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Distally Based Sural Fasciocutaneous Flap and Cross-leg Method for Soft Tissue Reconstruction of the Distal Leg, Ankle, and Hind Foot Defects

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ABSTRACT
This paper presents the authors' experience of using cross-leg and direct sural fasciocutaneous flaps for the treatment of various soft tissue defects in the lower limb. All surgeries were performed during 2010-2014. This nonrandomized descriptive prospective and retrospective study recruited 25 patients which consisted of 19 patients with direct sural fasciocutaneous flaps (age: 20-49 years) and six with cross-leg, indirect sural fasciocutaneous flaps (age: 6-48 years). The follow-up period ranged between six months - three years. The defects were located on calcaneus, malleolar area, tarsal area, and lower tibia. Out of 25 flaps, 22 showed complete survival (88%). Partial flap loss was found in five patients (20%) and complete loss in three patients (12%), including one (16.7%) using the cross-leg method and two (10.5%) using the ipsilateral flap. Out of 19 patients who underwent ipsilateral RSAFs, five patients had flap tip necrosis (< 10% flap area). Two of these patients were subjected to flap readvancement and reinsertion and three patients were managed with regular dressings. In one case, a superficial necrosis occurred and skin graft was required. The sural fasciocutaneous flap, even its cross-leg form, is useful for the treatment of severe and complex injuries and their complications in lower limbs. This type of flap offers excellent donor sites for repairing soft tissue defects in foot and ankle and distal leg.

Key words: Soft tissue defects; distally based sural artery flap; lower third tibia; foot; cross-leg.

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INTRODUCTION

Due to composite tissue defects, inadequate and tight local tissues, and poor circulation, soft tissue management around the lower third of the leg and foot poses a considerable challenge to the reconstructive surgeon [1]. Since tendons, bone, or hardware are frequently exposed because of the thinness of subcutaneous tissues, skin grafting is generally a poor option [2]. A durable flap with good skin texture, reliable vascularity, good arc of rotation, ease of dissection, and minimum donor site morbidity is the most desired option for coverage of such defects [3,4].

Locoregional flaps for lower leg and ankle defects, such as peroneal artery flap and anterior and posterior tibial artery flaps have the disadvantage of sacrificing a major artery in an already traumatized leg [5]. Supramalleolar flaps are another option but their reliability is questionable in case of vascular compromise [6]. Free tissue transfer is an ideal option in most circumstances but the need for a team approach and microsurgical expertise, along with prolonged operating time, high donor site morbidity, and a risk of complete failure limit its application [7]. Meanwhile, the absence of the required microsurgical expertise and facility at peripheral health centers, high-volume trauma centers, and the cost involved, and, sometimes, patient-related factors may preclude the option of free flap. Although free tissue transfer plays an important role in limb salvage, a thorough understanding of regional flap designs and their applications may provide easier and more cost-effective alternatives for soft tissue coverage of the injured lower extremity [8]. An ideal flap should be not only technically easy to harvest and reliable, but also associated with a high success rate and minimal donor site morbidity.

Although, the reverse sural artery flap (RSAF) can be applied as a gold standard for major tissue defects in the distal third of the leg and ankle, but the risk of necrosis is as high as 25% [8]. Randomized control trials in reconstructive surgery are a challenge due to varied presentation, limited number of cases, and also surgeons' preferences and experience [9].

In the present study, we used RSAFs and cross-leg RSAFs. We believe that cross-leg RSAFs are particularly valuable and can prevent limb amputation when obtaining flaps from the same leg is impossible due to severe defects. This was the first study to practice this novel technique.

MATERIAL AND METHODS

This nonrandomized descriptive prospective and retrospective study recruited 25 patients admitted between 2010 and 2014. The study was conducted at the Department of Plastic and Reconstructive Surgery of Isfahan University of Medical Sciences (Isfahan, Iran). Patients with posttraumatic defects in the lower third of the leg and hind foot requiring flap cover for exposed bone, tendon, and implant were included in the study. Overall, 19 patients underwent ipsilateral RSAFs. Due to trauma of the ipsilateral flap, cross-leg RSAFs had to be used for the other six patients. Associated risk factors in the patients for the flap performance were diabetes (n = 2) and smoking (n = 8).Defects were classified as moderate-sized and large based on their area (area = 20-50 cm^2 and ≥ 51 cm^2, respectively).

