

POSTERIOR INTERBONE ARTERY FLAP FOR COVERING SERIOUS FOREARM, WRIST AND HAND INJURIES

Sérgio José de Lima¹

Ricardo Pereira Domingos da Costa²

Emanoel de Oliveira²

Fabrcio Guimarães Prudente³

Marcelo Paris Mendonça³

Christiano Soares de Camargo³

ABSTRACT

Objective: To assess the results achieved with posterior interbone artery flap covering serious injuries of the distal third of the forearm, wrist and hand, evaluating the degree of effectiveness of this procedure. **Methods:** 35 patients with serious injuries of the distal third of upper limbs were studied. We assessed the kind of trauma, injury site, flap size, skin coverage need, clinical outcome and complications. **Results:** The most frequent mechanism of trauma was motorcycle accident. The most commonly affected regions were: dorsal hand, wrist volar regions and the first commissure. In all patients, the flap size was

enough to cover key tissues exposed by the injury. The donor area did not show complications, being primarily closed in 23 cases. The outcomes were good for 31 cases. In 22 patients, no complication was found, and the flap was completely lost in four. **Conclusion:** Posterior interbone artery flap provides good outcomes in covering serious injuries of the distal third of upper limbs, leading to a stable and reliable coverage, not compromising key irrigating arteries of the hand, enabling the performance of reconstruction procedures. Therefore, this is a useful alternative in such cases.

Keywords – Hand traumas; Wrist traumas; Surgical flaps

INTRODUCTION

The reconstruction of lost soft tissues in the distal segment of the forearm, wrist, and hand is a challenge⁽¹⁾. Tissue lesions in these regions are caused mainly by trauma, possibly leading to exposed bone, tendon, nerve and/or blood vessels^(1,2). Such lesions may require local, regional, or microsurgical flaps to cover these defects, in order to minimize infection, provide protection, and facilitate future

reconstructions⁽¹⁻³⁾. Soft tissue reconstruction in these regions should be fast, preferably in a single procedure, allowing for early mobility and a short hospital stay, in order to achieve satisfactory functional and aesthetic results⁽¹⁻³⁾.

Various types of flaps can be used to cover the distal forearm, wrist, and hand⁽⁴⁾.

Local flaps (Atasoy, Kuttler, Litter, Morberg) are used for small amounts of tissue loss and with specific indications^(1,2,5).

1 – Chief Physician, Hand and Reconstructive Microsurgery Clinic, Hospital de Urgências de Goiânia (HUGO), Goiânia, Brazil

2 – Physician, Hand and Reconstructive Microsurgery Clinic, Hospital de Urgências de Goiânia (HUGO), Goiânia, Brazil

3 – Resident, Department of Orthopedics and Traumatology, Hospital de Urgências de Goiânia (HUGO), Goiânia, Brazil

Study conducted at the Hospital de Urgências de Goiânia (HUGO), Goiânia, Brazil

Correspondence: Hospital de Urgências de Goiânia – COREME – Av. 31 de março esq. 5ª radial, s/n, 3º andar, St. Pedro Ludovico – Goiânia – Goiás.

E-mail: guimaraesmed@hotmail.com

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Free flaps obtained from other regions have drawbacks such as a long operating time, technical difficulties, and the need for microsurgical expertise and materials^(1,2,6).

Regional pedicle flaps have problems such as postoperative edema, large flap thickness, and longer surgery time when compared to local flaps⁽¹⁾. Even so, they are performed in the traumatized limb, ensure safe and stable coverage, and allow for subsequent reconstruction procedures and early mobility^(1,3,7). The retrograde flow forearm flap based on the radial artery (Chinese flap), as well as the flap based on the ulnar artery, guarantee these benefits. However, these are flaps that sacrifice the main arteries supplying the hand, besides resulting in severe damage to donor sites^(1,3,7). The dorsal ulnar flap has a short pedicle with limited rotation and is indicated in dorsal ulnar and proximal palmar defects^(2,3,7). The flap of the anterior interosseous artery has a weak pedicle and variable anatomy^(3,7).

The flap based on the posterior interosseous artery is a thin island fasciocutaneous flap^(2-4,7-10). It is indicated in distal forearm lesions⁽¹¹⁾, dorsal wrist and hand lesions^(2,3,7), lesions of the first commissure⁽¹⁻³⁾, and lesions of the thenar region⁽¹⁾. This flap is reliable and provides good coverage, and does not sacrifice the arteries vital for perfusion of the hand, with minimal morbidity at the donor site^(2,3).

