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Original Article

Non-microsurgical skin flaps for reconstruction of difficult wounds in distal leg and foot

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ABSTRACT

Purpose: To express the versatility of a variety of non-microsurgical skin flaps used for coverage of difficult wounds in the lower third of the leg and the foot over 4 years period. Five kinds of flaps were used. Each flap was presented with detailed information regarding indication, blood supply, skin territory and technique.

Methods: Altogether 26 patients underwent lower leg reconstruction were included in this study. The reconstructive procedures applied five flaps, respectively distally based posterior tibial artery perforator flap ($n = 8$), distally based peroneal artery perforator flap ($n = 4$), distally based sural flap ($n = 6$), medial planter artery flap ($n = 2$) and cross leg flaps ($n = 6$).

Results: In all cases, there were no signs of osteomyelitis of underlying bones or discharge from the undersurface of the flaps. Fat necrosis occurred at the distal end of posterior tibial artery perforator flap in one female patient. The two cases of medial planter artery flap showed excellent healing with closure of donor site primarily. One cross leg flap had distal necrosis.

Conclusion: Would at lower third of leg can be efficiently covered by posterior tibial, peroneal artery and sural flaps. Heel can be best covered by nearby tissues such as medial planter flap. In presence of vascular compromise of the affected limb or exposure of dorsum of foot, cross leg flap can be used.

Introduction

Traumatic wounds in the lower third of the leg and the foot combined with exposure of vital structures remain a challenging problem to any experienced reconstructive surgeon.[1] Lesions in these areas are represented with the highest complication rate due to subcutaneous position of the tibia and bones of the foot combined with lack of laxity of the skin and deficient muscle coverage. In addition, blood supply is deficient as a consequence of trauma or peripheral vascular disease.[2,3]

Studies of vessels and microcirculation in the leg and foot lead to the reconstruction of angiosomes.[4–6] This paves the way to the design of septocutaneous flaps, neurocutaneous flaps and perforator flaps.[7–10]

The aim of this article was to use a number of non-microsurgical skin flaps for coverage of the lower third of the leg and the foot.

Methods

From August 2012 to August 2016, 26 patients (age range 4–54 years) who underwent lower leg and foot reconstruction were included in this study. Four patients were female and the rest were males. The defects were mainly due to high acceleration injuries. Five flaps were used in this study: distally based posterior tibial artery flap ($n = 8$), distally based peroneal artery flap ($n = 4$), distally based sural flap ($n = 6$), medial planter artery flap ($n = 2$) and cross leg flaps ($n = 6$). The dominant cause was trauma with much more male patients affected ($n = 22$). Only 4 cases were due to chronic wounds and the rest were due to acute wounds (22 cases). Ethical approval for this kind of study did not require formal consent from a local ethics committee. Informed consent was obtained from all patients or their parents.

Postrior tibial artery perforator flap

Indication: Used for coverage of posteromedial part of the distal third of the leg.

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Prerequisite: A Doppler probe was used to identify the perforators 5–12 cm above the medial malleolus. Then, a tourniquet was used in all cases before elevation of the flap.

Blood supply: Suitable perforators are those that pursue a horizontal course through the subcutaneous tissue after passing through the intermuscular septum vertically. Perforators are present up to 10 cm above the medial malleolus.[11]

Skin territory: The territory lies between the greater and lesser saphenous veins and extend proximally to about 10 cm from the popliteal skin crease. The venous drainage comes from the venae comitantes, which accompany the arterial perforators.[12]

Technique: Posterior to the great saphenous vein, an incision was made. The intermuscular septum was exposed to identify the perforators. Elevation of the flap was executed at subfascial level. Septum was incised distal to the perforator to ease flap movement.[13] Tourniquet was released and anesthesiologist was asked to elevate blood pressure of the patient to detect any bleeding points.

Peroneal artery perforator flap

Indication: Used for coverage of posterolateral part of the distal third of the leg.

Prerequisite: The perforators were identified a Doppler probe above the medial malleolus. Then, a tourniquet was raised before elevation of the flap.

Blood supply: Perforators are located 6–10 cm above the lateral malleolus. Musculocutaneous and septocutaneous perforators are available with predominance of septocutaneous type in distal leg.[14]

Skin territory: It occupies the area between the lesser saphenous vein posteriorly and the posterior border of fibula anteriorly and extend proximally to the middle of the leg.[15]

Technique: An anterior incision was made down to the peroneal muscles and the septum was identified posterior to the fibula. Septocutaneous perforators were dissected and the rest of the flap was elevated.[16] As mentioned before, Tourniquet was released. Also, Blood pressure of the patient was elevated to detect any bleeding points.