Distally based sural fasciocutaneous flap and cross-leg methods were used for coverage in all cases and survival rate, successful coverage of the defect, and donor site morbidity were evaluated.

The administered flaps had the following characteristics:
Skin paddle size: 7×5-16×13 cm;
Pedicle length: 7-17 cm;
Pedicle width 4-5 cm;
Distance from popliteal crease: 1.5- 4 cm; and
Pivot point distance from the lateral malleolus 5-8 cm.

A predesigned form including information about the patients' gender, age, and occupation, vascularity, and wound characteristics (e.g. etiology, site, size, and depth of the wound) was used to collect data. After the surgery, the patients received adequate analgesics and antibiotics for seven days.

Skin markings for RSAF

Flap axis lay over the small saphenous vein. A standard flap skin paddle was placed in the middle third of the leg as per defect size. The surgical procedure was performed while the patient was under general anesthesia. The patient was placed in a prone position and the flap was raised without tourniquet control. The flap was outlined approximately at the junction of the two heads of the gastrocnemius. The precise location of the skin paddle was determined based on the length of the required pedicle. The pivot point of the pedicle was about 5-8 cm proximal to the tip of the lateral malleolus. The line of incision was traced over the course of the sural nerve and the small saphenous vein. The incision was started on the proximal edge of the flap and was continued to the gastrocnemius. The fascia was fixed to the flap by a few separate VICRYL® sutures. At midcalf, the sural nerve, superficial sural artery, and small saphenous vein were easily identified, ligated, and included within the flap.

The dissection was continued distally and the fibroadipose tissue around the pedicle was preserved. The pedicle was 4-5 cm wide including the sural nerve with its superficial artery and small saphenous vein. The dissection of the pedicle was discontinued at the pivot point. The flap was transposed to the recipient site over the skin bridge. The donor site was covered with a split-thickness skin graft and some partial primary repair. The viability of the flap was assessed by its color. Various techniques such as keeping the pedicle at least 4 cm wide using a gastrocnemius muscle cuff (especially when the flap is designed higher in the leg) and sural flap delay procedures (especially when large flaps are planned or when very distal foot defects need coverage) have been recommended to increase the blood flow and hence the survival of the flap (10-13). We included a gastrocnemius muscle cuff when the flap was raised from higher in the leg, delayed one flap, and maintained the pedicle width at a minimum of 4 cm in all cases (fig. 1).

