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Posterior interosseous artery flap in soft tissue reconstruction of forearm and hand injuries: Prospects and perspectives

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Abstract

Background: Trauma to the distal upper limb involving hand, wrist and forearm is common. While the search for ideal soft tissue coverage technique is ongoing, posterior interosseous artery (PIA) flap seems to be an effective approach, however, research work is limited.

Objectives: The aim of this study was to describe indications, effectiveness and post-operative morbidity of the PIA flap in providing soft tissue cover to hand, wrist and forearm.

Material and Methods: This is a prospective study of 30 patients during a period of five years, who presented with various aetiologies with loss of soft tissue over the distal dorsal hand, wrist and forearm and were followed-up for maximum of 27-months. All patients between 18 and 60 years of age who required soft tissue reconstruction of their distal upper limbs were included from both genders. Primary end-points were effective coverage and flap take-up.

Results: 30 patients were included with 20(66.7%) males and 10(33.3%) females with a mean age of 34.7±7.8 years (range: 21 to 52 years). The most common anatomical area involved was the dorsum of the hand and thumb (6, 20% each) followed by skin loss in first web space and wrist (5, 16.7% each) with 4(13.3%) cases of wrist injury and 2(6.7%) cases each of palmar aspect of hand and forearm. The mean wound area was 16.1±6.8 cm2 (range: 6 – 32 cm^2). The largest defects (32 cm^2) were present on dorsum of the hand and first web space. Complete flap survival without any untoward event was noted in 25(83.3%) cases while 5(16.7%) cases showed marginal necrosis. Flap oedema was noted in 6(20%) cases.

Conclusion: The flap survival rate is excellent with only minor complications which respond to conservative measures. Cosmetic and functional results are satisfactory both for the patient and the surgeon.

Keywords: hand surgery, pedicled flap technique, posterior interosseous flap, skin and soft tissue loss of the distal upper limb involving hand

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Introduction:

Distal upper limb injuries are common and loss of skin, muscle and bone loss is observed frequently in violent trauma of diverse aetiologies.[1] The commonest aetiologies of hand and forearm skin loss is trauma followed by burns and soft tissue tumour resection. Smaller defects (less than 1x1cm) are usually left to heal by secondary intention, however, larger defects necessitate soft tissue coverage.[2] The introduction of local fasciocutaneous flaps reconstruction of the hand and forearm have improved outcomes. Posterior interosseous artery (PIA) flap is the leading technique in hand and forearm coverage due to the preservation of normal blood and nerve supply distally. This flap has been used in coverage of defects of up to 45cm.[2,3]

The PIA flap was introduced by Zancolli[4] and Angrigiani[5] and received widespread acceptance due to the preservation of major forearm and hand vessels such as radial and ulnar artery. Another advantage was superior flap survival

Table-1: SStudy sample, patient demographics with clinical parameters

No	Age	Gender	Injury type	Site	Area (cm^2)	Flap status	Complication
1	37	Male	RTA	Dorsum	15	Survival	Congestion
2	24	Male	RTA	Dorsum	32	Margin. Nec	-
3	28	Male	RTA	Dorsum	30	Survival	-
4	39	Male	RTA	Dorsum	19	Survival	-
5	40	Male	RTA	1st Web	20	Survival	-
6	29	Male	RTA	1st Web	12	Survival	-
7	24	Male	RTA	1st Web	13	Margin. Nec	-
8	27	Male	RTA	Thumb	21	Survival	-
9	41	Male	RTA	Thumb	27	Survival	Congestion
10	37	Male	RTA	Thumb	8	Survival	-
11	44	Male	RTA	Thumb	28	Survival	-
12	35	Male	RTA	Palm	18	Survival	-
13	29	Male	RTA	Palm	18	Survival	-
14	32	Male	Electric	Palm	6	Survival	-
15	35	Male	Electric	Wrist	8	Survival	-
16	42	Male	Gunshot	Wrist	10	Margin. Nec	Infection
17	49	Male	Gunshot	Wrist	12	Survival	-
18	52	Male	Gunshot	Wrist	15	Survival	Congestion
19	21	Male	Blast	Palm	14	Survival	Congestion
20	26	Male	Blast	Finger	18	Survival	Congestion
21	29	Female	Blast	Forearm	19	Survival	-
22	28	Female	Flame burn	Forearm	20	Survival	-
23	38	Female	Flame burn	Dorsum	22	Survival	-
24	35	Female	RTA	Dorsum	15	Survival	-
25	36	Female	RTA	1st Web	12	Margin. Nec	Infection
26	40	Female	RTA	1st Web	10	Survival	-
27	42	Female	RTA	Thumb	9	Survival	-
28	45	Female	Gunshot	Thumb	8	Margin. Nec	Infection
29	29	Female	Blast	Palm	11	Survival	-
30	28	Female	Flame burn	Wrist	13	Survival	Congestion

