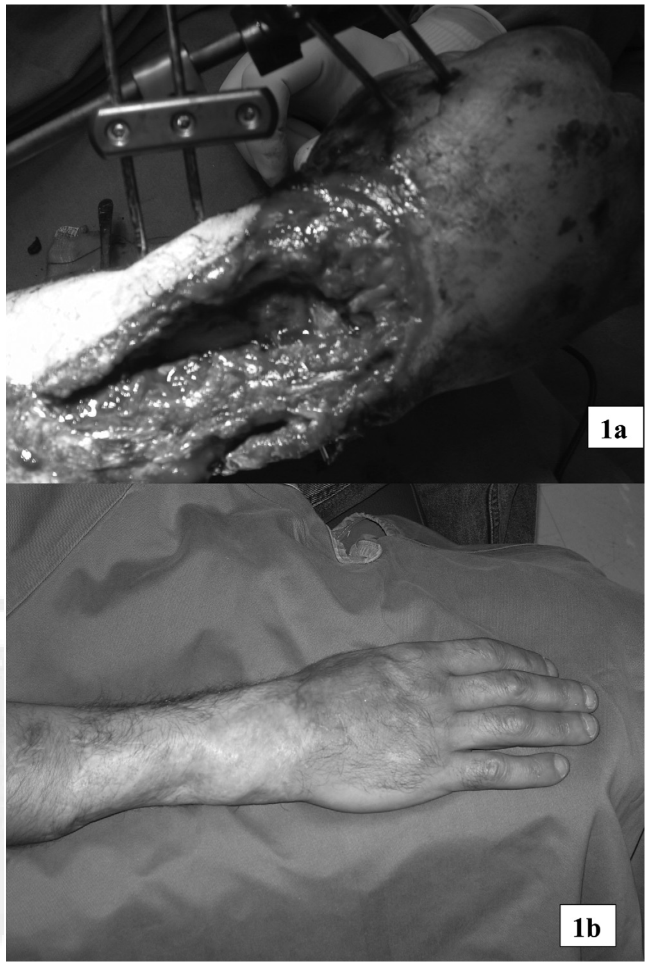

Figure 1. Preoperative photograph and final result of case 4. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

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hinge (Fig. 5). Simple rotation of the flap permits coverage of defect located at the midpalm or the proximal two thirds of the dorsum of the hand. F5

The radial septocutaneous distally based perforator flaps have been designed almost as a traditional Chinese fascial flap. The frequency of hand trauma involving tissue loss stimulated the research for developing new technical solutions more simple and economic. The regional flaps, such as the distal pedicle Chinese flap, were usually the surgeon's first choice whenever the local resources were overpassed. Still, this type of Chinese flap would present an important disadvantage as it involves sacrifice of a vascular axis of the hand, sometimes even the dominant one. The surgeon would be able to avoid this inconvenience when using distal perforators based on antebrachial radial flap[10]; moreover, this technique would allow covering of tissue loss, as far as the metacarpophalangeal joints.