The purpose of our research is to evaluate the results obtained with cutaneous coverage by posterior interosseous artery flap in serious injuries of the distal forearm, wrist, and hand by analyzing the degree of effectiveness of this procedure.

METHODS

The present study was conducted from January 2004 to August 2007 at the Hospital de Urgências de Goiânia, with the objective of clinically evaluating the posterior interosseous artery flap for coverage of traumatic injuries of the distal upper limb.

During this period, 58 patients with severe skin loss of the distal upper limb, leading to exposure of tendons, neurovascular structures, and/or bone were treated. Among these patients, 35 were selected and submitted to cutaneous coverage with a flap based on the posterior interosseous artery.

Patients who underwent other coverage procedures, whether due to a dorsal wrist injury in the

area corresponding to the distal anastomosis of the anterior and posterior interosseous arteries, or due to the surgeon's preference, were not included in the study.

The surgical technique was standardized with respect to the following anatomical considerations: The ulnar artery takes a short branch of the distal ulnar fossa: the common interosseous artery. This branch is divided in anterior and posterior interosseous arteries⁽¹²⁻¹⁴⁾. The anterior interosseous artery distally continues over the interosseous membrane to the proximal region of the pronator quadratus muscle, where it anastomoses with the posterior interosseous artery and the dorsal carpal network⁽¹²⁾.

The other branch of the common interosseous artery continues posteriorly between the radius and ulna, emerges through the interosseous membrane and enters between the supinator and the abductor pollicis longus^(12,13). The artery runs through the dorsal surface of the forearm over a line drawn between the lateral epicondyle of the humerus (LEH) and the ulnar styloid process (USP), corresponding to the septum between the extensor carpi ulnaris muscles and the small finger's extensor (Figure 1). Throughout this path, it emits cutaneous and muscular arterial branches, connecting with the posterior interosseous nerve and with muscles of the posterior compartment of the forearm^(9, 12-15) (Figure 2). Anastomosis with the anterior interosseous artery and dorsal carpal network occurs near the wrist joint^(9,12,13,15).

Penteado et al. and Zancolli et al. separately described the fasciocutaneous flap based on the posterior interosseous artery and its cutaneous branches^(9,15).



Figure 1 – Marking of the anatomical references of the flap.

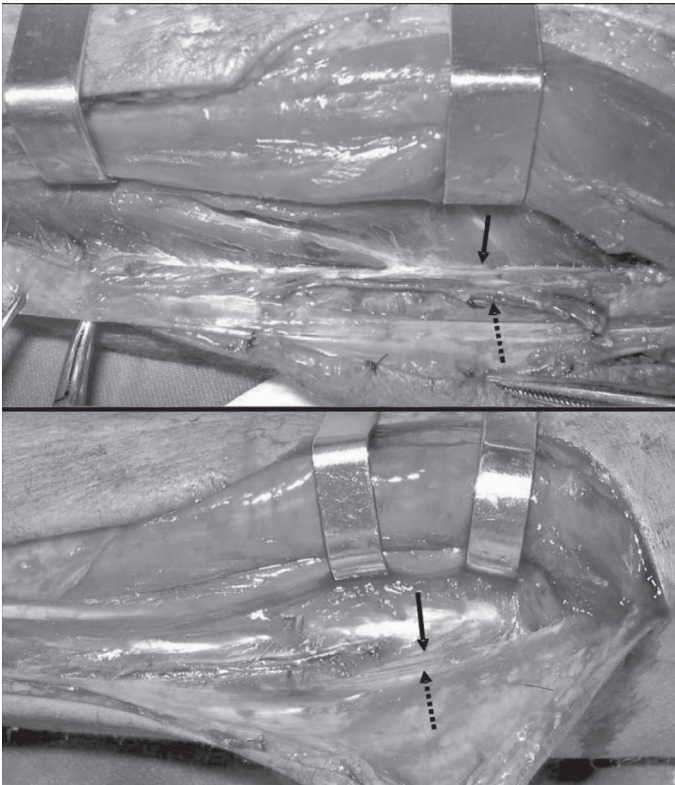


Figure 2 – Path of the posterior interosseous artery (dotted arrow) and its relationship to the posterior interosseous nerve (continuous arrow).

It consists of a forearm island pedicle flap with retrograde flow due to the distal anastomosis between the anterior and posterior interosseous arteries, with venous return by satellite veins^(9,13,15). It is indicated in cases of cutaneous coverage of the distal forearm⁽¹¹⁾, the dorsal region of the wrist and hand^(2,3), the first commissure^(1,3), and the thenar region^(1,2).

