Compound or Specially Designed Flaps in the Lower Extremities

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KEYWORDS

• Perforator flap • Propeller flap • Combined transfer • Osteoperiosteal flaps • Soft tissue defects • Leg and foot

KEY POINTS

- Novel and combined tissue transfers from the lower extremity provide new tools to combat soft tissue defects of the hand, foot, and ankle, or fracture nonunion.
- Flaps can be designed for special purposes, such as providing a gliding bed for a grafted or repaired tendon or for thumb or finger reconstruction.
- A variety of propeller flaps can cover soft tissue defects of the leg and foot.
- In repairing severe bone and soft tissue defects of the lower extremity, combined approaches, including external fixators, one-stage vascularized bone grafting, and skin or muscle flap coverage of the traumatized leg and foot, have become popular.

INTRODUCTION

The history of plastic surgery has been marked by the creation and subsequent evolution of flaps. Cutaneous flaps have undergone evolution during the past few decades. Ger[1] demonstrated the importance of muscle alone as a flap, and Taylor and colleagues[2,3] introduced osseous flaps in the form of vascularized iliac crest and fibula flaps. In a recent meta-analysis of lower limb reconstruction, Bekara and colleagues[4] report that the 5 most commonly used flaps were latissimus dorsi (accounting for 26% of all free vascularized flap transfers in lower extremities), anterolateral thigh (20%), rectus abdominis (9%), gracilis (8%), and serratus anterior (6%). These flaps were categorized as muscular (58%), fasciocutaneous (42%), or fascial (1%). These flaps are still the workhorses in reconstruction of the lower limb and are the most common flaps in clinical practice.

Beyond the introduction of new flaps, there has been a continuous push toward optimization of reconstructive techniques, both in terms of minimization of donor-site defects or morbidity and in refinements of the reconstructed site and function. In the last 3 decades, the advent of perforator flaps, described by Koshima and Soeda in 1989[5] and by Allen and Treece in 1994,[6] was a major technical advancement in reconstructive surgery. Since then, some new flaps have been described and many existing flaps have been improved, whereas donor-site morbidity decreased gradually with the muscle-sparing approach of perforator flaps. The community of reconstructive surgeons, moving away from the concept of the "reconstructive ladder," gradually embraced the "reconstructive elevator" concept[7] armed with many new advanced tools.

This article reviews the most used or recently proposed flaps, focusing especially on the

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European experience, with the acknowledgment that flap surgery is subject to experimentation by and imagination of surgeons, which are a starting point, to be completed over the years for each innovative flap.

FROM FREE PERFORATOR FLAPS TO PEDICLED FLAPS BASED ON PERFORANT VESSELS

Today, perforator flaps are universally considered the final frontier of flap harvesting, because they allow sparing of the muscle, taking just the skin and a subcutaneous tissue layer as a flap. The term "perforator flap" was first used by Koshima and Soeda in 1989 to describe flaps supported by "perforator vessels,"[5] which they defined as small vascular branches going from a main vessel to the skin and "perforating" all the structures (muscle, fascia, and so forth) before distributing to dermal and subdermal vascular networks to support the cutaneous layer. These small branches may also become the only circulatory source of the flap or even a receiving vessel for free flaps, which requires special skills (ie, super-microsurgery).[7]

Despite the Gent consensus on perforator flaps,[8] the definition of perforator flaps is still subject to debate. Nevertheless, the authors generally agree with the Gent terminology, which defines the flap by the name of the underlying nutrient vessel, even though many of the most commonly used perforator flaps are referred to by their "popular" name, such as an anterolateral thigh flap (ALT). Perforator flaps are an important part of daily clinical practice, and the ALT flap is actually the most frequently used free perforator flap, because it is capable of covering a great variety of loss of substance.

Several surgeons have used the concepts of perforator flaps in limb reconstructive surgery to harvest local flaps supported by small perforating branches.[9] Their experience especially underscores 2 aspects of the technique: first, the difficulty of pedicle dissection, demanding high microsurgical skills; and second, the absence of microvascular anastomosis, simplifying the procedure. They refer to these reconstructions as microsurgical nonmicrovascular procedures. One main advantage of such approaches may be the use of local resources to reconstruct lost tissue with the "like-to-like" concept. Experience with these local flaps led to the use of a skin island supplied with blood through a perforator pedicle that may be rotated through at least 90° to 180°: the propeller flap.[10] Besides having a more reliable vascular pedicle than traditional flaps, propeller flaps allow for great freedom in design and for wide mobilization, extending the possibility of reconstructing difficult wounds with local tissues and minimal donor-site morbidity.[10] Understanding the possibilities of this surgical technique, several surgeons have begun to use perforating branches to harvest non–well-defined and described flaps in a "freestyle" manner.

In the authors' experience, perforator propeller flaps used in a freestyle manner can be used with positive results in the upper and lower limb for the treatment of traumatic loss of substance, as well as after tumor excisions or burns, and in other conditions (**Fig. 1**). In selected cases, even complex defects may be treated with propeller flaps harvested as composite flaps. In 2009, the authors reported a successful case of reconstruction of the dorsal aspect of the index finger with extensor tendon loss by means of a composite propeller flap rotated 180° and based on the dorsal metacarpal artery; this included the extensor proprius indicis tendon to restore the continuity of the extensor common tendon of the index finger.[11]

PEDICLED CUTANEOUS FLAPS BASED ON PERFORANT VESSELS (PERFORATOR FREESTYLE FLAPS): BENEFITS AND RISKS

A vigorous debate has arisen around freestyle pedicled perforator flaps and propeller flaps, in particular around their safety in clinical practice. Propeller flaps are an appealing option for coverage of a large range of defects, because besides having a more reliable vascular pedicle than traditional flaps, they allow for greater freedom in design and for wider mobilization, extending the possibility of reconstructing difficult wounds with deep tissue defects with local tissues and minimal donor-site morbidity.[12]

Despite the widespread use of free perforator flaps, pedicled perforator flaps and propeller perforator flaps seem not to be as widely used, probably because of the danger of vascular complications caused by transfer of a flap attached only by its vascular pedicle, which is prone to shearing, kinking, and trauma. Bekara and colleagues[4] concluded from their meta-analysis that free and pedicled propeller flaps have similar risks of failure and development of complications. Although partial necrosis is more serious in a pedicled propeller flap than in a free flap, these flap types afford similar levels of coverage success (coverage failure: free flap 5% vs pedicled-propeller flaps 3%). D'Arpa and colleagues[13] reported complete survival of 79 (93%) of 85 freestyle pedicled perforator flap transfers. Six flaps (7%) had vascular complications that were managed with venous supercharging (2 cases),