Reverse-Flow Posterior Interosseous Flap—A Review of 68 Cases

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Abstract We are reporting our 10-year experience with 68 patients. Sixty-six flaps were of fasciocutaneous type and two were of osteofasciocutaneous type. These flaps were used for volar and dorsal traumatic hand defects, first web space reconstruction, thumb reconstruction, and repair of congenital anomalies. Sixty flaps (88.24%) had complete uneventful take-up. Four flaps developed partial necrosis, whereas four flaps suffered complete necrosis. The single most important factor for flap survival in our experience has been inclusion of at least two perforators to supply the skin pedal. The proximal flap dissection has a learning curve and all of our poor results were in the early part of our experience. We believe that posterior interosseous fasciocutaneous flap (PIF) is a versatile and reliable option for the challenging problems of hand soft-tissue coverage.

Keywords Skin coverage · Posterior interosseous artery flap · Reconstruction

Introduction

Restoration of adequate skin coverage is an essential part of any attempt to repair or reconstruct the hand. Many methods of providing skin coverage are available to the hand surgeon, ranging from relatively simple split thickness skin grafting to

more complex local flaps, regional flaps, and microsurgical free flaps. It would be highly desirable to have a technique for skin coverage within the repertoire of the hand surgeon that is reliable, versatile, and applicable in variety of situations and has minimal donor site morbidity. With better understanding of the blood supply, a group of flaps have emerged that has many of these qualities in common. This group can be called distally based reverse-flow flaps. Two important members of this family of retrograde flow flaps are radial forearm flap and posterior interosseous flap (PIA). Whereas both flaps have competing claims to similar indications and advantages, radial forearm flap has distinct drawback of sacrifice of a major arterial channel to the hand. The PIA flap is based on reverse flow into the posterior interosseous artery from its distal anastomosis to anterior interosseous artery (AIA) close to distal radioulnar joint.

The PIA flap was first described as a reverse-flow pedicle flap by Laijin et al. [11] in 1986 in Chinese literature [8] and in English literature by Penteado et al. [14] in 1986 and Zancolli et al. [10] in 1988. This was a major development, as this flap did not involve sacrifice of a major blood vessel. Since then many large series have appeared in literature detailing pros and cons of this flap. Despite accumulation of significant experience about this flap [1, 2, 6, 9, 12, 13], opinion remains divided regarding its exact merits. Purpose of this study is to describe our experience with distally based reverse-flow PIA flap over a period of 10 years (1993–2003) and define its advantages and limitations.

Material and Methods

Since 1993 the senior author has been using reverse-flow posterior interosseous fasciocutaneous flap (PIF) for coverage of soft-tissue defects of hand in both acute and elective

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settings. This is a combined experience from National Orthopedic Hospital, Bahawalpur, Pakistan and the University of New Mexico Hospital, Albuquerque, New Mexico, USA. In this retrospective study, we reviewed medical records, operative reports, and photographs. The patients ranged in age from 4 to 68 years, average age being 37.5 years. Fifty-six patients were males and 12 were females. Sixty-six flaps were of reverse-flow fasciocutaneous flaps based on posterior interosseous septocutaneous perforators. Two flaps were composite osteofasciocutaneous and included ulnar bone graft for reconstruction of osseous defects in hand. Flaps ranged in length from 4.5 to 13.5 cm in length and in width from 3.5 to 11 cm. Three cases with largest dimensions were 13.5×7 cm, 12×8.5 cm, and 10×11 cm. Ten flaps were used for first web space reconstruction after contracture release including one case of separation of thumb syndactyly in Aperts syndrome. Twenty-nine cases involved coverage of dorsal hand defects and 22 cases for palmar hand defects coverage. Seven flaps were done as part of staged reconstruction of the thumb.

