Flow-through arterialised venous free flap using the long saphenous vein for salvage of the upper extremity

Short running title: Flow-through arterialised venous free flap

Type of paper: Case report

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Abstract

We used two flow-through arterialised venous free flap transfers with the long saphenous vein to reconstruct major arteries and injured skin and soft tissues in the upper extremity. Operating time was reduced, only one donor site was used, and reconstruction of a long arterial defect (24 - 25 cm) was possible.

Key Words: Flow-through arterialised venous free flap, the long saphenous vein, upper extremity salvage

Introduction

In patients in whom the main arteries of the extremities are injured, the circulation may be impeded resulting in the risk to survival. The skin and soft tissues may be damaged severely and bones, ligaments, and muscles may be exposed. In cases of such severe trauma treatment is complicated. To salvage the limb it is necessary first to reconstruct the main arteries in the limbs to regain circulation.

In the past this was usually done using a vein graft of the long saphenous vein, but a vein graft without reconstruction of the damaged skin and soft tissues could fail for various reasons such as exposure and infection. Investigators have therefore introduced two procedures, the first of which is a free flap transfer for reconstruction of the damaged skin and soft tissues followed by a vein graft using the long saphenous vein [1-3]. The second is flow-through free flaps [4-6].

We have successfully reconstructed the main arteries, and so salvaged the limbs as well as reconstructing the soft tissue and skin by using a flow-through arterialised venous free flap from the long saphenous vein. This is more advanced than the simultaneous vein graft and free flap transfer, or flow-through free flaps.

Case reports

In two patients the survival of the upper limbs was threatened by damage to the main arteries as a result of a road traffic accident; in addition, the skin and soft tissues were injured, with exposed bones and muscles. They were treated by flow-through arterialised venous free flap using the long saphenous vein.

Operative technique

The recipient site was thoroughly debrided of necrotic tissues, and the proximal and distal portions of the artery to be reconstructed were prepared for anastomosis. The size of the flap was measured; it was designed in such manner that the route of the long saphenous vein in the medial thigh could be placed in the middle. The parts of the long saphenous vein from the distal and proximal sides of the flap were found first. The flap was then incised as required, and the flap harvested from the immediately superior level of the fascia of the thigh. Because the draining efferent vein is important in an arterialised venous free flap, several veins were found and dissected together, and the bleeding from the vein that becomes a tributary of the long saphenous vein was stopped completely. After the flap had been harvested it was taken to the recipient site. To achieve the required blood flow from the long saphenous vein, the distal long saphenous vein was anastomosed to the proximal artery in the recipient site and the proximal long saphenous vein to the distal artery in the recipient site. The draining efferent vein of the flap was anastomosed to the vein in the recipient site.

Case 1

A 13-year-old girl presented to the emergency room with a degloving injury of the right upper arm and the shoulder after a road traffic accident. Physical examination showed that the skin and soft tissues were severely damaged, the humerus was exposed, and the flexor muscles in the upper arm were also damaged. The brachial artery from the axillary artery to the distal brachial artery was injured, and there were no peripheral arterial pulses in the upper arm, the forearm, and the hand (Figure 1).

To salvage the upper extremity, we reconstructed the brachial artery, the skin, and soft tissues. A flow-through arterialised venous free flap using the long saphenous vein, 25 x 8 cm in size, was harvested from the left thigh (Figure 2). The axillary artery and the distal portion of the long saphenous vein were anastomosed, and the brachial artery was anastomosed to the proximal portion of the long saphenous vein. The arterial pulses in the upper arm and below the forearm recovered immediately the anastomoses had been made. Because the soft tissues of the upper arm were so severely damaged, the recipient vein could not be found, and so the draining efferent vein of the arterialised venous free flap could not be anastomosed to the recipient vein.

