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Original Article

Microsurgical free tissue transfer as a valuable reconstructive procedure in foot reconstruction

Mohamed El-Shazly, Mohamed Makboul

Department of Plastic Surgery, Assiut University Hospital, Assiut, Egypt

Address for correspondence: Dr. Mohamed El-Shazly, Department of Plastic Surgery, Assiut University Hospital, 71526 Assiut, Egypt.
E-mail: moh.elshazly@lycos.com

ABSTRACT

Background: Owing to the limited soft tissue donor sites in the foot area, the use of microsurgical tissue transfer is frequently becoming mandatory in this area, especially in cases of massive defects due to the common motor vehicle accidents in the territory of Upper Egypt. Free flaps offer a great variety of available tissues to cover larger, multifocal or multistructural defects. They also improve the perfusion of the infected poorly perfused areas. **Objectives:** In this study, we tried to evaluate foot defects according to their size, shape and site and to determine the general and specific parameters of free tissue transfer to the foot area in concomitance with the patients needs. **Materials and Methods:** Eleven patients were included in this study. For each patient, complete history was taken, general and local examination, photographic documentation, laboratory investigations, imaging and other investigations were performed. Free flap transfers were applied in all cases as follows: Latissimus dorsi flap in five cases, Rectus abdominis flap in three cases, Scapular flap in one case, Gracilis flap in one case and Radial forearm flap in one case. **Results:** Nine flaps survived. No infection or donor site complications were recorded. Every patient had the optimum free flap as regards the defect size, site, depth, condition, shape, donor site availability and the recipient vessels' condition. **Conclusion:** The study of the optimum free flap for foot reconstruction in relation to the defect present and patient conditions is crucial to have significant results.

KEY WORDS

Foot, free flap, reconstruction

The history of foot reconstruction began with an attempted morphologic restoration of the shape. The most ancient description is an Egyptian prosthesis found in a pharaoh's sarcophagus. The first written report on foot injuries was found in Roman war surgery books, in which amputation had already been suggested as the elective treatment for serious foot damages.[1]

The foot is an especially important part of the lower limb because of its integrated function as both a sensor and an effector. The covering skin of the foot is very peculiar, especially in the weight-bearing areas, where the non-shearing and padding properties make it quite resistant and strong. Due to a higher number of vehicular accidents, defects of the sole of the foot have increased, mostly afflicting young active people. Moreover, the stress caused by weight-bearing makes durable repair of these areas difficult and unreliable.[2]

In the past therapeutic options were mostly limited to local flaps, skin grafts or cross-leg flaps. Tubed-pedicle

flaps that had been applied as jumping flaps to reach the lower extremity were frequently used at the beginning of the 20th century.[3]

The development of microsurgery and the expansion of plastic surgery techniques have led to a significant increase in the surgical options for the salvage of the lower extremities. Foot surgery began to be more accurate and sophisticated, as surgeons sought a proper functional reconstruction rather than a pure morphologic restoration of the shape.[4]

Free flaps offer a great variety of available tissues to cover larger, multifocal or multistructural defects. They also improve the perfusion of the infected and poorly perfused areas.[5]

The treatment of choice depends on the site, dimensions and cause of the defect. Hidalgo and Shaw in 1986,[6] divided foot traumas into three classes according to the dimension and extension of the lesion, as follows:

Type I: Small soft tissue loss less than 3 cm^2 can be repaired by local flaps in weight-bearing areas and by skin grafts in non-weight-bearing areas.

Type II: Large tissue loss greater than 3 cm^2 without bone involvement, a free fasciocutaneous, musculocutaneous or muscle-plus-skin graft transfer is indicated.

Type III: Large tissue loss with bone involvement, a free osteocutaneous transfer is recommended.

MATERIALS AND METHODS

Eleven patients were included in this study with their age ranging from 8 to 53 years. They presented to our department with soft tissue problems, either acute or chronic defects, ulcers or unsteady scarring in the foot area. These problems were reconstructed with free-tissue transfers using five free flap options as follows: Latissimus dorsi (five cases), Rectus abdominis (three cases), Gracilis (one case), Radial forearm (one case) and Scapular flap (one case). The aetiologies were acute post-traumatic wounds with hardware exposure in six patients, unsteady scarring with recurrent ulcerations in three patients and chronic trophic ulcerations in another two patients.

