Reversed Posterior Interosseous Flap: Safe and Easy Method for Hand Reconstruction

Ahmed Hassan El-Sabbagh ·
Ahmed Abd El-Moaty Zeina ·
Al-Moddather El-Hadidy · Ahmed Bahaa El-Din

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Abstract Complex hand trauma presents multifaceted problems for the surgeon. Soft tissue defects of the upper extremity must be carefully assessed to determine the most appropriate method of coverage of hand. In this article, the reversed posterior interosseous flap was used for coverage of the hand. The injured areas include: dorsum of the hand (10 cases), the wrist (3 cases) and the dorsal thumb (2 cases). All flaps survived completely and none exhibited venous compromise. All donor sites were skin grafted. The reversed posterior interosseous flap is a versatile option for coverage of moderate sized defects of the hand and is specifically indicated for coverage of injuries of the wrist, dorsal hand and dorsal thumb.

Keywords Hand injuries · Reversed posterior interosseous flap · Dorsum of hand · Wrist and thumb

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A. H. El-Sabbagh (✉) · A.-M. El-Hadidy · A. B. El-Din
Plastic surgery unit, Mansoura University Hospital,
Mansoura, Egypt
e-mail: elsabbagh17@hotmail.com

A.-M. El-Hadidy
e-mail: modtherh@hotmail.com

A. B. El-Din
e-mail: ambahaeldin@yahoo.com

A. A. E.-M. Zeina
Student hospital, Mansoura University,
Mansoura, Egypt
e-mail: dr_z_81@hotmail.com

Introduction

Soft tissue reconstruction of the dorsum of the hand is always a difficult problem to tackle because of the involvement of muscle, tendon and bone. There are different flaps at our disposal that can be used to cover these soft tissue defects. This flaps include local perforator based flaps, reverse flow forearm flaps, distant flaps like the groin and abdominal flaps and free flaps. Each of these flaps has their advantages and disadvantages.

Reverse flow flaps have many distinct advantages such as easy preparation, being a single-stage procedure and one not requiring microvascular anastomosis [1].

The reverse posterior interosseous artery (PIA) flap is based on reverse flow through the PIA via anastomosis with the anterior interosseous artery and the dorsal carpal arches near the wrist joint. It is considered to be less reliable compared to the radial forearm flap because of variations in vascular anatomy. The distal reach of the PIA flap is also limited to the MCPJ of the fingers and the IPJ of the thumb [2].

This work presents our recent experience with the use of reverse posterior interosseous artery flap for reconstruction of soft-tissue defects the dorsum of the hand.

Patients and Methods

15 distally based reverse flow posterior interosseous flap flaps were performed for hand reconstruction between 2008 and 2010. Each patient received a full surgical explanation and a written consent was obtained. All patients were male. Their ages ranged from 12 to 57 years old. The recon-

structed areas included the dorsum of hand in 10 cases. Two flaps were used for thumb coverage and three flaps for wrist resurfacing. Motor car accident was the cause except one case due to electrical burn injury to the wrist. Only five cases was affected in right hand and the rest (10 cases) occurred in left hand. Contraindication is limited to patients with a history of high-energy fractures of the distal third of the forearm with suspected injury to the recurrent branch of the anterior interosseous artery, and deep scars to the dorsum of the distal forearm.

Operative Procedure

The anatomy and elevation of the reversed posterior interosseous flap have been described in detail by several authors [2–4].

A preoperative Doppler is essential to confirm presence of distal perforator just lateral to the medial end of ulna. Under general anaesthesia, the patients were placed in a supine position. The injured tissues were radically debrided. The size of the flap was planned based on a template of the defect. The flap is marked as originally described. The flap is designed like a tear drop (Fig. 1) and a tourniquet elevated without exsanguination of the upper limb. Dissection begins at the middle of the forearm starting at the ulnar border of the flap. Fascia is incised over the extensor carpi ulnaris muscle belly and dissection continues till reaching the septum between extensor carpi ulnaris and extensor digiti minimi where three to four constant muscle perforators from the posterior interosseous artery appear (Fig. 2).