Twelve hours after the operation, the flap began to swell and became congested. Medical leeches were applied and heparin given topically. Five days after the operation, the skin began to slough, and by 14 days after the operation the swelling and the congestion had almost disappeared. Nevertheless she developed full thickness necrosis of the skin. However, most of the subcutaneous tissue survived. Leeches and heparin were applied for 14 days, and a total of 16 leeches was used.

Fifty days after the operation, we did a functional free muscle transfer using the gracilis muscle for flexion of the elbow, and applied a split thickness skin graft to the fatty tissues of the arterialised venous free flap (Figure 3). After the second operation, the patient was able to flex the elbow, and the skin graft on the fatty tissues healed well (Figure 4). The angiogram done three months postoperatively showed that the brachial artery was patent (Figure 5).

Case 2

A 22-year-old man presented to the emergency room with a degloving injury of the anterior surface of the left elbow and the forearm after a road traffic accident. The skin and soft tissues were severely damaged, and the radial and ulnar arteries were injured. There were no peripheral arterial pulses in the forearm and hand. The distal humerus and the ulna were fractured. A specialist team in chest surgery insected the vein graft using the long saphenous vein to reconstruct the radial artery. However, the skin and the soft tissues were not reconstructed, so the vein graft was exposed. He developed a compartment syndrome in the forearm, and three days after the operation developed a thrombosis. There were no arterial pulses in the forearm or the hand (Figure 6). On day 4 after the operation, the thrombosed vein graft was removed. To reconstruct the radial artery, the skin, and soft tissues, we used an arterialised venous free flap including the long saphenous vein cut into an oval shape, 24 cm long and 11 cm wide (Figure 7a). In the distal portion of the flap, one draining efferent vein was anastomosed to the vena comitantes of the radial artery to prevent congestion, and in the proximal portion, two draining efferent veins were anastomosed to the cephalic veins (Figure 7b).

Four days after the second operation the flap swelled and became congested, more so in its distal portion. This was treated by medical leeches and heparin applied topically for two weeks. Twenty leeches were used, and after two weeks, the flap had stabilised, the distal quarter of the flap sloughed and exposed the dermis. A portion in the quarter had necrosed through the full thickness, and the subcutaneous fat was exposed. We decided to let the wound heal by secondary intention. It healed completely, and the patient was discharged (Figure 8). The angiogram done three months after the second operation confirmed that the radial artery was patent (Figure 9).

Discussion

In cases of severe injury to the extremities when circulatory upset and tissue damage threaten the survival of a limb, immediate and complicated care is required. Different approaches have been reported: Lin et al. used the free flap transfer for reconstruction of skin and soft tissues and used the saphenous vein as a graft, for salvage of an extremity or for the construction of a recipient vessel in the free flap transfer [1]. Serletti et al. [2] and Ciresi et al. [3] salvaged the extremity with a bypass graft, sometimes with a simultaneous free flap transfer or a delayed free flap transfer. However, Ciresi et al. suggested that it is better to do the bypass graft and the free flap transfer simultaneously to reduce the operating time and the stay in hospital. Yavuz et al. [4], Koshima et al. [5], and Brandt et al. [6] used flow-through free flaps. In other words, the main artery was reconstructed by using the pedicle of the flow-through free flap to salvage the extremity. The skin and soft tissue defects were reconstructed simultaneously. Without the vein graft the pedicle of the free flap itself acts as the vein graft. Brandt et al. used the flow-through free flap primarily in the hand and fingers, so the length of the revascularised part was extremely short. Koshima et al. used the method only in cases in which the arterial defect was less than 20 cm.

We used the long saphenous vein for the reconstruction of the main artery, and simultaneously raised an arterialised venous free flap using it as a pedicle, and treated the defects in the skin and soft tissues. The advantages of our method are: by first, dissecting the long saphenous vein and raising the arterialised venous free flap simultaneously, the operating time was greatly reduced. Secondly, our method of using the long saphenous vein and the free flap transfer generates two donor sites, but it generates only one donor site in the medial thigh, and so the morbidity at the donor site is reduced. Thirdly, in patients with arterial defects 24 – 25 cm long as described, reconstruction of the arterial defect was not possible with a flow-through free flap, so our method is a useful alternative.