Anatomy

The posterior interosseous artery (PIA) is commonly a branch of common interosseous artery, but in about 18% of the cases it can arise from ulnar artery [9]. It pierces the interosseous membrane and emerges in the posterior compartment under the supinator muscles at an average distance of 7 to 8 cm from the lateral epicondyle. In the posterior compartment it gives recurrent interosseous branch, which anastomoses with the terminal branches of profunda brachii artery. The PIA continues distally and overlies on the surface of abductor pollicis longus, deep between ECU and EDM muscles. Here it is closely accompanied by posterior interosseous nerve and a plexus of veins. The PIA becomes progressively narrow and superficial and lies under the deep fascia in intermuscular septum in distal part of the forearm. About 2 cm proximal to distal radioulnar joint, it receives an anastomosis from the dorsal branch of the AIA and ends at dorsal aspect of the wrist where it participates in the dorsal carpal arch. This anastomosis with the AIA is quite consistent [2, 4, 9, 14] and is the basis of distally based reverse-flow posterior interosseous flap. However, Angrigiani et al. has shown, by their intravital injection studies, that the distal third of forearm is irrigated by direct flow through the recurrent branch of anterior interosseous artery and the narrowest middle portion of the PIA represents a choke anastomosis between the interosseous arteries.

Along its course in the intermuscular septum, the PIA gives multiple cutaneous and muscular branches. The septocutaneous branches arise vertically and feed the rich

arborizing and interconnected plexus under the skin of posterior aspect of the forearm. The most proximal relevant perforator (MPRP) is the cutaneous branch from the PIA in its proximal portion [7]. It is consistent, but its origin is variable and can arise from recurrent interosseous or common interosseous artery [2]. Moreover, it can occasionally be intertwined with the branch of the posterior interosseous nerve to extensor carpi ulnaris (ECU) and not available for inclusion in the flap. A second, very consistent cutaneous branch of the PIA arises close to the middle of the forearm and is the usual source of blood supply to the flap. At the distal third of the forearm, the PIA gives six to eight perforators of variable diameter to the skin. Venous drainage is from both the superficial and the deep systems. One or two venae comitantes ordinarily follow each of the perforators with communicating branches between the venae comitantes, allowing reverse flow via both crossover and bypass patterns. Sufficient reverse-flow venous drainage through the venae comitantes and the superficial veins contained in the pedicle occurs to ensure flap survival.

Operative Technique

The procedure is done under tourniquet control but without exsanguination to maintain visibility of perforators and small vessels. With the arm on side table, elbow is flexed 90° and wrist in full pronation, a straight line is drawn from lateral epicondyle to the distal radioulnar joint (DRUJ). This represents the axis of the PIA. The fulcrum or axis of rotation of the flap lies 2.5 cm proximal to DRUJ where PIA anastomoses with dorsal recurrent branch of AIA (Fig. 1a). The distance from this fulcrum to the proximal edge of skin defect is measured and is the length of the pedicle. This distance is then translated on the PIA axis proximal to the fulcrum. The skin defect to be grafted is debrided and final defect is outlined on a sterilized piece of paper and extrapolated on the axis proximal to the end of pedicle (Fig. 1b). The dissection begins at the distal end of the pedicle at the level of wrist and progresses proximally. It is important to make sure that distal anastomosis between PIA and AIA exists. If the anastomosis is absent, the procedure is aborted and alternate methods of coverage are used. The skin incision is carried down to the fascia overlying the vascular axis. PIA is very superficial in the distal third of forearm and lies between ECU and EDM. It is important to maintain a sleeve of deep fascia 5 mm in width on either side of the septum between ECU and EDM (Fig. 1c, d). PIA and accompanying vena comitantes are reliably found in this septum. Trying to isolate the pedicle from the sleeve can result in necrosis of flap. Dissection proceeds proximally with careful ligation or electrocoagulation of muscular perforators to ECU and EDM. The

