The Distally Based Radial Forearm Flap in Reconstruction of Complex Defects of the Hand

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ABSTRACT:

BACKGROUND:

The hand is exposed to various types of trauma, the majority of which involve multiple tissues which needs to be repaired in the most perfect way. The distally based radial forearm flap is one of the commonly used flaps for reconstruction of hand defects.

AIM OF THE STUDY:

The aim is to test the applicability and the versatility of the distally based radial forearm flap in complex soft tissue reconstruction of the hand.

METHODS:

Nine patients were treated using distally-based radial forearm flaps. There were seven males and two females, mean age was 21 year. Reconstructed sites involved the thumb, the first web, the palm and dorsum of the hand. Neurofasciocutaneous flap was transferred in one case, adipofascial flap in one case, all the remaining flaps were fasciocutaneous island flaps.

RESULTS:

All the flaps survived completely. There were two donor sites complications, but no major functional disturbances. No patient had symptoms of cold intolerance or other ischemic changes.

CONCLUSION:

Distally based radial forearm flap is very useful in hand reconstruction especially when no suitable local flaps can solve the problem and it can permit further surgical procedures to be done underneath when indicated.

KEYWORDS: radial forearm flap, adipofascial flap, vascularised nerve graft, thumb reconstruction.

INTRODUCTION:

The hand is the part of the body most commonly injured. These injuries can involve the skin, tendons, nerves, bones or combinations of all that. It is generally accepted that using a distant flap, pedicled to the trunk (like abdominal flaps) or a free flap using microvascular techniques, are the only available choices for complete closure in large skin defects [(1)], however, the former are associated with a number of disadvantages, such as prolonged fixation and the necessity for a two-stage operation, and the later need a well trained staff with experience in microvascular anastamosis and an operating room with high standards facilities, however The radial forearm flap can be used in single stage and does obviates the need for micro vascular experience and facilities[(2)].

Concepts about the radial forearm flap:

Two main concepts were raised by the Chinese (radial forearm) flap: The first is a new mode of vascularization of flap.

The forearm flap is not an axial pattern flap because the pedicle does not belongs to the skin territory, as the flap is nourished by small arteries in a very thin membrane which links the vascular axis and the flap (the intermuscular septum) (Fig.1B). This type of flap is now called a flap with meso. With the possibility of using this flap as an arterial retrograde flow gives A very wide range of applications, as this flap can be used in any way, pedicled or free, proximally or distally based[(2)]. The territory of Radial forearm flap may be extended from the lower third of the anterior aspect of the arm proximally to the wrist flexion crease distally [(3)]. Theoretically, all the skin of the forearm can be raised on the radial artery. In practice, however, the limits of the flap are the border of the ulna, medially, and the midline of the dorsal aspect of the forearm, laterally, [(2)] (Fig.1A).

Vascular supply:

The flap is supplied by the radial artery, from which arise many small arteries that perforate the anterior brachial fascia which are more abundant in the distal third of the forearm than in the proximal third.

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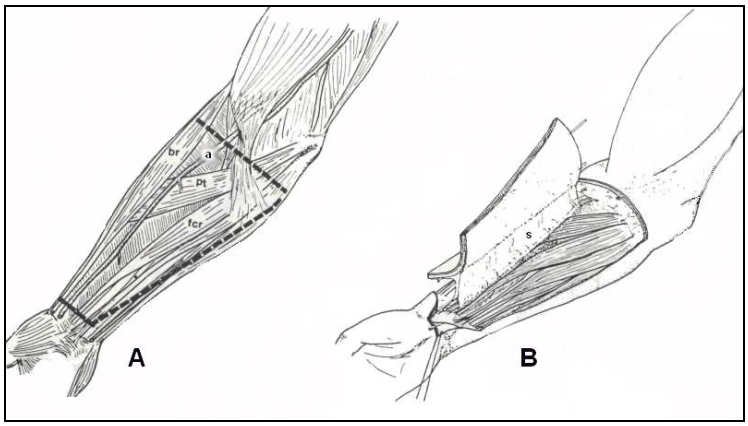
The perforators pass through the loose connective tissue (meso) between flexor carpi radialis & brachioradialis muscles, penetrate the fascia and are distributed throughout the subcutaneous tissue, ensuring an adequate blood supply to the flap [4].