Unlike the conventional free flap, the arterialised venous free flap does not require the sacrifice of major vessels, it is generally thin, the selection of the donor site is generally not limited, the dissection is not difficult, and the procedure is quick. It is therefore widely used. However, severe postoperative swelling, discolouration, formation of bullae, and unpredictable partial necrosis of the flap are serious problems [7,8], particularly in those patients with a large arterialised venous free flap. To improve survival of the arterialised venous free flap, various methods have been suggested including surgical and chemical delay [7]. Woo et al. reported that it is important to relieve the congestion in the flap by connecting as many efferent veins as possible [8].

In case 1 almost all the skin was necrotic because the draining efferent vein was not connected, and in case 2 where two draining veins were connected in the proximal portion the skin survived. However, in the distal portion where only one draining vein was connected, the skin became partially necrotic. This can be explained by the high pressure arterial blood flow entering the afferent vein of the arterialised venous free flap, which suddenly raised the pressure in the flap. If the draining through the efferent vein was not effective, deoxygenated haemoglobin would accumulate in the flap, causing ischaemia. If this persisted, it would cause swelling, discolouration, and formation of bullae, and finally result in partial necrosis of the region in which the extraction of oxygen and nutrients was minimal [8]. In our case, the size of the flap was large, about 25 x 8 cm, and 24 x 11 cm, so substantial congestion was anticipated, and the draining efferent veins were to be anastomosed as far as possible. When we attempt the arterialised venous free flap in future cases using the long saphenous vein we shall anastomose at least four draining efferent veins.

Two shortcomings have come to light. First, the arterial autograft is superior to the venous graft. This has been confirmed by clinical and experimental work. Secondly, because the proximal and distal portions of the venous graft are exchanged to correspond with the blood flow, the gradually increasing diameter of the vein does not secure the congruence of the anastomosis [9,10].

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Legends

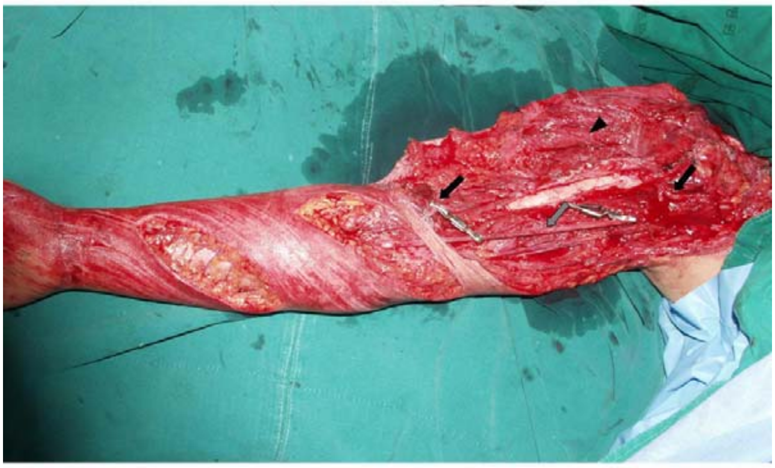

Figure 1. Case 1. Preoperative view. The skin, soft tissues, brachial artery (arrows), and flexor muscles (arrowhead) were severely injured. Grey arrow indicates the median nerve.

