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ORIGINAL ARTICLE

Technical tips in reverse flow posterior interosseous artery flaps

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Abstract
Objective: For avoiding contracture formation, coverage of exposed tendons, bones, nerves, joints or vascular structures, flaps are preferred over other soft tissue reconstruction techniques used in hand. Reverse flow posterior interosseous flaps as an option in hand reconstruction and the ways to obtain higher survival rates based on our experience is described and discussed in this article.
Materials and Methods: From July 2003 to June 2013, 45 patients aged between 7 and 69 years (mean 34.6 years) were operated for soft tissue reconstruction of hand using distally based posterior interosseous flap.
Results: Operative plan was changed ın one out of 45 flaps due to small pedicle calibre. Only one of the flaps was totally necrosed. No partial necrosis was seen.
Conclusion: Reliability of posterior interosseous flaps are sometimes unpredictable due to the anatomical variability of posterior interosseous artery. We do not attempt to make pedicle dissection more proximal to the midpoint of dorsal axis line. Extension of the distal part of reverse flow posterior interosseous flap into the distal third territory is strongly recommended in every case, especially for more distant defects. By doing so, we include a piece of skin with numerous septocutaneous perforators arriving from posterior interosseous artery and their accompanying veins in the distal third region, thus obtaining higher survival rates. We believe that reverse flow posterior interosseous flaps are reliable in reconstruction of hand defects and the application of those operative techniques used in this study improve flap survival rates.

Keywords: Perforator; Posterior Interosseous Artery; Flap.

INTRODUCTION

Soft tissue reconstruction of hand must be performed by using tissues which will minimize contractures and will successfully cover exposed tendons, bones, nerves, joints or vascular structures. Flaps enable those exposed structures to survive, be durable against stress such as shearing and trauma and, provide an optimal environment for proper functioning. Therefore, reconstruction elevator instead of reconstruction ladder is followed in soft tissue reconstruction of hand, depending on the size and location of defect and the structures exposed. Most commonly used local distant flaps for soft tissue reconstruction of hand include reverse flow radial forearm flap, dorsoulnar flap and, posterior interosseous flap, in which each come along with its own drawbacks. The most important advantage of posterior interosseous flap is that it does not sacrify any major vessels supplying hand while providing sufficiently large skin island and can reach as far as metacarpophalangeal joint or at most proximal interphalangeal joints. However, reverse flow posterior interosseous flap survival may be unpredictable. In order to obtain better flap survival results, we offer some modifications in flap harvest on the basis of our previous experience (1), and share the results.

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MATERIALS and METHODS

From July 2003 to June 2013, 45 patients aged between 7 and 69 years (mean 34.6 years) were operated for soft tissue reconstruction of hand using distally based posterior posterior interosseous flap. Written Informed Consent Form is taken from the participants of the study. Details about the defects, flaps and donor sites are shown in Table 1. Patient and First of all, dorsal axis line from lateral epicondyle of humerus to distal radioulnar joint is drawn. The middle point of dorsal axis line where, the dominant perforator arises, is marked. Although it is not compulsatory, especially during planning of narrow flaps which the donor sites are expected to be closed primarily, identification of dominant perforator by using a hand doppler, around the midpoint of dorsal axis line is done in order to be sure to include the dominant perforator to the flap. Following this, flap is outlined according to the location and dimensions of the defect over the dorsal axis line.

Then, the distance between the proximal edge of the planned flap and distal radioulnar joint is divided into three equal parts along the dorsal axis line, and distal edge of flap is always extended the into the distal third territory for one or two centimeters. By doing so, inclusion of skin perforators and accompanying vein/s from the distal third region is maintained (Figure 1).

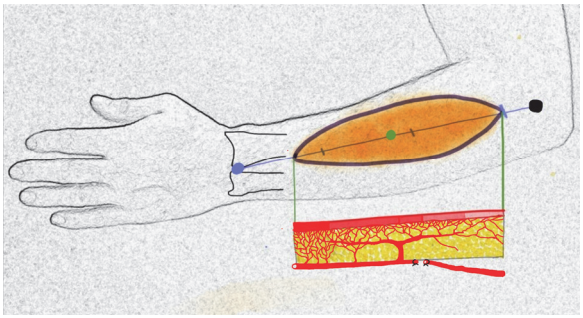

Figure 1. Flap planning is seen. Proximal circle (black) shows lateral epcondyle of humerus and distal circle (blue) indicates distal radioulnar joint. Dorsal axis line is drawn between these two points. Around the midpoint of dorsal axis line dominant skin perforator indicated by middle circle (green) arises. Dominant perforator is always included in the flap. Pedicle dissection is continued one centimeter more proximal to dominant perforator. Divide the distance between the proximal edge of the planned flap and distal radioulnar joint over the dorsal axis line into three equal territories. Distal edge of the flap must be extended into the distal third territory to incorporate more perforators supplying flap along with concomitant veins. In short, all the perforators from the dominant perforator till the distal edge of the skin flap are included in the flap.

