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Review

Distally based perforator flaps for reconstruction of post-traumatic defects of the lower leg and foot. A review of the anatomy and clinical outcomes

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ABSTRACT

Study aims: To report the surgical anatomy of the perforator arteries at the lower leg, analyse clinical outcomes in previous studies, and forward methodological recommendations for future studies of post-traumatic perforator flap reconstructions.
Methods: A study sample of 640 human patients drawn from 24 clinical reports was included for review. The sample comprised of four subsets: sural flap reconstructions ($n = 257$), saphenous flaps ($n = 122$), supramalleolar flaps ($n = 92$), and propeller flaps ($n = 169$).
Results: Statistical analysis of samples from anatomical studies documents significant differences in the perforator distribution from the tibial and peroneal artery; peroneal perforator arteries are randomly organised whereas tibial artery perforators are clustered at three definite levels. The failure rates in clinical studies ranged from 0% to 6%, being lowest for supramalleolar flap reconstructions and highest for saphenous flaps; however, differences between the four subsets were not statistically significant at the 95% confidence level. Due to methodological flaws, outcome comparisons in the actual study sample should be interpreted cautiously; in most clinical studies both risk variables and outcome indicators are poorly defined. The outcome of Dynamic Infrared Thermography imaging of post-transposition changes of flap perfusion is reported.
Summary: Fasciocutaneous perforator flaps seem to have high survival rates and represent a feasible approach to post-traumatic reconstructions, especially in low-resource settings. A template for data gathering is recommended for higher accuracy in future comparative studies, and for scientific analysis of success and risk factors. New imaging techniques indicate a promising potential of micro-circular angiogenesis during the first two weeks after flap transpose.

Contents

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Review objectives

The aim of the actual review is firstly to summarise the surgical anatomy of the perforator arteries at the lower leg and thus help to establish a consensus on surgical techniques in post-traumatic reconstructions. Secondly, the article analyses clinical outcomes in previous studies in order to recommend a consensus for the design of future clinical trials.

Classification

The "Tokyo" consensus on classification of the propeller flaps is not covering distally hinged fasciocutaneous flaps, as these are not completely islanded [1]. The anatomical study by Nakajima grouped distally hinged fasciocutaneous flaps into venoadipofascial pedicled fasciocutaneous flaps (VAF), neuroadipofascial pedicled fasciocutaneous flaps (NAF) and veno-neuroadipofascial pedicled fasciocutaneous flaps (V-NAF) [2,3]. The "Perforator-Plus-Concept" combines the V-NAF flap with a perforating source vessel. This flap is nourished by two sources, by the perforator artery at the pivot point plus the veno-neuroadipofascial vessels in the base of the flap [4]. The concept of the "Super Sural Neurofasciocutaneous Flap" developed by Ayyappan paved way for harvesting of more expandable hinged flaps with range onto the dorsum of the foot up to the metatarsophalangeal joints [5].

Sural perforator flaps

Surgical anatomy

The sural perforator flap follows the longitudinal suprafascial vascular plexus of the median superficial sural artery around the sural nerve and the small saphenous vein. The flap integrates in its distal base a perforator from the peroneal artery as the source vessel (Fig. 1). The median superficial sural artery, which is the accompanying artery of the sural nerve, gives off two accompanying arteries to the lesser saphenous vein [6–8]. These arteries with the lesser saphenous vein penetrate the deep fascia at the proximal quarter of the leg, and descend with the sural nerve and its arteries to the lateral malleol [9]. In the distal third of the leg, accompanying arteries of the lesser saphenous vein anastomose with the septocutaneous perforators of the peroneal artery. Several anatomical studies of peroneal artery perforators claim that the perforators are clustered at certain levels [9–13]. Examining the data from the most comprehensive of these studies, Schaverien's study of 30 specimens, goodness-of-fit testing shows that the levels of perforators from the peroneal artery are normally distributed, and not clustered; solid perforators are randomly distributed and can be found at any level (Shapiro–Wilk test $p = 0.2$) (Fig. 2). The finding is of medical significance and demonstrates that careful dissection is mandatory in each case to identify a proper vascular source for the flap. Perforator artery diameters are reported in the range from 0.2 to 1.1 mm with a mean of 0.8 mm (SD 0.2) whereas accompanying veins have a mean diameter of 1.7 mm (SD 0.5) [10].

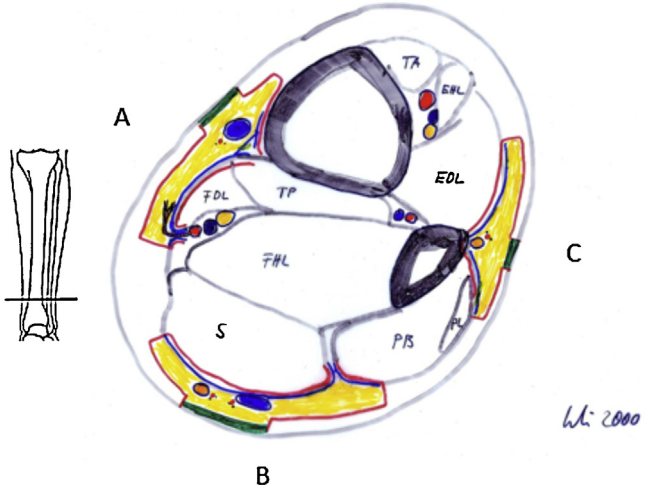

Fig. 1. Cross-section through the bases of the three fasciocutanous flaps in the distal third of lower leg. (A) Saphenous flap; (B) sural flap; (C) supramalleolar flap.

Surgical technique

The procedure is described in detail in previous studies and only key features are highlighted here [13–20]. The skin peninsula is designed similar to the defect, but larger by 1–2 cm, surrounded by an adipofascial rim. The anterior incision should expose the adipofascial pedicle with the sural nerve and the small saphenous vein. The septum between peroneus brevis muscle and soleus muscle should be identified. If no appropriate perforator is identified by the ventral approach, a dorsal approach is indicated: subcutaneous fat and fascia is split over the ventral rim of the Achilles tendon, and the septum between the soleus muscle and peroneus brevis muscle is identified and explored for perforator vessels. Division of more than one perforator proximal to the pivot

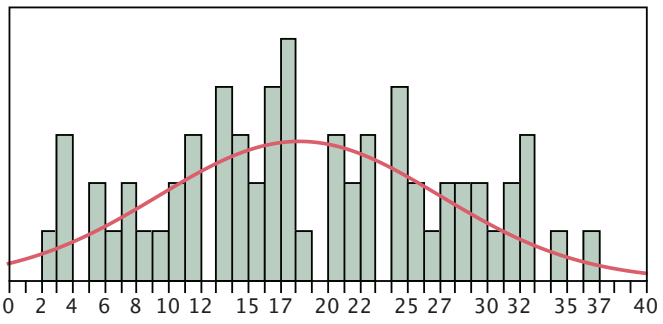

Fig. 2. Distribution of perforators of the peroneal artery according to Schaverien et al. [12], distances measured in cm from the tip of the lateral malleol. The red curve illustrates the normal distribution.