Figure 1 (a) Fulcrum of rotation of vascular axis is about 2 cm proximal to the ulnar head. Usual length of the pedicle and the territory that can be covered is shown. (b) Surface marking of the vascular axis and outline of the flap. (c) Vascular axis is preserved in

the intermuscular septum between ECU and EDM and a fasciocutaneous flap is raised. (d) A 5-mm sleeve of fascia is preserved on either side of the vascular pedicle. (e) The flap is transferred to recipient site through an open wound or tunneled under a bridge of skin and set-in.

muscular branches of posterior interosseous nerve (PIN) are also carefully avoided. The dissection is more critical in the proximal third of the forearm as PIA lies deeper and in close proximity to PIN. The PIA at this level runs on Abductor Pollicis Longus (APL) and is covered by ECU and EDM.

At the proximal end of the pedicle, the dissection begins on the edges of the flap. Dissection on the edges of the flap starts on the ulnar side. At this point, we try to identify the most proximal relevant perforator (MPRP) to the skin island. In our experience, the most critical factor in flap survival has been inclusion of at least two MPRPs. The PIA gives off four to six septocutaneous perforators along its course [15]. Largest of these perforators “medial cutaneous perforator” is located 1–2 cm distal to the middle of forearm. If not enough MPRPs are seen in the proximal flap, then skin pedicle is extended distally to include more perforators. Once the MPRPs have been identified and their sleeves preserved up to the skin peddle, the PIA is ligated 2 cm proximal to these. Elevation of the entire fasciocutaneous flap continues. We suture the fascia to dermal edges of the cutaneous island to prevent shearing. A portion of ulna supplied by PIA can be included to make an osteofasciocutaneous flap. Once completely detached, the flap is rotated and either tunneled or inset through an open incision depending on integrity of local tissues (Fig. 1e). The flap is sutured or stapled at recipient site. The donor site is closed primarily if width is less than 5 cm. Split-thickness skin grafts are used for larger defects.

Results

We graded the results as good, satisfactory, and poor. A good result was complete flap take with no requirement for secondary procedures for wound coverage. A satisfactory result meant partial superficial necrosis with requirement for debridement and split thickness skin grafts. A poor result meant total flap necrosis with requirement for definitive coverage by other means. Of the 68 flaps, 60 (88.24%) were rated as good result with complete uneventful healing of PIA flap. This included two cases with osteofasciocutaneous flaps. Four (5.88%) flaps developed necrosis that ranged from 20 to 50% of the total surface area. Necrosis was superficial with viable deep fascia. In two of these cases, we could only include only one MPRP in each flap and proximal continuation of the PIA dived

Figure 2 In two cases, vascular pedicle dived anteriorly in the middle of the forearm and proximal part of the vascular axis was absent. As a result only one MPRP was available.

Figure 3 (a) Loss of skin on dorsum of the hand in a 19-year-old female patient with exposed extensor tendons. (b), (c) Coverage with posterior interosseous flap and final functional result.

deep between ECU and EDM to exit through the fourth extensor compartment (Fig. 2). In these cases, we had to rely on a single distally located MPRP to supply cutaneous island. In both these cases, we misjudged the proximal distribution of MPRP, and this resulted in superficial necrosis of the proximal portion of the flap after inset. Four cases suffered complete necrosis and had to be salvaged by groin flaps. Two of these flaps were tunneled to reach the recipient site and two were inset after open incision. All of these four failures happened during initial part of our experience with PIF. Early on, we tried to isolate the pedicle from its fascial sleeve during our dissection. This skeletonization of the pedicle in our opinion may have contributed to pedicle damage causing partial necrosis. Now we consistently retain a 5-mm sleeve of fascia around the pedicle. There was no neurological deficit or vascular disturbance in the hand resulting from flap elevation. Majority of flaps showed good adaptation at the recipient site.