After seeing the continuity of anterior and posterior interosseous arteries in the septum between extensor carpi ulnaris and extensor digiti minimi, dissection is beginned on the ulnar border and, proceeds proximally along the same septum. The dominant skin perforator, located around the midpoint of dorsal axis line, is always included in the flap and pedicle dissection is carried out in the area between the distal radioulnar joint and one centimeter proximal to the dominant perforator. Posterior interosseous nerve is identified in this septum and care is taken not to harm posterior interosseous nerve during pedicle dissection. Portion of the flap, which is more proximal to the dominant perforator is being dissected subfacially until the proximal border of flap (Figure 1). Pedicle dissection is not performed in this region. In brief, the dominant perforator located around the midpoint of dorsal axis line, and all other perforators located until the distal edge of the planned flap are included in the flap (Figure 1).

Afterwards, dissection continues on the radial side of flap distally until the pivot point. After the dissection is completed, flap is ready for adaptation to the recipient site (Figure 2a,2b,2c,2d). Flap donor sites can be closed either by skin grafting or primary closure. Since dissection of the pedicle is not performed more proximally in the septum between extensor carpi ulnaris and extensor digiti minimi, injury to the muscle branches of posterior interosseous nerve does not occur.

Figure 2a. Soft tissue defect exposing extensor tendons over the dorsum of hand (Case 45).

Figure 2b. Wound debridement on second postinjury day and flap planning is seen (Case 45).

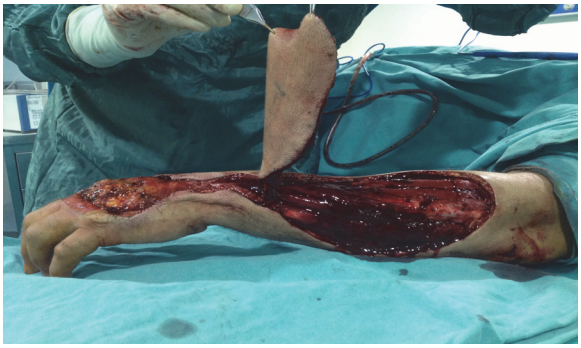

Figure 2c. A reverse flow posterior interosseous flap, with 18x9 cm dimensions, is elevated (Case 45).

Figure 2d. Flap is seen after adaptation onto the defect on postoperative 15th day (Case 45).

