



# Free-style perforator flaps in the reconstruction of the lower limb



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## Free-style perforator in the reconstruction of the lower limb

**INTRODUCTION:** *The evolving concept of free-style flaps with one or more perforators able to lend support, has been shown to have noteworthy advantages in the context of reconstructive surgery, especially in relation to the distal portion of the lower limb. Among the advantages, an analogy of the covering tissues with pre-existing ones in the compromised area, reduced morbidity of the donor site, less time spent in theatre and a greater flexibility from the surgeons' point of view.*

**MATERIAL AND METHODS:** *Between 2009 and 2012, 18 patients were treated with local free-style flaps for lesions involving the leg and the foot. The median age of the patients, (11 men and 7 women) was 63.2 years. Subsequently, the patients were followed up for 6 months-1 year.*

**RESULTS:** *In the period following surgery all the free style flaps have survived completely; further surgery has not been warranted. Healing of the donor sites took place by primary intention in 17 cases; in one case, a V-Y advancement flap adapted as a cover for a loss of substance of the calcaneus, it occurred by secondary intention.*

**DISCUSSION AND CONCLUSIONS:** *Lower limb reconstruction, in virtue of the fact that adjacent tissues for reconstruction are scarce and vascularization is an issue, has always constituted a problem which has not been easy to solve for the surgeon. The application of the free-style concept to loco-regional flaps has yielded satisfactory results in our experience, from both a functional as well as an aesthetic point of view.*

**KEY WORDS:** Foot reconstruction; Free-style flap; Lower limb reconstruction.

## Introduction

"Plastic surgery is a constant battle between blood supply and beauty".<sup>1</sup> Thus wrote Gillies, highlighting the direct link between the act of reconstruction and vascularization. The end result of a reconstructive procedure

is primarily attributable to the stability of the vascular component, which is fundamental in that it ensures survival and proper functioning of tissues that have been transferred to the recipient site.

The works of Manchot and Salmon on the arteries of the body lead to the recognition of precise vascular territories which are supplied by well-defined and constant vessels<sup>2,3</sup>. In the following years Fujino evaluated the axial perfusion of perforating vessels in relation to flaps<sup>4</sup>. However Hallock et al discerned direct and indirect perforators according to the structures they traverse before piercing the deep fascia<sup>5</sup>.

Perforators that pierce the deep fascia without traversing any other structural tissue are called direct perforators. All other perforators that first run through deeper tissues, mainly muscle, septum, or epimysium, are called indirect perforators.

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In 1988, Kroll and Rosenfeld introduced the concept of the perforator flap <sup>6</sup>.

Perforator flaps are comprised of skin and/or subcutaneous fat and are based on perforators isolated from their artery of origin which may pass either through or in between the deep tissues (mostly muscle) <sup>7</sup>.

Their main advantage is that dissection of such flaps spares the muscle, and in contrast to musculocutaneous flaps, which use the muscle portion as vessels carrier, there is less morbidity at the donor site; moreover, the dimensions of the flap are preserved <sup>8</sup>.

These relevant aspects determined a more widespread use of these flaps as time took its course, especially following the applications by Taylor et al, which confirmed the efficacy of Doppler ultrasound in localizing the perforators in the pre-operative evaluation <sup>9</sup>.

In 2004, Wei and Mardini introduced in their milestone work the term "free-style", describing free flaps based on nameless perforators taken from the thigh region. They demonstrated that Doppler ultrasound is capable of detecting perforators of reasonable proportions which allows a free-style flap to be set up safely, without the risk of anatomical inconsistencies and in usually non-utilized areas, meaning, the latter, the advent of new reconstructive options <sup>10</sup>.

The defects of the lower limb and foot have always been a reconstructive challenge for the surgeon, who has to consider both form and function. A free-style approach to the reconstruction of the foot, ankle and distal third of the leg (portions of the lower limb of greater restorative complexity) with local flaps is reported.

## Material and Methods

Between 2009 and 2012, 18 patients were treated with loco-regional perforator flaps set up in a free-style fashion at the Department of Plastic and Reconstructive Surgery of the University "Sapienza" of Rome. The age of the patients ranged from 28 to 82 years. In all cases, there was loss of tissue in varying regions of the leg and foot as a result of trauma, surgical oncology, vascular surgery, pressure sores, ischaemic lesions in vasculopathic or diabetic patients. We describe in detail three cases representative of different anatomical regions and vascular sources.

For the reconstruction, in all cases, a local free-style flap which consisted of skin and subcutaneous tissue was utilized. In designing the flaps, the vascular axes and the distribution of the perforators which could sustain them were taken into consideration. Common approach to patients affected by atherosclerosis/diabetes was a pre-operative assessment of the vasculature through CT angiography to determine the anatomical pathways; in each case a Doppler ultrasound was carried out to determine the localization of the vessels in order to lay out a surgical plan. Availing of a portable ( Hadeco BV-100,

Japan ) Doppler proved to be a valuable aid in the visualization and hence precise localization and characteristics of the perforators. Only perforators with a pulse were deemed as being suitable.