It is generally accepted that a standard, distally-based radial forearm flap relies on a retrograde vascular flow provided by the ulnar artery through the palmer arches, so that damage to the palmer arches limits its use in some (sever) mutilating injuries [1]. Allen test should well be applied with or without Doppler examination.[1]

Venous return It is ensured by the venae comitantes which have a diameter of more than 1 mm close to the elbow [2].

Nerve supply: Sensibility is mainly supplied by the anterior cutaneous nerve of the forearm, but the discriminative sensibility is poor and the radial forearm flap cannot be considered as a good sensate flap [2].



(Fig. 1), A.The territory of the radial forearm flap. B. Elevation of flap. Note radial artery and venae comitantes at base of fascial septa (s), (Grabb &Smith's Plastic Surgery, IV. Upper extremity & Hand, 1991; 31:870).

PATIENTS AND METHODS:

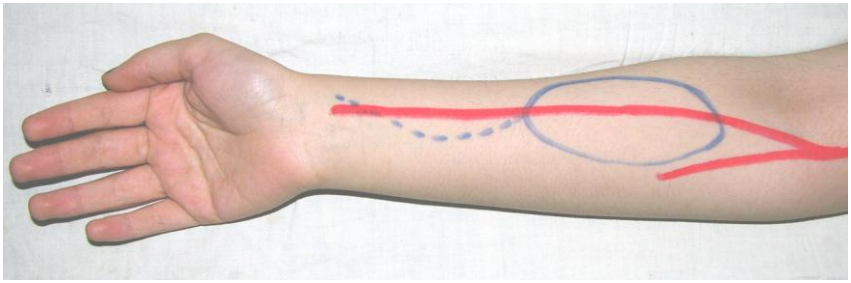
Between April 2002 and April 2005, 9 distally based radial forearm flaps were used for soft tissue reconstruction of 9 hands at Al Wasity Hospital for reconstructive surgery. The indication was either acute or old trauma. Reconstructed sites involved the dorsum of the hand (one), the palm (two), the first web (three), and the thumb (three). Adipofascial flap was transferred in one case, and fasciocutaneous flaps were transferred in the remaining cases (8 cases).

One flap was transferred with a vascularised nerve, which was part of the lateral cutanous nerve of the forearm to graft the radial palmer digital nerve of the index finger and it is sutured at the recipient site under an operating microscope.

In one case there was bone graft (from the radius) for reconstruction of the proximal phalanx of the thumb at the same session of flap transfer. In two cases the patients needed application of mini external fixators at the same session of flap transfer. Hands were immobilized with a splint for 7 to 10 days. Rehabilitation programs were started 1 week after the surgery. The range of follow-up in this study was between 4 and 24 months.

Operative procedure:

The course of the radial artery is drawn on the anterior surface of the forearm between the lower end of the radius distally and the midpoint between the medial and lateral epicondyle of the humerus proximally and the flap is marked on the skin approximately over the middle third of the anterior aspect of the forearm (Fig. 3).



(Fig. 3) planning the radial forearm flap.

The length of the pedicle needed to allow the flap to cover the defect is estimated by a pattern made of a piece of paper. Distal to the flap, the incision is made over the radial vascular axis to expose the pedicle. Proximally to the flap, a short incision allows the control of the radial artery. Dissection is begun on the ulnar side, including the fascia, until it reaches the radial border of the flexor carpi radialis. The muscle and its tendon are then retracted ulnar-wards to deepen the dissection in order to spare attachments of the meso and the radial artery to the flap. On the radial side, the flap is released from the underlying brachioradialis muscle. Care should be taken with the sensory branch of the radial nerve.

On the ulnar border of brachioradialis the dissection is deepened to pass beneath the radial artery. The radial artery and venae comitantes are then clamped proximal to the flap.

The tourniquet is released to verify the vascularization of the flap and of the hand. The tourniquet is then reinflated and the vascular axis is divided proximal to the flap. The flap and its vascular axis are progressively released from the underlying flexor muscles until the flap covers the defect without tension.

In case we decide to take an adipofascial flap, the incision made through the skin along the course of the artery but not to involve the deep fascia, and after undermining on both sides to the required width we incise the adipofascial layer only & continue our dissection like in the classical fasciocutaneous flap.

The donor site is closed directly when the flap is relatively small in size. In case the flap was medium to large in size, the donor site is covered by a split-thickness skin graft.

