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Clinical Evaluation of Free Anterolateral Thigh Flap in the Reconstruction of Major Soft Tissue Defects in the Leg and Foot

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ABSTRACT

Extensive soft tissue defects of the lower third of the leg and foot present a challenging problem to plastic surgeon. Their reconstruction has a variety of therapeutic options starting from skin graft, local flaps and microvascular free tissue transfer. In this study, we reconstructed soft tissue defects in the leg and foot in 22 patients using free anterolateral thigh flap (ALTF) as designed by Song. Trauma was the commonest cause in our patients (18 cases, 81.9%). The perforators, on which we based the cutaneous paddle, was mostly musculocutaneous 19 cases (86.4%), septocutaneous perforators were present 2 cases (9.1%) and no cutaneous perforators in one case (4.5%). This flap can be used as a neurosensory flap, specially in sole of the foot reconstruction, where the lateral cutaneous nerve of the thigh is anastomosed to a recipient sensory nerve. Dissection of the free ALTF needs experience and good knowledge of its anatomical variations. However, because of its long vascular pedicle (8-12 cm) and the wide diameter of its artery (2 mm) and vein (2.5 mm), it is a versatile flap for transfer in difficult recipient areas. The success rate in this study was 86.4%, including the early cases of our learning curve, venous thrombosis was the main cause of flap failure. The free anterolateral thigh flap is a thin and relatively large versatile flap suitable for coverage of defects in the lower leg and foot.

INTRODUCTION

Extensive soft tissue defects of the lower third of the leg and foot present a difficult problem to the plastic surgeon as they are usually associated with exposed important structures such as vessels, nerves, tendons, joint cavity or bone **[1,2]**.

Trauma is the commonest cause of soft tissue defects of the lower extremity, followed by tumours **[3]**, where as venous ulcers contributes the majority up to 70% of all leg ulcers **[4]**. Reconstruction of soft tissue defects have a wide range of therapeutic options, starting from skin grafting over muscles, intact fascia, tendons and periostium **[5]**, local flaps **[6]**, cross leg flap **[7]**, muscles or myocutaneous flaps **[8-11]**, fasciocutaneous flaps, medial, posterolateral and anterolateral septocutaneous flaps **[12-13]**. The dorsalis pedis artery flap **[15]**, the reverse flow peroneal artery flap **[16]** are among the reconstructive procedures of the lower extremity. The base of the septocutaneous flap can be completely separated and rotated 180 degrees on a single perforator, to cover the most distal leg defects **[17]**. The adipofascial flap **[18]** or its modifications **[19]** were described to reconstruct soft tissue defects in the leg. Adipofascial flap was used as an island flap based on one of the perforators of the posterior tibial and peroneal arteries **[20]**. Microvascular free tissue transfer have undergone progressive refinement, free groin flap **[21]**, free dorsalis pedis flap, free lateral forearm flap **[22]** and free radial forearm flap **[23]** had been used with great success for reconstruction of complete planter foot defects. Free anterolateral thigh flap (ALTF) was introduced by Song **[24]** for reconstruction of various simple and complex soft tissue defects in very difficult anatomic regions **[25]**. Free (ALTF) was used successfully for treatment of post traumatic lower and upper limb open fractures and degloved foot dorsum **[26]**. Free (ALTF) had been used as a combined chimeric flap for reconstruction of combined complex defects in the head and neck and lower extremity with excellent results **[27-30]**. The aim of our work is the operative study of the anatomical variations of the vascular pedicle of the free (ALTF), as well as its clinical evaluation in

reconstruction of major soft tissue defects in the leg and foot.

PATIENTS AND METHODS

This study included 22 cases with challenging soft tissue defects in the leg and foot of various etiologic factors. All patients were admitted to the Plastic and Reconstructive Surgery Unit, Tanta University Hospital in the period between November 1999 to May 2002. All patients were subjected to thorough clinical examination and appropriate laboratory and radiological investigations.

Flap design and elevation and operative technique:

