



Original Research

Emergency repair of upper extremity large soft tissue and vascular injuries with flow-through anterolateral thigh free flaps



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ABSTRACT

Background/Objectives: Complex extremity trauma commonly involves both soft tissue and vascular injuries. Traditional two-stage surgical repair may delay rehabilitation and functional recovery, as well as increase the risk of infections. We report a single-stage reconstructive surgical method that repairs soft tissue defects and vascular injuries with flow-through free flaps to improve functional outcomes.

Methods: Between March 2010 and December 2016 in our hospital, 5 patients with severe upper extremity trauma received single-stage reconstructive surgery, in which a flow-through anterolateral thigh free flap was applied to repair soft tissue defects and vascular injuries simultaneously. Cases of injured artery were reconstructed with the distal trunk of the descending branch of the lateral circumflex femoral artery. A segment of adjacent vein was used if there was a second artery injury. Patients were followed to evaluate their functional recoveries, and received computed tomography angiography examinations to assess peripheral circulation.

Results: Two patients had post-operative thumb necrosis; one required amputation, and the other was healed after debridement and abdominal pedicle flap repair. The other 3 patients had no major complications (infection, necrosis) to the recipient or donor sites after surgery. All the patients had achieved satisfactory functional recovery by the end of the follow-up period. Computed tomography angiography showed adequate circulation in the peripheral vessels.

Conclusions: The success of these cases shows that one-step reconstructive surgery with flow-through anterolateral thigh free flaps can be a safe and effective treatment option for patients with complex upper extremity trauma with soft tissue defects and vascular injuries.

1. Introduction

Complex extremity trauma that causes skin and soft tissue defects and also vascular injuries can lead to permanent disabilities. Treatment of these cases is always challenging for surgeons [1–4]. Traditional surgical treatment is performed in two stages; the first to repair the vascular injury, and the second to reconstruct the soft tissue defects with free or pedicled flaps [5–9]. These two-stage surgical procedures commonly require significant time to complete, which delays patients' subsequent rehabilitation and functional recovery, and also increases the risk of complications such as infections, including osteomyelitis.

A flow-through technique has been reported to repair soft tissue and vascular injury simultaneously in a single-stage surgery [10–12]. Flow-

through flaps allow repair of the injured soft tissues, as well as revascularization through anastomosis to the body parts distal to the injured site. Patients with complex injury to the extremities reportedly achieve satisfactory recoveries after one-stage flow-through free flap reconstructive surgery.

A limited study reported the repair of upper extremity large soft tissue defects and major vascular injuries with a free flow-through anterolateral thigh flap. This has the advantage of providing large flow-through free flaps, with a minimal conspicuous scar at the donor site [13].

Herein, we report 5 patients treated with flow-through anterolateral thigh free flaps during reconstructive surgery to repair large soft tissue and vascular injuries of the upper extremity.

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2. Material and methods

2.1. Study design and participants

This was a prospective observational study performed at an urban academic teaching hospital between March 2010 and December 2016. The hospital ethics committee approved the study protocol. All of the study participants signed informed consent. We would like to state that the current research work has been reported in line with the PROCESS criteria.

All the included 5 patients had severe upper extremity injury with a large skin defect and major vascular injury, and agreed to receive one-stage reconstruction surgery with flow-through anterolateral thigh free flaps on the recommendation of the primary treating surgeon. Excluded from the study was any patient unable or unwilling to sign the informed consent, or had concomitant major injury such as chest or abdominal injury that precluded emergency surgery for the extremity [14].

2.2. Surgical technique

The 5 patients received basic blood tests that included complete cell counts, basic metabolic panel, coagulation study, and type and screen; and extremity imaging studies such as X-ray and computed tomography angiography (CTA). The surgeries were performed with patients under general anesthesia. Skin flaps were prepared based on the severity of the individual patient's extremity injury, with perforator flaps for less contaminated wounds, and musculocutaneous flaps for contaminated wounds or deep wounds with large muscular defects.

A long segment of the distal trunk of the descending branch of the lateral femoral circumflex artery was preserved, to reconstruct the major vessel in the injured upper extremity. After thorough wound debridement of the injured upper extremity, emergency one-stage repair of the large soft tissue defects and vessel injury of the upper extremity was performed with flow-through anterolateral thigh free flaps (Fig. 1). The upper extremity soft tissue defects were covered by the thigh free flaps. The injured artery was reconstructed and anastomosed to the femoral circumflex artery to regain blood flow. A segment of vein close to the descending branch of the lateral femoral circumflex artery (either the lateral femoral circumflex vein or the great saphenous vein) was also used for reconstruction if there was a second artery injury. The thigh area for the donor flap was sutured primarily. External fixation was applied if there was concomitant bone fracture or a requirement for postoperative nursing care.