The defect was large (about 20 × 15 cm in dimension) in five cases, smaller longitudinal defect (about 10 × 5 cm in dimension) in four cases and small defect (about 5 × 8 cm in dimension) in two cases.

In the five large soft-tissue defects (20 × 15 cm in dimension), we used the free muscle or myocutaneous latissimus dorsi flap [Figures 1a, b]. In the smaller longitudinal defects (10 × 5 cm in dimension), we used the free rectus abdominis muscle flap in three patients with defects on the heel, Achilles tendon and medial aspect of the foot [Figures 2a-c] and the free scapular flap for a shallow chronic ulcer on the lateral aspect of the foot in one patient [Figures 3a, b]. In one patient, we used the free gracilis muscle to cover a small defect (about 5 × 8 cm in dimensions) with bone exposure and the free radial forearm flap for an unsteady scar on the lateral malleolus and lateral foot area [Figures 4a, b].

Full history was recorded for each patient to clarify the aetiology of the defect, age and weight of the

Figure 1: (a) Preoperative soft tissue bulk defect, unsteady scarring and chronic ulceration over the foot dorsum and sole in a 25-year-old patient, (b) Late postoperative view of the case in Figure 1a

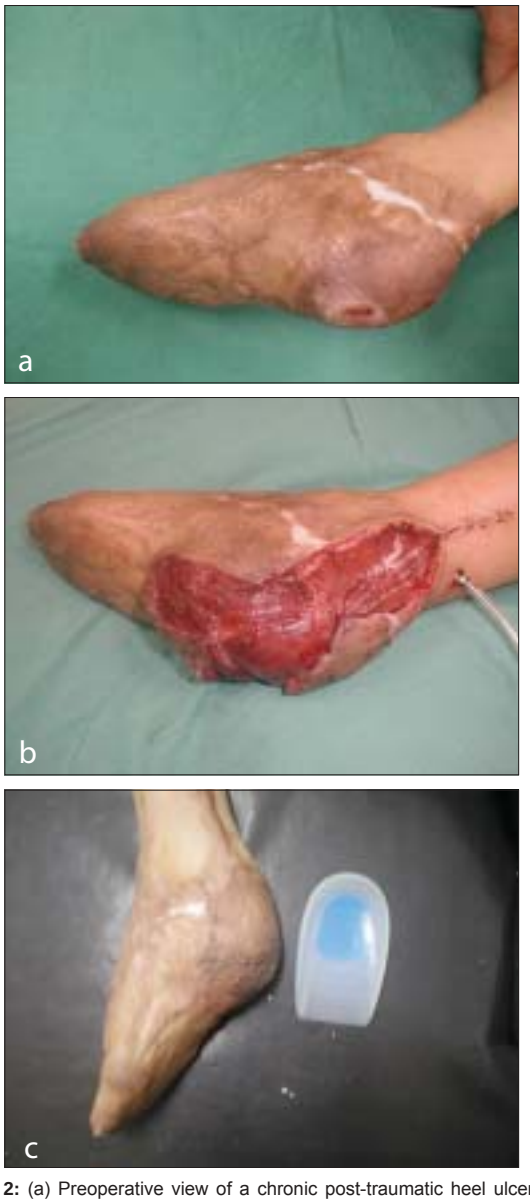

Figure 2: (a) Preoperative view of a chronic post-traumatic heel ulcer in an eight-year-old patient, (b) Intraoperative view of the case in Figure 2a, (c) Late postoperative view of the case in Figure 2a

patient, concomitant diseases, concomitant leg fracture, ulcerations or scarring and working activity. General and local examinations of the patient were also conducted. Evaluation of each foot defect was performed considering the following:

- Amount of the tissue loss (dimension, depth and extension of the defect).
- Localization (weight-bearing or non-weight-bearing areas).
- Neurovascular damage.
- Recipient site condition.
- Patient needs according to his or her occupation,

Figure 3: (a) Preoperative view of a chronic ulcer with osteomyelitis in the foot dorsum in 26-year-old patient, (b) Few months' postoperative view of the case in Figure 3a

Figure 4: (a) Preoperative view of a chronic unsteady scar in the lateral foot aspect in a 35-year-old patient, (b) Late postoperative view of the case in Figure 4a

age, walking activities, environment and type of the preferred foot wear.