The flap is then incised from the radial side as a fasciocutaneous flap till reaching the septum (Fig. 3). Some musculocutaneous perforators have to be cauterized during dissection at the radial side. The flap is incised proximally with the deep fascia and the posterior interosseous artery and venae comitantes are dissected proximally from the posterior interosseous nerve (Fig. 4). The flap is dissected in a retrograde manner along its course till reaching the pivot point (Fig. 5). Just radial to the distal end of ulna, the perforator is identified (Fig. 6). The flap is incised distally to the subcutaneous tissue. It then rotated and inset into the defect. The perforator is irrigated with xylocaine and heard

Fig. 1 Designing of the flap

Fig. 2 Elevation on the ulnar side

with Doppler to ensure that there is no tension (Movie 1). The donor site was covered with a split thickness skin graft.

The following rules are applied during the first postoperative week:

- (1) The dorsum of the hand was placed on a 10–20° extension of the wrist.
- (2) Elevation of the hand in all cases
- (3) and intravenous antibiotic prophylaxis.

Results

All flaps survived and patients discharged at 10th post operative day and had adapted well to the area after about 45 days. The flaps were assessed by physical examination using criteria such as temperature, turgor and colour of flap. There was neither venous congestion nor numbness after using reversed flow posterior interosseous flap. The largest

Fig. 3 Elevation on the radial side

Fig. 4 Identification of posterior interosseous artery and nerve proximally

flap measured 9×11 cm and the smallest flap measured 4×7.5 cm. The longest follow up was 6 months and the shortest period was 1 month.

Durable flap coverage of the treated defects over the hand was achieved. Finally all flaps provided stable coverage and reasonable contour. All donor sites were grafted immediately and shows excellent take and left exposed at day of discharge from hospital. All patients were satisfied with the cosmetic results in long-term follow up assessments.

All donor sites were skin grafted. The take of grafts were quite good. However, the presence of hair was obvious especially on the volar aspect of wrist region (Table 1).

Clinical Cases

Case 3

A 52-year-old man had a degloving injury of the dorsum of left hand with exposure of the medial end of the ulna. The

Fig. 5 Elevation of the flap on its pedicle

Fig. 6 Rotation of the flap on its perforators

defect was 7.5×10 cm. The flap measured 8.5×11 cm. The donor site was skin grafted (Fig. 7).

Case 7

A 33-year-old man crushed his left hand in a machine with injury to the radial artery and median nerve crush injuries to the second and 3rd metacarpal bone region. He underwent repair of the median nerve and radial artery with fixation of the 2nd and 3rd metacarpal bones by Kirschner wires. He developed ischemia of the palmar area. A deficit of 3.5×7 cm resulted from removal of gangrenous area. The flap measured 5×8.5 cm. The donor site was skin grafted. The rotated flap was not passed through a subcutaneous tunnel, but was inserted into the recipient site through an incision made distal to the pivot (Fig. 8).

Discussion

In the traditional reconstructive ladder, coverage of vital structures of the hand by split-thickness or full-thickness skin grafting cannot be done [5]. The use of sufficiently large, more durable and well-vascularised tissue is essential for preservation of hand function.

The free tissue transfer provided the advantage of supplying extensive tissue during a one-stage operation. However, there are some disadvantages such as special surgical skill; well-organized team and long hospital stay [6].

Distally based island fasciocutaneous flaps in the forearm have proved to be simple, versatile and reliable; they can be used to reconstruct a great variety of soft tissue defects of the hand.