Sural flap

Indication: Used for coverage of heel area.

Prerequisite: A tourniquet was used and the patient was placed in lateral position.

Blood supply: It is supplied by vasa nervorum along the sural nerve which is accompanied by the lesser saphenous vein. The pivot point is about 5 cm above the tip of the lateral malleolus.[17]

Skin territory: It lies between the posterior border of tibia and the posterior border of fibula and does not extend above the popliteal fossa.

Technique: The axis of the flap was centered over the midpoint of popliteal fossa to the midpoint between the lateral malleolus and tendoachilles. The pedicle was at least 4 cm wide.[18]

Medial planter artery flap

Indication: Used for coverage of planter surface of foot and heel.

Prerequisite: The posterior tibial artery and dorsalis pedis arteries are palpable. Tourniquet is needed before elevation of the flap.

Blood supply: The flap is supplied by the medial planter artery which arises from the posterior tibial artery. The medial planter artery divides into smaller digital branches that travel with common digital branches of medial planter nerve. Cutaneous branches of the medial planter artery and medial planter nerve perforate the planter fascia and supply the skin overlying the medial instep area.[19]

Skin territory: The non-weight bearing medial instep area is the skin territory of the flap.[20]

Technique: Proximal to the metatarsal head, a transverse incision was made. The neurovascular pedicle was found between abductor halluces and flexor digitorum brevis muscles. One or more perforators were identified and dissected. Then the rest of the flap was elevated beneath the planter fascia with communication to the underlying perforators. The flap was advanced in a V–Y pattern in a proximal direction and the donor site was closed primarily.[21,22]

Cross leg flap

Indication: Used if there was no available local flaps in the same leg or there was peripheral vascular insufficiency.

Prerequisite: Above knee tourniquet was needed before elevation of the flap.

Blood supply: It is supplied by musculocutaneous perforators that lie in distal half of the gastrocnemius muscle.[23]

Skin territory: The proximal two thirds of the posterior surface of the leg represent the territory of the flap.[24]

Technique stage one: A rectangular incision was made on the back of the leg 8 cm above both malleoli with the base of the flap directed superiorly. The medial border was 2 cm from the posterior border of the tibia. The lateral border was 2 cm from posterior border of the fibula. The dissection was carried upwards in the subfascial plane. The dissection might extend up to the popliteal fossa safely (1: 4) to ensure placement of the flap without tension. Careful hemostasis was done. Skin graft was applied in the same setting and was secured by tie over dressing. The two legs were immobilized by plaster of Paris for 3 weeks.

Technique stage two: After 3 weeks, a big clamp was applied on the flap pedicle for three days. The flap was observed for any signs of congestion or impaired vascularity. With intact vascularity, the patient was transferred to the operating theatre for separation. Any residual part of the flap on the donor site was discarded. The appearance of skin graft alone on the donor site was better than the mosaic appearance of the residual part of the flap and the skin graft.[25]

Results

For 17 patients, the lesion was on the right side; while for the left 9 patients, the defect was on the left side. The flap size ranged from 2 × 3 cm to 11 × 17 cm.

Posterior tibial artery flap

Eight cases, five males and three females, were covered by distally based posterior tibial artery perforator flap. Their age ranged between 24 and 50 years. The aetiology was due to acute trauma in all cases. The flap was designed islanded in five cases and peninsular in three cases. Flap size ranged from 1.5 × 4 cm to 6 × 13 cm (Figs. 1 and 2). Fat necrosis occurred at the distal end of posterior tibial artery perforator flap in one female patient. This was treated successfully by frequent dressing.

Peroneal artery flap

Four cases were reconstructed by distally-based peroneal artery perforator flap. Only one case was female and the rest were males