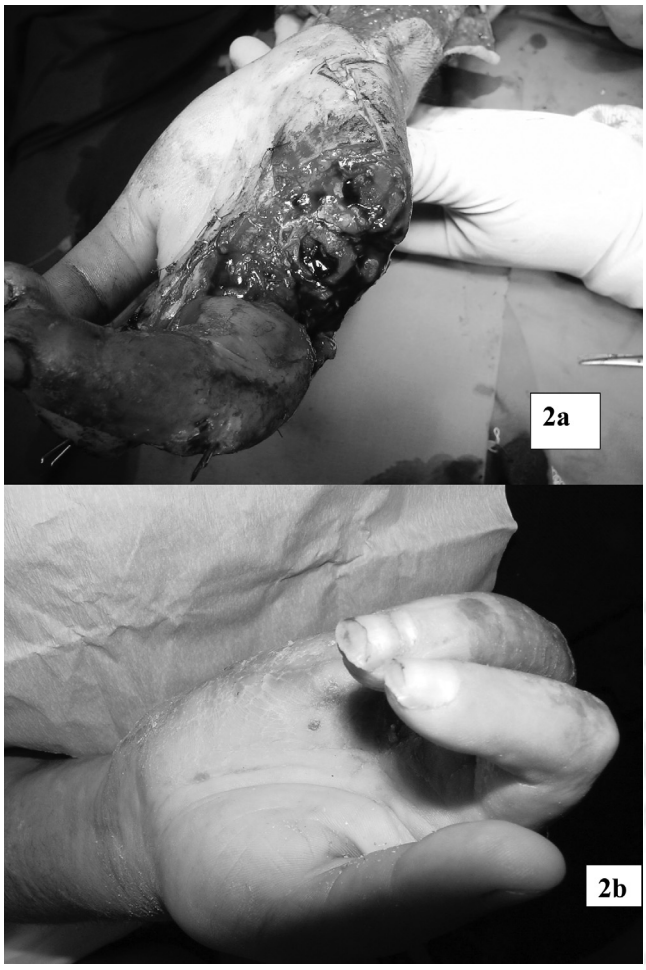

Figure 2. Preoperative photograph and final result of case 10. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

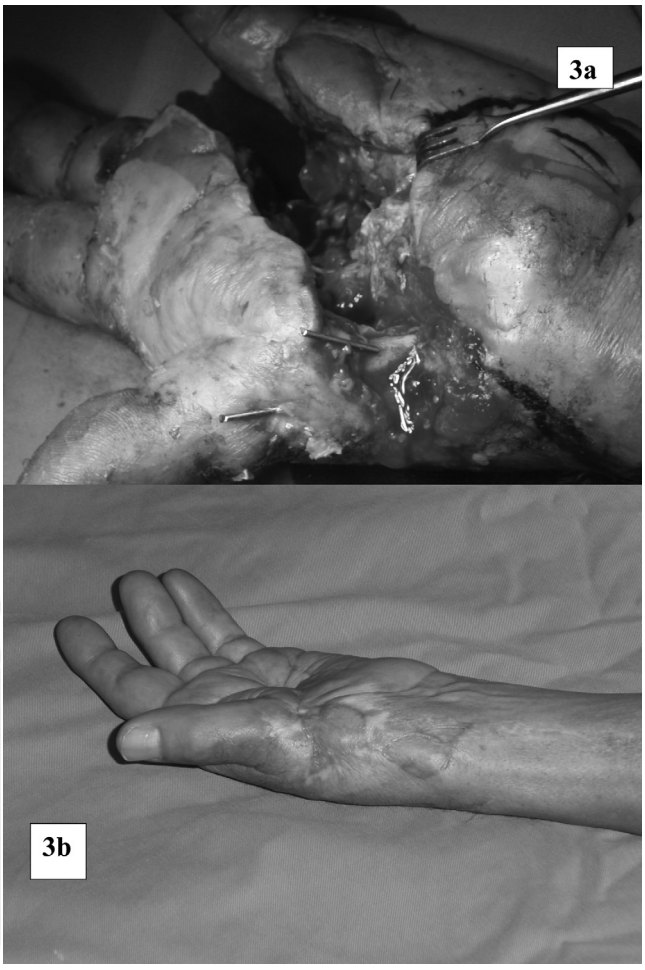

Figure 3. Preoperative photograph and final result of case 13. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

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We performed four distally based (reversed flow) adipofascial pedicled radial forearm flap based on the small perforators around the radial-styloid process. We used some of the 10 small perforators (0.3–0.5 mm in diameter) from the distal radial artery around the radial-styloid process. The longitudinal chain-linked vascular plexuses[11] (suprafascial, paraneural, and perivenous) formed by the forearm ascending and descending branches of septofasciocutaneous perforators meet and cross over with the transverse carpal vascular plexuses around the radial-styloid region. On the basis of these directional-oriented plexuses, distally based adipofascial pedicled radial forearm fasciocutaneous and adipofascial flaps were designed and successfully applied in our patients. The pivot point was located at 1–2 cm above the radial styloid. The skin island plus adipofascial pedicle measured between 6–20 cm in length, with the adipofascial pedicle 3–6 cm in width. The cephalic vein has no positive role for venous drainage in distally based flaps. In two of our cases, a radial flap was primarily performed as the initial treatment, and in another two cases to repair a partial postoperative necrosis after an initially used ulnar fascial flap.

