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Reliability and Versatility of Posterior Interosseous Artery Flap in Reconstructing Hand Soft Tissue Defects

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ABSTRACT

Background: The posterior interosseous artery flap (PIAF) is indicated in the reconstruction of soft tissue defects on the 1st webspace, dorsal & volar aspect of the hand and wrist. The PIAF is a long-lasting and aesthetically pleasing solution for covering deficiencies in soft tissue when bone and/or tendons are exposed on the dorsal & palmer sides of the thumb, hand & wrist.

Objective: This research aimed to assess the PIA fasciocutaneous flap in reconstruction of hand defects in terms of aesthetic appearance, hand function & morbidity at the donor site.

Methods: This case series research was carried out on 15 cases with soft tissue hand defects. All cases underwent full history taking, clinical evaluation, laboratory investigations and radiological evaluation with plain X-rays.

Results: Regarding the scar assessment, it was good in 12 (80%) cases and fair in 3 (20%). DASH score ranged from 30-60 with a mean of 38.7±11.25. Regarding donation site problems, only 2 (13%) cases had cold intolerance and numbness. Regarding the incidence of complications, there were 1 (7%) patient had distal flap necrosis and 1 (7%) had venous congestion. The hospital stay of the studied cases ranged from 4-10 days with a mean of 6.9±1.83 day. The follow-up of the studied cases ranged from 3-6 months with a mean of 4.3±1.11 months.

Conclusions: The reverse-flow posterior interosseous artery flap (PIAF) is a reliable and versatile flap for defects resurfacing of mild to moderate size on the dorsal & palmar aspect of the hand up to the MPJ, thumb up to the IP joint & 1st web space.

Key Words: *Posterior Interosseous Artery Flap – Reliability – Versatility – Reconstructing – Hand soft tissue defects.*

Ethical Committee Approval: The research was done after approval from Institutional Review Board of Sohag Faculty of Medicine. An informed written consent was obtained from all cases.

Disclosure: No conflict of interest.

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INTRODUCTION

The relative extensiveness of soft tissue abnormalities in the hand, along with the limited amount of skin available there, makes soft tissue regeneration a difficult task for the plastic and reconstructive surgeon **[1]**. Common causes of the hand soft tissue defects include infection, deep burns, trauma & tumour removal **[2]**.

Early reconstruction and coverage of hand defects is required to minimize infection and also to facilitate speedy recovery and discharge from the hospital by means of a single, effective operation that maximises functional outcomes with shortest hospital admission. The use of regional flaps is essential in case of local flaps are insufficient to the reconstruction **[3]**.

Restoration of both function and aesthetic appearance of the hand is the main goal of soft tissue reconstruction. When used appropriately, cutaneous grafts and skin replacements can be an effective reconstructive solution for many abnormalities **[4]**. Due to advancements in free tissue transfer, doctors now have more alternatives for covering up damaged hands during reconstruction. Difficult though it may be, using forearm-based donor tissues results in superior hand reconstructions and much reduced morbidity at the donor location **[5]**.

For this purpose, for hand reconstruction, a distally based dorsal forearm fasciocutaneous flap based on the posterior interosseous artery (PIA) was presented by Zancolli and Penteado et al. **[6,7]**. The PIA flap is suitable for soft tissue defect reconstruction on the 1st webspace, dorsum, & palmar aspect of the hand and wrist **[8]**.

With the PIA flap, covering wrist and palm, volar side defects with exposed median and/or

ulnar nerve and extending the 1st webspace in situations of thumb adduction contracture are now feasible, making it a very long-lasting and aesthetically pleasing option for soft-tissue coverage of defects with exposed bone and/or tendons **[9]**.

There are two possible methods for treating the flap donation site: Primary closure or cutaneous grafting. Most importantly, significant blood vessels are protected while using this flap as opposed to others used locally and distally, such as the radial forearm flap **[10]**.

This research aimed to assess the PIAF in reconstruction of hand defects as regard to hand function, aesthetic appearance, and donation site morbidity.

PATIENTS AND METHODS

This prospective research was performed on 15 cases, with soft tissue hand defects in Plastic Surgery Department, Sohag University Hospital, Egypt.

