

Original Article

Reverse Flow Posterior Interosseous Flap for the Reconstruction of Soft Tissue Defects in Electrocuted Wrist

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Objective: To describe experience with the reverse flow posterior interosseous island flap for reconstruction of mutilating ectectically injured wrist.

Study Design: Prospective case series study

Place and duration: Department of Plastic Surgery and Burn Unit Nishtar Hospital, Multan from June 2005 to June 2010

Materials and Methods: 25 Posterior Interosseous Artery Flaps in 22 patients, as in 3 patients PIA flap was done bilaterally, for the coverage of wrist defects secondary to electrocution. After resuscitation and multiple debridements when wound was ready and patients were stable Posterior Interosseous Artery Flaps were done.

Results: The flaps survived in all patients with a marginal loss over the distal edge of the flap was noted in one patient. Regarding the donor site morbidity only one case had partial STSG loss.

Conclusion posterior interosseous flap is a versatile, reliable and a very useful regional tool for the coverage of electrocuted wrist defects.

Key Words posterior interosseous flap

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Introduction

Any injury to the hand carries the potential for serious handicap. High tension electrical injuries result in major tissue destruction. Electrical injuries in the wrist region create many problems for both patient and surgeon. The involvement of various anatomical structures (e.g. bones, tendons, vessels and nerves) and the depth of the lesions jeopardize hand function. In such conditions early soft tissue cover is required.¹

There are many options to cover defects of electrically burned wrist. The choice lies between using a distant flap or free flap using microvascular techniques or a local flap. Free flaps are time consuming; require specialized equipments and intensive post operative care. Distant flaps may require multiple stage reconstruction, prolonged hospitalization and immobilization. Single stage procedure to reconstruct soft tissue defects of hand minimize infection, allow early mobilization and reduce hospital stay. If the local flaps are insufficient to meet the requirement then regional flaps need to be used.

Distally based island fasciocutaneous flaps like Radial forearm flap^{2,3} and Ulnar artery forearm flap^{4, 5} are popular for soft tissue coverage of hand although with clear disadvantage of sacrificing a major artery of hand.

The posterior interosseous artery flap is a type B fasciocutaneous flap according to the Cormak and Lamberty classification⁶ reported by Laijin et al⁷, Zancolli⁸, Penteado et al.⁹ (1986), Masquelet and Penteado¹⁰, and Costa and Soutar¹¹ for reconstruction of hand defects. Its main advantage is that it avoids sacrificing the two main arteries forearms. This flap can be proximally or distally based as an island flap. Osteofasciocutaneous variety of the posterior interosseous flap was described by Costa et al¹² in 1988 for reconstruction of thumb defects. Now it has been considered as the workhorse for coverage of skin defects over distal forearm, wrist and hand.

In this paper, we described our experience with the reverse posterior interosseous island flap for reconstruction of mutilating ectectically injured wrist.

Materials and Methods

This prospective study was conducted in the Department of Plastic Surgery and Burn Unit Nishtar Hospital, Multan from June 2005 to June 2010. We have performed 25 Posterior Interosseous Artery Flaps in 22 patients, as in 3 patients PIA flap was done bilaterally, for the coverage of wrist defects. Our study plan was approved by the ethical committee of our institution. All the necessary information regarding this was given to all the patients and attendants. A written consent was obtained from the patients/parents or guardians. During that study period all the details of patients regarding their medical report, operative notes, pre and post operative photographs, duration of hospital stay and outcome were filed individually. All the data was analyzed using SPSS 10 software to calculate Descriptive statistics.

25 flaps were performed in 22 patients as in 3 patients PIA flap was done bilaterally. In this study we included those patients who had a soft tissue defect at the wrist exposing the underlying structures and at least one of the major artery of hand (Ulnar or radial) spared. We excluded following patients

- 1- Both the major arteries of hand (Ulnar and radial) are involved
- 2- Medical co-morbidities.
- 3- Debilitated and Very old patients.
- 4- Other associated injuries (fracture of the bones of forearm on the same side)
- 5- Extensive electrical burns

All of these patients reported in A & E Department Nishtar Hospital Multan, where patients were received. After initial evaluation and resuscitation of patients Initial debridement was done in A & E Department. These patients were shifted to the ward after the patients were resuscitated and initial debridement done along with fasciotomies where indicated. In the mean time all the efforts were made to exclude the systemic complication of electrical burn. In the ward strict intake and output monitoring was done. We took the help of Laboratory to exclude myoglobinuria. Patients were kept on cardiac monitor for next 48 hours. After that time a second look of the wound was done under General anesthesia. Extensive debridement was done that time. Daily dressing was done. Until the situation of wound was clear, repeated debridements were done. We did the flap coverage after 2-4 weeks.