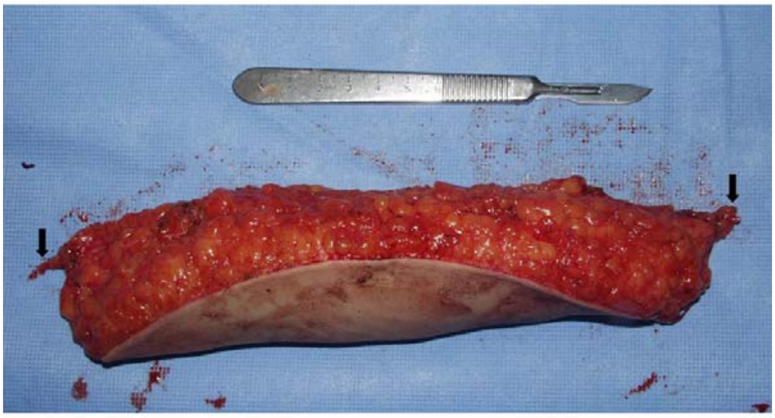

Figure 2. Case 1. Flow-through arterialised venous free flap (25 x 8 cm) harvested from the left medial thigh. Arrows indicate the long saphenous vein.

Figure 3. Case 1. Functional gracilis muscle free transfer for flexion of the elbow, and split thickness skin graft to cover the wound. (a) Second preoperative view. The granulation tissue is visible on the viable fatty tissues of the flow-through arterialised venous free flap. (b) Second intraoperative view showing the gracilis muscle (arrow) and its pedicle (arrowhead).

Figure 4. Case 1. Postoperative view three months after the second operation. Flexion of the elbow was possible after the functional gracilis muscle free transfer.

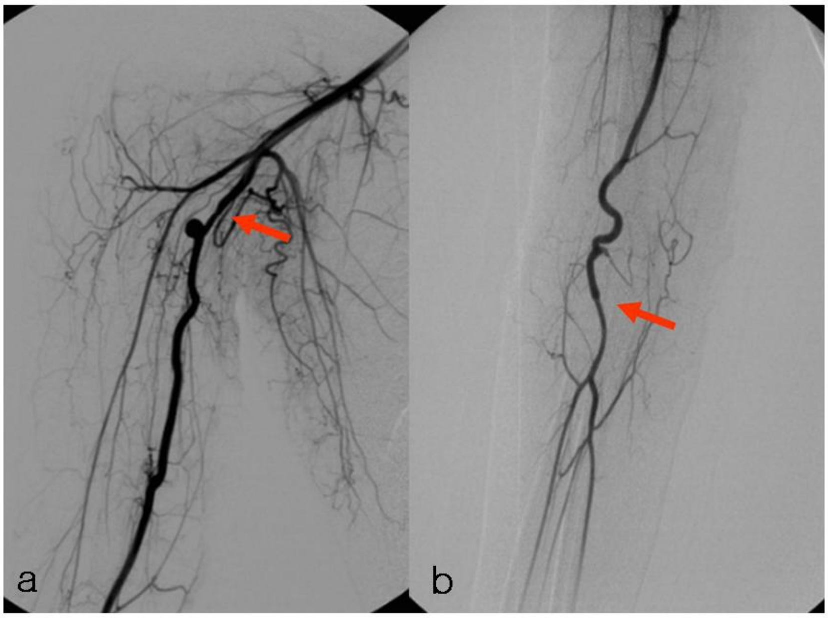

Figure 5. Case 1. Postoperative angiogram. The reconstructed brachial artery is patent. Arrows indicate (a) proximal and (b) distal ends of the long saphenous vein.

