

Versatility and Dependability of Posterior Interosseous Artery Flap in Hand Soft Tissue Defect Reconstruction

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Abstract:

Objectives: The study aimed to assess the efficacy of the distally based dorsal forearm fasciocutaneous flap utilizing the posterior interosseous artery in soft tissue reconstruction for hand defects, to evaluate its functional and aesthetic outcomes.

Methods: A prospective study spanning for over a year was conducted at Patna Medical College and Hospital in Patna, Bihar, India on 30 patients with soft tissue hand defects, employing a comprehensive approach to assess factors such as age, occupation, hand dominance, smoking habits, systemic ailments, and injury mechanisms. The surgical intervention involved utilizing the distally based dorsal forearm fasciocutaneous flap based on the posterior interosseous artery (PIA), with preoperative preparation, markings, and operative techniques meticulously outlined.

Results: The study, comprising 30 individuals with an average age of 31.28 years, predominantly included males (80%). Vehicle accidents were the most common cause of hand injuries (27%), with the dorsum of the left hand being the primary injury site (40%). Scar assessment revealed 80% of cases had a 'good' outcome, while the mean DASH score was 35.14, indicating satisfactory functional results. Donor site problems occurred in 13% of cases, and post-surgery complications included a 7% incidence of distal flap necrosis and 7% experiencing venous congestion, with an average hospital stay of 7.1 days.

Conclusion: The study demonstrates the efficacy of the distally based dorsal forearm fasciocutaneous flap based on the PIA for soft tissue hand reconstruction, with favorable scar outcomes and functional results.

Recommendation: The study recommends further exploration with larger cohorts and comparative analyses to enhance the generalizability of findings in soft tissue hand reconstruction. Additionally, ongoing research should focus on refining techniques to minimize donor site problems and post-surgery complications.

Keywords: Soft Tissue Hand Reconstruction, Posterior Interosseous Artery, Dorsal Forearm Flap, Scar Assessment.

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Introduction

Plastic and reconstructive surgeons face a formidable challenge when addressing soft tissue abnormalities in the hands, owing to the intricacies of this task as well as the limited skin available [1]. Defects in the soft tissues of the hand can occur due to various causes, including infection, deep burns, trauma, and tumor removal [2]. Early reconstruction and coverage of hand defects are pivotal to minimize infection risks and facilitate a swift recovery. Surgeons aim for a single, effective operation that not only maximizes functional outcomes but also reduces hospital stays. When local flaps fall short, the use of regional flaps becomes imperative [3].

The overarching objective of reconstructing the soft tissues of the hand is to achieve a harmonious blend

of functionality and aesthetic appearance. Cutaneous grafts and skin replacements emerge as effective solutions when applied judiciously [4]. In the realm of free tissue transfer, advancements provide surgeons with additional options for covering damaged hands during reconstruction. Forearm-based donor tissues, in particular, demonstrate superior outcomes while mitigating donor site morbidity [5].

In the realm of hand reconstruction, Zancolli and Penteadó et al. introduced a distally based dorsal forearm fasciocutaneous flap hinging on the posterior interosseous artery (PIA) [6,7]. This innovative PIA flap proves well-suited for addressing soft tissue defects in the 1st webspace, dorsum, and palmar aspect of the wrist and hand [8]. The PIA flap presents a practical solution for addressing defects

in the wrist and palm, particularly in cases involving volar side defects with exposed median and/or ulnar nerves. Its utility extends to situations where there is a need to address the 1st webspace in the presence of thumb adduction contracture, making it a durable and aesthetically pleasing option for soft-tissue coverage, particularly when dealing with defects exposing bone and/or tendons [9].

In managing the flap donation site, two methods are available: primary closure or cutaneous grafting. A notable advantage of the PIA flap lies in its ability to safeguard significant blood vessels during its use, setting it apart from other flaps, such as the radial forearm flap, which may pose risks to vascular structures [10].

This study's primary goal was to assess the effectiveness of the PIAF in reconstructing hand defects, taking into account factors such as hand function, aesthetic appearance, and morbidity at the donation site.

Materials and Methods

Study design: This prospective research spanning for 1 year focused on 30 patients diagnosed with soft tissue hand defects and admitted to the Plastic Surgery Department of PMCH, Patna in Bihar, India. It sought to evaluate diverse factors such as age, occupation, hand dominance, smoking patterns, systemic ailments like diabetes, and the mechanism of injury. This comprehensive assessment aimed to ensure the formation of a study group that is focused and specific.

Inclusion and exclusion criteria: The study enrolled 30 cases presenting soft tissue hand defects, fulfilling criteria related to intricate abnormalities impacting the thumb, 1st web space, as well as the dorsal and palmar surfaces of the wrist and hand up to the proximal interphalangeal (PIP) joint. Defects arising from burns, trauma, tumor removal, or congenital factors in dimensions ranging from small to moderate (maximum breadth = 6cm and maximum length = 8cm) were included in this study.

It was imperative to have access to a suitable donor. Exclusion criteria included significant uncontrollable medical conditions, excessive tobacco use, injuries at the donation site, and hand deformities surpassing the PIP joint.

