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Reversed Radial Perforator Adipofascial Forearm Flap for Soft Tissue Defects of the Hand

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ABSTRACT

Background: Soft tissue defects of the hand and wrist can result from trauma, burn, infection, ischemia, or neoplasm. Using the radial forearm flap was criticized due to sacrifice of a main arterial axis in the hand and the ugly scar left after its harvest.

Patients and Methods: This study included twenty four patients who were operated by distal radial perforator forearm fasciosubcutaneous flaps and skin grafts applied either immediately or at a second stage, to cover soft tissue defects in the hand as distal as the interphalangeal joints. The number and position of perforators were reported as well a the outcome of surgical procedures.

Results: It was found that the average number of radial artery perforators was 18 perforators; most of them (50%) arise between brachioradialis and flexor carpiradialis in the distal forearm, within 6cm proximal to the styloid process.

Twenty two flaps (91%) were successful. Total flap loss occurred in one case, while marginal flap necrosis occurred in another one. Skin graft was applied immediately over the flap in 18 and three of them showed partial graft loss, while all the delayed grafted cases showed complete graft take. Ischemia at the edges of skin incisions and wound dehesince occurred at the donor site in 2 cases.

Conclusion: Reversed radial perforator adipofascial flap of the forearm can be harvested for coverage of nearby defects mainly in the hand. This flap can reach distally as far as the web spaces of the hand provided that the pivot point is not less than 3cm from the radial styloid process. Skin graft is better applied one week later after the resolution of oedema.

INTRODUCTION

Soft tissue defects of the hand and wrist can result from trauma, burn, infection, ischemia, or neoplasm. In recent years, the volar radial forearm fasciocutaneous pedicled flap has been used extensively to cover large areas of hand and wrist defects. This radial forearm flap uses the retrograde flow of he radial artery to provide a robust blood supply to the flap and can be raised in a single-stage procedure without microvascular surgery to cover defects in the hand and wrist [1].

With routine use of the retrograde radial forearm flap some drawbacks to this flap have become apparent. The need to sacrifice the radial artery during the harvest of the flap, in addition, donor site morbidities such as poor skin graft take, delayed wound healing, and conspicuous donor scarring also limit use of this flap in some patients [2,3].

Fascial flaps that are based on the distal radial perforators were recently described. They have that advantages of keeping local skin and at the same time keeping intact one of the two major axes to the hand [4,5].

A perforator flap is a flap consisting of skin and/or subcutaneous fat. The vessels that supply blood to the flap are isolated perforators. These perforators may pass either through or in between the deep tissues (muscle or septal perforators) [6]. Acceptable perforator flap donor sites have four common features: A predictable and consistent blood supply, at least one large perforator (diameter 0.5mm); sufficient pedicle length for the procedure and donor site that can be closed primarily with the absence of excessive wound tension [7].

Perforator flaps represent an important resource in covering tissue defects in the forearm and the hand [8]. Perforators emerging from all four main source arteries of the forearm can become vascular sources for such flaps. The transversal anastomoses between perforators emerging from different main arteries, as well as the longitudinal anastomoses between perforators emerging from the same principal artery are significant from the vascular point of view. That fact explains the possibility of harvesting very long fasciosubcutaneous flaps or

fasciocutaneous flaps with a very proximal skin island, as well as relatively large and long transposition flaps [9].

Depending on their composition, the flaps can be cutaneous, subcutaneous, fasciosubcutaneous or fascial and according to the angiosome concept, they can also include other several structure, as bone, tendon, and nerve [10].

Perforator arteries fan out at both surfaces of the deep fascia to form a minor subfascial plexus and a rich suprafascial plexus, which give branches to the subcutaneous adipose tissue to form another abundant vascular plexus. The vascular plexus sends branches to the cutaneous tissue to form a dense subdermal vascular plexus and nourish the overlying skin. In the subcutaneous, these perforators also send branches to the superficial sensory nerve and subcutaneous veins to form a paraneural plexus and perivenous plexus to nourish them [11,12].

The adipofascial flap can be used as a random-pattern defect-based hinge flap. When one or two sizable perforators are incorporated in the base, larger flaps can be raised safely. A skin graft is applied on the fascial surface of the transferred flap, and the donor site is closed primarily. For reconstruction of moderate-sized defects, a turnover adipofascial flap is a simple and reliable method. However, because of its limitation of safe dimensions, it should not be used for larger defects. A skeletonized perforator-based flap has the additional advantage of increased reach [6].