The research was done after approval from Institutional Review Board of Sohag Faculty of Medicine. An informed written consent was obtained from all cases.

Criteria for inclusion included complicated abnormalities affecting the thumb, 1st web space, palmar & dorsal surfaces of the wrist and hand up to the PIP joint. Malformations of the hand caused by trauma, burns, tumour removal, or birth defects are typically small to moderate in size, with a maximum breadth of about 6cm & a maximum length of around 8cm. Having access to a suitable donor is also important.

Major unmanageable medical conditions, excessive smoking, donation site injuries, and hand deformities more extensive than the PIP joint were all excluded from the research.

All cases were subjected to: Full history taking including age, occupation, hand dominance, smoking, systemic illness such as diabetes and mechanism of injury, clinical evaluation includes general examination to detect any associated injuries and local examination of the hand to determine the site, shape & size of the defect, any motor or sensory deficit and availability of healthy donation site. Also, routine laboratory investigations, radiological evaluation with plain X-rays (lateral, oblique & posteroanterior views) to check the bone integrity were performed. Pre and postoperative photographic documentation were done.

Preoperative preparation and markings:

All cases were operated under general anesthesia with the patients in supine position. Broad spectrum third generation cephalosporin was administered at the time of induction. An arm tourniquet was applied after a few minutes of upper limb elevation. The elbow was bent ninety degrees, and the wrist was completely pronated. The flap's vascular axis was a straight line from the distal radioulnar joint to the lateral epicondyle of the humerus. The anterior interosseous artery and posterior interosseous artery (AIA and PIA) anastomosis was detected using auditory Doppler and designated around 2cm proximal to distal radioulnar joint on this axis. One measured from the defect's center to its edge, and then marked the flap's proximal vascular axis at the same distance. The fasciocutaneous flap center was noted approximately 9cm distal to the lateral epicondyle of the humerus.

Operative technique:

Scrubbing and disinfection with povidone iodine was performed. Following surgical debridement, a mark was made on sterile gauze to indicate the location of the defect, and this outline was then extrapolated across the proximal forearm donation site.

Flap raising:

A zigzag or lazy S-shaped incision was made in the skin, with its centre aligned with the intended flap pedicle. The fascia covering the extensor digiti minimi (EDM) and extensor carpi ulnaris (ECU) muscles was incised and a portion of this tissue was incorporated into the flap pedicle. Then, dissection was continued between the muscle and fascia until the posterior interosseous artery was exposed. The septocutaneous perforators aided in this process by directing the dissection to the tissue's base. The dissection was performed proximally while preventing damage to the posterior interosseous nerve (PIN). Cauterizing all muscle branches, the dissection was carried out proximally on the radial side of the flap design, ultimately leading to the proximal end of the flap. In order to prevent the shearing of perforators during flap manipulation, the fascia was sutured to the dermis. Next, we dissected along the ulnar side of the flap, working our way down to the wrist. After 15 minutes of clamping the artery's proximal end and deflating the tourniquet (average time was about 90 minutes), haemostasis was established, allowing for proper retrograde flow in the flap and limb perfusion. Re-inflating the tourniquet, ligating and dividing the proximal end of the artery, and then

gently elevating the flap to release the neurovascular bundle without damaging the artery or the posterior interosseous nerve. Once the whole flap has been lifted, it was set up over the defect, with drains underneath. Incisions were made in the intervening tissue to provide room for the pedicle or flap could be tunnelled through the subcutaneous tissue and set into the defect. The donation site was closed directly unless large flap >5cm in width was elevated in which split thickness cutaneous graft was required. Volar slab in 30 degrees wrist extension was applied for seven days.

Postoperative care and follow-up:

In the early stages of recovery, the flap was meticulously observed to ensure its continued health. For 7 days, the forearm and wrist were immobilized in a slab before beginning active and passive mobility. Protocol for follow-up was once a week for the first month, then once a month after that. At the end of the follow-up period, the functional result of the surgery was evaluated using the DASH (disability of the arm, shoulder and hand) outcome questionnaire. Aesthetic outcome was assessed based on scar assessment of both donor and recipient areas measured as being good, fair and poor. The existing data for all flaps were analyzed retrospectively and the outcomes assessed.