Discussion

The PIA flap is a useful tool in the armamentarium of the plastic and hand surgeons. It has proved to be extremely versatile for coverage of traumatic hand defects. Earlier

accounts mainly described its use for release of first web space contracture. With time, however, the indications for PIF have expanded to include dorsal (Fig. 3a–c) and volar wrist and hand defects (Fig. 4a–c), and even up to proximal part of fingers. The more distal reach, however, requires extra length of pedicle and inclusion of less perforators risking necrosis. Brunelli [5] obtained coverage up to DIP levels by extending the wrist and exteriorizing the pedicle as a two-stage procedure. We were able to extend our distal reach up to PIP level without needing to exteriorize the pedicle.

Since the use of PIA flap, our use of other vascular axis flaps (radial artery or Chinese flap and ulnar artery flap) or free flaps has been limited to situations where PIF is not possible because of prior trauma to pedicle area, prior surgery, or the vascular anomalies precluding its use. When feasible, PIF represents our first choice for resurfacing the defects of dorsal and palmer surface of the hand up to PIP joint level and first web space reconstruction. In our experience, PIA flap has a learning curve associated with it. All of our four failures were encountered in early part of our series. We attributed these to our initial attempts at isolating and skeletonizing the pedicle. After these initial failures, we started including a sleeve of deep fascia of 5 mm on each side of the pedicle. Fujiwara et al. [10] had similar recommendation in his study. Dissection is

Figure 4 (a) Loss of volar skin of the palm with exposed tendons and neurovascular structures. (b), (c) Coverage with posterior interosseous flap and final functional result.

difficult in the proximal one-third of the forearm because the artery lies deep and in close relationship to the PIN. Coverage of distal defects requires raising the flap more proximally. In our experience, inclusion of at least two perforators supplying the skin pedal has been the most critical step in flap survival.

The literature describes a 2% incidence of an absent anastomosis between PIA and AIA. We did not encounter this anomaly in our series. We encountered two cases of vascular anomalies, which possibly contributed to partial flap necrosis. As mentioned in “**Operative Technique**” our dissection started distal to proximal. In two cases, there was an anomalous proximal continuation of the PIA. Close to middle of the forearm, the PIA dived deep under the EDM and then disappeared in the interosseous membrane without proximal continuation so that more proximal elevation of the artery was not possible. This finding gives credence to the view of Angrigiani et al. [2] that there is choke anastomosis between anterior and posterior interosseous arteries and the flap could be named as recurrent dorsal AIA flap. Only one perforator could be included in these two cases. Both these cases were among the four cases, which developed partial necrosis. In this situation, we recommend extending the skin pedal more distally to include another MPRP. This will affect the length of the flap and pedicle as well as the distal reach of the flap. One cannot extend the flap proximally in these situations, as this will risk tip necrosis. Balakrishnan et al. [3] recommended shaping the flap as a teardrop by extending the skin pedal all the way down to the fulcrum to include as many perforators as possible. The flap is not tunneled but rather inset after an open incision. Fujiwara et al. had no flap congestion or necrosis by extending the distal edge as far as the distal radioulnar joint. This modification, however, results in a long and bulky flap especially with volar defects.

The venous outflow of the distally based PIF is in a retrograde fashion through venae comitantes. Mazzer 1996 [13] described 34% incidence of edema and congestion of the flap inset. Chen 1998 [8] recommended adding a venous anastomosis when there was congestion after the inset. We did not have this problem in our series and felt that venae comitantes that accompany PIA are adequate for venous drainage even with very large flaps. We again emphasize that maintaining the sleeve of deep fascia around pedicle maintains the integrity of arterial and venous channels and reduce these complications. The technique of subcutaneous tunneling or inset via an open incision did not affect flap survival in our series. Also, the size of flap did not affect survival as long as two or more MPRPs are included in the flap.

In conclusion, posterior interosseous reverse-flow flap is a fairly safe and effective choice in a variety of skin coverage needs in the hand. Its dissection may be somewhat tedious, but it has distinct advantage of not sacrificing one of the main arteries to the hand. One can, on occasions, encounter unusual anatomy and should be prepared to modify surgical plan accordingly.

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