

# A strong reconstruction option for tissue loss on hand and wrist due to firearm injury in the Syrian war

## Reverse posterior interosseous flap

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### Abstract

All of the injuries were the open injuries with bone or tendon structures in the hand and wrist region as a result of the firearm injury (FI) in the Syria. In the study, we assessed the outcomes of the posterior interosseous flap (PIF) on hand and wrist that we used for the Syrian injured people including civilians and soldiers in this War. PIF was applied to 77 patients who composed of 43 female and 34 male that all patients were evaluated for tissue loss resulting from gunshot wounds and injured in the War between 2014 and 2020 years with tissue loss in hand and wrist as a result of FI. The flap survival rate was 100% for all the patients. The dimensions of flaps ranged from 4.1 cm × 2.2 cm to 9 cm × 5.4 cm with 0.51 ± 0.12 cm thickness. The mean pedicle length was 6.33 ± 1.08 cm. The surgery for PIF took 68.8 ± 22.1 minutes, while blood loss was 60 ± 24 mL. We observed no palsy conditions including the posterior interosseous nerve. The donor sites were treated by primary intention in the patients. We found the superiority of PIF with the postoperative follow-up comfort, ease of fracture healing, easy and fast, easy-to-apply method and no second additional session requirement in FI patients. We did not detect flap necrosis in any patient or observe a flap-related complication. As a result of the present study, it strongly supports the thesis that PIF is the best option in these cases.

**Abbreviations:** FI = firearm injury, PIF = posterior interosseous flap.

**Keywords:** firearm injury, hand, posterior interosseous flap, Syrian war, wrist

## 1. Introduction

In wars and conflicts, different kinds of injuries can occur in several types of armed conflict bodies.<sup>[1]</sup> Firearm injury (FI) in the Syrian Civil War has remained at a higher incidence and affects the people in terms of surgical treatments.<sup>[2–5]</sup> Since the reduction and healing of hand and wrist fractures due to FI is very important, choosing and applying the suitable skin flap has critical importance for surgeons. Otherwise, recovery can be

delayed undesirably and aesthetic and reconstructive outcomes will not be satisfactory.<sup>[6,7]</sup>

The use of several types of flaps comes to the fore in hand and wrist injuries.<sup>[8]</sup> One of the most recently preferred of these flaps is posterior interosseous (PIF), which Lu et al initially reported in 1986 according to the literature.<sup>[9]</sup> Following their report, PIF has evoked international attention among reconstructive surgeons, especially for hand-related surgeons. With the absence of the necessity of the second surgical session, it creates its superiority over the interpolation flap.<sup>[10]</sup> Free flap, another strong and wide option for treatment of the PI has been a difficult method to apply because it may cause a loss in a major artery to the hand and the flap viability is low. The postop fracture reduction with PIF seems a more useful method than those because it allows splint applications and is considered to be the best method in typical cases.<sup>[11]</sup> Hence, it is one of the most widely preferred flaps for plastic surgeons.<sup>[12–14]</sup>

In the Syrian Civil War, all of the injuries in the hand and wrist region as a result of the FI were the open injuries with bone or tendon structures. In this clinical study, we assessed the outcomes of the PIF on hand and wrist that we used for the Syrian injured people including civilians and soldiers in this War.

## 2. Material and methods

### 2.1. Participants

In the study, PIF was applied to 77 patients who injured in the War between 2014 and 2020 years with tissue loss in hand and wrist as a result of FI. Although this method was applied in tissue loss due to cancer burns or diabetes wounds, it was not included

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The datasets generated during and/or analyzed during the current study are not publicly available, but are available from the corresponding author on reasonable request. All data generated or analyzed during this study are included in this published article [and its supplementary information files].

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**Table 1**  
Demographic properties of patients, flap size, and operations.