Table 1. Details about defects and flap donor sites

Case	Etiology	Location of the Defect	Pedicle Length	Number of Perforators	Skin Bridging	Skin Graft Use in Donor Recipient Site
1	Severe windblown	1st web space, 12X4 cm.	4	3	+	-/-
2	Crush injury	Dorsum of hand, 6x6cm.	4	2	+	+/-
3	Amputation through metacarpophalangeal joint of 5th finger	Hypothenar region,8X5 cm.	4-5	2	+	-/-
4	Gunshot injury	Dorsum of 3rd metacarp, 8X3cm.	4	3	+	-/-
5	Crush injury	Dorsum of 1st metacarp,8X4,5cm.	3	2	+	-/-
6	Amputation through metacarpophalangeal joint of thumb	Thumb, 12X4cm.	4	2	+	-/-
7	Necrosis	Ulnar site of wrist,6,5X4cm.	2,5	2	+	-/-
8	Gunshot injury	Dorsum of 2nd-4th metacarp,8X4cm	4	3	-	-/+
9	Sequele after crush injury	1st web space,9X3cm.	4	3	+	+/-
10	Sequele after crush injury	Dorsum of hand, 8X3,5cm	3	2	+	-/-
11	Sequele after crush injury	Hypothenar area, 7X4cm	1	2	+	-/-
12	Severe windblown hand	1st web space,10X3cm	4	2	Abandoned	Abandoned
13	Sequele after crush injury	Hypotenar area,12X4cm	3,5	3	-	-/-
14	Severe windblown Hand	1st web space, 8X2cm	3	2	+	-/-
15	Crush injury	Dorsum of hand, 9X6cm	2	3	-	-/+
16	Crush-avulsion injury	Palmar side of wrist,8X4cm.	4,5	2	+	-/-
17	Sequele after crush injury	Dorsum of 2nd metacarp, 12X3cm	2	3	-	+/-
18	Sequele after crush injury	Dorsum of hand, 10X4cm	3	2	-	+/+
19	Amputation of 4th & 5th finger	Hypothenar region, 11X4,5cm.	2	2	+	-/-
20	Sequele after crush injury	Defect over the dorsum of 4th & 5th metacarpal bone and 3rd, 4th & 5th fingers, 13x7cm	3	3	-	-/+
21	Gunshot injury	Thenar region, 10,5X5cm.	4	1	+	-/+
22	Crush-avulsion injury	4th & 5th metacarpal region, 10,5X6cm	4	2	+	-/-
23	Crush-avulsion injury	Hypothenar region,8X5cm.	4	2	-	+/-
24	Crush injury	Radial side of hand dorsum, x5cm	3	2	-	+/-
25	Gunshot injury	3rd web space, 10X2,5cm.	3	2	+	-/-
26	Sequele after crush injury	2nd finger metacarpal rea,14X4cm.	1	2	-	-/-
27	Sequele after crush injury	1st web space,6X4cm	3	2	+	-/-
28	Crush injury	Dorsum of hand, 5X3cm.	4	2	+	-/-
29	Crush injury	Dorsum of hand, 6,5X3cm.	4	2	-	-/-
30	Crush injury	Dorsum of hand,11X4cm.	4	2	+	-/-
31	Sequele after electrical burn injury	Dorsum of 3rd metacarp, 20X3cm.	1	3	+	+/-
32	Sequele after crush injury	1st web space,9X4,5cm.	2	3	+	-/-
33	Crush injury	Dorsum of hand, 10X2,5cm.	3	2	-	+/+
34	Sharp injury causing skin defect	Defect exposing tendons over dorsum of 4th & 5th metacarp, 10X4cm.	4	3	+	-/-
35	Sequele after crush injury	1st web space,12X4cm.	3	2	+	-/-
36	Gunshot injury	Dorsum of thumb, 12X3,5cm.	3	3	+	-/+
37	Burn injury sequele	1st web space, 8X4cm.	3	2	-	-/-
38	Amputation through 4th &5th finger	Hypothenar region, 6X4cm.	4	2	+	-/-
39	Sequele after crush injury	1st web space,13X3,5cm.	2	2	+	-/-
40	Sequele after crush injury	3rd web space, 10X3cm.	3	2	+	-/-
41	Sequele after crush injury	Dorsum of thumb,6,5X3cm.	3	2	+	-/-
42	Crush injury	Amputation through 4th & 5th fingers,11X4,5cm.	2	2	+	-/-
43	Sequele after electrical burn injury	Defect over dorsum of 3rd & 4th fingers of hand,20X3cm.	2	3	+	+/-
44	Crush injury	Dorsum of 3rd- 5th fingers of hand 11X5,5cm.	2	3	-	+/+
45	Crush injury	Dorsum of hand, 18x9cm	2	3	-	-/+

RESULTS

Anastomosis between anterior and posterior interosseous arteries could be seen in all the cases however, one flap was abandoned since the pedicle calibre was too small (Case 12). In this case, the pedicle was insufficient to supply the flap and the reconstructive plan has changed. One total and no partial necrosis was seen in this study. Flap survival rate is 97.72%. There was no weakness of extensor muscles during the postoperative course. There were no postoperative infections or hematomas in either donor site or in recipient site. Venous congestion or wound dehiscence was not observed in our cases. Donor sites in seven cases required skin grafting after flap transfer while the rest were closed primarily. No tendon exposures in the donor site were seen in the postoperative follow-up period.

DISCUSSION

Only a few local distant options exist that can be used for soft tissue reconstruction of defects over the dorsum of hand, palmar region and, first web space region. However each option has its own drawbacks. Most commonly used local distant flaps for reconstruction of those regions include radial forearm flaps, dorsoulnar flaps and posterior interosseous flaps. Despite still an important flap, groin flaps are now less frequently used when compared to past, since it postpones the time for onset of hand rehabilitation for 2-3 weeks due to the need for immobility until the flap is divided. If it is not possible to use local flaps or local distant flaps for any reason, free flaps are being used.

Radial forearm flap offers a versatile, simple, effective and one stage method for skin and soft tissue reconstruction of almost any part of volar or dorsal hand (2,3,4), however it requires sacrification of one of two major arteries of hand and forearm which is a major drawback. On the other hand, posterior interosseous flap does not require sacrification of any major vessel, which is accounted as an important advantage. Although posterior interosseous flaps can not reach as distal as reverse flow radial forearm flaps, they can still cover defects as distal as metacarpophalangeal joints of fingers.

Dorsoulnar flaps can cover proximal defects located over the dorsum of the hand, wrist, thenar and hypothenar eminences (5). Whereas distally based posterior interosseous flaps can cover large dorsal hand defects up to metacarpophalangeal joints, extensive lesions over the ulnar border of hand (6), and over palm of hand(7) while also successfully reconstructing the first web space up to the interphalangeal joint of thumb (Figure 2a,2b).

Because of those advantages posterior interosseous flaps emerge as a reconstructive option in cases whenever there is an indication for its use. In this study, our experience related to reverse flow posterior interosseous artery flap is shared. Most of the cases of this study are performed by the second author.