The reverse posterior interosseous flap was first reported in 1986 by Lu et al. in China and by Pentecost in English

Table 1 Patient summary

Patient	Age (years)	Aex	Aetiology	Lesion site	Size of the defect(cm)	Size of the flap(cm)	No. of perforators	Follow up (months)
1	44	male	motor car accident	left dorsum of hand	6×9	7×10.5	2	2
2	29	male	motor car accident	left thumb	4×6	5×7.5	2	2
3	52	male	motor car accident	left dorsum of hand	7.5×10	8.5×11	2	3
4	40	male	motor car accident	right dorsum of hand	6×7.5	7×9	2	1
5	25	male	machine injury	wrist volar area	4×6	5×9	2	4
6	18	male	motor car accident	left dorsum of hand	5×6.5	6×8	2	1
7	33	male	machine injury	wrist volar area	3.5×7	5×8.5	2	6
8	26	male	motor car accident	left dorsum of hand	5.5×7	7×8	2	3
9	37	male	motor car accident	left dorsum of hand	6×7.5	7×9	2	1
10	28	male	motor car accident	left thumb	7×5.5	8×7	2	2
11	41	male	motor car accident	right dorsum of hand	6×7.5	7×9	2	1
12	23	male	motor car accident	left dorsum of hand	4×6	5×7	2	1
13	30	male	motor car accident	right dorsum of hand	8×10	9×11	2	3
14	24	male	motor car accident	left dorsum of hand	7×9	8×10.5	2	2
15	11	male	electrical burn	wrist volar area	3.5×6	4×7.5	2	2

literature [7, 8]. Since its report, the reverse posterior interosseous flap has evoked universal interest among plastic surgeons and hand surgeons. They are currently one of the most widely used skin flaps in reconstructive surgery, reported to be the next most useful skin flap taken from the forearm after the radial forearm flap [9–14].

The posterior interosseous reverse flap receives low arterial pressure from the anterior interosseous artery, and blood flow in the distal third of the skin flap (proximal third

of the forearm) is unreliable, and prone to necrosis [15, 16]. There have been varying reports concerning the rate of necrosis in this distally based posterior interosseous flap [17]. Penteado et al. also stated that the proximal quarter of the forearm is the territory of the recurrent interosseous artery, and is therefore not suitable for a distally based flap [8]. For this reason, 6 cm of the proximal forearm was not included on drawing the skin island.

Of the anatomic variants of the posterior interosseous artery that cause unreliability of blood flow, the most serious problems are caused by arterial hypoplasia in the mid forearm. Angrigiani et al. reported that in 74 of 80 subjects the posterior interosseous artery was at its thinnest in the mid forearm. Loss of continuity of the posterior interosseous artery was observed in the middle third of the forearm by Penteado et al. in 4 of 70 fresh cadavers and in 1 of 80 arms in 40 fresh cadavers, in 1 of 80 clinical cases by Angrigiani et al. [8, 15].

Although we did not experience such problems, if blood flow is unreliable despite the previous measures, or if it is difficult to preserve the motor branch of the posterior interosseous nerve, it should always be kept in mind that additional venous anastomoses can be performed and the flap can be used as a free flap [16].

Using Doppler is an essential step in using reverse flow posterior interosseous flap for coverage of the hand. It is essential to hear the distal perforator near the medial end of ulna. It was heard in all cases before elevation of the flap. Intraoperatively, the distal perforator is heard again before sitting the flap into the defect.

Although the distal perforator usually nourishes the flap, we recommend including at least two. In case of inadver-

Fig. 7 **a** Exposure of dorsum of left hand. **b** Postoperative result after 3 months

Fig. 8 **a** Fracture of left 2nd and 3rd metacarpal bones. **b** Exposure of left wrist volar area. **c** Postoperative result after 6 months. **d** Postoperative result after 6 months

tent injury is observed during dissection, the second perforator can serve as a lifeboat or a turbocharger [18].

One of the causes of flap failure is twisting of the pedicle; this complication can be prevented by including a cuff of fascia at the entrance of the skin vessels to the flap and by paying attention during the inset of the flap [19].

Handling of perforators during harvest can result in vasospasm, which makes the vessel dissection more difficult and may result in thrombosis of the perforator. To overcome this, one should use intermittent topical xylocaine, especially during dissection of perforators, and keep these vessels wet during the whole dissection [20].