After the reconstructive surgery, the repaired upper extremity was elevated and kept warm. Routine antibiotics, analgesics, anti-spasmodic, and anti-thrombotic treatments were applied. Upper extremity blood supply and discharges from the flaps and the thigh donor sites were closely monitored. Patients were encouraged to participate in rehabilitation as early as possible and were followed for up to 60 months after the surgery. At the end of the follow-up period, CTA was repeated to assess peripheral blood circulations.

3. Results

We enrolled 5 patients in this analysis, 2 females and 3 males, with ages ranging from 2 to 55 years (Table 1). All of them had upper extremity (upper arm, forearm, or wrist) large soft tissue defects and vascular damages from either traffic accidents or crush injuries. The mangled extremity severity scores (MESS) were between 7 and 9. The times from injury to emergency surgical operations were between 5 and 12 h. The sizes of the soft tissue defects ranged from 13×7 to 30×10 cm².

One patient had only one artery injury (radial artery), and the other 4 patients had two artery injuries (the ulnar artery with either the brachial or radial artery). None of the 5 patients had palpable distal limb arterial pulses. Four patients had sluggish capillary refills and one

patient had a pale hand with no detectable capillary refill. During the operations, the sizes of the anterolateral thigh free flaps were between 14×8 and 32×12 cm². The length of the major reconstructed artery ranged from 4 to 10 cm. During the follow-up after the surgeries, all the donor flaps survived. There was no complication involving the thigh donor sites. Patients began rehabilitation for functional recovery as early as possible when tolerated, or underwent subsequent bone fracture treatments, if necessary.

3.1. Case 1

A 45-year-old woman experienced injury resulting from a traffic accident (Fig. 2). She had a right upper arm-to-forearm injury with a soft tissue defect size 30×10 cm². Both the brachial artery and the ulnar artery were injured (8- and 10-cm ruptures, respectively) with a thrombosis observed in the brachial artery. Her MESS was 7. A 32×12 -cm flow-through left anterolateral thigh flap was prepared and transplanted to the right arm to cover the defected soft tissue. The injured brachial artery was reconstructed and anastomosed to the descending branch of the femoral circumflex artery to regain vascularization. A segment of the great saphenous vein was used to reconstruct the injured ulnar artery. External fixation was used after the surgery. The postoperative recovery was uneventful. This patient was followed for 60 months. Her right elbow and wrist flexion and extension and hand grip function were almost fully recovered. CTA showed satisfactory circulations to the right arm at the end of the follow-up.

3.2. Case 2

A 20-year-old man presented with trauma to the right forearm and wrist due to a crushing injury from operating a machine (Fig. 3). His MESS was 9 and the size of skin defect was 22×10 cm², with accompanied distal radial and ulnar fractures. The preoperative CTA showed ruptures of both the ulnar artery and radial artery. During the surgery, a 25×8 cm² anterolateral thigh free flap was transplanted to repair the arm soft tissue injury. Similar to case 1, the injured radial artery was reconstructed and anastomosed to the descending branch of the femoral circumflex artery to regain vascularization. A segment of the great saphenous vein was used to reconstruct the injured ulnar artery. Unfortunately, the thumb became necrotic during the postoperative recovery period. After debridement, an abdominal pedicle flap was used for repairment. At the 6-month follow-up visit, CTA showed satisfactory blood circulation.

4. Discussion

In the current study, we describe 5 patients who had severe upper extremity trauma, with both large soft tissue defects and major vascular injuries. Emergency reconstructive surgeries were performed with flow-through anterolateral thigh free flaps. All the 5 patients had satisfactory functional recovery at the end of the follow-up period.

Previous studies reported that early emergency surgery to repair extremity injuries was safe and effective, and could potentially yield better functional outcomes [15–17]. However, complex extremity trauma commonly involves both soft tissue and vascular structures. Emergency surgical repair should reconstruct both damaged soft tissue and vessels. Traditional 2-stage operations may delay recovery and increase the risk of infections [8,9]. The flow-through flap can repair large soft tissue and vascular defects in a single one-stage operation and provides blood supply through anastomosis to the free flaps without disrupting distal circulation to the extremities [18,19]. This potentially makes the flow-through flap a better option to repair both soft tissue and vascular injuries in the extremities. The one-stage simultaneous repair of both soft tissue defects and vascular injuries may save recovery time, improve rehabilitation, and decrease the risk of infections.

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