The line between the anterior superior iliac spine and the lateral border of the patella is drawn on the donor thigh and the mid point of this line is marked. Two centimeters above this point is usually the exit point of the cutaneous perforator. The transparent pattern of the recipient defect is placed on the donor site with the site of donor perforator in the center of the flap (Fig. 1). The medial margin of the flap is incised first down to the deep fascia and epimysium of the rectus femoris muscle. The edges of the deep fascia and epimysium are secured to the subdermal tissue. The flap is then undermined and raised laterally towards the intermuscular septum between the rectus femoris and the vastus lateralis muscles. The descending branch of the lateral circumflex femoral artery (LCFA) and its septocutaneous perforator, or the beginning of the musculocutaneous perforator may be seen in the intermuscular space. After locating and mobilizing the vascular pedicle and the cutaneous perforator, the other three margins of the flap were incised (Fig. 2). Superiorly, care is taken not to injure the lateral cutaneous nerve of the thigh which lies above the deep fascia and emerges anterior to the anterior superior iliac spine, this nerve can be later anastomosed with a cutaneous nerve at the recipient site, if neurosensory flap is required. If the perforator passes through the vastus lateralis, then a cuff of muscle must be included in the vascular pedicle (Fig. 3). However, in the late cases it was possible in most cases to dissect the perforator from within the muscle, whenever possible. A second surgical team prepare the recipient sit by removing the diseased unhealthy tissue and preparing the recipient vessels and sensory nerve if required for anastomosis with that of the donor vessels and nerve. After complete elevation of the flap, the pedicle artery was ligated and ischemia time was recorded. Heparinized saline was used for lavage of the artery and veins during anastomosis. The anastomosis between the recipient and donor vessels was done using 7/0 Ethilon interrupted sutures. In case with post traumatic vessel disease, a vein graft was used to lengthen the pedicle of the flap and A-V loop was performed to achieve microvascular anastomosis with healthy proximal vessels. In case of nerve anastomosis, the end of the donor nerve (lateral cutaneous nerve of the thigh) and recipient nerve (sural or saphenous nerve) were approximated by 2-3 stitches of 9/0 Ethilon. The donor site is closed primarily after undermining on both sides if its breadth is 8 cm, or less (Fig. 4), or with split thickness skin graft when its breadth is more than 8 cm (Fig. 5). Flap monitoring was performed every one hour for the first 24 hours, then every two hours for two days and frequent observation of the flap till the end of the 12th postoperative day. This was usually performed regarding the color, temperature and capillary refill. Heparin was not given routinely in every patient as it was only given in the presence of A-V loop, long venous interposition graft, intraoperative thrombosis, problematic anastomosis, free flap revision or exposure to irradiation. Aspirin, 75 mg, tablets were used in all cases 3 times daily during the first week, then once daily.

RESULTS

Figs. (5-16):

22 free anterolateral thigh flaps (ALTF) have been performed for reconstruction of soft tissue defects in the leg and foot. 19 flaps were successful (86.4%) while three flaps were lost (13.6%) secondary to venous thrombosis. In this series 17 patients were males and 5 patients were females, whose ages ranged from 8 to 70 years. The diameter of arteries in the flaps varied from 1.8 to 2.3 mm and the length of the vascular pedicle was 8-12 cm. The pedicle artery was always accompanied by two veins, the diameter of the veins varied from 1.5-3 mm. The cause of the soft tissue defect of the foot and leg was trauma in 18 patients, tumours in 2 patients, unstable scar after burn over the ankle and heel region in one case and venous ulcer in one case. In 20 cases the defect was simple, only soft tissue without involvement of bone, whereas, it was complex in 2 cases. The site of the defect

was on the lower third of the leg (12 cases), heel and weight-bearing surface of the sole (8 cases) and 2 cases on the upper and middle third of the leg. The smallest size of the defect was 15 x 8 cm. While the largest one was 33 x 16 cm with mean size 24 x 12 cm. Arteriography was performed in 10 cases and was normal in 6 cases, while 4 cases showed varying length of segmental stenosis. Duplex ultrasonography was performed in 12 cases and was normal in 11 cases, in the last case there was segmental irregularity and stenosis of anterior tibial artery. The operative time of the first three cases was 8-10 hours. Secondary to improvement of the learning curve the operative time was reduced dramatically to be 4-6 hours in the last 5 cases. In all cases the operative time was 4-10 hours (mean of 5.30 hours). In this study the musculocutaneous perforators were the commonest type (19 cases), septocutaneous perforators (2 cases), no cutaneous perforators was detected in one case and the flap was changed to tensor fascia lata flap. Neurosensory flaps were used in 2 cases, the microneuro-anastomosis were performed between the anterior branch of the lateral cutaneous nerve of the thigh and the sural nerve in one case and the saphenous nerve in the other case. In all cases the microvascular anastomosis was performed proximal to the site of the defect, end to end anastomosis was performed in 13 cases while end to side was done in 9 cases and the anastomosis was done with either the anterior or the posterior tibial artery. Early post operative complications were noted as arterial thrombosis in one case where reexploration was done with flap survival. Venous thrombosis occurred in 4 cases with incomplete flap salvage in one case and total flap loss in three cases. Haematoma was found in 3 cases which were complicated by wound infection and complete resolution with conservative management. Infection whether mild or moderate was reported at the donor site or recipient site in 9 cases with complete resolution with conservative management. At the donor site failure of graft take was complete in one case which needed regrafting and incomplete in 3 cases which healed by conservative management.

Table (1): The aetiological causes of soft tissue defect in the leg and foot.