There have been reports of measures to avoid venous congestion, such as anastomosing the venae comitantes or subcutaneous veins to veins at the recipient site, or not exposing the vascular pedicle by including intermuscular septa and muscle fascias. Simply, including cutaneous and subcutaneous veins in the flap pedicle protect the flap. This method has the following benefits: inclusion of cutaneous and subcutaneous veins in the flap pedicle maintains the venous circulation, and the flap pedicle is closed with its own skin extension, so it is less likely to be compressed [21].

Skin graft was applied immediately in all cases. Before application of skin graft, good haemostasis is carefully done. Gauze soaked with epinephrine (1/100.000) was applied to the donor site. Vasoconstriction produced by adrenaline may decrease oedema of the donor site and enhance the take of skin graft. Moreover, it guards against haematoma formation.

Extension of the wrist joint helps in fitting the flap up to the base of fingers easily without tension especially when two perforators are included as in this series.

The flap is designed like a teardrop, the tip of which corresponds to the pedicle. Once the flap is rotated 180°, the pointed end of the flap sits snugly between the skin flaps raised by dividing the intervening skin bridge between the recipient and donor sites (Fig. 7). When the flap has to traverse a long distance across the dorsum and ulnar border of the hand (e.g., to the palm), a tennis racket-shaped flap is raised, with the “handle” corresponding to the long pedicle. The intervening skin bridge is incised and the handle of the racket shape is inset into the defect (Fig. 8) [4]. This allows maximum use of the length of the flap without losing several centimetres of the flap over normal tissues.

Several factors limit the use of reverse flow posterior interosseous flap such as difficulty of dissection, inconsistent anatomy and possible injury of posterior interosseous nerve. Also, the flap is relatively small size in comparison to the radial forearm distally based flap, long time of elevation, needs learning curve and possible venous congestion. By elevation of the flap as described, it can be safer than the original technique in that it maintains the venous circulation and avoids pressure on the pedicle due to skin tension, hematoma or swelling. The major disadvantage is that it leaves a skin grafted area of the donor site. However, the deformity is limited to the injured limb.

One of the merits of the reverse posterior interosseous flap is good quality of the skin paddle that match with the volar wrist, dorsum of the hand up to base of fingers and dorsum of the thumb. In addition, being a small vessel with a secondary importance to the vascular supply of the hand, moderate to large sized flaps can be harvested to cover these areas. Moreover, this modified method is thought to be safer than the original technique in that it maintains the venous circulation and avoids pressure on the pedicle due to skin tension, hematoma or swelling.

Pearls and Pitfalls

Before Operation

Careful examination of the limb clinically and hearing of perforators by Doppler probe is an essential step in doing a surgical strategy for reconstruction of the leg. An arrangement is made with the orthopaedic surgeon if bone fixation is needed. Incision and dissection needed for fixation is discussed thoroughly in order not to interfere with the proposed flap territory.

During Operation

If reasonable Doppler signals are identified on preoperative examination then the procedure is begun by elevation of tourniquet without exsanguination. Although the field is filled with congested blood in the first few moments but this helps to great extent in easy detection of perforators during dissection. Dissection from the ulnar side helps to identify the septum rapidly and easily and shorten the time of operation. Inclusion of more than one perforator in the pedicle is better than one. This depends on the trauma situation and flap inset without tension. More than one perforator acts as a life boat for survival of the flap. Continuous irrigation of perforator with xylocain spray

(10%) guards against spasm of the perforator. Gauze soaked with adrenaline (1/100.000) helps to great extent the take of skin graft.

Postoperative

Elevation of the hand and avoidance of pressure on the flap protects the flap from oedema and congestion and reduce hospital stay.

In summary, with increasing knowledge of reversed posterior interosseous flap entity and refinements of surgical techniques, the use of the flap can be safe and reliable.

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