Variables	Posterior interosseous artery flap
Number of patients	77 (%100 Survival)
Age (yr)	33.1 ± 11.2 (ranged: 15–48)
Gender	Male / female: 34 / 43
Flap areas	2304.2 (SD 588.2) mm <sup>2</sup>
Flap dimensions	4.1 × 2.2–9 × 5.4 cm
Flap thickness	0.51 ± 0.12 cm
Pedicle length	6.33 ± 1.08 cm
Operation time	68.8 ± 22.1 min
Blood loss	60 ± 24 mL

SD = standard deviations.

in the present article. Following the approval of the Medical Ethics Committee of our institution for the study, written consent was obtained from all participants. The patients' characteristic is shown in Table 1.

## 2.2. Posterior interosseous flap anatomy

The PIF-feeding artery originates from the interosseous, which is a branch of the arteria ulnaris. Following upper site membrane of antebrachial-interosseous, it shows a descent between the muscles of abductor pollicis longus and supinator. PIA creates an anatomic anastomosis 2.5 cm near the radial site of the radioulnar joint with the “dorsal branch of the anterior interosseous artery” and “the dorsal carpal branch of the radial artery”. This vascular anatomical construction allows surgeons to generate an inverted flap tissue from the dorsal site of forearm. Various vascular variations have been identified in this region; although any variation does not prevent a flap use (Figs. 1 and 2).

## 2.3. Surgical technique

Before the operation, Doppler was performed to the end of the ulna medial only to confirm the presence of a lateral distal perforator. All injured tissues were debrided radically following general anesthesia. The flap size was aimed according to the FI shape and effectiveness. Dissection started in the forearm, beginning from the ulnar site of the flap, after marking. Extensor fascia was cut on the carpi ulnaris muscle group. The dissection continued from the extensor carpi ulnaris and posterior interosseous artery to the septum between the 3 and 4 fixed muscle perforators, where the extensor digitorum was minimized. The PIF was then cut proximally from the radial side with the deep fascia as a facial skin flap until it reached the septum, and the PIF and vena comitantes were proximally dissected from the PIF related nerve. The flap was cut distally into the subcutaneous tissue and embedded in the tissue. A sensation was taken with Doppler to confirm whether there is enough arterial tension. The process was completed by covering the donor area with a skin-graft.

## 2.4. Data analysis

Patients' results were evaluated with descriptive statistics. Clinical features of all patients were recorded before the operation. Flap size, pedicle thickness, and length were measured intraoperatively. Functional results and aesthetic results were

evaluated 2 weeks after surgery. Numerical values from 0 to 5 were given to each of the 6 categories, including hand position, pain, functional and emotional acceptance, dexterity and lifting ability were evaluated by patients' outcomes.

## 3. Results

The patients were composed of 43 female and 34 male that all patients were evaluated for tissue loss resulting from gunshot wounds. The oldest patient was 48 years old, while the youngest was 15 years old (mean age was 33.1 ± 11.2 years old). The flap survival rate was 100% for all the patients. The dimensions of flaps ranged from 4.1 cm × 2.2 cm to 9 cm × 5.4 cm in size with 0.51 ± 0.12 cm thickness. The pedicle-length was 6.33 ± 1.08 cm. The operation-time for PIF was 68.8 ± 22.1 minutes, while blood loss was 60 ± 24 mL.

The donor sites in all patients healed by primary approach. We did not see any palsy conditions including the posterior interosseous nerve.

When all patients were considered, particularly long-term follow-up results were satisfied with the cosmetic aspect. The scope of the durable flap on the hand of the treated defects was provided with clean results. All flap applications showed constant coverage and a reasonable contour. All donor sites were skin grafted and they were quite good. Together with the donor sites that were immediately grafted, they were excellent intake and exposed on the day they were discharged from the hospital.

## 4. Discussion

In war-related gunshot injuries, flap options cannot be preferred unless the patient is obliged due to the difficulties in the reduction and healing of hand and wrist fractures, due to multiple traumas in the patient.<sup>[4,15]</sup> As the posterior interosseous flap allows splint applications in postoperative fracture reduction, it is considered to be a better and useful flap method.<sup>[16,17]</sup> As a result of the present study, it strongly supports the thesis that PIF is the best option in these injured cases.