RESULTS:

Seven of the patients were males and two were females; ages ranged from 6-36 years (mean 21). All flaps were distally-based islands. The sizes of the transferred flaps ranged from 3 x 4 cm to 7 x 9 cm. All flaps survived completely without any loss, and healing was uneventful at the recipient sites. All patients gained a good, durable cover for the soft tissue defects on their hands with very good color match. There were no haematoma or seroma under any flap, neither infection. Six of our patients obtained definitive surgery, without any need for revision or auxiliary procedure (case no.2, 3, 4, 5, 6, and 7) (Table 1). Only two cases needed skin graft for the donor site, the remaining seven donor sites were closed directly. There were some donor-site complications. Wound healing was delayed at the donor site in one patient (case no.9) due to partial skin graft loss which healed within 4 weeks. Two patients (case no.1 and 6) developed hypertrophic scar along the suture line and contracture that required Z-plasty for release. In three patients, further reconstructive procedures were needed to achieve a good functional result, two of them (case no.1, 8) required debulking of the flap (Fig.8), and one needed third web reconstruction (case no.9) (Fig. 9). We didn't encounter flap congestion postoperatively apart from mild hyperemia with noticeable swelling of the flap in most of our patients which improved within the next 48-72 hours. No patient had symptoms of cold intolerance of the hand, ischemia or other functional deficits as a result of scarifying the radial artery. The two point discrimination test at the tip of the index of the patient with the vascularised nerve graft was 6 mm after a period of four month.

Table I. Indication, site of operation and Operative procedures performed

Case No.	Indication	Site	Flap	Outcome	Auxiliary procedures
1	Electrical burn	Thumb	Wound excision FC flap	Bulky flap Scar cont. Deviated the dista phalanx	Debulking Z-plasty Subcondylar-osteotomy+k-wire
2	Electrical burn	Thumb	Wound excision Adipofascial flap plus SG	Good	None
3	Blast injury	Thumb	Scar excision FC flap Bone graft	Good	None
4	Traumatic contracture	First web	Web release K-wire FC flap	Good	None
5	Bullet injury	First web	Wound excision Neurorhaphy External fixation NeuroFC flap	Good	None
6	Bullet injury	First web	Wound excision K-wire+FC flap	Good	None
7	Blast injury	Palm	Wound excision tenolysis FC flap	Good	None
8	Burn contracture	Palm	Contracture release, FC flap	Good	Debulking
9	Bullet injury	Dorsum	Wound excision FC flap External fixation	Third web contracture Partial graft loss	Third web reconstruction

(FC= Fasciocutaneous, SG=Skin Graft, cont.=Contracture)

DISCUSSION:

The radial forearm flap was first described in the People's Republic of China in 1978 at the Ba-Ba Chung Hospital [5].

Since then several authors thoroughly investigated the hemodynamic and functional changes of the hand and arm after harvesting the radial artery. Brodman and coworkers[6] and Suominen et al[7] stated that Doppler studies showed an increase in the ulnar artery diameter and in the ulnar artery blood flow with a higher peak flow velocity as well as a higher ulnar/brachial artery peak flow velocity ratio. Ciria-Lloréns et al [8] found that within 4 to 5 months postoperatively the blood flow through the anterior and posterior interosseous arteries reaches a relative flow percentage close to that of the radial artery before its excision. Iida et al stated that a collateral circulation develops within 2 months after harvesting a radial artery flap [9]. While the foregoing account spells a great degree of satisfaction, there are cryptic fears of producing circulatory embarrassment or malfunction (like cold intolerance or ischemia or both) of the hand. Fortunately, in line with the experience of a number of other surgeons, we have had no such complications although Jones and O'Brien reported three cases of acute hand ischemia[10], and some authors recommended vein grafting of the radial artery defect on a routine basis (6, 17, 25) which seemed unnecessary in our cases. We think that arterial grafting should be reserved only for patients with a remarkable decrease in hand perfusion that causes significant ischemic signs. We make certain that Allen's test is carried out preoperatively and repeated before induction of anesthesia and by applying a vascular clamp proximally on the radial artery for reconfirmation of continuity of the palmer arch before dividing the radial artery proximally. The greatest advantage of the distally based radial forearm flap in the reconstruction of the hand seems to lie in the feasibility of one-stage reconstruction for

various tissues as well as performing multiple tasks in one session. The lateral cutaneous nerve of the forearm and the superficial radial nerve can be included in the flap as a vascularised nerve graft. In our series, we used the flap as a carrier of the lateral cutaneous nerve of the forearm as a vascularised nerve graft to reconstruct the defect in the radial palmer digital nerve of the index (Case No. 5) **(Fig.6)**. The advantages of this vascularised nerve are invaluable in a bed of scar tissue with exposure of bones, joints, and tendons. In that case, the two point discrimination test was 6mm after 6 months.