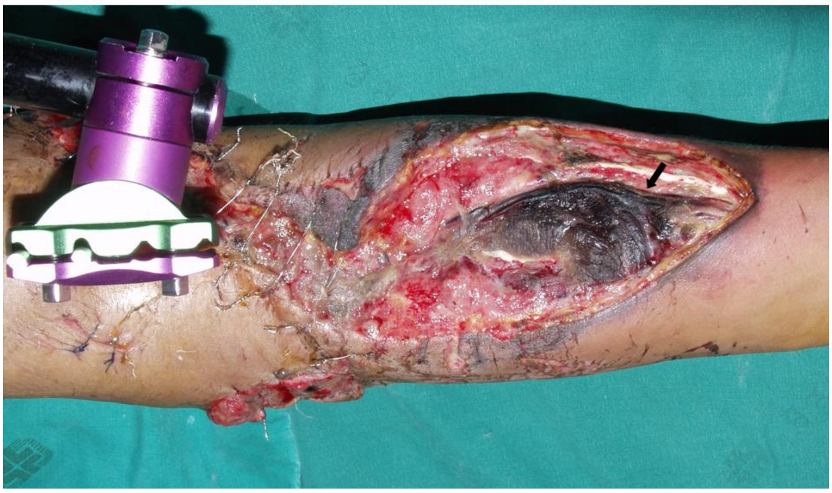

Figure 6. Case 2. Preoperative view. The defects of the skin and soft tissues are visible,

as is thrombosis (arrow) of the vein graft for reconstruction of the radial artery. Flexor muscles were necrotic.

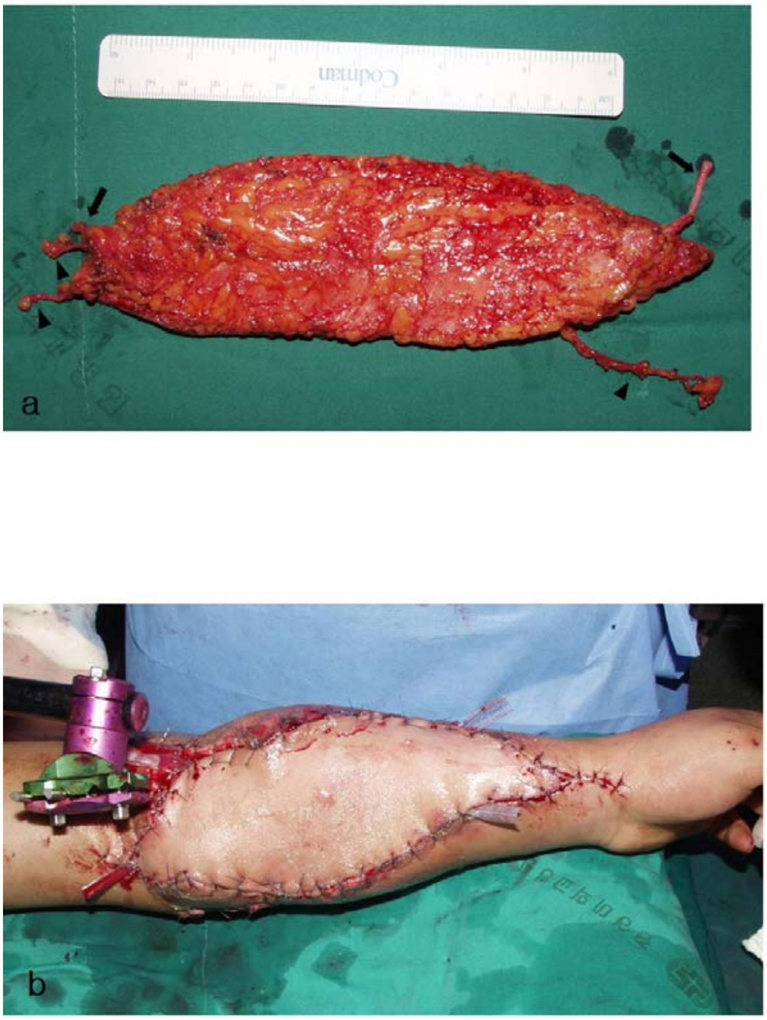

Figure 7. Case 2. (a) Harvested flow-through arterialised venous free flap (24 x 11 cm) showing the long saphenous vein (arrows) and the draining efferent veins (arrowheads). (b) Immediate postoperative view.

Figure 8. Case 2. Postoperative view three months after the operation. The defects of the skin and soft tissues were well healed after the flap.