In all cases, flap harvesting was carried out within 20–25 min. In all cases, the flaps were reflected on the debrided defect area (Figs. 6 and 7) and a split skin was applied. The hand is immobilized for 2 weeks in a plaster slab to protect the flaps. F6,F7

RESULTS

All patients were followed up for at least 6 months (6–15 months, mean 9.4). Both the donor and the recipient sites healed successfully. Two of the ulnar flaps presented partial necrosis (25–35% of their area) and in both cases distally based radial perforator flaps have been alternatively performed to cover the ensuing defect.

The esthetic (Figs. 1b, 2b, 3b, and 4b) and functional result were good in all cases. Moderate wrist stiffness

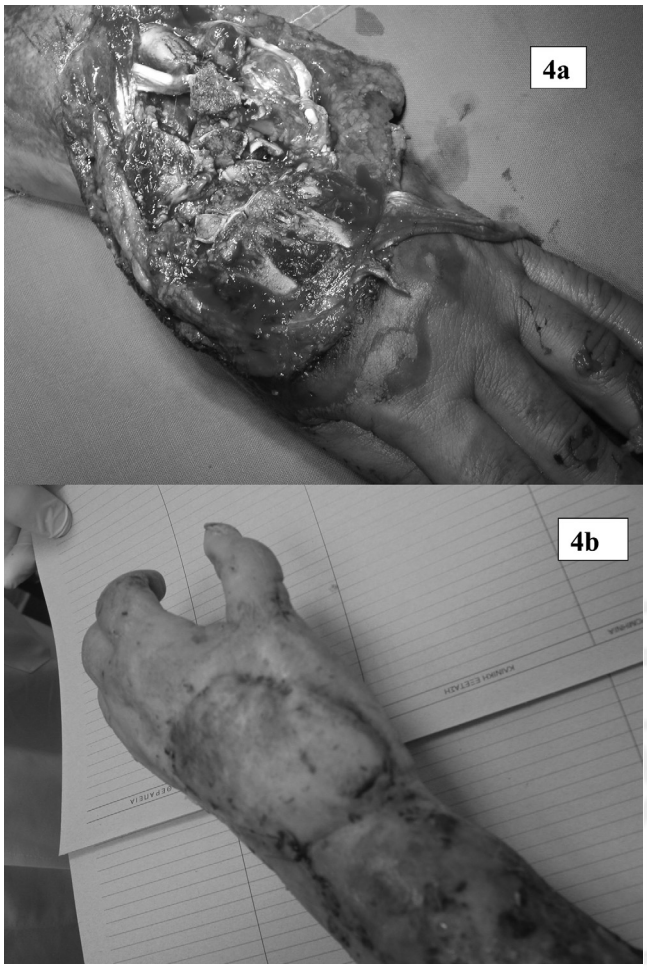

Figure 4. Preoperative photo and final result of case 14. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

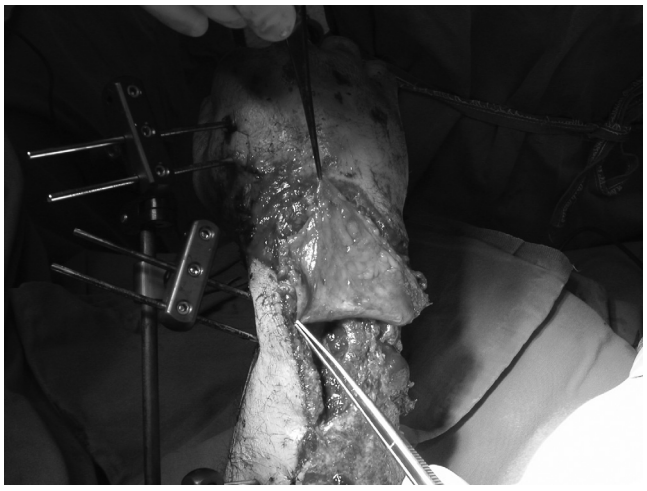

Figure 6. Intraoperative photograph. Flap adjustment on the defect area. Case 4. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