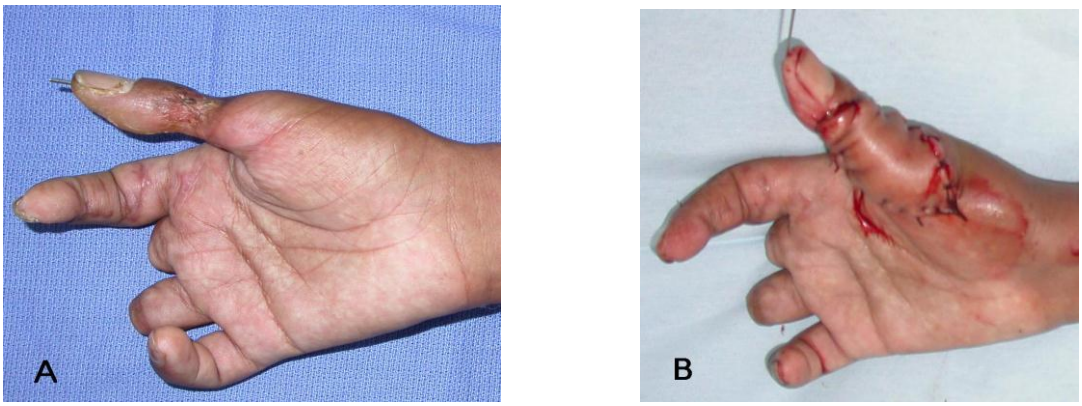
(Fig. 6) Case No. 5: A & B; Preoperative photographs.

(Fig.6) (continue) C. x-ray film showing trauma to the bony framework, D. markings, E. wound excision, F. Flap elevation, G. Flap setting & wound closure, H & I. 6 weeks later.

In 1983, Biemer and Stock reported the first osteocutaneous radial forearm flap. They used this flap for one-stage reconstruction of a defect of the terminal thumb after traumatic amputation [11]. The case in our series with reconstruction of the proximal phalanx of the thumb was not an osteocutaneous flap, but we used the donor site of the flap as the same donor site of the bone graft, the achievement of complete wound closure in single stage enabled us to do this bone graft at the same session of flap transfer.

The flap can also be used as a carrier of a vascularised tendon grafts (palmaris longus, flexor carpi radialis or brachioradialis), these can be used to repair the extensor tendons of the hand which have advantages over the conventional tendon grafts, and this technique was first reported in 1983 by Reid and Moss [12].

A major disadvantage lies in the cosmetic deformity that is produced in the donor site in the form of linear scar (when small island flaps taken), and the skin graft in larger flaps. Musa A. Mateev reported in 2004 a new fashion of this flap by modifying its shape to minimize its donor site morbidity, he takes narrow long flap and divide it to 2-3 parts depending on the perforators present and rearrange these flaps in the recipient site and close the donor site directly with minimal tension[13]. The adipofascial flap has double advantages; it decreases the donor site morbidity as it makes direct closure possible, and decreases the bulk of the flap when minimum thickness is required. In our series after observing the bulky flap on the dorsum of the thumb in case 1 we used adipofascial flap for reconstruction of the dorsum of the thumb in case 2.



(Fig. 7) Case No. 3. Blast injury; A. Bone & Soft tissue defect, B. Setting of the Flap.

(Fig. 9) Case No.9. Bullet injury; A. Original trauma, B. Flap healing 3 months post-op.

CONCLUSION AND RECOMMENDATIONS:

Distally based radial forearm flaps can be used with small to moderate size composite tissue detects of the hand. It can be done in the form of skin flap, adepofascial flap, osteocutneous flap, tendocutneous flap and neurocutneous flap.

The procedure is technically easy, and postoperative complications are minimal. It enables the surgeon to do multiple tasks in one procedure (bone graft, nerve graft, tendon graft… under the flap), due to the achievement of completely closed wound with a good durable cover in one session.

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