## "PLANTAR" CASE

A 71-year old male who presented with a lesion secondary to a vasculopathy with consequent arterial insufficiency; the loss of tissue pertained to the left plantar region at the level of the fifth metatarsal bone, with osteomyelitis at the head of the metatarsal; the diameter of the defect was 3 x 3 cm. A CT scan of the vasculature of the lower limb was carried out pre-operatively in this individual, in order to establish the characteristics of the vascular axes. In order to cover the tissue loss, a V-Y advancement flap was utilized, based on the perforators of the lateral plantar artery of the foot. In the design of the flap, two detected perforators were included; particular attention was paid to the cutaneous laxity, so as to ensure that healing of the donor site would take place by primary intention. The length of the flap was taken to be the entire area of the lateral plantar support; the width was similar to the one of the defect.



Fig. 1: Case 1 preoperative: loss of tissue pertained to the left plantar region at the level of the fifth metatarsal bone.



Fig. 2: Case 1 intraoperative: flap advanced and sutured.



Fig. 3: Case 1 postoperative: one months.

The incision was carried out from the base to the tip of a margin of the triangular flap; the dissection was started subfascially. The two chosen perforators were then dissected with care, the other ones were tied and cut. The flap was advanced and sutured. (Figg. 1, 2, 3)

#### “CALCANEOS” CASE

The second case, a 31-year old male, presented with a chronic infection of the deep plantar fascia, due to a decubitus ulcer of the right calcaneus, measuring 7cm x 3cm, stage III: the prolonged immobilization was the result of a road traffic accident 5 years earlier; despite numerous procedures, the clinical picture had failed to improve. The lesion, caused by the excision of pressure ulcer on the heel, was sealed by the V-Y advancement flap based on perforating lateral malleolar vessels and a calcaneal Z-plasty. (Figg. 4, 5, 6)



Fig. 4: Case 2 preoperative: decubitus ulcer of the right calcaneus.



Fig. 5: Case 2 intraoperative: V-Y advancement flap based on perforating lateral malleolar vessels and a calcaneal Z-plasty.



Fig. 6: Case 2 postoperative: one months.



Fig. 7: Case 3 preoperative: wound in the medial third/distal posterior third of the left leg.



Fig. 8: Case 3 postoperative: twenty days.

#### “LEG“ CASE

A 76-year old female who presented with a post-surgical defect for a wide excision after a histopathological diagnosis of nodular malignant melanoma (2,4 mm in width). The wound was located in the medial third/distal posterior third of the left leg. A colour Doppler ultrasound was carried out on the patient for an accurate evaluation of the perforating vessels. Upon covering the surgical debris a local flap based on a perforator of the posterior tibial artery was set up. In the pre-operative design of the flap, more perforators were included and relevant ones, which turned out to be more prominent during surgery in accordance with ultrasound, were marked with bigger spots. The dimensions of the neighbouring flap, analogous to those affected by the loss of tissue, allowed for the suturing and healing of the donor site by primary intention. The incision reached the muscular fascia; a suprafascial dissection enabled the main perforator to be isolated. (Figg. 7, 8)

## Results

In the days following the procedure, the loco-regional free-style flaps which were set up for the reconstruction of the tissue losses involving the distal part of the lower limb and of the foot, were pinkish in colour. There was no sign of stasis or congestion at the level of the perforator flaps and no haematomas nor seromas in the treated areas. As time went on, no surgical evaluation for necrosis was necessary.

Healing of the donor sites took place by primary intention in 17 cases; in the "calcaneous case" it occurred by secondary intention on the distal portion of the flap.

The cases were followed up for one, three, six and twelve months from the procedure.

The patients were pleased with the procedure, both from a functional as well as an aesthetic point of view.

## Discussion

The lower limbs are often affected by traumatic processes and lesions of the skin and underlying tissues of the most varied aetiologies: infective, neoplastic, iatrogenic, vascular and systemic. The leg has distinct characteristics which render it susceptible to quite unique problems. In fact the whole body weight is carried and supported by the lower limbs. Hydrostatic pressures exerted on the leg increase the incidence of oedema and deep venous thrombosis. Furthermore the lower limb often bears the repercussions of atheromatous disease.

Sensation in the plantar region is essential to walk properly; unfortunately, there are very few potential donor sites for sensate plantar flaps at the level of the distal third of the leg and foot.

Tissue loss inherent to the foot is usually worsened by the fact that the surrounding tissues, which could be utilized for the reconstruction are few and supplied by vasculature that is often compromised by the injury; a cover with skin grafts may be inadequate and only feasible for limited defects, as well as yielding unsatisfactory aesthetic results.

Local flaps can be set up for defects involving the proximal or medial third of the leg, but for cases involving the distal third, there is paucity of possibilities: in the case of fasciocutaneous flaps, the length-width diameter must be borne in mind; it cannot be excessive and donor site closure often requires a skin graft.