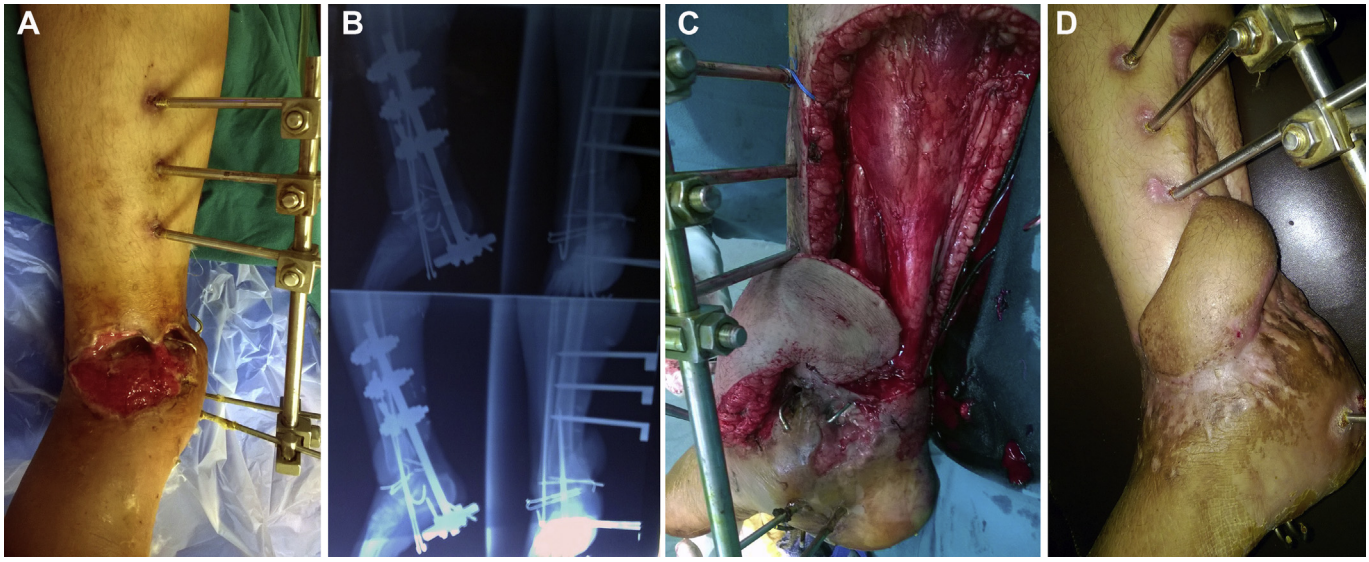

Fig. 1. Severe trauma to the lower third of leg and ankle joint with exposure of bone and hardware and coverage by posterior tibial artery perforator flap. A: Exposure of bone and hardware; B: X-ray showed multi fragmentary fracture with multiple fixation; C: Rotation and in setting of the flap; D: Complete healing of the flap (5 months postoperative).

Fig. 2. Exposure of previously repaired tendoachilles and coverage by posterior tibial artery perforator flap. A: Exposure of repaired tendoachilles (3 months ago); B: Coverage by posterior tibial artery perforator flap (3 months postoperative).

(3 cases). The age ranged between 28 and 52 years. The aetiology was due to acute trauma in all cases. The flap was designed islanded in one case and peninsular in three cases. Flap size ranged from 3 × 8 cm to 11 × 17 cm. No complications were detected (Fig. 3).

Sural flap

Six cases aged between 12 and 34 years were operated with distally based sural flap. All cases were male. The aetiology was due to chronic ulcer in one case and acute trauma in the rest. The flaps were islanded in all cases. Flap size ranged from 5 × 4 to 7 × 6 cm (Fig. 4). Marginal necrosis occurred in one patient who was a heavy smoker. Debridement was done and the case healed conservatively.

Medial planter artery flap

Two cases were covered with medial planter artery flap. All cases were male. Age ranged between 4 and 6 years. The aetiology was due to trophic ulcer as sequelae of spina bifida. The flaps were designed in a V–Y fashion (Fig. 5). Flap size ranged from 2 × 3 to 3 × 4 cm. The flaps showed excellent healing with closure of donor site primarily.

Cross leg flap

Cross leg flaps were used in six cases. All cases were male. Age ranged between 26 and 54 years. The aetiology was due to chronic ischemia with peripheral vascular insufficiency in one case. The rest of cases were due to acute trauma. The flaps were transposed from the other limbs. Flap size ranged from 7 × 12 to 13 × 15 cm (Fig. 6). One cross leg flap with chronic cause presented with distal necrosis (Fig. 7). This patient was a heavy smoker and had one vessel limb with chronic ischemia more than 20 years. Also, he was skin grafted for seven times before which all failed.