Statistical analysis:

After the data was gathered, a code sheet was made. SPSS was used for data collection, organisation, tabulation, presentation, and analysis. V25 of IBM, USA. Mean and standard deviation were used to display quantitative data (SD). Frequency and percentage presentations of qualitative variables were used.

RESULTS

Regarding scar assessment, it was good in 12 (80%) cases and fair in 3 (20%). DASH score ranged from 30-60 with a mean of 38.7±11.25 and this indicates the good functional outcomes of PIAF. Regarding donation site problems, only 2 (13%) cases had cold intolerance and numbness. Regarding the incidence of complications, there were 1 (7%) patient had distal flap necrosis and 1 (7%) had venous congestion. The hospital stays of the studied cases ranged from 4-10 days with a mean of 6.9±1.83 day. The follow-up of the studied cases ranged from 3-6 months with a mean of 4.3±1.11 months. And Table (1) shows demographic data, Aetiology, Site of lesion, Duration of surgery, Defect and flap size of the studied cases.

Table (2) shows scar assessment, DASH* score, Donation site problems, complications, hospital stay and follow-up of the studied cases (n=15).

Table (1): Demographic data, Aetiology, Site of lesion, Duration of surgery, Defect and flap size of the studied patients (n=15).

	n=15
Age (years)	29.20±11.11
Sex:	
Male	12 (80%)
Female	3 (20%)
Aetiology:	
Post-traumatic contracture	1 (7%)
Electrical burn	2 (13%)
Sharp object	3 (7%)
Motor car accident	4 (60%)
Machine injury	2 (13%)
Site:	
Dorsum of the right hand	4 (27%)
Dorsum of the left hand	6 (40%)
Ulnar side of left hand	1 (7%)
Left palm	2 (13%)
Right palm	2 (13%)
Duration of surgery (minutes)	140.7±10.33
Defect size (cm)	6.3±1.44 x 4.53±0.99
Flap size (cm)	7.3±1.44 x 5.60±0.97

Data are presented as mean ± SD or frequency (%).

Table (2): Scar assessment, DASH* score, Donor site problems, complications, hospital stay and follow up of the studied patients (n=15).

	n=15
Scar assessment:	
Good	12 (80%)
Fair	3 (20%)
DASH score	38.7±11.25
Donor site problems:	
Cold intolerance and numbness	2 (13%)
Complications:	
Distal flap necrosis	1 (7%)
Venous congestion	1 (7%)
Hospital stay (day)	6.9±1.83
Follow-up (months)	4.3±1.11

Data are presented as mean ± SD or frequency (%).

Case Presentation:

Case (1): 29-year-old male patient with post-electrical burn raw area on the left-hand ulnar side reconstructed with distally based PIA flap (Fig. 1).

Case (2): 14-year-old male patient with post burn adherent scar on the dorsal aspect of right hand resulting from coverage of previous traumatic raw area with STSG. Excision of the scar and reconstruction by distally based PIA flap (Fig. 2).

Fig. (1): Case No. 1 (A): Preoperative, (B): Two weeks postoperative, note direct closure of the donation site, (C): Three months postoperative.