Aetiological causes	No.	Percent
Trauma	18	81.9
Malignant tumours	2	9.1
Burn	1	4.5
Venous ulcer	1	4.5

Table (2): Site of the defect.

Site of defect	No.	Percent
Lower one third of the leg	12	54.5
Heel and weight bearing sole	8	36.4
Upper and middle third of the leg	2	9.1

Table (3): Preoperative vessels evaluation.

	Arteries			Veins		
	Palpable	Unpalpable	Total	Palpable	Unpalpable	Total
1- Clinical (Palpable distal pulsation)	18 +ve	4 -ve	22	21	1	22
2- Arteriography (Segmental stenosis)	6 -ve	4 +ve	10	-	-	
3- Duplex ultrasonography (Segmental stenosis)	11 -ve	1 +ve	12	-	-	

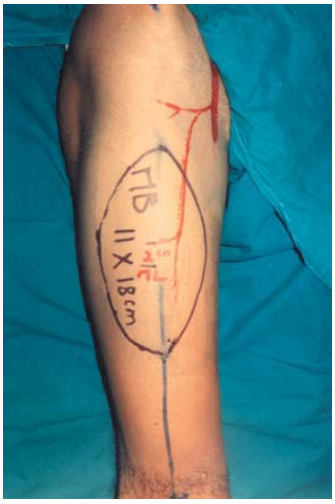

Fig. (1): Diagram illustrating the design of the flap.

Fig. (4): Primary closure of donor site.

Fig. (5): Donor site closure with split-thickness graft.

Fig. (2): Complete flap elevation with long vascular pedicle.

Fig. (6): Post-traumatic soft tissue defect of the heel "preoperative".

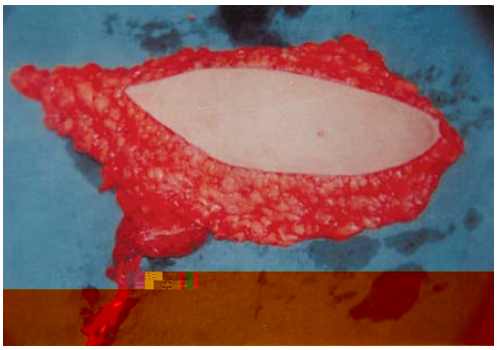

Fig. (3): Free ALTF with part of vastus lateralis (muscle cuff) on the same vascular pedicle with musculocutaneous perforator.

Fig. (7): Reconstruction with free LATF.

Fig. (8): Full weight-bearing of the same patient.

Fig. (9): Soft tissue defect following Sim's amputation.

Fig. (10): Early postoperative view after reconstruction with free ALTF.

Fig. (11): Preoperative complex defect upper $^{1}/_{3}$ tibia with segmental bone loss (7 cm).

Fig. (12): Late postoperative with sound healing of the flap and skin grafting.

Fig. (13): Post venous ulcer "firy-red" skin with frequent ulceration.

Fig. (14): Excision of the venous ulcer.

Fig. (15): Late postoperative with loss of upper part of the flap.

Table (4): Types of microvascular anastomosis.

Recipient arteries	Type of micro-anastomosis		Total
	ETE	ETS	
Posterior tibial	11	4	15
Anterior tibial	2	-	2
Femoral (subsartorial canal)	-	2	2
Popliteal	-	3	3
Total	13 (59.1%)	9 (40.9%)	22 (100%)

ETE = End to end anastomosis.
ETS = End to side anastomosis.

Table (5): Early postoperative complications.

Postoperative complications	No.	%	Fate
a- *Thrombosis:*			
Arterial	1	4.5	Reexploration with flap salvage
Venous	4	18.2	Incomplete flap salvage in one case and total flap loss in 3 cases
b- *Haematoma:*			
Donor site	2	9.1	Complicated by wound infection
Recipient site	1	4.5	Complete resolution with conservative management
c- I*nfection:*			
Moderate			
Donor site	2	9.1	Complete resolution with
Recipient site	2	9.1	conservative management
Mild			
Donor site	2	9.1	Complete resolution with
Recipient site	3	13.6	conservative management
d- *Graft failure:*			
Incomplete	2	9.1	Conservative management
Complete	1	4.5	Regrafting
e- Flap necrosis	3	13.6	Excision and cross leg flap in one case and split thickness graft in 2 cases