Vascular Anatomy: The posterior interosseous artery (PIA) originates from the common interosseous artery at the proximal forearm in 68% to 94.3% of the cases [9, 13, 14, and 15]. Less frequently, it originates from the Ulnar artery directly. [13] It usually has two venae comitantes. After passing between the chorda obliqua and the interosseous membrane, the posterior interosseous vascular pedicle emerges in the deep

extensor compartment of the forearm, below the distal edge of the supinator muscle and in close relation with the posterior interosseous nerve. In the posterior compartment it gives recurrent interosseous branch, which anastomoses with the terminal branches of profunda brachii artery. The posterior interosseous vascular pedicle then runs in the intermuscular septum between the extensor carpi ulnaris and the extensor digiti minimi. At about 2.5 cm proximal to the ulnar styloid, the PIA is joined by a branch from the anterior interosseous artery.[11] It finally ends on the dorsal aspect of the carpus where it participates in the dorsal carpal arch.

In electrical trauma of the wrist region, when complete destruction of the radial and ulnar arteries occur vascularisation of hand is possible by means of the interosseous system, particularly through the posterior interosseous artery. So in our study we included those patients who had at least one named artery (ulnar or radial artery) spared from the electrical trauma.

Surgical Technique: Preoperatively we performed hand held Doppler in all cases as a part of essential clinical examination of flap to locate the cutaneous perforators. Doppler is an extremely useful tool in marking the major central skin perforator. No false positive result was found in our study. The importance of Doppler was many folds in electrical burns where there is issue of patency of one of major arterial channel of hand. Our recommendations are to use Doppler as an essential tool in the PIA flap.

Patient is placed supine and surface marking of the posterior interosseous artery is drawn along a line joining the lateral epicondyle of humerus and the ulnar styloid with the forearm in mid pronation. A point 9cm distal to the lateral epicondyle of humerus marks the centre of the fasciocutaneous element of the flap. In initial 5 cases we followed the original operative technique as described by Zancolli and Angrigiani. In this Technique the dissection starts by making an incision along the line proximal to the pivot point to ascertain the presence of distal PIA communication with the anterior interosseous artery (AIA). If there is any doubt about this vessel, the operation is aborted and the patient receives only a small incision on the forearm. However later on we modified it as we ascertained the presence of anastomosis between PIA and AIA by Pre-operative Doppler. After making Doppler study we straight away elevated flap that saved our operative time. This was also described by Puri V et al.¹⁶ We also included a generous sleeve of fibro fatty tissue on each side of pedicle Fujiwara et al. had similar recommendations in his study.¹⁷

Flap size varied in width 2-8cm and in length 4-14cm in our study. We raised smallest flap of 2-4cm size and flaps of largest dimensions in our study was

14x8.5cm (1 case) and 14x7cm (3 cases). In 2 cases we closed donor site primarily where defect size was < 4 cm otherwise in remaining cases we grafted the donor area. Route of transposition of our flaps were "Tunneling" in 08 cases. Otherwise in remaining cases we opened the skin bridge for flap transposition.

We immobilized wrist and hand post operatively for 14 days and removed all stitches / staples all 8 to 10 days post operatively. Post operatively we monitored the flap survival clinically based on skin colour, temperature, skin turgor, capillary refill and colour of blood and pin prick. These assessments were done 6 hourly for first 24 hour and later on 8 hourly for 4 days next.

All the patients were followed up weekly in the first month, then monthly afterwards. During the follow up period we recorded the flap progression and its outcome. During that period details with photographs were recorded in individual files. Among 22 patients 20 patients were available for follow up for 6 months or more. Among remaining 2 cases, 1 patient was followed up for 2 month or less and 1 patient never came for follow up.

Results

Demographic characteristics of the patients included in this study have been given in table I. Among 22 patients all were males except 2 females. The ages ranged from 11 to 45 years. Of 22 patients 20 had high voltage electrical trauma. In all these patients negligence was a sole factor of all these accidents.

Patients had low voltage current accidents. Out of 22 patients, 16 patients had injury on right wrist, in 3 patients there was bilateral involvement of wrist and in 3 patients only left side was involved. Most of the patients in our series were operated between 3rd and 4th week of injury. Earliest operation was done after 2nd week and maximum delay was 4.5 weeks.



Figure I: Electrical injury of the patient having injury to wrist



Figure II: Reverse flow posterior interosseous flap showing a marginal necrosis (treated with flap advancement, suturing)



Figure III: Bilateral Reverse flow posterior interosseous flap (post operative 2 weeks)



Figure IV: left hand of the same patient (figure III)