Anatomical variability of posterior interosseous artery is a threat against the viability of reverse flow posterior interosseous flaps. Major anatomic variations have precluded the final dissection of posterior interosseous flap in 6% of cases of Buchler and Frey's experience (8). It has been reported that posterior interosseous artery anastomoses with anterior interosseous artery in all (100 cadavers) of the anatomic dissections performed by Costa et al (6). However according to Penteado et al. the rate of presence of anastomosis was 98.6% (9). This anastomosis was observed in all the cases presented here in this article however, operative plan has changed in one patient since the pedicle calibre of reverse flow posterior interoseeous flap was too small therefore, the reconstructive plan has changed intraoperatively. This patient was 7 years old. We believe that, special attention must be paid for reverse-flow posterior interosseous flap as a reconstructive option in patients under 10 years of age.

Pedicle dissection in proximal part of forearm becomes more complicated (10). The most proximal relevant perforator may sometimes be intertwined with posterior interosseous nerve branch to extensor carpi ulnaris muscle, therefore in such cases, inclusion of this perforator to flap becomes impossible (10). Even if it is not intertwined and possible to include this perforator to flap, tedious and difficult dissection is required that may risk flap survival and may cause injury to posterior interosseous nerve branches. Cheema TA et al. has tried to include the most proximal relevant perforator as long as they could and had a 88.24% of complete flap survival rate but no mention about posterior interosseous nerve or its branches' injury (10). Due to the anatomical variability of posterior interosseous artery in the proximal part of forearm and, in order to prevent possible injuries to small nerve branches of forearm extensors we do not attempt to make dissection in this region and our flap survival rate is 97.72%.

Akinci et al. reviewed 87 cases of reverse flow posterior interosseous flaps retrospectively and reported that in 6 (5 partial, 1 total) out of 24 cases, posterior interosseous flaps which were harvested from the proximal third of forearm and distal edges of flaps were not extending to the distal dorsal forearm, necroses developed. This accounts for 25% of necrosis rate. On the other hand, out of 34 flaps, which were raised from the proximal third while the distal end was extended into the boundaries of distal third of dorsal forearm, necrosis developed in 2 (one partial, one complete). This accounts for approximately 6% of failure. As a result, in the previous study by Akinci et al. extension of the distal part of reverse flow posterior interosseous flap into the distal third territory was strongly recommended in every case, especially for more distant defects, to obtain higher survival rates (1). This suggestion is routinely applied during flap planning in this study (Figure 1,2b). At the distal third of dorsal forearm six to eight septocutaneous perforators branch from posterior interosseous artery which are accompanied by one or two vena commitantes and they are interconnected to form a rich plexus subcutaneously (10).

This may be the reason for the lower necrosis rates we report. In our study, we divided the dorsal forearm into three equal parts from the proximal border of the planned flap to distal radioulnar joint along the dorsal axis line, unlike previous studies dividing the whole length of dorsal axis line into three parts. Such a planning provides us the opportunity to include more perforators to the flap arising from the distal portion of posterior interosseous artery and is a reliable guide for marking the distal limit of flap. Elongation of the distal border of flap (1,11) into the distal third territory for one or two centimetres, improves flap survival rates both because of the additional arterial supply by numerous perforators from posterior interosseous artery (1) and also because of the presence of rich vascular plexus in that region which improves venous drainage[11]. In our previous series of posterior interosseous flap, there was a higher overall (total and partial) flap necrosis rate (10.4%) (1). While in this study flap survival rates is 97.72% (Figure 2d).

Variations can be seen during the dissection of proximal third of forearm (1,10). Dissection is easier in the middle third of the forearm both because the vascular pedicle is more superficial and also because the terminal motor branches of radial nerve to extensor muscles already penetrate extensor muscles in the proximal third (12). That's why we always include the dominant perforator, the major blood supply of this flap, which is located around the midpoint of dorsal axis line, and do not proceed pedicle dissection more proximal to the midpoint of dorsal axis line, both because we consider the reports about increase in injuries for radial nerve branches (12) and because of the increased anatomical variability in that region (10).

There is concern using the posterior interosseous artery because of variabilities in anatomy. The survival rates we obtained in reverse flow posterior interosseous flaps prove that extension of the distal edge of flap into the distal third territory enables us to include all the perforator arteries and accompanying veins into the flap from the dominant perforator around the midpoint of dorsal axis line, till the distal edge of the flap located in the distal third territory, which is important in improving flap survival rates. Avoiding pedicle dissection in the proximal dorsal forearm is important in preventing injuries to posterior interosseous nerve and its branches. However this avoidance doesn't violate flap survival. We believe that reverse flow posterior interosseous flaps are reliable in reconstruction of hand defects and the application of those operative techniques used here in this study improve flap survival rates.

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