DISCUSSION

In our study trauma was the commonest cause or soft tissue defects in the leg and foot (18 cases, 81.9%), while (2 cases, 9.1%) were secondary to ablation of malignant tumours (one case, 4.5%) after excision of unstable post-burn scar and the last case was secondary to venous ulcer. The lower third of the leg was the commonest site (12 cases, 54.5%), heel and weight bearing area were (8 cases, 36.4%), while the upper and middle thirds of the leg was (2 cases, 9.1%). The smallest defect was 15 x 8 cm while the largest one was 33 x 16 cm in diameter. Swartz and Mear **[31]**, Stempro and Stevenson **[32]**, stated that most of their soft tissue defects in the lower extremities were post traumatic, where as in Wienzeig and Davis **[33]** series trauma was reported in 48% and vascular insufficiency represented 40% of cases. Serafin et al. **[1]** operated on 50 free flaps and their defects were at the distal third of the leg and foot, while Banic and Wulff **[34]** operated on 15 children with post traumatic lower leg and foot defects. In our series, 3 patients were considered having cute lesions (2 after tumour ablation and 1 early post trauma) while in (19 cases) the defects were chronic (more than 3 months). Flap failure was reported in 3 cases in our study and all were in chronic defects (13.6%). Godina **[35]** reported failure rate 0.75% in acute cases, 12% in subacute cases, 9.5% in chronic cases. However, Devansh **[36]** reported 3% failure rate in acute post-traumatic leg defects and 9.5% in chronic defects in the same region. In this study the largest flap was 33 x 16 cm. Zhou et al. **[37]** had transferred 32 free ALTF for reconstruction of multiple soft tissue defects and the largest flap was 15 x 10 cm, whereas the largest flap in Koshima et al. **[26]** series was 25 x 18 cm. In our study, we found that the descending branch of the lateral circumflex femoral (LCFA) and its venae comitants were the vascular pedicle in 21 cases (95.5%) and in one case it was the transverse branch of the (LCFA). The origin of the (LCFA) was the profunda femoris artery in 20 cases (91%) and in the other two cases it took origin from the common femoral artery directly just behind the inguinal ligament. Song et al. **[24]** Koshima et al. **[38]**, Kimata et al. **[39]** had reported that the descending branch of the lateral circumflex femoral vessels are the vascular pedicle of the ALTF in all cases. Cormack and Lamberty **[40]**, in their study on the arterial anatomy of skin flaps including the lateral circumflex femoral vessels found that this artery is originating from the profunda femoris artery in 75% and from the femoral artery in 25%, this was also reported by Chuan et al. and Koshima et al. **[41,26]**. We found that the descending branch of LCFA has an external diameter more than (2 mm) with long vascular pedicle ranged (8-12 cm) in length. The two venae comitants accompanying the

descending branch of the LCFA has always an external diameter larger than that of the artery with an average diameter of (2.5 mm). Chuan et al. **[41]** stated that the length of descending branch of LCFA may reach (8-12 cm) and its average diameter was (2.1 mm) and its two vena comitants was (2.3 mm). Zhou et al. **[37]**, found that the diameter of the artery in 32 free ALTF varied from (1.5 to 2.5 mm) and the length of the vascular pedicle was (5 to 12 cm). In our study we found that, in 19 cases (86.4%) musculocutaneous perforators were the presenting type, in two cases (9.1%) septocutaneous perforators were present. In one case (4.5%) we were not able to find a perforator going to the flap, in this case we shifted to tensor fascia lata myocutaneous free flap based on the transverse branch of the LCFA. Chuan et al. **[41]** found that musculocutaneous perforators reported 59.8% while septocutaneous perforators represented 40.2% in his series (42 cadavers, 50 healthy lower limb). Ayad **[42]** in his cadaveric dissection of ALTF found that in (75%) of cases there was a branch passing perpendicular, penetrating the vastus lateralis and originating from the descending branch of LCFA and he perfered to take a cuff of muscle fibers around the musculocutaneous branch of the main pedicle to avoid vessel injury or spasm. In Kimata et al. **[39]** series, no perforators were found in 4 cases (5.4%) despite of thorough examination, 18.1% were septocutaneous and 81.9% were musculocutaneous.

Conclusion:

Free anterolateral thigh flap (ALTF) is suitable for coverage of defects in the lower extremity region that require thin and relatively large flap. From our study we can conclude that the free (ALTF) has many advantages that can be summarized as follow:

1- Elevation of the flap is safe and can be changed into tensor fascia lata myocutaneous free flap, or anteromedial thigh flap whenever indicated.

2- ALTF has a long vascular pedicle which can be dissected up to the deep femoral vessels ranging from 8-12 cm.

3- The diameter of the proximal end of the vascular pedicle is approximately 2 mm or more which is as wide as the radial artery.

4- The flap can be raised as a composite flap with vascularized vastus lateralis, rectus femoris, ilium and tensor fascia lata. This has a great advantage in the presence of complex defects or osteomyelitis.

5- The skin of the flap is pliable and wide.

6- The donor site is far from the leg and foot region and allow simultaneous two teams to work together. This makes the operative time more shorter.

7- The donor site can be closed primarily or covered with split-thickness skin graft.

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