The flap dissection starts with the demarcation of a dorsal line between the LEH and the USP and its division into proximal, medial, and distal thirds^(2,9,13-15) (Figure 1). The skin is then incised and dissection of the subcutaneous and antebrachial fascia is carried out in both the proximal and distal directions, exposing the supinator muscle and the intermuscular septum between the extensor carpi ulnaris muscles and extensor of the small finger^(9,13-15). Deep dissection is performed carefully, preserving the cutaneous branches that pierce the deep fascia along the intermuscular septum toward the skin and runs distally to expose the distal anastomosis^(9,13-15) (Figure 3).

The most distal site that allows rotation of the flap is over the region of its distal anastomosis with the anterior interosseous artery (Figure 4). A tunnel is then made toward the recipient area^(2,7). The donor area is closed by primary suture (flaps < 5 cm) or skin grafting^(2,3).

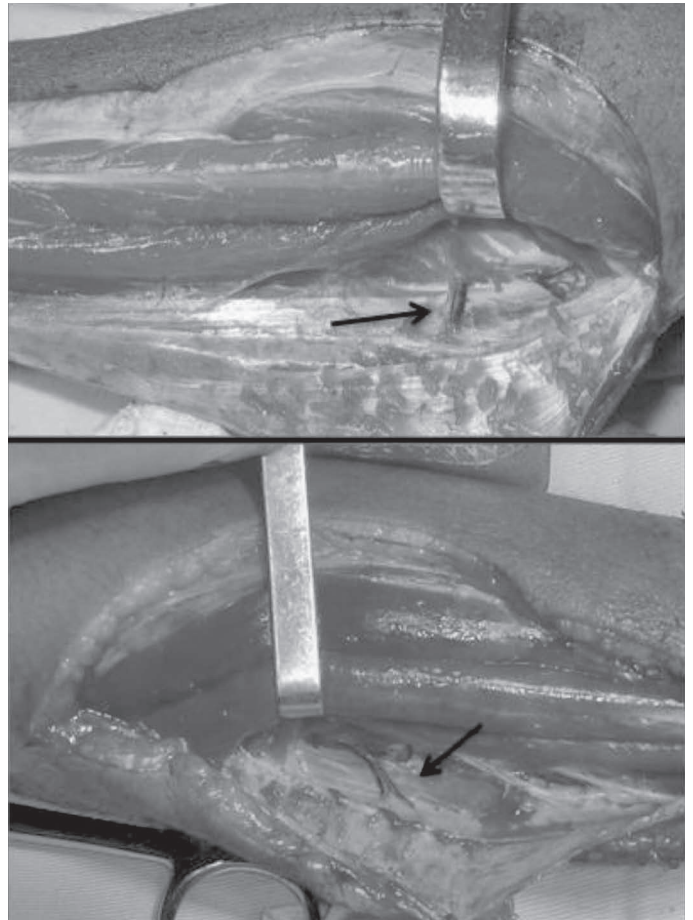


Figure 3 – Perforating cutaneous branches (arrows).



Figure 4 – Definition of the pedicle and flap rotation arc.

In the literature, among the boundaries and measurements of the flap reported are: - distance from the LEH to the USP: 21.5 to 29 cm^(9,13); - distance from the LEH to the posterior interosseous artery: 6.5 to 11 cm. This distance corresponds to the junction of the proximal and medial thirds of the LEH and USP⁽¹³⁾; - distance from the LEH to the first cutaneous

branch of the posterior interosseous artery: 7 to 14 cm⁽¹³⁾; - number of cutaneous branches in its path: 4 to 14 branches^(9,13,15); - the thickest cutaneous branch is located close to the emergence of the artery, from 5.1 to 11.4 cm from the LEH; - distal anastomosis is present in all cases. This anastomosis lies between 1.5 to 3.2 cm from the USP^(3,13). Penteado et al. describe the absence of anastomosis in 1.4% of their cases⁽⁹⁾; - arc of rotation of up to 19 cm centered on the distal radio-ulnar joint (DRUJ)^(8,9,13).

Of the patients, 28 were male and seven female. The average age was 37 years, ranging from seven to 70 years. The mean follow-up period was 22 months, ranging between one and 43 months.