Table I: Demographic Characteristics of Patients

Patients	Age (years)	Sex	Low voltage / high voltage	Nature of soft tissue defect at volar wrist	Side	Operation after injury	Flap size (cms)
1	23	M	high voltage	Exposed tendons/amputation of little finger	Right	3 weeks	12x6
2	25	M	high voltage	Exposed tendons/ amputation of index and little finger partial gangrene of the ring finger	Right	2 weeks	11x5
3	34	M	high voltage	Exposed tendons/ median nerve/ partial gangrene of the thumb and ring finger	Right	3 weeks	14x6
4	22	M	high voltage	Exposed tendons	Right	3 weeks	12x5
5	15	M	high voltage	Exposed tendons	Right		15x6
6	22	M	Low voltage	Right side. Exposed tendons and partial gangrene of the middle finger	bilateral	3 weeks	Right side. 12x6 Left side. 13x6
7	11	M	high voltage	Exposed tendons	Right	4.5 weeks	4x8cm
8	34	M	high voltage	Exposed tendons/radius bone/radial artery involved	Right	4 weeks	12.5x6
9	27	M	high voltage	Exposed tendons	Left	2.5 weeks	14x7
10	28	F	Low voltage	Exposed tendons/nerves	Right		14x8.5
11	45	M	high voltage	Exposed tendons/bone/ amputation of all fingers	Right	3 weeks	12.5x5
12	44	M	high voltage	Exposed tendons ,radial artery involved	Right	4 weeks	11x5
13	34	M	Low voltage	Exposed tendons	Left	3 weeks	10x6
14	37	F	Low voltage	Exposed tendons	Right	3 weeks	12x5
15	38	M	Low voltage	Exposed tendons/ amputation of little finger, partial gangrene of the ring finger	Right	4weeks	13x6
16	29	M	high voltage	Right side. Exposed tendons and nerve Left side. Exposed tendons	bilateral	3 weeks	Right side. 12x6 Left side. 13x5
17	23	M	high voltage	Exposed tendons/ partial gangrene of the ring finger, thumb	Right	2.5 weeks	10x6
18	24	M	high voltage	Right side. Exposed tendons and partial gangrene of all the fingers Left side. Exposed tendons with amputation of thumb and index fingers	bilateral	3 weeks	Right side. 10x6 Left side. 12x6
19	21	M	high voltage	Exposed tendons/ amputation of thumb	Left	4weeks	
20	24	M	high voltage	Exposed tendons	Right	3 weeks	11x6
21	27	M	high voltage	Exposed tendon with scar at the wrist	Right	3 weeks	12.5x5
22	30	M	high voltage	Exposed tendons/ median nerve/	Right	4weeks	10x6

The flaps survived in all patients. Although marginal loss over the distal edge of the flap was noted in one patient (Patient 7). This was managed with flap advancement and suturing. Mild oedema developed in all patients and subsided over a time of two weeks except in one (Patient 5) where oedema was moderate and subsided in about three months. None of our cases showed any evidence of venous congestion. Regarding the donor site morbidity only one case had partial STSG loss. Few examples of our patients are shown in figures I, II & III.

Discussion

It is reported that electrical burns constitute between 0.04 % to as high 32.2 % of admissions to major burn centers.¹⁸⁻²¹ Mortality rates are significant with these type of injuries as high as 59 %. electrical burns account for approximately 1000 deaths each year in United States, 5th most common cause of occupation death.¹⁹ Although the hand accounts for only 2.5–3% of the total body surface area, it is involved in up to 80% of treated burn injuries.^{22,23} For coverage of soft tissue defects of wrist in electrical trauma numerous options exist. The Fasciocutaneous flaps like Radial, Ulnar and PIA forearm flaps has proved to be simple versatile and reliable in reconstruction of great variety of soft tissue defects of hand and wrist. Posterior Interosseous Artery Flap is extremely useful and superior because it preserves vascularity of hand. The distally based posterior Interosseous artery flap depends on retrograde flow from complex vascular arcade at the level of dorsum of wrist between the Posterior Interosseous Artery and the dorsal branches of radial and Ulnar arteries.

Several authors⁹⁻¹¹ have described rare anatomical variations in posterior Interosseous artery anatomy like: Failure of the middle third of the posterior Interosseous Flap, Absence of anastomosis between recurrent dorsal branch of anterior Interosseous Artery and Posterior Interosseous Artery at the level of middle third of the posterior forearm, Narrowing of PIA in middle third of forearm, and Termination of PIA in the middle third of the forearm. However we did not find any anatomical variation in our study.

Zancolli and Angrigiani⁸ recommended primary closure of donor side only when the flap raised is 3-4 cm wide. We followed the same described by Zancolli.

Regarding complications we have had no complete loss of flap in any of our cases. In one case only marginal superficial flap necrosis occurred was managed with flap advancement and suturing. This is similar to the series of Zancolli and Angrigiani⁸ who reported no complications whatsoever in their series of 25 cases. Masquelet and Penteado [9] reported only one case of partial necrosis of flap in their series of eight

cases. Costa and Souttar¹¹ in their series reported only three cases of venous congestion but on flap necrosis. In our series, preoperative assessment of the anastomotic branch, continuity of the PIA and the presence of perforators was done by Doppler study. We recommend that Doppler is essential in preoperative planning as it not only shorten tourniquet time but it also save tedious and exhausting dissection.

Conclusion

PIA flap is a versatile reliable and a very useful tool for the coverage of large varieties of hand and wrist defects. Though elevation of this flap is tedious but it is a number one option to cover soft tissue defects in the wrist secondary to electrical injuries.

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