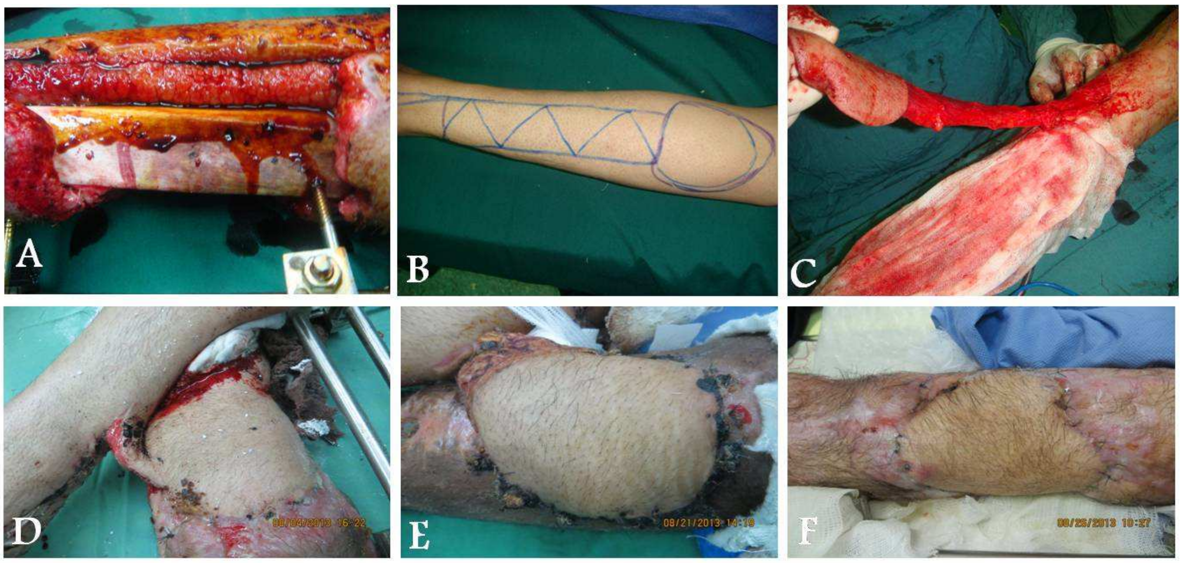

Figure 1: Procedure of sural falp surgeryA. Defect area B. Preoperative marking C. Flap insertion D. Cross leg reversural flap (one week after surgery) E. Flap insertion (After 16days) F. Cutting the pedigraft Flap

The flaps were assessed daily and the first dressing was done on the third day after surgery.

The patients were discharged once the flap and split skin grafting were healthy on assessment after the first dressing and subsequent dressings. The patients were followed up once weekly for the first month and then once a month for six months for three years.

RESULTS

A total of 25 (2 female and 23 male) patients were studied. Two participants were diabetic and eight were smokers. The mean age of the patients was 30 years (range: 6-49 range). The mean area of defect was 47±36.10 cm^2 (range: 12-208 cm^2). The mean duration of surgery, calculated from flap elevation to the end of the procedure, was 66.36±23.64 minutes in totally and 83.44±9.89 minutes (70-120 minutes)in cross-leg method and 61.02±12.35 minutes (45-70 minutes) in ipsilateral method (Table 1). Out of 25 flaps, 22 showed complete survival (88%). Partial flap loss was found in five patients (20%) and complete loss in three patients (12%), including one (16.7%) using the cross-leg method and two (10.5%) using the ipsilateral flap. Out of 19 patients who underwent ipsilateral RSAFs, five patients had flap tip necrosis (< 10% flap area). Two of these patients were subjected to flap readvancement and reinsertion and three patients were managed with regular dressings. Significant flap loss (nearly 100%) with exposure of tendon or bone was seen in two patients with ipsilateral RSAFs as compared to one patient with cross-leg RSAFs. Three patients with cross-leg RSAFs were subjected to partial flap loss. Two of these patients were subjected to flap readvancement and reinsertion and one patient was managed with regular dressings. Six cases had donor site wound dehiscence which healed by secondary intention. Partial skin graft loss requiring regrafting was seen in three patients. The mean duration of hospital stay in the ipsilateral and cross-leg groups was seven and 26 days, respectively. All patients with RSAFs had bulky flaps and required subsequent thinning procedures on follow-up (Table 2).

DISCUSSION

Composite tissue defects, inadequate and tight local tissues, and poor circulation turn soft tissue management around the lower third of the leg and foot into a considerable challenge to reconstructive surgeons [1].

Free flap is currently the treatment of choice for large soft tissue defects of the lower extremity and it solves the problem of donor site morbidity in the immediate vicinity of the flap. It is, however, a technically demanding procedure for surgeons with less microsurgical experience.

Table 1: Baseline and Clinical Characteristics of patients

Characteristics		Frequency	Percentage (%)
Gender	Female	2	8
	Male	23	92
Smoker	Yes	8	32
	No	17	68
Diabetic	Yes	2	8
	No	23	92
Age, year		30±19.08	
Area of defect (cm^2)		47±36.10	
Duration surgery (minutes)		66.36±23.64	
Methods	Iipsilateral flap	19	76
	cross-leg	6	24
Mechanism of defect	Car accident	8	32
	Motorcycle accident	15	60
	Falling and crush accident	2	8
Associated Injury	Head trauma	11	44
	Intra abdominal hemorrhage	8	32
	Chest wall and lung injury	4	16
	Vascular injury	4	16
	Another site bone fracture	18	72

Table 2: Outcome of Distally based sural fasciocutaneous flap and cross-leg method

Outcome	Total(n=25)	Ipsilateral RSAF(n=19)	Cross-leg RSAF(n=6)
Duration surgery (minute)	66.36±23.64	61.02±12.35	83.44±9.89
Partial flap loss	5(20%)	2(10.5%)	3(50%)
Complete loss	3(12%)	2(10.5%)	1(16.7%)
Readvancement and reinsertion	4(16%)	2(10.5%)	2(33.3%)
Managed with regular dressings	4(16%)	3(15.8%)	1(16.7%)
Duration of hospital stay (day)	11.76±7.35	7.02±3.65	26.78±8.96

Flap Anatomy

In 1987, Ferreira et al. presented the concept of fasciocutaneous flap of the distal pedicle based on the inframalleolar perforators. Masquelet et al. were the first to describe the vascularization of the skin in the lower limb and the arteries which follow the trajectory of the peripheral nerves [14].