Today, hand and wrist injuries due to firearms are conditions requiring separate surgical accumulation and importance. In traditional plastic reconstructive approaches, it is not considered an appropriate way to cover the critical structure of the hand with a Split/full-thickness skin graft.<sup>[18]</sup> It is important to use a vascularized, durable and sufficiently large flap to maintain hand function at adequate levels. Transferring the free tissue during a one-step process also brought the advantage of providing large tissue. In addition to a long hospital stay, there are some restrictive conditions, such as the need for high-level surgical skills with a well-organized patient care team.<sup>[19]</sup>

Distal-based fasciocutaneous flaps on the forearm have proven to be simple use, versatile and reliable flaps; they can be used to reconstruct a wide variety of soft tissue defects of the hand.<sup>[20]</sup> In this sense, PIF has aroused increasing interest in plastic hand surgeons and is one of the most frequently used skin flaps in reconstructive surgery.<sup>[11,16,17]</sup> Although it has support from the anterior interosseous artery, it has low arterial pressure.<sup>[21]</sup> As the distal third of the flap or, in other words, the proximal third of the forearm, the blood flow is weak, it carries a risk of necrosis.<sup>[22]</sup> The most serious problems of the anatomical variants of the posterior interosseous artery that cause the unreliability of blood flow are caused by arterial hypoplasia in the middle of the forearm.<sup>[23,24]</sup> In our practice in the present study, we did not see

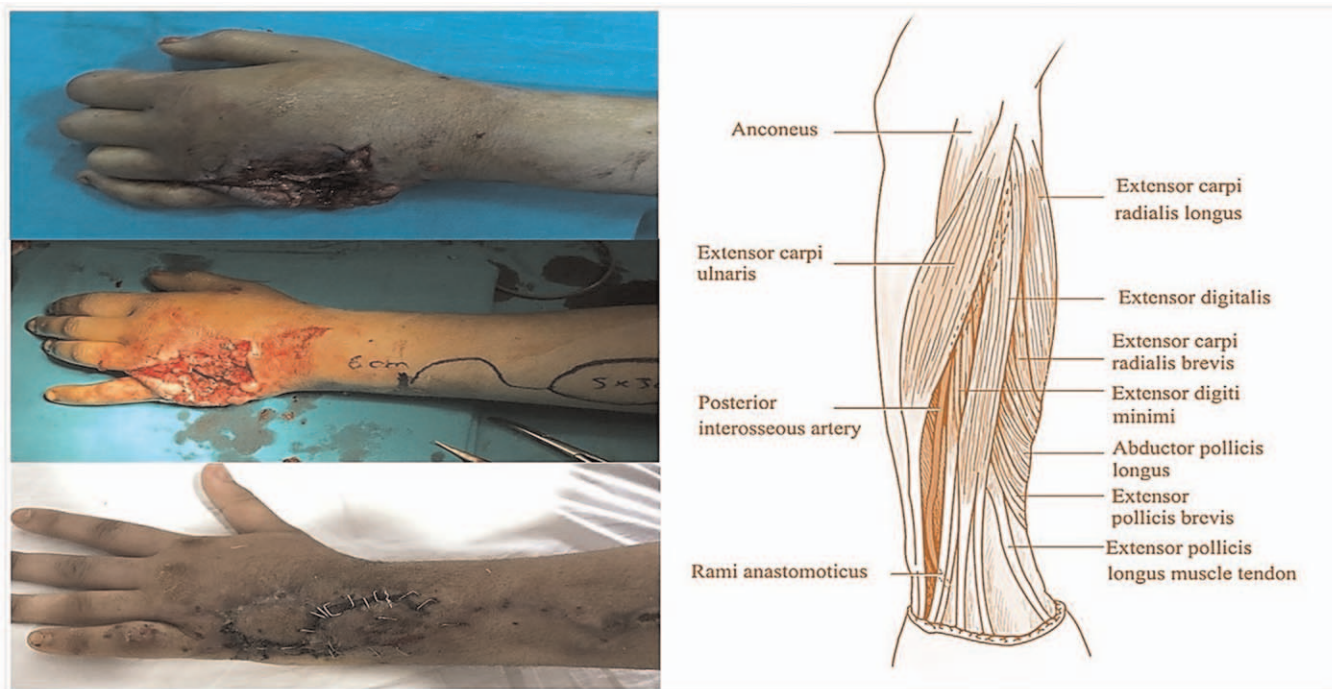


Figure 1. A 5x3cm defect with pre/postoperation images and anatomic details of forearm.