Postoperative care

In all cases, there were no signs of osteomyelitis of underlying bones or discharge from the undersurface of the flaps. The length of hospitalization was 2 weeks longer in cross leg flap group than

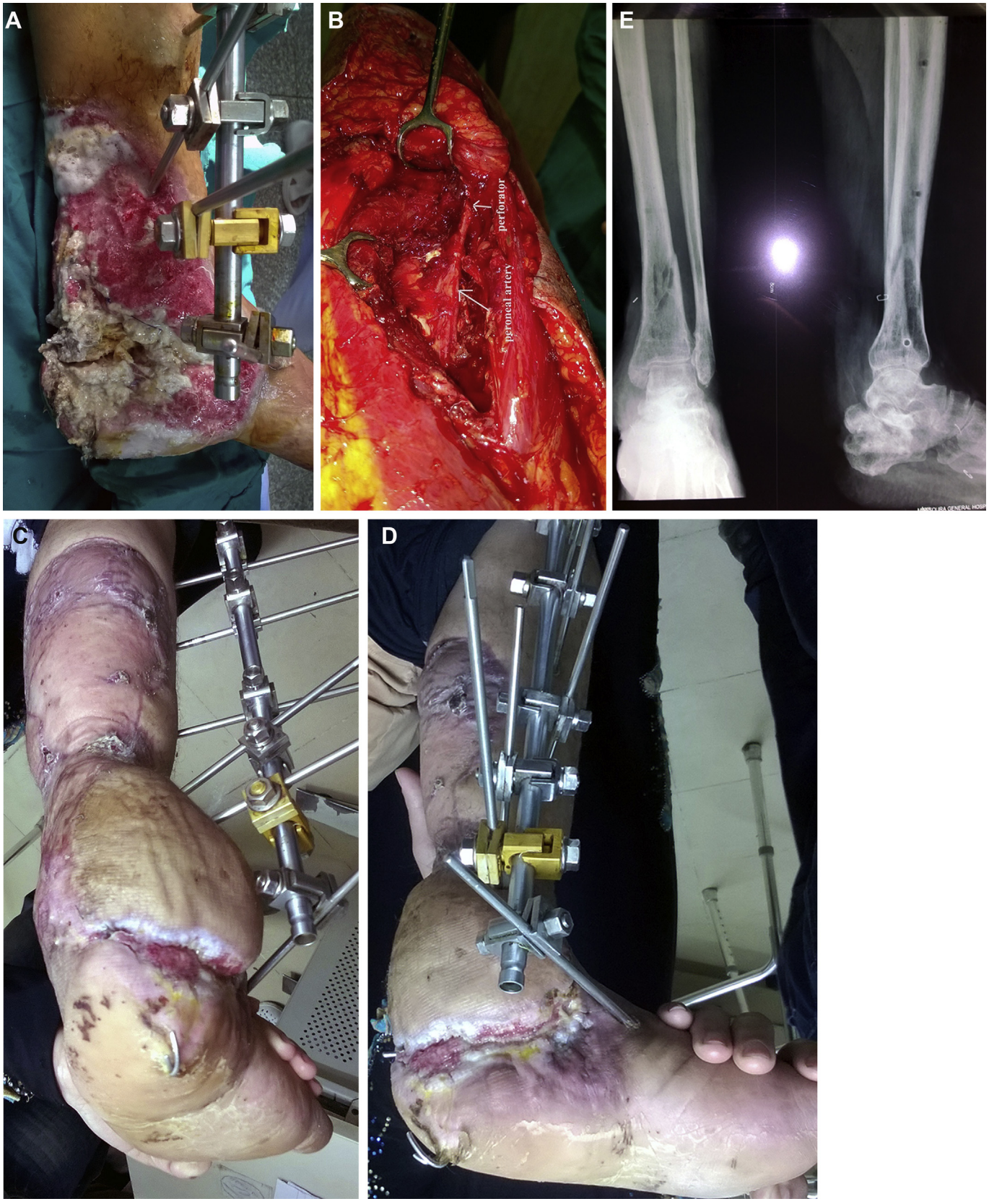

Fig. 3. Exposure of bone in lateral side of right lower leg and ankle joint and coverage by peroneal artery perforator flap. A: Degloved lateral side of leg and exposure of bones of the ankle joint; B: X ray showed fractures of tibia and ankle bones; C: Elevation of the flap with dissection of peroneal artery and its perforator; D: Healing of peroneal artery perforator flap (8 months postoperative); E: X ray showed healing of bone (8 months postoperative).

