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ORIGINAL ARTICLE

Posterior Interosseous Artery Flap for Resurfacing Posttraumatic Soft Tissue Defects of the Hand

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Abstract The need for soft tissue coverage of large defects in the hand and the wrist following trauma is a common problem for hand surgeons. Flap coverage of these defects can be either in the form of distant or regional flaps. The posterior interosseous artery flap recently has emerged as a front runner in these situations by its virtue to preserve both the major arteries to the hand. Thirty-two posterior interosseous artery flaps were used in 32 patients with complex soft tissue defects of the hand. All these defects were posttraumatic. There were associated skeletal and soft tissue injuries in 20 patients. The donor site was closed either primarily or by a split skin graft depending on the size of the defect. All flaps healed well, and there were no incidences of flap necrosis. The donor site required a split skin graft in 24 patients. The flap was bulky in one patient and transient extensor carpi ulnaris weakness was seen in three patients. The posterior interosseous artery flap is a versatile flap for coverage of soft tissue defects of the hand. Good aesthetic results can be achieved with minimal donor site morbidity. Harvesting the flap requires a precise surgical technique and as many perforators as possible should be preserved to ensure flap viability.

Keywords Flap coverage · Hand defects · Pedicled forearm flaps

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Introduction

Soft tissue defects of the hand due to trauma are common in today's scenario. High energy trauma and industrial and work place accidents are the common causes. Coverage of these defects usually requires a flap because of the complex nature of these injuries, to improve function and to enable faster recovery. Flaps may be harvested as a distant pedicled flap such as the abdominal flap, vascularized free flap, or regional forearm flap. Local flaps from the hand may not be possible in many situations, especially if the defect is large. Regional forearm flaps in common use are the radial forearm flap, ulnar artery flap, dorsal ulnar flap, and the posterior interosseous artery flap. In recent times, the posterior interosseous artery flap described by Zancolli and Angrigiani [15] has gained widespread acceptance and popularity since there is no need for sacrificing a major vessel of the hand unlike the radial and ulnar artery flaps. The flap has a good reach and is applicable to defects as distal as the proximal phalanx of the thumb. With this background, we analyzed the results of 32 patients who received posterior interosseous flap coverage for posttraumatic soft tissue defects of the hand at our institution over a period of 2 years (June 2003–August 2005). The purpose of this study is to highlight the utility and versatility of the posterior interosseous artery flap and to share our experience in the usage of this flap in resurfacing large defects of the hand.

Materials and Methods

From 2003 to 2005, 52 patients with complex posttraumatic soft tissue defects in the hand with or without bony and tendon injuries attended our institution. Of these 52

patients, 32 underwent soft tissue reconstruction using the posterior interosseous artery flap. Twenty-eight patients were men and four were women. The right hand was reconstructed in 23 patients, and the left hand, in nine patients. The average age was 38 years (range, 18–64 years). The patients were followed up for an average period of 4 years (range, 3–5 years). Etiology was occupational injury in 19 patients (industrial and farmyard injuries) and high velocity road traffic accident in 13 patients. Most of the patients were operated electively after a mean delay of 4 days. All skeletal injuries were stabilized before flap coverage. Further surgical interventions to address associated skeletal and soft tissue injuries were required in 20 patients. Patient demographics, size of the flaps, and site of the defects are summarized in Table 1.

Surgical Technique

All patients were operated by a single senior surgeon. All patients were operated under an axillary block. To start with, a thorough debridement was done, and measurements were taken for the dimensions of the flap. The length of the vascular pedicle was measured from the point of rotation to the proximal edge of the defect. The course of the posterior interosseous artery was marked by a line extending from the lateral epicondyle to the ulnar head, which represents the axis

Table 1 Patient demographics and surgical data.