any similar complications related to firearm injuries in Syrians. If the blood flow is unreliable or it is difficult to maintain the motor branch of the posterior interosseous nerve, the free flap can be used as an alternative. Of course, it should not be forgotten that free flap is a hard-to-apply method and it causes loss in a major artery to the hand and it has disadvantages compared to PIF application.

Using Doppler is a crucial approach to be able to hear the distal perforator near the medial end of Ulna in the use of posterior interosseous flap to close the hand. In all FI cases where we applied this flap, the distal perforator was heard by Doppler before the flap was raised and before the flap sat in the defect area.<sup>[25]</sup> One of the causes of flap failure is the bending of the pedicle; this complication can be prevented by including a



Figure 2. A 7x7 cm defects with pre/postoperation and one month follow-up images.

contract cage at the inlet of the skin vessels at the entrance of the flap and paying attention during placement of the flap.<sup>[26]</sup> Measures such as anastomosis of subcutaneous vessels to vessels in the recipient area can be beneficial to prevent venous obstruction.<sup>[27]</sup> All injuries were in the hand and wrist region developed as a result of FI in all patients, with bone or tendon structures exposed with fractures.<sup>[14,27]</sup> Tendons and nerve repairs were performed after the fracture reductions of the patients, and then PIF was applied to all patients after preop drawings were made. We achieved good hemostasis before the skin graft was applied and the adrenaline-produced vasoconstriction is applied to the donor area with gauze soaked in epinephrine, as it can reduce the edema of the donor region and increase skin graft uptake. We did not detect flap necrosis in any patient or observe a flap-related complication.

Difficult dissection limits the use of reverse flow PIF, such as possible injury to the posterior interosseous nerve and inconsistent Anatomy of it. One of the key advantages of PIF is to have a good skin paddle quality that matches the part of the hand to the bottom of the dorsum of the thumb and fingers. In addition, as a small vein secondary to vascular nutrition of the hand region, medium to large flaps can be collected to cover these areas. This modified method, which maintains venous circulation and prevents pressure on the pedicle due to skin tension, hematoma or swelling, is considered safer than the original technique. In this study, we observed the superiority of PIF compared to the interpolation flap with the postoperative follow-up comfort, ease of fracture healing, easy and fast, easy-to-apply method and no second additional session requirement in FI patients. In patients with FI, interpolation flap is not preferred due to the reduction and healing of the donor site and wrist and wrist fractures due to multiple traumas. However, we think that PIF is the best method in such cases because it allows splint applications in postop fracture reduction.

In our study, there were some restrictions due to the patients' being foreign nationals. First, patients have difficulty in long-term follow-up because they did not reside in Turkey and were foreign nationals. Therefore, we could only publish the short-term results of FI patients. Secondly, because we are not the only hospital on the border that interferes with such injuries in the region, we have been deprived of including more cases in all of our FI patient numbers.

## 5. Conclusion

All injuries were in the hand and wrist region developed as a result of FI in all patients, with bone or tendon structures exposed with fractures. Tendons and nerve repairs were performed after the fracture reductions of the patients, and then PIF was applied to all patients after preop drawings were made. We found the superiority of PIF with the postoperative follow-up comfort, ease of fracture healing, easy and fast, easy-to-apply method and no second additional session requirement in FI patients. We did not detect flap necrosis in any patient or observe a flap-related complication. As a result of the present study, it strongly supports the thesis that PIF is the best option in these cases.

## Author contributions

**Conceptualization:** Murat Ucak.

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**Investigation:** Murat Ucak.

**Methodology:** Murat Ucak.

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**Writing – original draft:** Murat Ucak.

**Writing – review & editing:** Murat Ucak.

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