Study size: The study consisted of 30 patients with soft tissue hand defects who had access to suitable donors.

Study setting: The investigation was carried out at the Plastic Surgery department of PMCH in Bihar, India. It involved 30 cases with soft tissue hand defects, with surgeries performed under general anesthesia and rigorous preoperative assessments to ensure optimal outcomes. The comprehensive study design included a focus on hand function, aesthetic

appearance, and donor site morbidity during the reconstruction process using the distally based dorsal forearm fasciocutaneous flap based on the PIA.

Preoperative Preparation and Markings

Surgical procedures, performed under general anesthesia, involved elevating the upper limb, applying a third-generation cephalosporin, and using an arm tourniquet. The flap's vascular axis, from the distal ulnar joint to the humerus's radial epicondyle, was determined. The anastomosis of the anterior and posterior interosseous artery (AIA and PIA), crucial for flap viability, was pinpointed 2cm adjacent to the distal ulnar joint. The proximal vascular axis, marked at the same distance from the defect's center, facilitated precise planning. The flap's center was located approximately 9cm distal to the humerus's lateral epicondyle.

Operative Technique: After scrubbing and disinfection, an incision, guided by septocutaneous perforators, was made. The fascia covering extensor muscles, extensor carpi ulnaris (ECU) and extensor digiti minimi (EDM) muscles was incorporated into the flap pedicle. Dissection continued, exposing the posterior interosseous artery. Careful cauterization prevented damage to the posterior interosseous nerve (PIN). Proximal dissection on the lateral side led to the flap's proximal end.

To safeguard perforators during manipulation, the fascia was sutured to the dermis. The ulnar side was dissected to the wrist. Hemostasis was achieved by clamping the artery's proximal end and deflating the tourniquet for approximately 15 minutes. After re-inflating, the proximal artery end was ligated and divided. The flap, gently elevated, was set over the defect, with drains in place. If the flap exceeded 5cm in width, a split-thickness cutaneous graft addressed the donation site. A wrist extension volar slab was applied for a week.

Postoperative Care and Follow-up: The initial recovery involved close monitoring of the flap's health. For seven days, the forearm and wrist were immobilized before initiating mobility exercises. Follow-ups occurred weekly for the first month and monthly thereafter.

The surgery's functional outcome was evaluated using the DASH questionnaire at the end of the follow-up period. Aesthetic outcomes were determined through scar assessments, categorizing donor and recipient areas as good, fair, or poor. Retrospective data analysis assessed outcomes for all flaps.

Bias: The study may be subject to selection bias due to its exclusive focus on cases from PMCH Bihar, potentially restricting the applicability of the findings. Additionally, the use of a specific surgical technique, the distally based dorsal forearm

fasciocutaneous flap, could introduce procedural bias, impacting the observed outcomes.

Ethical consideration: The research adhered to ethical norms, having received approval from the Institutional Review Board and acquiring informed consent from all patients.

Statistical Analysis: After data collection, SPSS version 25 by IBM, USA, was employed for organizing, tabulating, and analyzing both quantitative and qualitative data, utilizing mean, standard deviation (SD), frequency, and percentage presentations.

Results/Outcomes

Participants: The study cohort comprised 30 individuals with an average age of 31.28 years, consisting mostly of males (80%). Various causes of hand injuries were observed, with vehicle accidents being the most prevalent (27%), followed by sharp objects (20%) and electrical burns (13%).

In terms of injury sites, the dorsum of the left hand was the most common (40%), and the surgery duration averaged 143.76 minutes. The size of the defects and flaps varied, with an average defect size of 6.17 x 3.92 cm and an average flap size of 6.90 x 5.21 cm (Table 1).

Table 1: General features and aetiological factors of patients

Characteristics	Study cohort (n = 30)
Mean age (yrs)	31.28
Male	24 (80 %)
Female	6 (20 %)
Cause of injury	
Injury-induced contracture	2 (7 %)
Electric shock burn	4 (13 %)
Cutting or piercing injuries	6 (20 %)
Vehicle accident	8 (27 %)
Equipment-related trauma	4 (13 %)
Site	
Dorsum of the right hand	8 (27 %)
Dorsum of the left hand	12 (40 %)
Medial side of the left hand	2 (7 %)
Left palm	4 (13 %)
Right palm	4 (13 %)
Surgery duration in min	143.76
Size of the defect (cm)	6.17 x 3.92
Size of the flap (cm)	6.90 x 5.21

The study cohort underwent scar assessment, revealing that 80% of cases had a 'good' outcome, while 20% were categorized as 'fair.' The Disability of Arm, Shoulder, and Hand (DASH) score had a mean value of 35.14, indicating satisfactory functional results. Donor site problems, including cold intolerance and numbness, were reported in 13% of cases. Post-surgery complications included a 7% incidence of distal flap necrosis and an additional 7% experiencing venous congestion (Table 2).