No	Age/sex	Side	Defect site	Flap size (cm)	Etiology	Donor site closure		Remarks
						SSG	Primary	
1	23/M	Right	Volar wrist	9×6	RTA		+	
2	18/M	Left	Dorsum hand+fingers	12×8	Industrial injury	+		Transient ECU weakness
3	34/M	Left	I webspace	6×4	Industrial injury		+	Marginal flap necrosis
4	47/M	Right	Dorsum hand	6×4.5	Farm yard injury		+	
5	64/M	Right	Dorsum thumb	7×6	Industrial injury	+		
6	42/F	Left	Dorsum hand	12×7	RTA	+		
7	50/M	Left	Dorsum hand+thumb	16×10	RTA	+		
8	40/ F	Right	Dorsum hand	8×6	RTA		+	
9	45/M	Left	I web space	6×8	Industrial injury	+		
10	33/M	Left	Dorsum hand	9×6.5	Farmyard injury	+		Marginal flap necrosis
11	30/M	Right	Volar wrist	7×8	RTA	+		
12	34/M	Right	Dorsum thumb	10×5	RTA	+		
13	37/M	Right	I webspace	5×2.5	Industrial injury		+	
14	41/M	Right	Dorsum thumb	5×7	RTA		+	
15	48/F	Left	Dorsum hand+fingers	10×6.5	Industrial injury	+		
16	28/M	Right	Thenar eminence	9×7	Industrial injury	+		Bulky flap
17	45/M	Right	Volar wrist	8×5	RTA	+		
18	40/M	Right	Dorsum hand+thumb	11×8	RTA	+		
19	39/F	Right	Dorsum hand	9×6	Industrial injury	+		
20	35/M	Right	Dorsum thumb	6×8	RTA	+		
21	40/M	Right	Dorsum hand+thumb	8×10	Farm yard injury	+		
22	41/M	Left	Dorsum hand+thumb	9×7	RTA	+		
23	36/M	Right	Dorsum thumb+fingers	11×8	Industrial injury	+		
24	42/M	Right	Dorsum hand	6×9	Industrial injury	+		
25	35/M	Right	Dorsum hand	7×8	Industrial injury	+		
26	34/M	Right	I webspace	5×4	Industrial injury		+	Persistent ECU weakness
27	29/M	Left	Dorsum hand+fingers	10×7	Industrial injury	+		
28	60/M	Right	Dorsum hand+I webspace	8×6	RTA	+		
29	23/M	Right	Dorsum thumb	7×5	RTA		+	
30	29/M	Right	Dorsum hand	9×6.5	Industrial injury	+		Transient ECU weaknes
31	38/M	Right	Volar wrist	7×8	Industrial injury	+		
32	36/M	Right	Dorsum hand	8×10	Industrial injury	+		

SSG split skin graft, *ECU* Extensor carpi ulnaris

of the flap. The point of rotation was marked 2.5 cm proximal to the DRUJ corresponding to the distal anastamosis. The length of the pedicle was marked on the axis of the flap, and the size and shape of the flap were designed as per the defect. Flap dissection starts with the identification of the vascular pedicle and proceeds proximally including as many perforators as possible. These perforators are considered important for the viability of the flap and needs to be identified carefully and preserved. The vascular pedicle was raised with an overlying pad of skin to avoid strangulation of the pedicle during closure. The harvested flap was transposed to the recipient site either directly for defects on the dorsal aspect and along the radial or ulnar side for volar defects. The flap was anchored with stay sutures, and a small window was left open in the dressing to monitor the viability of the flap. The donor site was either closed primarily or by using a split skin graft from the thigh.

The flaps were closely monitored during the early post op period for viability. The arm was elevated to minimize post op venous congestion. The limb was splinted for 7 days followed by active and passive mobilization. The average hospital stay was 10 days (6–19 days). Patients were followed up at regular intervals. Physiotherapy protocol depended on the associated skeletal and soft tissue injuries. The postoperative functional outcome was analyzed at ultimate follow-up using a quick DASH outcome questionnaire. Cosmetic outcome was assessed based on three parameters: flap thickness, color match and appearance of the donor site defect. Each parameter was assessed independently on a scale of 10, and the final score was determined by calculating the mean of the three scores.