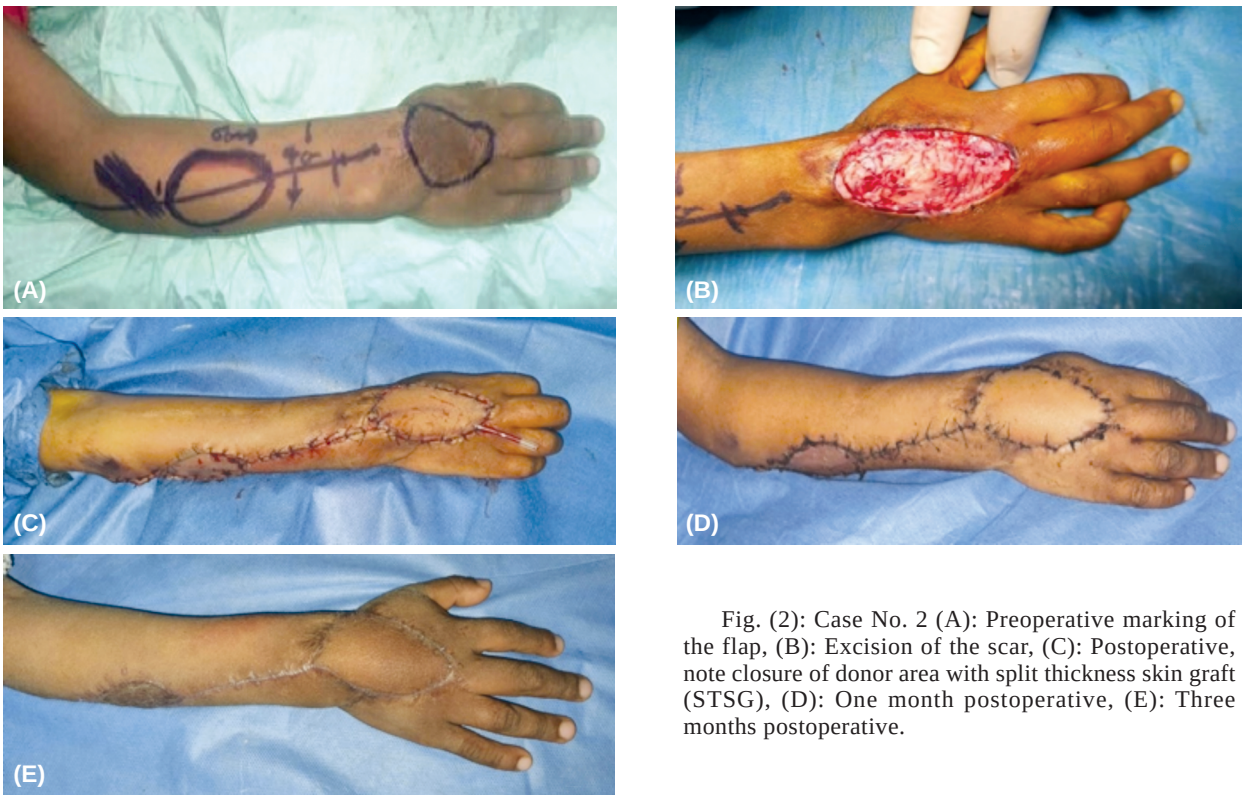

Fig. (2): Case No. 2 (A): Preoperative marking of the flap, (B): Excision of the scar, (C): Postoperative, note closure of donor area with split thickness skin graft (STSG), (D): One month postoperative, (E): Three months postoperative.

Case (3): 18-year-old female patient with traumatic raw area on the dorsal aspect of left hand with exposed extensor tendons resulting from motor car accident. Reconstruction by distally based PIA flap was done (Fig. 3).

Fig. (3): Case No. 3 (A): Preoperative: Site of defect and preoperative markings, (B): Intraoperative; the perforator to PIA flap is marked by forceps, (C): Intraoperative; flap raising on its pedicle, (D): Immediately postoperative; closure of donor site with STSG, (E): Three months postoperative.

DISCUSSION

In 1986, Lu et al. **[11]** and Penteado **[7]** reported the reverse posterior interosseous artery flap (PIAF) for the first time in English literature. Plastic and hand surgeons have shown widespread interest in the reverse flow PIAF since its report.

A distally based flap should not be used in the proximal one-fourth of the forearm since this is the area of the recurrent IA according to Penteado et al., **[7]**. This is why while depicting the skin island, 6 centimetres of the proximal forearm were left off. For example, in 74 of 80 cases, the PIA was found to be at its narrowest in the middle part of the forearm as described by Angrigiani et al., **[12]**.

It is important to keep in mind that if blood flow remains unreliable despite the aforementioned efforts or if it is difficult to preserve PIN motor branch, then further venous anastomosis can be performed **[13]**.

In this research, males outnumbered females in ratio of 4:1. This male preponderance was also seen in the series of authors including Costa H et al. **[15]**, and Dap F et al. **[16]**, and this can be explained by higher incidence of hand injuries in males.

In this research extension of the distal incision beyond the safe point of 2cm proximal to the distal radioulnar joint was avoided to prevent damaging the anastomosis between the anterior and PIA

which is regarded as the most important anastomosis in the wrist for survival of this flap.