With the introduction of the era of forearm perforator flap surgery as a reconstructive tool many advantages were added as less donor site morbidity, primary flap thinning, better functional and esthetic results of the recipient site, easy technique learning and preservation of a major vessel in the forearm, thus, eliminating the potential complications of acute or chronic hand ischemia [13].

PATIENTS AND METHODS

This study included twenty four patients complained of soft defects of the hand as distal as the proximal interphalingeal joints due to trauma, burn or soft tissue tumor ablation, who were admitted to Plastic and Reconstruction Surgery Unit, Tanta University Hospital from January 2006 to January 2011. Patients with defects that can be closed primarily, spontaneously or by using split thickness skin graft were excluded.

Pre-operative assessment of all cases included full history taking, general and local examinations of the defect, routine laboratory investigations, X-rays to the affected limb and metastatic work-up for tumor cases.

Localization of the vascular pedicle by duplex was done together with pre-operative photography as well as pre-operative marking of the flap including the course of radial artery, radial styloid process and the pivot point 3cm proximal to radial styloid process, (Fig. 1). The distance between the pivot point and the proximal limit of elevation should be equal to that between the pivot point and the distal limit of the defect.

Skin was prepared and the affected upper limb was positioned and a tourniquet was applied. Debridement of the wounds or excision of soft tissue tumors was done (Fig. 2a,b). Associated injuries were repaired if required.

Curved forearm skin incision was done so that the line marking radial artery was centralized within the skin incision. Subdermal skin dissection was done preserving flimsy layer of subcutaneous fat within the skin flap (Fig. 3).

Skin flaps were dissected on both sides of the incision for a distance more than the width of the defect needed to be covered but with a maximum dissection width for about 10cm. Skin flaps were retracted by sutures.

Dissection of the flap was started from the ulnar side, then from the radial side and flap was left attached in the middle along the course of the radial artery by the perforators (Fig. 4). Superficial radial nerve was preserved in all cases while cephalic vein was ligated proximally in the forearm. Elevation of the flap was done by dissection of radial artery perforators from proximal to distal till reaching the pivot point (Figs. 5,6). Tourniquet was then removed and the vascularity of the flap was assessed.

In setting of the flap was done by turning it over the defect after incision of the skin bridge between the pivot point of the flap and the defect (Fig. 7). Primary closure of the donor site was done without drainage (Fig. 8). The surface of the flap was covered by split thickness skin graft either immediately or one week later (Fig. 9a,b). Postoperative slab was applied and hand was elevated.

Duration of hospital stay & early complications were recorded. Patients were followed-up for at

least six months. During the follow-up visits skin graft take and healing of donor site of the forearm together with cosmetic and functional aspects of the reconstructed site were assessed.

RESULTS

This study included twenty four patients complained of soft tissue defects of the hand as distal as the proximal interphalingeal joints who were admitted to Plastic and Reconstruction Surgery Unit, Tanta University Hospital from January 2006 to January 2011.

Most of our patients were males: 18 cases (75%) and were of the middle age group. The youngest patient was 5 years old while the oldest was 62 years old. The dorsum of the hand was included in 18 cases (75%) and the palmar aspect in 6 cases (25%).

Causes of the soft tissue loss were direct blunt trauma in 12 cases (50%), sharp injury as well as deep burn each was in 5 cases (20.8%), soft tissue sarcoma was the aetiology in one case (4.2%) and marjolin ulcer was the cause in the remaining case (4.2%). Cases with exposed tendon parenchyma (paratenon loss) were 14 cases (58.3%) tendon injuries were present in 8 cases (33.3%) and 3 of them were associated with segment loss. Associated bone fractures were found in 2 cases (8.3%).

Most of our cases (19=75%) were repaired immediately after recent trauma, burn eschar debridement and after excision of the soft tissue tumours. Delayed repair was done in 5 cases (21%) with old hand trauma. Primary tendon repair was done in 5 cases, in which there were no segmental tendon losses using modified Kessler technique. Palmaris longus tendon graft was used in 2 cases and silicon rods were used in one case.

During the intraoperative dissection of the flaps, radial artery perforators were studied and the preoperative duplex markings of the main forearm perforators were coincided with the intraoperative dissection of the perforators as regard to their sites and diameters.

The distances of origin of these perforators from the radial styloid process were classified into a group of zones as shown in Table (1).