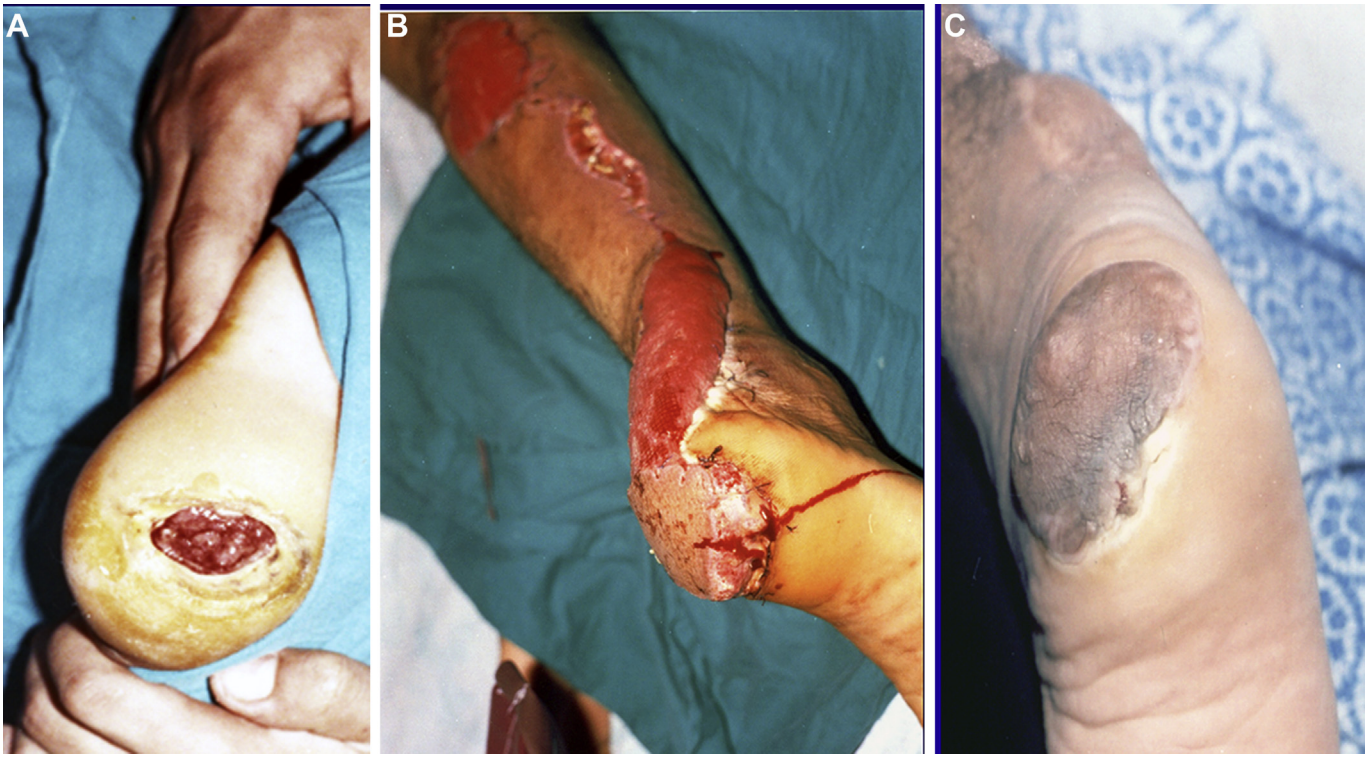

Fig. 4. Exposure of chronic ulcer of heel of right leg covered with distally based sural flap. A: Exposure of heel; B: Early postoperative; C: Postoperative view after 6 months.

perforator flap group. The average hospital stay for perforator flaps was 10 days. Follow-up extended up to 8 months.

Discussion

Not all patients are candidates for free flaps. The existing comorbidities, impaired vascular status, lack of resources, together with potential high risk complications, are contraindications for free flaps.[26] Also, lpedicled muscle flaps (e.g. soleus and tibialis anterior) are small and can cover only small defects with high incidence of distal muscle necrosis in the exposed part.[27] In 1981, fasciocutaneous flaps were described by Pontén.[28] Later on, a classification was made for these flaps with consequent various designs that results in numerous clinical applications.[29–31]

In this work, eight flaps were raised on perforators of the posterior tibial artery. The perforators were present in all cases and there were no need to dissect the posterior tibial artery for mobilization of the flap.[32,33] This flap was ideal for coverage of lower posteromedial portion of the leg. Careful attention was needed to protect the posterior tibial artery and the posterior tibial nerve during dissection.[34]

The peroneal artery is the least of the arteries of the leg that has vascular abnormalities or atherosclerosis.[35] This allows the perforators of the peroneal artery in the distal leg which is mainly septocutaneous to be used safely in diabetic patients.[36] In consideration of presence of sizable perforators on lateral side of leg, a large size flap can be executed. A big flap (11 × 17 cm) was used to cover the entire lower half of lateral leg and the calcaneus with complete survival of the flap. Actually, the dissection on the lateral side is easier and safer than on the medial side.