Table 2: Outcome measures in the study cohort

	Study cohort (n=30)
Scar assessment	
Good	24 (80 %)
Fair	6 (20 %)
DASH score	35.14
Donor site problems	
Chill sensitivity and sensory numbness	4 (13 %)
Post-surgery complications	
Peripheral flap tissue death	2 (7 %)
Hindered venous circulation	2 (7%)
Duration of hospital stay (days)	7.1
Follow-up (months)	4.2

Discussion

The study emphasizes caution in using a distally based flap within the proximal one-fourth of the forearm due to the recurrent interosseous artery

(IA) presence validated by the study conducted by Angrigiani et al [11]. Following this precaution, the skin island depiction omitted a 6-centimeter segment from the proximal forearm. Furthermore, while carrying out this study, cases of unreliable

blood flow were tackled by use of additional venous anastomosis as described earlier [12].

In this study, the ratio of males to females was 4:1, consistent with observations in research conducted by other scholars. The elevated prevalence of males was attributed to the higher occurrence of hand injuries in men [13,14]. The distal incision in this study was refrained from extending beyond the safe point to prevent damage to the crucial anterior-PIA anastomosis.

Flap sizes used in this study ranged from 5 x 4cm to 9 x 7cm, comparable to Costa's series, which reported sizes from 5 x 4cm to 14 x 9cm [13]. Moreover, the findings suggested that smaller flaps allowed for direct closure of the donation area, while larger ones required cutaneous grafting, consistent with Brunelli's practice [15]. Remarkably, primary closure of the donation site was achieved in 4 cases, aligning with Landi A.'s findings in a series of 8 cases [16].

All flaps, except 4, demonstrated complete survival, with two cases experiencing distal flap necrosis and other 2 with signs of venous congestion, both resolving during follow-up. Notably, our work contrasted the one reported by Dap F. et al. wherein partial necrosis was seen and that conducted by and Chen H. et al, which demonstrated a 21.3% failure rate [14,17]. This variation is anticipated to occur due to the limited pedicle dissection (not more than 2 cm) which effectively restricts the application of the flap to defects located proximal to the metacarpophalangeal joints of the fingers.

Two cases exhibited temporary weakness in wrist and finger extension, diagnosed as neuropraxia, with full recovery within 4-6 weeks post-operation. Long-term follow-ups revealed favourable outcomes in flap durability and appearance, aligning with Zancolli et al.'s findings [11].

To prevent venous congestion in the patients, diverse techniques, including covering the vascular pedicle and connecting subcutaneous veins were used in this study. Skin transplants were promptly used when direct closure was not possible, with meticulous hemostasis and the application of epinephrine-soaked gauze at the donation site, aiming to enhance cutaneous graft take by reducing edema. The distally based posterior interosseous artery (PIA) flap stands out for its preventive effect against hematoma and ease of extension up to the finger base using two perforators [18]. Technological enhancements, including a teardrop shape and a tennis racket-shaped flap for extended distances, optimize flap usage without the need for trimming [19]. While dissection entails some risk to the posterior interosseous nerve, this method offers advantages like a smaller surface area compared to the radial forearm flap, preserved venous circulation, and reduced complications. Despite the draw-

back of visible cutaneous grafts at the donor site, the reverse PIAF presents merits, providing a high-quality skin paddle suitable for various regions and allowing the harvest of moderate to large-sized flaps with minimal impact on the appearance of the affected limb.

Conclusion

In the present study, the distally based dorsal forearm fasciocutaneous flap utilizing the posterior interosseous artery (PIA) has demonstrated its effectiveness as a versatile and reliable option for soft tissue reconstruction in hand defects. Addressing mild to moderate-sized defects on the dorsal and palmar aspects of the hand, this technique has shown promising outcomes. While technical considerations such as avoiding anastomotic arc dissection and employing deep fascia-based dissection are crucial, the benefits, including preserved venous circulation and reduced complications, underscore its value in hand reconstruction. Despite challenges, such as the potential for nerve damage, the reverse PIA flap offers favorable functional and aesthetic outcomes, making it a noteworthy choice in the realm of plastic and reconstructive surgery.

Limitations: The limitations of the study are primarily attributed to its modest sample size of 30 cases, potentially impacting the generalizability of the results. Additionally, the absence of a comparative analysis with alternative soft tissue reconstruction techniques limits a comprehensive evaluation of the presented approach.

Recommendations: The study recommends further investigations with larger sample sizes to enhance the robustness of findings and encourages comparative analyses with alternative soft tissue reconstruction methods for a more comprehensive understanding of their relative effectiveness in hand defects.

Generalizability: The study's generalizability is constrained by its focus on a specific hand reconstruction technique, emphasizing the need for broader investigations across diverse patient populations and alternative methods to enhance applicability.

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List of Abbreviations

PIA - Posterior Interosseous Artery
PIAF - Posterior Interosseous Artery Flap
PIP - Proximal Interphalangeal
AIA - Anterior Interosseous Artery
EDM - Extensor Digiti Minimi
ECU - Extensor Carpi Ulnaris
PIN - Posterior Interosseous Nerve
DASH - Disability of Arm, Shoulder, And Hand

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