Patients were evaluated for the determinant type of trauma, the location of the lesion on the upper limb, the area exposed by the injury, the size of the flap obtained, the need for cutaneous coverage in the donor and recipient areas, and complications encountered. Good results were defined as the analysis of the flap as cutaneous coverage of the open area and not the final function of the limb⁽¹⁾.

The main cause of trauma was motorcycle accidents, with 21 cases, followed by six cases due to car accidents, four occurred as a result of improper handling of industrial machines, three were burns from fireworks, and one was caused by farm machinery.

Regarding the site of trauma, 15 were on the back of the hand (Figure 5), six were in the volar region of the wrist, six were in the first commissure, four were in the region of the amputation stump of the thumb,

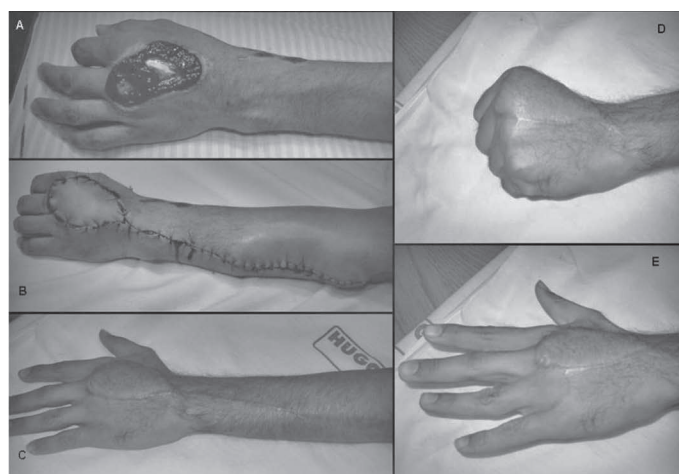


Figure 5 A – Dorsal hand injury with tendon exposure. B – Final intraoperative result with donor area closed primary. C – Five months after surgery. D and E – Final mobility of the fingers.

three were in the hypothenar region, and one was at the amputation stump of the wrist.

The lesion's exposed area was highly variable. On average, these areas were 7.5 X 4.9 cm, and areas between 4.5 to 17 cm in length and 2 to 8 cm in width were observed.

The size of the flap obtained was, on average, 6.5 x 4.25 cm, ranging from 4 to 8 cm in length and 3 to 6 cm in width.

The donor area was closed primary in 23 cases and covered with skin grafts in 12 cases. The flap was not enough to cover the entire lesion in nine cases, and was complemented with skin grafts in the granulation area (Figure 6).

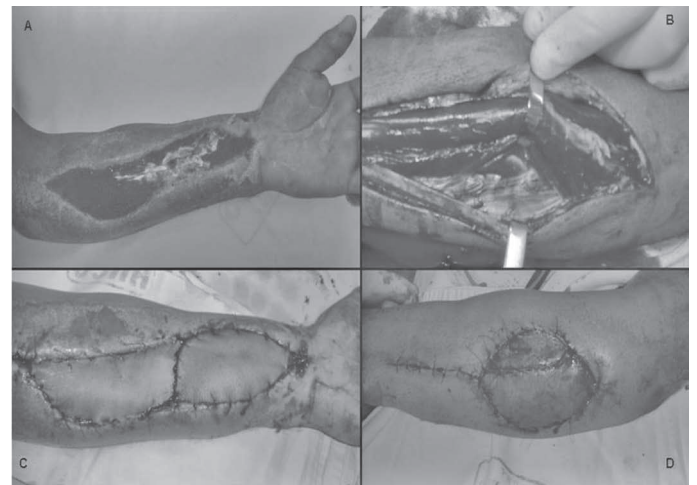


Figure 6 A – Extensive injury to the volar aspect of the forearm with exposure of muscle and tendon. B – Dissection of posterior interosseous artery and its perforators. C – Final appearance of the flap. D – Donor area with skin grafting.

RESULTS

There were no complications in 22 patients. In five cases there was partial necrosis of the edges of the flap, and of these, three cases progressed to scar retraction. One case had partial dehiscence of the suture, three had partial epidermolysis, and four flaps progressed to total loss (Chart 1).

Regarding the cutaneous coverage offered by the posterior interosseous artery flap, we obtained good results in 89% of the patients (Figure 7). Only the flaps with total loss failed to cover the exposed area. Considering the final function of the wrist and hand, the results were highly variable, probably due to the severity of the trauma and not the flap itself. That assessment was not the aim of this study.