Results

The size of the flaps ranged from 5×2.5 cm to as large as 16×10 cm (Figs. 1, 2, 3, and 4). The flaps healed uneventfully in 30 patients. In two patients, there was marginal necrosis of the distal part of the flap, probably due to tight closure but did not require any additional surgical procedures. The donor area was closed directly in eight patients. In the remaining patients, the donor area required split skin grafting for closure. The donor site morbidity was minimal, except for partial loss of SSG in two cases, otherwise, the cosmetic result at the donor site was acceptable. Mild superficial infection was seen in two patients, which resolved with parenteral antibiotics and local wound care. The flap was thin and acceptable in all cases, except in one patient where it turned out to be bulky, but the patient being a manual worker accepted it. Three patients had weakness of the extensor carpi ulnaris postoperatively, of whom two recovered completely, and one patient had persistent weakness on examination, but he had no functional deficit. The mean quick DASH score assessed at last follow-up was 18.12 (2.5–59.1). The postoperative hand function was primarily determined by the presence of associated injuries as shown in Table 2. The mean cosmetic score was 7.15/10 (5.3–9).

Discussion

Soft tissue defects of the hand are usually due to high-energy trauma. They are often mutilating, precluding the use of local tissues for coverage. Skeletal and tendon injuries are a common association. Regional flaps from the forearm like the radial forearm flap [12] and the ulnar artery flap [7] have been in conventional usage for a long time. The usage of these flaps has decreased considerably ever since the posterior interosseous flap gained popularity and surgeons have become quite familiar in using it.

The PIA flap has the advantage of preserving both the radial and ulnar arteries, which is not possible with the radial and ulnar artery-based flaps [9]. The dominance of

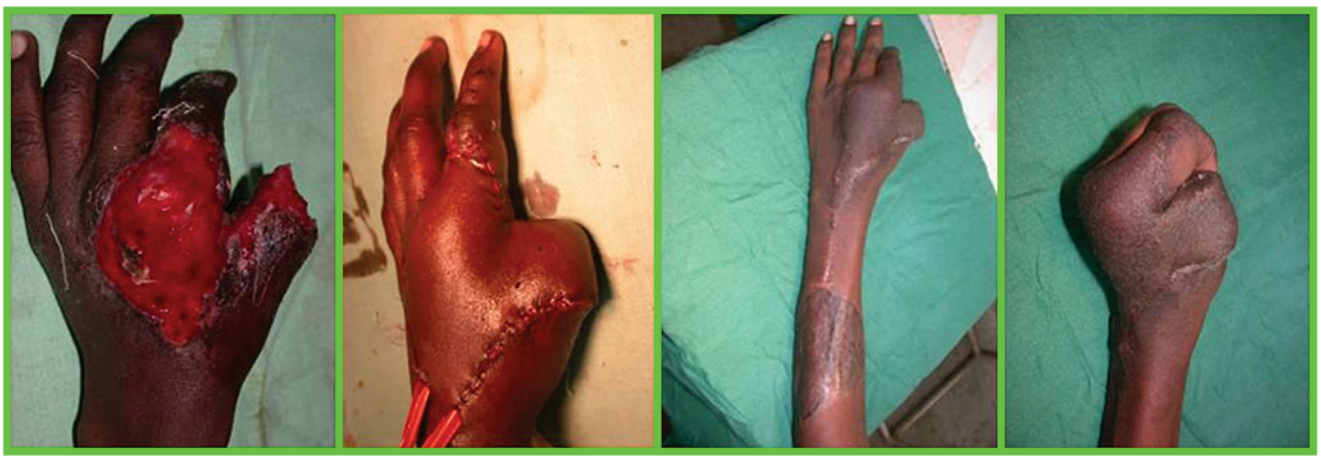

Figure 1 A blast injury of the left hand with traumatic amputation of the thumb. Postoperative and follow-up photographs after PIA flap coverage show a good cosmetic and functional result.