Laboratory studies included:
- Complete blood count (CBC).
- Blood sugar.
- Renal function tests.
- Liver function tests.
- Prothrombin time and activated partial thromboplastin time.

Imaging studies:
- Leg and/or foot radiographs.
- Chest radiograph if indicated by medical examination or the patient's history.

Other tests
- Doppler or angiography to assess the vascular pattern of the foot and leg once needed in those patients with difficult clinical evaluation of the limb vascularity and/or patients with heavy trauma with a suspect of vascular injury.
- Allen's test in patients with radial forearm flap.
- ECG.

Techniques
A meticulous planning of each defect was accomplished with a pattern. Two teams were involved in the surgery, one for the donor tissue harvesting and the other for preparing the recipient site. The choice of the recipient vessels was dependent on the vascular condition of the foot and leg, choosing either the anterior or the posterior tibial artery. All microvascular anastomoses were performed as interrupted end-to-end anastomoses using 10/0 black nylon sutures with lancet point 3/8 circle needle. Except in the free rectus abdominis muscle and the radial forearm flaps, only one vein anastomosis was done in our series.

Postoperative care
- All patients were admitted to the ICU for at least 48 h, where they generally received: systemic broad-spectrum antibiotics which were followed later by the oral form, Heparin 20000 IU/day in the form of continuous infusion for five days to be decreased gradually after the fifth day by 5000 IU daily till complete withdrawal on the 10th postoperative day, and 4000 ml IV fluids/day in the form of Lactated Ringer solution which was decreased gradually starting from the sixth day to be completely withdrawn on the 10th postoperative day too.
- The patients were positioned on air mattresses, with both legs slightly elevated.
- Flap sites were warmed by controllable pumped heaters.
- Flaps were monitored for colour, capillary refill, temperature and fullness every two hours in the first two days and four times per day until two weeks postoperatively with the aid of a Doppler probe to check the patency of the microanastomoses and to survey the skin or muscle island.

Follow-up care
- Observing contour and stability of the reconstruction, after two weeks and at 1, 3, 6, 12 and 18 months postoperatively. Any long-term problems or complications on resumption of walking and weight-bearing were also assessed.

RESULTS

All flaps survived except two cases: one of the latissimus dorsi flaps and the gracilis flap. There were no deep infections, donor site complications or interference with the function at the donor sites. In patients with defects of the sole, load and walking ability were generally recovered in one month. Custom-made shoes had been recommended for three to six months in patients with bulky latissimus dorsi flaps and thin rectus abdominis flaps. The ideally situated skin island, either of the fasciocutaneous radial forearm or the myocutaneous latissimus dorsi ones, over the calcaneal bone was perfect in terms of padding of this weight-bearing area. Durability of the flaps was determined through periodic clinical examinations and patients' records. Two patients with radial forearm flap and latissimus dorsi flap needed, refashioning and debulking respectively, six months postoperatively.

DISCUSSION

There are many free flap options for reconstruction of the foot area which may include muscle or myocutaneous flaps, like the Latissimus dorsi, Rectus abdominus, Gracilis, Scapular and Radial forearm flaps.

Since O'Brien *et al.*[7] first used a free groin flap to reconstruct a foot defect in 1973, free flaps have been widely used to reconstruct the sole of the foot. After the free latissimus dorsi procedure was described by

Baudet *et al.*,[8] in 1976, many authors used this and other myocutaneous flaps to repair wide foot defects.[9] Because of the excessive thickness of those flaps, the use of the free latissimus dorsi muscle-plus-skin graft was advocated.[10] Later in the 1980s, the use of fasciocutaneous flaps was strongly suggested as a standard for foot reconstruction.[11]