The sural nerve comes down the leg in close relationship with the small saphenous vein. This nerve is supplied by the superficial sural artery in the proximal third of the calf and by fasciocutaneous branches arising from the peroneal artery in the distal half of the leg along the suprafascial course of the sural nerve. This sural artery anastomoses with the peroneal artery by means of 3-5 fasciocutaneous perforators which ensure adequate inverse irrigation of the flap. The peroneal artery supplies the sural nerve and venous anastomoses circulate along this artery to ensure venous return.

In 1994, Hasegawa et al. affirmed that the pivot point of the flap must be at least 5 cm above the tip of the lateral malleolus [15]. However, as demonstrated by Zhang et al. in 2005, the vascular pivot point of the distally based sural flap can be safely designed even 1.5 cm proximal to the lateral malleolus [16].

Considering the high failure rate in performing this flap (caused by variable vascular anatomy), Jeng and Wei advised the use of preoperative Doppler examination to identify perforators and their distance from the lateral malleolus in each clinical case [17]. Bocchi et al. stated that the constant use of a Doppler probe during the preliminary evaluation provided more safety to the surgical procedure and increased the success rate of the suralartery flap [18].

With respect to the size of the flap, the largest dimension documented in the literature was 17 cm × 16 cm. Meanwhile, the complication rate is known to increase with flap size [19]. When larger flaps are used, the larger pedicle may be compressed more easily once it is tunneled. Postoperative swelling may hence increase. This will, in turn, increase venous congestion of the flap and raise the risk of partial necrosis of the skin bridge under which the graft is tunneled [20]. Some studies did not tunnel the flap under the skin to prevent the compression of the fatty pedicle against the skin, especially in the postoperative phase when more swelling develops

[21]. Other modifications to increase size included delaying [22-24], using a wider than usual pedicle [25], supercharging [26], and harvesting a midline cuff of the gastrocnemius muscle with the flap [27].

In a series of 70 sural flaps used for soft tissue coverage of the distal leg, the overall success rate was 86% for the flap alone or combined with a skin graft. However, the partial or complete flap necrosis rate was 36%, which was unfavorable. Risk factors included patient age of more than 40 years, peripheral artery disease, venous insufficiency, and diabetes mellitus. Tobacco use, chronic alcoholism, and minimal family support were secondary risk factors for flap failure [28]. In a large study of 179 RSAFs, Wei et al. (2012) observed partial flap necrosis in 11.2% of the cases. They concluded that partial necrosis rate was significantly higher in the flaps with top edge locating in the upper 1/9 of the calf, in the flaps with length-width ratio ≥ 5:1, and in the flaps with width of skin island (width) ≥ 8cm [29]. The major disadvantage of this flap is the scarification of the sural nerve leading to anesthesia of the lateral foot. However, the long-term disability is minimal in most patients. An insensate flap and the final scar, especially when skin grafting of the donor site is needed, are other drawbacks. However, poor cosmesis would be a lesser concern in traumatology (30).

CONCLUSIONS

To conclude, RSAFs and even cross-leg RSAFs are reliable for moderate-sized defects of the lower third of the leg and hind foot. Both flaps gave a good functional outcome. Ipsilateral RSAFs had the advantage of ease of surgery, speedy recovery, shorter hospital stay, and no donor site morbidity. RSAFs should be chosen for defects on distal leg and hind foot toward medial malleolus and moderate-sized defects. The sural fasciocutaneous flap, even its cross-leg form, is useful for the treatment of severe and complex injuries and their complications in lower limbs.

Conflict of Interests

None to declare

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Author`s contribution

A.H, and AK.A, designed the study and prepared a draft of article. All authors approved the final version of paper.

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