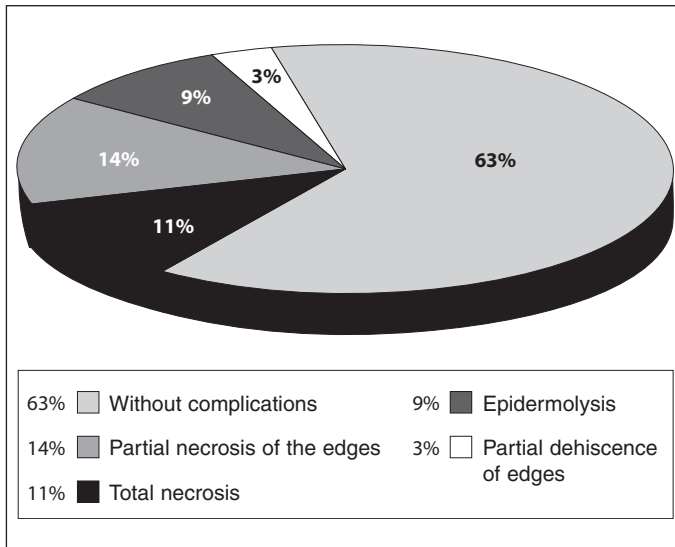


Chart 1 – Complications encountered in flap implementation.



Figure 7 – A – Injury of the first commissure. B – Final intraoperative appearance. C – Two weeks after surgery. D – Six months after surgery with the flap area equalized with the rest of the hand.

DISCUSSION

The number of injuries of the upper limb is growing exponentially with the technological advance of civilization, resulting in an increase in the kinetic energy of trauma, and consequently more complex lesions that need stable cutaneous coverage^(5,16). Traumatic injuries of the hand with loss of skin tissue and exposure of noble structures need adequate coverage for protection of these structures and to facilitate their future reconstruction^(1,3).

Since its description by Penteadó et al. and Zancolli et al., the posterior interosseous artery flap is increasingly being used^(4,8,9,15). For lesions of the dorsal, thenar, and hypothenar regions of the hand, the first commissure and volar region of the wrist, this type of flap is effectively indicated^(1,2,4,11). It has good coverage

with a long arc of rotation, and does not injure the main arteries supplying the hand^(1-4,8,14).

The average patient age and the gender most affected by this type of injury (trauma of the distal upper limb) found in this study are consistent with the literature^(2-4,7,17).

The dimensions of the flaps described are, on average, between 1.5 X 4 cm to 9 X 11 cm^(2,3,8,11,14,17). However, there are descriptions of flaps with dimensions up to 21 X 10 cm⁽¹⁸⁾. The lesions we have found fall under this average flap size, with the exception of five lesions that were larger, but the area of exposed noble tissues was in this range.

The literature shows that the donor site has minimal morbidity^(2,4,10). We found no complications related to the donor area. It can be closed primarily or covered with skin grafts depending on the size of the donor site^(2,3). Scarring shows no retractions and has good aesthetics^(1,2). We used a skin graft from the ipsilateral arm when implementing the flap.

All flaps had good coverage of the proposed injured area in the immediate postoperative period. However, we lost four of these flaps (11%) during follow-up, constituting poor results⁽¹⁾. The probable causes of these losses were venous congestion, injury to the distal anastomosis in the trauma, and technical failure in the implementation of the flap, all of which have been described in the literature^(1,2,7,11,17). Other causes for loss of the flap, such as arterial insufficiency⁽¹⁰⁾, infection^(1,17) and diabetic angiopathy⁽⁷⁾, were not found in this study. The total losses were covered with a Chinese flap or skin grafting after granulation.

Partial necrosis of the edges of the flap, suture dehiscence, and epidermolysis were the other complications we observed, which have also been reported in the literature^(1,3,8,17), and did not jeopardize the proposed coverage. Epidermolysis was merely observed, while the rest was treated with closure by secondary intention.

Radial neurapraxia, hematoma, and infection are other complications that have been described in the literature, but were not found by us^(2,4,10). Three of the five cases of partial necrosis led to scar retraction, which has not been described in the literature.

During the follow-up of the flaps, they were either already thin at first^(2,4), or evolved with regression of the initial bulging by the subcutaneous excess after eight weeks on average, resulting in equalization with the surrounding skin area.

CONCLUSION

The posterior interosseous artery flap provides good results in covering severe injuries of the distal upper limb, promoting stable and reliable coverage

without sacrificing the main arteries supplying the hand, and allowing reconstruction procedures to be performed. It is therefore a valid option in such circumstances.

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