rate and reach was quite extensive as it was possible to provide skin coverage from elbow to the thumb and palm of hand. Further modifications have been presented with similar success rates. These modifications include reverse PIA flap which can reach farther distally, and reports have shown successful coverage of dorsum of hand and first phalanx of thumb on the dorsal aspect.[6,7] The distal island modification of this technique allows easy closure of the donor area with preservation of the micro-vasculature and coverage of distal forearm and hand. The critique of this technique include high rates of anatomical variabilities, shorter pedicle length in the reverse technique and higher rates of venous congestion due to compromise of the venous drainage.[8]

The current study presents our experience with the PIA flap technique in all of its variations as indicated for various types of skin defects in the hand, wrist and forearm.

Material and Methods:

This is a prospective study conducted at the Plastic & Reconstructive surgery ward, Hayatabad Medical Complex, Peshawar and our private clinic at Zia Medical Complex, Peshawar between January 2012 and December 2016 (60-months). All patients were included according to the declaration of Helsinki, where all patients provided informed consent before undergoing any invasive procedure. We included patients with forearm, hand and wrist injuries of various aetiologies between 18 and 60 years of age. Patients with diabetic or ischaemic ulcers, coagulopathies and extensive degloving injuries unsuitable for PIA flap were excluded.

Pre-operative history, physical examination radiological and laboratory tests were used to exclude concomitant comorbidities, as well as to optimise the patients before undergoing surgery.

The axis of the flap extends from the lateral epicondyle of humerus through the distal radioulnar joint. The PIA emerges from the inferior edge of the supinator muscle overlying the interosseous membrane and the dominant perforator lies 2cm distal to the midpoint on this line. All of these landmarks were marked with an

Figure. 1: A) First web contracture with scarring extending into thenar eminence. B) Release of contracture. C) 2 months post-operative views of posterior interosseous artery flap coverage

Figure. 2: A) Pre-operative view FAI injury to first web leading to tissue loss and fracture of thumb metacarpal. B) Immediate post op of islanded PIA flap. C) 3 weeks post-operative view

Figure. 3: A) Firearm injury to first web leading to soft tissue loss. B) Post-operative views of PIA flap coverage

indelible marker before surgery. All procedures were performed under general anaesthesia by a team of plastic surgeons.

The patient was placed in a supine position with careful antiseptic application and draping the affected upper limb followed by positioning the affected forearm either abducted and pronated or flexed at elbow on to chest by placing a folded towel under forearm. Before commencing the dissection, the wound was thoroughly debrided, and a size estimation was again performed to design a matching flap. Tourniquet was applied during the dissection and identification of the vessels and nerves. Dissection was started at the ulnar border of the flap. Here fascia are dissected sharply until extensor carpi ulnaris (ECU) and extensor digiti minimi (EDM) were reached. The septum between these two muscles was identified. The dissection is then performed from the radial side to raise a fasciocutaneous flap. Proximal incision and identification of the PIA is performed in a retrograde manner. For a reverse PIA flap, the identification of distal perforator branches is performed. The flap is rotated towards the recipient site and the pedicle is tunnelled sub-cutaneously taking care not to kink it. In cases where osseous and musculo-tendinous transposition was required, the middle to distal one third of ulna without inclusion of the distal radioulnar joint can be fashioned to form the thumb, metacarpal or carpal bones as required.

Data was collected about patient demographics, size of the defect (centimetre square), follow-up duration (months), flap survival and complications. This data was entered and analysed in SPSS version 22.0. Continuous variables are presented as mean±standard deviation. Frequency tables are presented to reflect patient characteristics, flap survival and complications.

Results:

30 patients were included with 20(66.7%) males and 10(33.3%) females with a mean age of 34.7±7.8 years (range: 21 to 52 years). There were 17(56.7%) cases due to road traffic accidents (RTA), 2(6.7%) cases due to electric burns, 3(10%) cases due to flame burns, 4(13.3%) cases due to gunshot wounds and 4(13.3%) due to blast injury.

The most common anatomical area involved

Figure. 4 A) Soft tissue defect of dorsum of hand secondary to road traffic accident. B) Immediate post-operative view of PIA flap coverage. C) 10 days post-operative view

Figure. 5 A) Crush injury of hand leading soft tissue defect of hypothenar eminence of palm. B) Post-operative view of PIA flap coverage. C) 3 months post-operative view

was the dorsum of the hand and thumb (6, 20% each) followed by skin loss in first web space and wrist (5, 16.7% each) with 4(13.3%) cases of wrist injury and 2(6.7%) cases each of palmar aspect of hand and forearm.