Muscular flaps may be useful, but their excision entails a functional compromise for the patient, as well as an unsatisfactory aesthetic outcome because of their bulkiness.

In the case of microsurgical flaps, the operative time, the need for a highly specialized surgical team and relevant tools and meticulous post-surgical follow-up can be a complex issue for certain plastic surgery units.

The ideal procedure for a lesion should guarantee a com-

plete functional recovery of the affected segment and at the same time minimize damage at the donor site: in the case of perforator flaps, the cutaneous innervation remains intact, muscle and deep fascia are saved; in contrast to traditional flaps, morbidity at the donor site is minimized and the reconstructed segment recovers well<sup>11</sup>. In relation to traditional flaps, the distally-based sural flap is associated with loss of sensation along the lateral aspect of the foot superficially due to a disruption in the continuity of the sural nerve and a poor aesthetic outcome; however it has selective indications for certain areas<sup>12,13</sup>.

Of recent interest propeller flaps, which may undergo hypovascularization due to twisting of the pedicle once the flap is turned around the pivot point and suffer of partial or complete necrosis<sup>14,15</sup>.

Microsurgical flaps are penalized by the potential complications, also at the donor site, and may suffer of total necrosis as well.

Free-style flaps can be designed in accordance with each perforator detected by Doppler signal, therefore all parts of the body may be used without having to take the pathway of the artery of origin into account; anatomic variants are therefore not an issue and the surgeon has freedom in the approach to the reconstruction<sup>16</sup>. Upon covering the defect of the lateral region of the foot a V-Y advancement flap based on the perforators of the lateral plantar artery was chosen<sup>17</sup>. Combining the concept of the perforator flap with the V-Y plasty principle offers noteworthy advantages: major freedom of movement compared to the classic V-Y advancement flap and possibility to cover vaster areas of tissue with an excellent functional result<sup>18</sup>. The overall aim of the reconstructive procedure from an anatomical and clinical perspective was that the patient could have a good quality of life, especially in relation to the activities of daily living, hence, mobilization as well as an adequate cover of the supporting surface layer.

Musculocutaneous flaps were in the past the flaps of choice as the muscular component heals, covers and drains well in virtue of their blood supply. Perforator flaps too are well perfused; moreover, they are more resistant to ischaemia, and there is less of a functional deficit at the donor site in mobilized patients<sup>19,20</sup>.

In reconstructing a lesion consequent to the excision of a malignant melanoma of the leg, a loco-regional free-style flap based on a perforator of the posterior tibial artery has yielded positive results and functionality due to the analogy of tissues and the primary closure of the donor site; in addition, the aesthetic outcome has not been overlooked, important aspect especially in female patients<sup>21</sup>.

## Conclusions

Though at times the nature and diameter of certain lesions warrant alternative surgical options, in our expe-

rience, the advantages of using loco-regional free-style flaps, whenever possible, is based on the fact that tissues used for the reconstruction bear the same characteristics as the injured tissues; moreover, a meticulous patient evaluation and pre-operative assessment helps to achieve the final aim of lesser morbidity at the donor site, functional recovery, a satisfactory aesthetic result and shorter periods of hospitalization.

## Riassunto

**INTRODUZIONE:** L'evoluzione del concetto di lembi free-style basati su una o più arterie perforanti in grado di apportare sostegno, ha dimostrato avere notevoli vantaggi nell'ambito della chirurgia ricostruttiva, soprattutto in relazione alla porzione distale dell'arto inferiore. Tra i vantaggi, una analogia dei tessuti di copertura con quelli preesistenti nella zona compromessa, ha ridotto la morbilità del sito donatore ed il tempo operatorio garantendo una maggiore flessibilità dal punto di vista chirurgico.

**MATERIALE E METODI:** Tra il 2009 ed il 2012, sono stati trattati 18 pazienti con lembi locali free-style per lesioni che coinvolgevano la gamba ed il piede. L'età media dei pazienti, (11 uomini e 7 donne) era 63,2 anni. Successivamente, i pazienti sono stati seguiti per 6 mesi-1 anno.

**RISULTATI:** Nel periodo post-operatorio tutti i lembi free-style sono sopravvissuti completamente, non hanno necessitato di un ulteriore intervento. La guarigione dei siti donatori è avvenuta per prima intenzione in 17 casi; in un solo caso è stata necessaria la chiusura per seconda intenzione della residua perdita di sostanza in regione calcaneare mediante un lembo di avanzamento V-Y.

**DISCUSSIONE E CONCLUSIONI:** La ricostruzione dell'arto inferiore, in virtù del fatto che i tessuti adiacenti sono scarsi e la vascolarizzazione è problematica, ha sempre costituito un problema di non facile risoluzione per il chirurgo. L'applicazione del concetto di lembi free-style loco-regionali ha prodotto nella nostra esperienza risultati soddisfacenti, sia da un punto di vista funzionale che estetico.

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