In this research, the smallest one was 5 x 4cm & largest flap was 9 x 7cm. In Costa's series **[15]**, the size of the cutaneous flaps ranged from 5 x 4cm to 14 x 9cm. The donation area was immediately sealed with 3-5cm-wide flaps, while larger flaps required cutaneous grafting of the donation site; this is also noted by Brunelli **[17]**. Direct closure of the donation site in two cases was performed in this research. In Landi A. **[18]** research, series of 8 cases, primary donation sites has always been possible.

All flaps survived completely except in two cases; one of them developed distal flap necrosis and the other suffered from venous congestion. The two cases resolved completely during follow up. Dap **[16]** observed partial necrosis in 7 (21%) of the 34 flaps caused by venous congestion, while Chen H. et al. **[19]** reported a failure rate of 21.3%. (3 out of 14 flaps). This can be explained by not dissecting the pedicle more than 2cm proximal to the wrist joint to preserve as much distal anastomosis as possible for the retrograde perfusion, which actually limit the flap use to defects not distal to the metacarpophalangeal joints of the fingers.

Weak wrist and fingers extension occurred in one case who was followed by nerve conduction research and was found to be neuropraxia as a complete recovery of nerve function was achieved within 4-6 weeks from the time of operation.

The long-term follow-up show good flap durability and elasticity, acceptable appearance, good texture for skin resurfacing as reported also by Zancolli et al., **[12]**.

There have been reports of a variety of techniques for preventing venous congestion, as covering the vascular pedicle with intermuscular septa and muscle fascia or surgically connecting subcutaneous veins to veins at the recipient site. By incorporating them into the flap pedicle, protection of the flap is obtained **[20]**.

If the wound could not be closed directly, a skin transplant was used right away in our trial. Haemostasis is performed meticulously before a skin transplant is applied. The donation site was covered with 1/100,000 epinephrine-soaked gauze. Adrenaline's potential to cause vasoconstriction has led to speculation that it might improve cutaneous graft take by reducing donation site oedema. The prevention of haematoma development is another benefit.

When 2 perforators are used, as in this series, the flap may be simply and comfortably fitted up to the base of the fingers by extending the wrist joint.

The distally based PIA flap has undergone a number of refinements on a technological level. The teardrop shape of the flap is meant to mimic the pedicle. After a 180-degree rotation, the flap's pointed end nestles between the cutaneous flaps raised by breaking the skin bridge between the donor and recipient locations. When the flap must travel a great distance, a tennis racket-shaped flap is formed on the dorsal aspect & ulnar border of the hand (towards the palm), with the "handle" corresponding to the long pedicle. The racket-shaped handle is incised through the connecting bridge of skin, and then inserted into the resulting defect **[13]**. As a result, the whole length of the flap can be utilised, rather than being trimmed down to accommodate surrounding healthy tissue.

The posterior interosseous nerve can be damaged during dissection of a reverse flow posterior interosseous flap, because the architecture of the human body varies from patient to patient. In comparison to the radial forearm distally based flap, this one has a smaller surface area, a longer learning curve, and a higher risk of venous congestion during flap elevation. Because the venous circulation is preserved and pressure on the pedicle is prevented in the event of skin tension, hematoma, or oedema, elevating the flap in this manner may be preferable to the original approach. The most significant drawback is the visible donor-site cutaneous graft. However, only the wounded limb is affected by the deformity **[21]**.

The reverse PIAF has certain advantages, including a skin paddle of high quality that conforms to the volar wrist, hand dorsal aspect, and dorsal aspect of the thumb. Furthermore, since this is a relatively minor conduit in the hand vascular supply, it is possible to harvest flaps of moderate to large size to cover these regions **[22]**.

Conclusion:

The reverse-flow anastomosis is a reliable and versatile flap for resurfacing of mild to moderate size defects on the dorsal aspect and palmar aspect of the hand up to the MPJ, first web space and thumb up to the IP joint. Paying strict attention to technical obstacles, as avoiding anastomotic arc dissection between the anterior & posterior inter-

osseous arteries and performing a proximal-distal flap dissection using the deep fascia, and avoiding its tunnelling for inset, will contribute to flap survival.

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