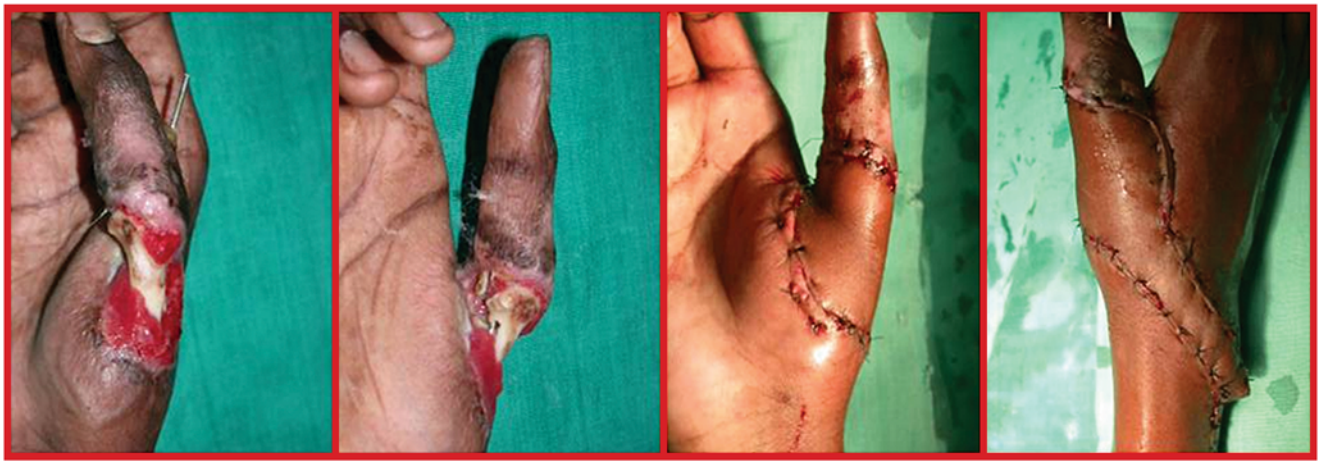

Figure 2 A workplace accident with severe injuries to skin, tendons, and fracture of the first metacarpal. Postoperative photographs show a thin flap with excellent color match.

the ulnar artery in supplying the hand is controversial [3, 10]. Though the sacrifice of radial artery is often asymptomatic, complaints of cold intolerance have been reported [13, 14]. It is safe to say that both the radial and ulnar arteries are important for the blood supply of the hand and the use of posterior interosseous artery flap avoid sacrificing either of these vessels.

There have been many reports regarding the anatomical inconsistency of the posterior interosseous artery [2, 11]. Some authors have also advised preoperative Doppler to confirm the presence of the vessel and its anastamosis with the anterior interosseous artery. In our series, we did not do preoperative Doppler, so our dissection was from distal to proximal, starting with the identification of the distal anastamosis and proceeding proximally with flap dissection. The distal anastamosis was constantly present in all patients in our series similar to reported results by several authors [5, 6]. It is best not to use the flap in case of severe injuries to the forearm to ensure flap viability.

The distal reach of the flap in our series was up to the proximal interphalangeal joint of the thumb. Defects beyond this point may be difficult to cover with a PIA-pedicled flap [1]. Using the posterior interosseous flap beyond this point may cause traction on the pedicle and can cause vascular insufficiency later if a longer pedicle is used. We were able to harvest flaps as large as 16×10 cm. The flaps are usually thin and pliable, unlike the bulky radial forearm flaps. The PIA flap provides excellent color match for defects around the dorsal aspect of the wrist and the hand. The flaps raised in our series were quite thin in majority of the patients. The flap was bulky in only one patient (3.1%) contrary to the report by Buchler and Frey [4] who reported bulkiness in 30% of their patients.

Figure 3 A case of dorsoulnar skin defect with amputation of the little finger following a machinery injury. Postoperative appearance of the donor site, recipient site, and hand function after posterior interosseous flap.