Long linear scar and skin graft of the donor site were the main drawbacks that make the sural flap used as a second line to other perforator flaps in this series.[37] Later, medial planter flap was adopted for coverage of heel area and was elevated in young children with good outcome as regard flap survival and donor site morbidity.

Actually, the planter surface of the foot and the heel has a special feature of glabrous skin and strong connections of fibrous tissue between skin and subcutaneous tissue. So, reconstruction of this area will be better by local flap from the same area.[38,39] The classic design of medial planter flap require skin graft of the donor site and results in dog ear deformity if not become islanded. V–Y pattern has the advantage of eliminating these problems with complete fitting into the surrounding tissues. Two children were presented with trophic ulcer following myelomeningocele. The donor site was closed primarily with excellent healing.

For more than 150 years, the cross leg flap still has its place among other reconstructive procedures.[40,41] This flap has several designs such as transversely oriented, longitudinally oriented, and distally-based or proximally-based.[42] In this series, the results were good except for one patient with distal necrosis of the flap. Noncompliance of the patient to stop smoking with the presence of severe peripheral vascular insufficiency was a real problem. In addition, the patient had the history of failed operations for the same lesion seven times before.

Peninsular flap was used when the arc of rotation was less than 90° (6 cases). If more than that, an island flap was dissected (12 cases). Island flaps provide wide arc of rotation and consequently allow placement of the flap without tension.[43] In general, peninsular flaps are more safe than island flap as they have dual arterial supply (perforator and random) and dual venous drainage with less tendency for venous congestion and arterial spam that may occur with island flaps.

For flap survival, the following requirements need to be fulfilled: (1) usage of Doppler for marking of perforators; (2) no extension beyond skin territory area; (3) inclusion of more than one perforator; (4) no skeletonization of perforator and (5) no twisting of the pedicle.

Fig. 5. Exposure of chronic ulcer of heel due to myelomeningocele of right leg covered with medial planter flap. A: Chronic ulcer of heel; B: Excision of ulcer; C: Perforators of medial planter artery; D: Postoperative view of flap after 6 months; E: Postoperative view of donor site after 6 months.

One of the drawbacks of fasciocutaneous flaps was skin grafting of the donor site which resulted in depression deformity. Also, sensory disturbances might occur if one of the sensory nerves was injured. Fortunately, most of the patients in this study were male and could accept these complications.

It was a routine to inform patients about details of the operation. This was augmented by showing pictures of previous cases. All these data helped the patients to understand that the operation is a reconstructive procedure rather than an aesthetic procedure.

Fig. 6. Severe trauma to right foot after motor car accident with exposure of hardware. A: Exposed dorsum of right foot; B: X ray of right foot showing severe trauma to the bones of the foot; C: Cross leg flap; D: Healing of the flap (3 months postoperative).

In summary, microsurgical free flaps cannot be ignored. It is ideal for large and extensive defects and has the potential to restore lost function. However, this procedure mandates a well-trained team, special costly instruments and sutures. On the other hand, local flaps did not need microanastomosis or necessities high cost in comparison to free tissue transfer. Most of our cases were due to acute trauma (22 cases) where there was a wide zone of injury. So, the recipient vessel for free flap might be damaged or inflamed with subsequent possibility of flap thrombosis. Also, peripheral vascular insufficiency was a contraindication for microsurgery. All our cases were in the distal lower leg and foot where end to end anastomosis to a main vessel may be required for free flap transfer.

Fig. 7. Chronic ulcer on the lateral side of right lower leg since 20 years with history of failed skin grafts (7 times before). A: Chronic ulcer on the lateral side of right lower leg; B: Debridement of the ulcer; C: Cross leg flap; D: Healing of the flap with partial distal necrosis (2 months postoperative).

Needless to say, all local flaps were based on perforators and collateral branches of the main vessels with no scarification of the main arteries. Also, local flaps were suitable for coverage of medium sized defects and even for large defects (11 × 17 cm).

Indeed, skin flaps were effective tools for coverage of distal leg. Other available options are free flaps or amputation.[44] Cross leg flaps come to the front line in cases with peripheral vascular insufficiency.

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