Figure 7. ••• AQ7

Figure 5. Intraoperative photograph of flap harvesting-case 4. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

with less than 20° range of motion limitation was observed in two cases. There were no infections, necrosis, or fracture nonunions. Rehabilitation for 2–4 months was necessary for recovering and achieving a satisfactory functional result. Permanent loss of finger extension was noted in the patients who declined extensor tendon reconstruction. No complaints from the donor site were reported.

DISCUSSION

Fascial flaps based on septocutaneous perforators of the ulnar and radial artery were described, which have been used to cover dorsal and palmar hand defects.

The ulnar fascial flap is mainly used to cover defects on the palmar surface of the wrist, especially when well-

vascularized tissue is needed to cover the median nerve, when surrounded by dense scar tissue following previous injury or surgery.[1,4] If the skin is of appropriate quality, it may preferable to use a fascial flap, which can be wrapped around the nerve to protect it. The radial flap is more adequate for covering defects on the radial area of the dorsal or palmar hand or the lateral area of the wrist.

The ulnar forearm flap can be purely fascial or fasciocutaneous.[1,2] Harvesting of a fascial graft reduces the overall morbidity without causing additional skin loss. The distal–ulnar artery flap[2] can be used to cover dorsal wrist and hand defects. It has several advantages over the radial-forearm flap. Flap harvesting is straightforward, no flexor tendons are exposed, a major artery is not sacrificed, there is no need to perform vascular anastomoses, the donor site scar is well covered on the medial side of the forearm and in case of failure other more intricate flaps can be easily employed. The ulnar artery perforator based fascial flap is indicated for the coverage of defects in areas where increased mobility of the underlying structures is mandatory. It can also be used to cover both hand and forearm defects fashioned as a distally or proximally based island flap, respectively. The flap dimensions are 20 cm in length and 9 cm in width, with the ulna lying at its median axis. The fascial-ulnar flap can also be based on the proximal[8] perforators of the ulnar artery.

One disadvantage of the flap is the small length of its pedicle (~3 cm), which limits the flap rotation arc. In our patients, the extended variant of this flap (up to the middle of the forearm) was employed, which proved to be sufficient for covering the proximal third of the midpalm or hypothenar areas and more than the proximal 2/3 of the dorsal aspect of the hand.

Several variants of the ulnar artery based flap have been described such as the neurocutaneous island flap of the dorsal branch of the ulnar nerve, which is based on cutaneous perforators of the ulnar artery.[3,5] The principle of flap vascular supply via perforators can be applied in the radial-forearm flap.[2] It has been described as a adipofascial radial flap[5] based on perforators of the radial artery.

The ulnar artery perforator based fascial flap is very useful to cover dorsal and palmar hand defects, easy to perform, and effective. It combines little donor site morbidity and reliability. In 4 cases, we successfully used a radial forearm adipofascial flap, in two as first choice and in the other two after partial necrosis of the previously performed ulnar fascial flap. The distally based septocutanous perforator radial flap[32] is one of these alternative techniques.

Distally based hand and forearm adipofascial flaps consist of the subcutaneous fat and fascia of the hand and/or forearm. They are easy to elevate, the operative time is typically less than 1.5 h and can cover surfaces ranging from an individual finger to the entire dorsum of the hand. The blood supply is based on the rich profusion of perforators that exist in the hand and wrist. If desired, a skin paddle can be included with these flaps. Between these flaps, we avoid the need for a lengthy free flap procedure, avoid the meticulous dissection required by the posterior interosseous flap, and avoid the loss of radial artery required by the reverse flow classically described radial forearm flap.

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AQ1: Kindly provide the degrees/educational qualifications of all the authors.

AQ2: "Sacrifying" has been changed to "sacrificing." OK?

AQ3: Journal style is to generally list out all authors. Kindly replace "et al." in this reference with the missing author names.

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