It was found that the total number of perforator ranged between (13) and (23) with an average number of 18 perforators, half of them arise within zones I and II. Accordingly most of radial artery perforators (50%) arise within 6cm proximal to radial styloid process mainly between brachioradialis and flexor carpiradialis in the distal forearm, this is followed by the proximal perforators (30%) which arise (>12cm) proximal to the styloid process between brachioradialis and pronator teres in the proximal forearm. The pivot point of the distal radial perforator flap should be at least 3cm proximal to the radial styloid process.

It was also found that most of radial artery perforators were septocutaneous (60%), direct cutaneous in (20%) and septomyocutaneous in (20%) of our series.

Twenty two flaps (91%) were successful, (Figs. 10a,b; 11a,b,c; 12a,b,c). Total flap loss occurred in one case, which needed surgical debridement and groin flap reconstruction, another case was complicated by marginal flap necrosis that needed only dressing and split thickness skin graft (Fig. 13). Minor ischemia at the edges of skin incisions and wound dehiscence occurred at the donor site in 2 cases (Fig. 14).

Skin graft was applied immediately over the flap in 18 cases (75%) while it was delayed for one week in the remaining 6 cases (25%). Three of the immediately grafted cases (16%) showed partial graft loss and revision of the graft were indicated in two of them (Fig. 15a,b), while all the delayed grafted cases showed complete graft take.

Twenty patients (83.3%) of our cases came regularly during follow-up period for six months. 13 cases (65%) were satisfied as regard to donor site scaring, function and cosmeses of the reconstructed sites. One case (5%) was moderately satisfied. While poorly satisfied 6 cases (30%) suffered from ugly forearm scars and hand stiffness which improved partially by scar therapy and frequent physio-therapy later on.

Table (1): The distances of origin of radial artery perforators from the radial styloid process.

Zone	Distance from radial styloid process	Average No.	Percent
(I)	0-3 cm	4	20
(II)	3.1-6 cm	5	30
(III)	6.1-9 cm	2	10
(IV)	9.1-12 cm	2	10
(V)	>12 cm	5	30
Total		18	

Fig. (1): Preoperative marking of the flap.

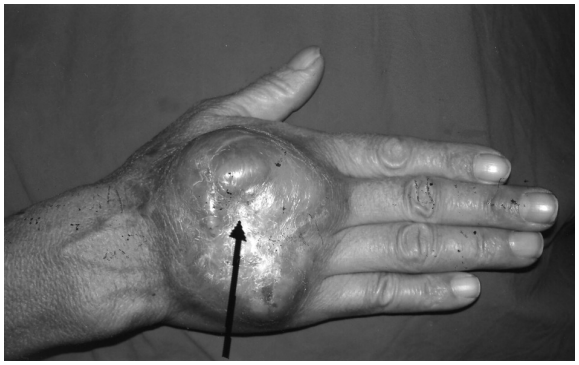

Fig. (2-A): Soft tissue tumor on the dorsum of the hand.

Fig. (2-B): Excision of the tumor.

Fig. (3): Dissection of skin flaps.

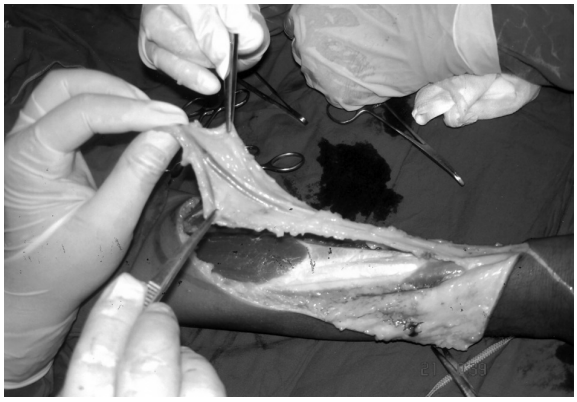

Fig. (4): Dissection of the distal radial perforator adipofascial flap.

Fig. (5): Elevation of the distal radial perforator adipofascial flap.

Fig. (6): The pivot point of the flap.

Fig. (7): In setting of the flap over the defect.

Fig. (8): Primary closure of the donor site.

Fig. (9-A): The flap after one week.

Fig. (9-B): Skin graft applied on the flap after one week.

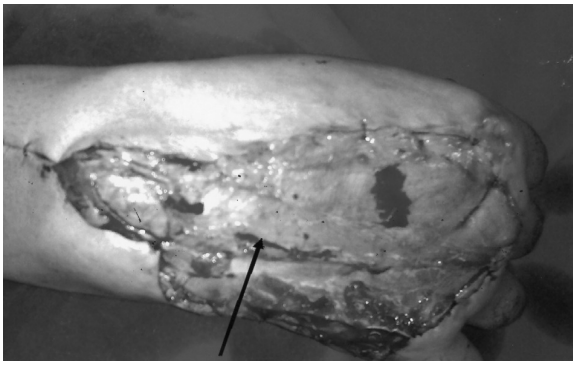

Fig. (10-A): Distal radial perforator adipofascial flap on a dorsal hand defect.