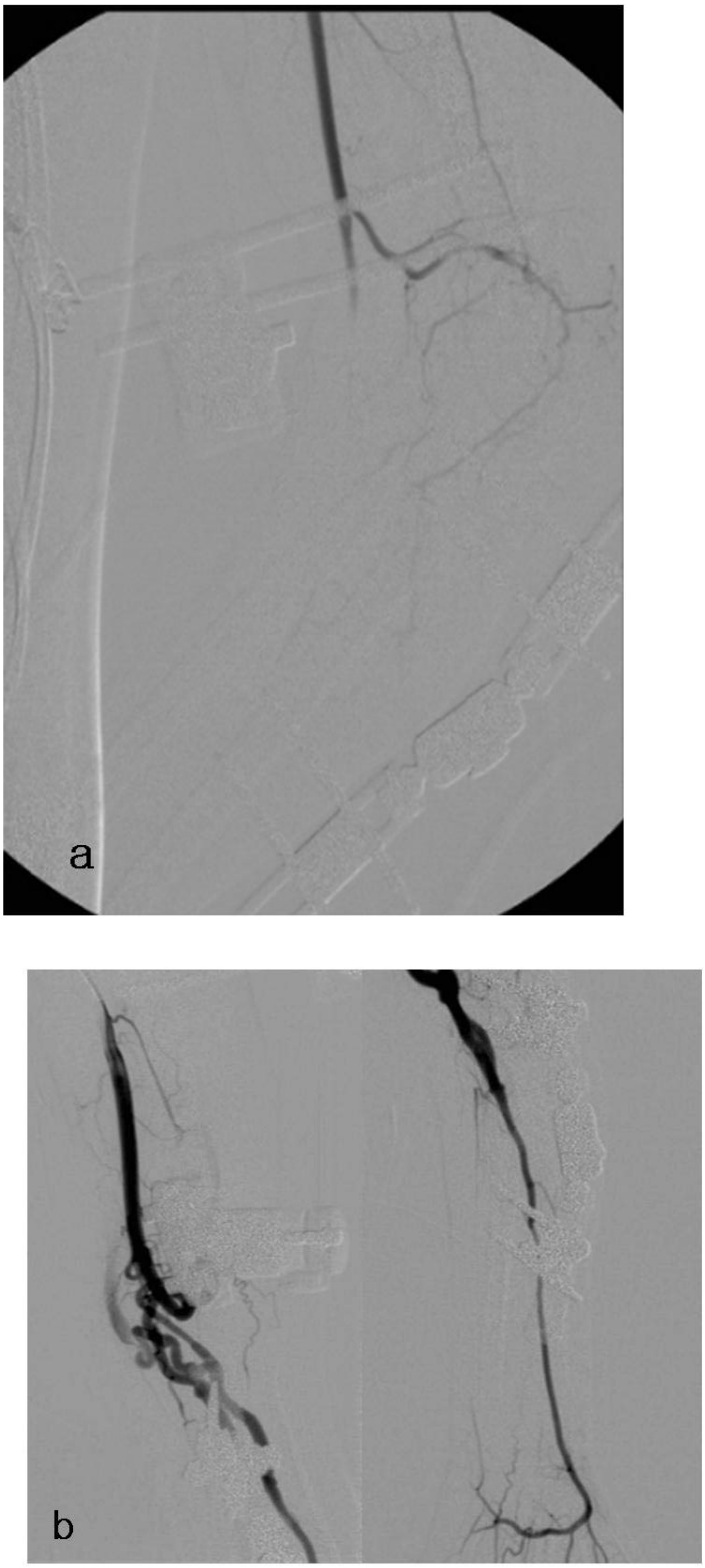

Figure 9. Case 2. (a) Preoperative angiogram. The radial and ulnar arteries were injured,

but there was minimal collateral circulation. (b) Postoperative angiogram. The reconstructed radial artery was patent and the palmar arch is visible.