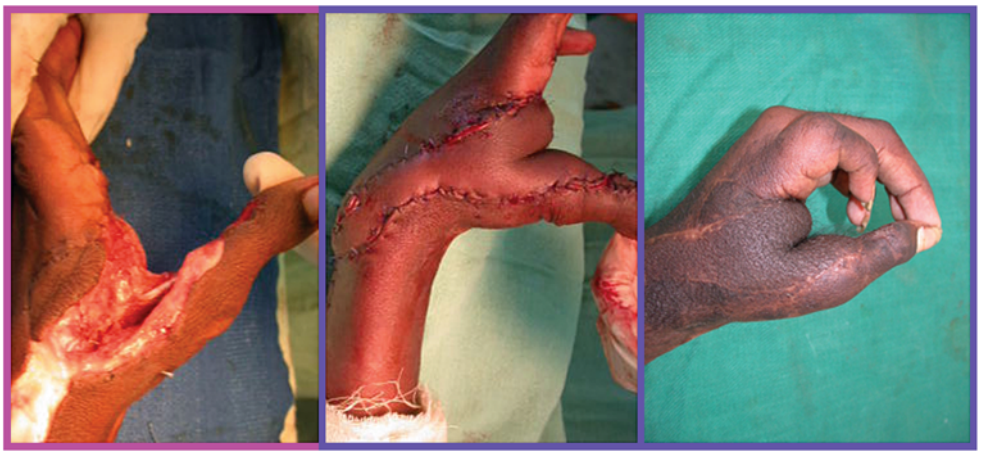

Figure 4 A case of I webspace injury with fracture of the base of I metacarpal. Intraoperative photograph after debridement and K wire fixation of the fracture. Final follow-up photograph showing good hand function.

Table 2 Functional and cosmetic evaluation scores.

Patient	Additional injuries/surgeries	Quick DASH score	cosmetic evaluation
1		4.5	7
2	Metacarpal # fixation, Extensor tendon repair	6.8	6.6
3		4.5	7.3
4		6.8	7.3
5	Amputation at PPX level–phalangeal distraction lengthening	22.7	6.3
6		17.5	8.6
7	Amputation of thumb and index finger	38.6	5.3
8	Metacarpal # fixation	9.1	8
9	Bennett # fixation	17.5	8.6
10	Metacarpal # fixation	4.5	7.3
11		4.5	7.6
12	Disarticulation of the thumb at PIP joint	25	6.6
13	Extensor tendon repair	2.5	9
14	Extensor tendon repair	4.5	6
15	Metacarpal # fixation, extensor tendon repair, distraction lengthening of index finger	20.5	6
16		2.5	8
17		4.5	7.3
18	Amputation of thumb at PPx level–distraction lengthening, delayed modified Jones transfer for radial nerve palsy due to # shaft humerus	40.9	6.3
19	Amputation of II and III fingers,	52.3	7.6
20	Extensor tendon repair	9.1	6.6
21	Amputation at the level of I metacarpal	38.6	6
22	Amputation at PPx level, fixation of I metacarpal base #	59.1	6.6
23	Amputation of thumb and index finger—distraction lengthening of both	34.1	6.3
24	Amputation of little finger	12.5	6.6
25		9.1	8
26	II metacarpal # fixation	15.9	7.3
27		17.5	7
28	Metacarpal # fixation, extensor tendon repair	25	7.6
29	Amputation at the level of I metacarpal shaft	43.2	7.3
30		4.5	6.6
31	Metacarpal # fixation	9.1	8
32		12.5	7.3

Presence of concomitant veins precluding the need for venous anastamosis and noninterference with the lymphatic drainage of the forearm, which is mainly on the palmar side, are additional advantages. Flap loss due to venous congestion has been described in several previous studies [8]. We encountered marginal flap necrosis in two patients and required removal of some sutures but did not threaten the viability of the flap. Venous congestion is a real possibility with the PIA flap, and the pedicle should be wide enough, and strangulation must be avoided to prevent flap congestion. The PIA flap may be avoided in females if the donor area is excessively hairy as it is a cosmetic concern. The donor site is amenable for primary closure depending upon the size of the defect. Larger defects may be closed with a split skin graft, which might cause an ugly scar on the forearm.

Free flaps such as lateral arm flap may be a viable alternative to pedicled flaps since they offer flexibility in size and shape and may not add to the donor site morbidity. Harvesting and flap insertion may be time consuming in case of free flaps and requires a lot of expertise and careful postoperative care. Distant pedicled flaps have been in use for a long time and they need to be staged, were cumbersome, and may delay postoperative rehabilitation especially in posttraumatic cases.

To conclude, the posterior interosseous flap has definitely emerged as the preferred option for resurfacing large defects around the hand and the wrist. Being a small less important vessel, it can be safely sacrificed leaving the major vessels untouched. It provides a good color match especially for dorsal defects, and most often, they are thin. Though we did not encounter any anatomical variations, some large scale studies have demonstrated anatomical variations in 5% of the individuals including complete absence of the posterior interosseous artery. Familiarity with these variations, a meticulous surgical technique and a proper learning curve are required for the successful harvest and usage of this flap.

Conflict of interest The author declares no conflict of interest.

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