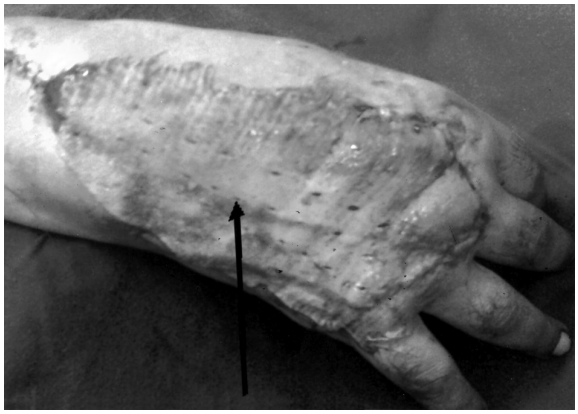

Fig. (10-B): Graft applied immediately over the flap.

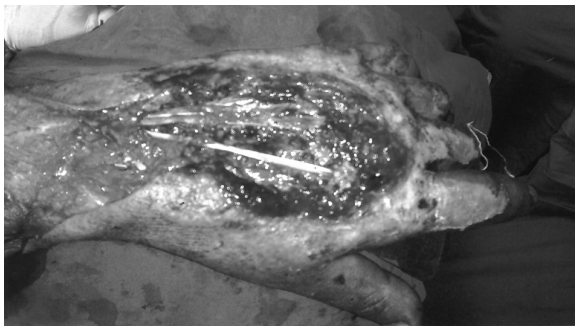

Fig. (11-A): Dorsal hand defect with exposed tendons.

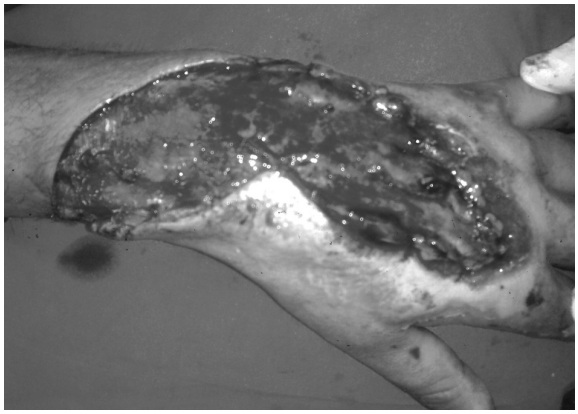

Fig. (11-B): The flap is applied to cover the defect.

Fig. (11-C): Graft applied immediately over the flap.

Fig. (12-A): Dorsal hand defect with exposed tendons.

Fig. (12-B): The flap is applied to cover the defect.

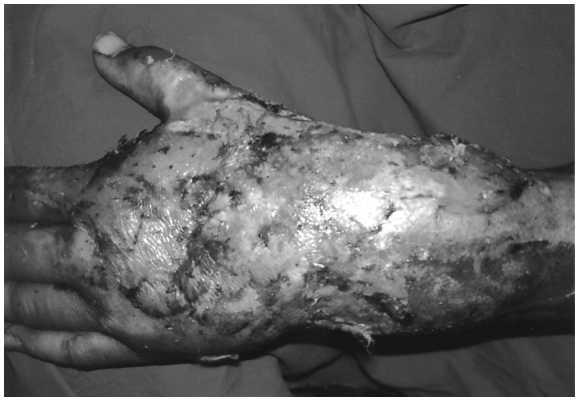

Fig. (12-C): Complete take of a delayed graft.

Fig. (13): Marginal flap necrosis.

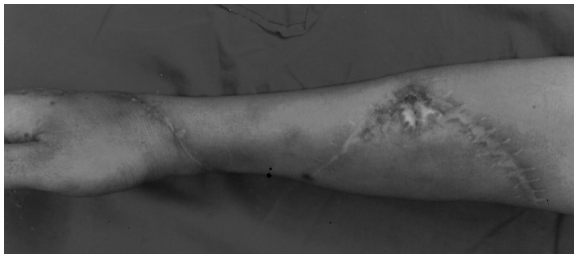

Fig. (14): Minor ischemia at the donor site.