The latissimus dorsi flap can be harvested as a pure muscle flap or as a myocutaneous flap, based on the thoracodorsal artery. Its advantages are large dimensions, easy dissection, long pedicle and large diameter of the vessels. Its main disadvantages are thickness of the flap and sacrificing of a major muscle.[8] In our five patients who were managed by the latissimus dorsi muscle, we had a wide covering tool either with a durable skin paddle for weight bearing or covered by split-thickness graft in non-weight-bearing areas. It was the ideal solution for the massive defects of our patients, especially in the presence of infection or diminished blood supply in the area to be reconstructed. However, it was a disadvantage for the patients in the selection of suitable footwear postoperatively, so many debulking procedures were needed in one case. One latissimus dorsi flap failed intraoperatively due to patient's haemodynamic instability through the procedure in the form of an insufficient intravenous fluid therapy and inadvertent vasopressor injection to raise the blood pressure by a junior anaesthetist, which led to an irreversible arterial spasm. This patient was treated then with a temporary coverage by a split-thickness skin graft.

Rectus abdominus flap is a muscle flap harvested from the anterior abdominal wall, based on the epigastric vessels (superior and inferior). The main disadvantage is weakness of the anterior abdominal wall and the donor site should be closed using a mesh.[12] This narrow rectus abdominis muscle was a good option for the three narrow defects in our series. Because it is a thin muscle, one of our patients needed a silicon heel application to prevent the occurrence of trophic ulcers [Figure 2c].

The gracilis flap is a muscular or myocutaneous flap, with a small skin paddle that can be harvested from the medial side of the thigh, based on the medial circumflex femoral artery. Its advantages are easy dissection, vessel diameter of approximately 2 mm and length of approximately 6 cm. Its donor site can be closed directly without a functional defect.[13] Although it failed in our series, the gracilis flap has the same criteria like the rectus abdominis muscle, with less morbidity, but with a shorter vascular pedicle. This failure was due to the preoperative plan to use the peroneal vessels as recipients to be away from the zone of injury. The exploration of these vessels took a lot of time because of their deep position, so we changed the plan to explore the posterior tibial vessels. Although the anastomoses were patent, the transferred muscle expressed a moderate degree of vascular perfusion. We think that this long operative time led to initial ischemic changes with micro-capillary thrombosis.

As the Rectus abdominis flap has more morbidity in comparison to the Gracilis, we reinforce the anterior abdominal wall with its intact anterior and posterior rectus sheaths with a piece of prolene™ mesh which may minimize the expected morbidity to its lowest rate.

The radial forearm flap is harvested as a pure cutaneous flap based on the radial artery. Its advantages are easy dissection, long pedicle with large diameter vessels, reinnervation through cutaneous nerves and the possibility to include a bone.[14] The free radial forearm flap was a useful adjunct for one shallow soft tissue defect in our study. It was selected for its thin component that did not interfere with the postoperative function and footwear, however, its donor site morbidity was the main patient complaint.

The scapular flap can be harvested from the infraspinous fossa of the scapula based on the circumflex scapular artery. Its advantages are easy dissection, long pedicle, large diameter of vessels, direct closure of the donor site and possibility of creating composite flaps combined with other muscle flaps, while its disadvantages are thickness of the flap and difficult reinnervation.[15]

We have recently applied the scapular flap in our department. It was performed in one case in this series in which a moderate thickness flap was needed for a large chronic ulcer on the lateral aspect of the foot with subsequent satisfactory use of footwear. It is actually a good flap regarding vascular reliability, tissue amount and thickness with less donor site morbidity in comparison to the radial forearm flap. It is an ideal flap for wounds which are not deep with no or minimal infection.

We have followed our patients for a period of 18 months, many of them are still followed till this date. Special attention is directed to the long-term problems or complications on resumption of walking and weight-bearing. Although some of our patients are still using custom-made shoes or special shoe appliances and accessories, none of them have experienced problems in walking or weight-bearing. Free flap reconstruction in the foot area is sometimes absolutely indicated. It gives vascularity, tissue volume and coverage. The final choice of the most suitable treatment always depends on the preference of the surgeon but a correct evaluation of each clinical case and its needs is crucial to have patient satisfaction. The patient satisfaction is evaluated according to the reconstructive model durability, use of suitable footwear, use of adjunctive appliances, walking activities, donor site morbidity and aesthetic outcome. Although, there is no one flap who could be considered fully satisfactory for a given defect in each individual, each of the flaps used in this study presented the patient with some of these satisfaction criteria.

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