The mean wound area was 16.1±6.8cm^2 (range: 6 – 32 cm^2). The largest defects (32 cm^2) were present on dorsum of the hand and first web space. The donor skin area was closed with split skin graft (SSG) in 24(80%) cases while the remaining 6(20%) cases were closed primarily. No donor area complications were noted. Table 1

Complete flap survival without any untoward event was noted in 25(83.3%) cases while 5(16.7%) cases showed marginal necrosis which were left to heal with secondary intention. Of the 5 cases of marginal flap necrosis, three were diabetic and 2 had history of smoking. Three of these patients had infection (Methicillin resistant staphylococcus aureus on C/S) which responded to antibiotics and two patients responded to conservative measures within two weeks and were left to heal with secondary intention.

Flap congestion and oedema was noted in 6(20%) cases. All cases with flap congestion subsided with conservative therapy (limb elevation, dressing modification) within one week postoperatively.

Discussion:

Hand is the functionally most mobile area of the human body and so is its involvement in devastating injury. Functional and structural preservation of hand function is of utmost importance due to the disability it incurs by loss of function. The PIA flap has a very unique value in hand and forearm reconstruction due to its diverse neurovascular supply.[9] The PIA flap depends on the retrograde flow from the dorsum of the wrist and forearm as well as the communicating branches of the radial and ulnar arteries.[10] The anatomy of this flap is well defined and the neurovascular landmarks fairly constant in their location with little anatomical variations. Some commonly cited anatomical variations described in the literature are the PIA origin at middle forearm, narrowing of PIA in middle forearm and occasional absence of anastomotic branches with the anterior interosseous artery.[11] In our study we did not encounter any anatomical variations and we encourage the use of this flap because the vascular anatomy is fairly constant and inclusion of at least two perforators gives best results.

This flap utilisation is commonly criticised across studies for higher rates of venous congestion in the graft.[12] The reason however, does not relate to the flap neurovascular anatomy but it seems that inclusion of the subcutaneous draining veins lead to congestion as well as injuring the smaller venae comitantes. Costa et al[13] in a review of 81 cases described PIA flap in majority of dorsal hand defects with more than 93% success rate without any untoward events. Similarly, Puri et al,[14] has described 25 cases with various causes of trauma. The most common cause of injury to the hand was in RTAs which is in agreement with our study. Patient demographics of our study are largely in agreement with our study with majority of young males involved in industrial type of injuries.

The technique described by majority of authors

is to provide cover in dorsal hand injuries involving but not limited to the first web-space and fingers. Ashok Gavaskar[15] in a series of 32 patients performed the PIA technique where majority of the injuries involved the dorsum of the hand and the first web space mostly involving the dominant hand in young males. This is in agreement with our study.

Most common complication for this technique is oedema, congestion and marginal flap necrosis.[7,12,16] The most common reason cited is injury to the perforators, kinking of the pedicle and obstruction of the venae comitantes. In our study, similar findings were noted where there were 5 cases of post-operative congestion. However, these cases resolved with limb elevation within the first two weeks post-operatively. The overall cosmetic and functional results as presented by Gavaskar[15] in his case series are encouraging. In our study, we obtained nearly 95% cosmetic and functional outcome at six months follow-up, which is in agreement with the above mentioned study. Similar results are presented by Liu et al,[17] who used the PIA flap to repair digital defects.

The limitations of our study are its smaller samples size, and experience from a single team of plastic surgeons. These can be ameliorated by designing a large scale multicentre study to analyse the utility of this flap in hand and wrist defects as well as its complications and their management.

Conclusions:
Soft tissue defects are common following trauma and burns. The posterior interosseous artery flap is a versatile technique to provide soft tissue and skin cover for these defects and is a very useful technique in the armamentarium of a plastic surgeon with expertise in hand surgery. The flap survival rate is excellent with only minor complications which respond to conservative measures. Cosmetic and functional results are satisfactory both for the patient and the surgeon.

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Role and contribution of authors:
Dr. Rashid Khan, conceived the idea, collected the data and references and did writing of manuscript

Dr. Habibullah Shah, collected the references and helped in introduction writing

Dr. Huma Gul, collected the data and references and helped in discussion writing.

Dr. Muhammad Salman Khan, collected the data and references and critically review the article

Dr. Atifullah Khan, collected the references and critically review the article

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