Fig. (15-A): Partial loss of a graft that was applied immediately to the flap.

Fig. (15-B): Successful revision of partial graft loss.

DISCUSSION

Several surgical techniques use local flaps to resurface skin defects of the hand. One group of local flaps is distally based; these are raised from the volar aspect of the forearm. The axial-pattern reverse radial forearm flap provides a good amount of tissue for coverage, and is one of the primary flaps used for the reconstruction of soft-tissue defects of the hand. The advantages of this pedicled flap are that it is a safe, simple, and effective one-stage procedure providing thin, pliable, relatively hairless, good quality skin with a robust blood supply. The main disadvantages of this flap are sacrifice of a major artery, which may jeopardize hand viability, and morbidity of the donor site **[14]**.

Fascial flaps like the other kinds of flaps are well vascularized and in addition they are the only flaps that can provide gliding surface for tendons either on the volar of the dorsal surface of the hand. If a fascial flap is used, the overlying integument remained intact at the donor site to permit a standard closure resulting in an ideal linear scar **[15,16]**.

The first described fascial flap from the forearm was depending on the radial artery for its survival **[17]**. This flap like its fasciocutaneous version was criticized due to harvesting of a main vascular pedicle in the hand.

The distally based radial forearm fasciosubcutaneous flap with preservation of the radial artery **[18]** is based on the septocutaneous perforators of the distal radial artery. This method substantially avoids the two main drawbacks of the axial-pattern reverse radial forearm flap.

We dissected about 18 (average number) radial artery perforators, distributed along the course of radial artery in the forearm. We found that the preoperative duplex markings of the main forearm perforators were coincided with the intraoperative dissection of the perforators as regard to their sites and diameters. Routine preoperative imaging of the forearm perforators is not mandatory in all cases, this finding is similar to that of Adam et al. **[19]** in their research on 45 cases with perforator flaps in the forearm.

Koshima et al. **[20]** reported forearm fasciosubcutaneous flaps based on the distal radial & ulnar artery perforators which were comparable to our results as regard to their average number.

Change et al. **[21]** found about 10 perforators 0.4mm in diameter extending from 1.5cm above the radial styloid process to the bifurcation of the Radial artery. These perforators pass through the septum, fan out on both surfaces of the deep fascia and form a rich chain-linked longitudinal plexus of the integument along the course of the main artery.

Weinzweig & Chen **[18]** reported that distally based forearm fasciosubcutaneous flap is nourished by perforators situated 5-8cm above the radial styloid process. The anatomic study by Rambe and Pho **[22]** showed similar results. Braun et al. **[23]** reported about 22 Radial artery perforators along their cadaveric study, localized mainly at 5-8cm above wrist crease, while El-Khatib and Zeidan **[24]** in troduced an anatomic study of 8 cases using adipofascial flap based on distal perforators of the radial artery located 2-7cm from Radial styloid process.

One case in our series was ended in complete flap necrosis and another one showed marginal loss. We explained that by the too much encroachment on the pivot points of these two flaps. The pivot point was less than 3cm in both of them.

Three out of 18 immediately grafted cases showed partial graft loss and revision of the graft were indicated in two of them, while all the delayed grafted cases showed complete graft take.

It has been reported that distally based fasciosubcutaneous flaps often suffer minor skin-graft loss when grafted immediately. This phenomenon has been thought to be attributable to flap edema and an apparent decrease in flap vascularity during the immediate postoperative period **[25]**.

Most of the lymphatic and venous drainage of the hand courses through the volar surface of the forearm, large flaps raised in this region, such as the distally based radial perforators forearm fasciosubcutaneous flap, block these lymphatic and venous channels, producing temporary hand edema that is inconvenient in previously traumatized hands. Some authors prefer to delay skin grafting until the flap edema subsides to avoid this problem **[26]**.

Ischemia at the edges of skin incisions and wound dehesince occurred at the donor site in 2 cases. This may be attributed to extensive thinning and wide dissection of the skin flaps in these cases.

Summary and Conclusion:

Reversed radial perforator flap of the forearm can be harvested as adipofascial for coverage of nearby defects mainly in the hand. The maximum width for this flap should not exceed 9cm while its length can reach the entire length of the forearm without limitations. This flap can reach distally as far as the web spaces of the hand without fear of tension or compression to its pedicle.

The pivot point of the flap must be at least 3cm proximal to styloid process and the skin graft is better applied one week later after the resolution of edema.

This flap has many advantages as easy technique learning, primary thinning, less donor site morbidity and preservation of the major forearm vessels.

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