Keystone and Pedicle Perforator Flaps in Reconstructive Surgery

New Modifications and Applications

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KEYWORDS

• Keystone flap • Perforator flap • Reconstruction

KEY POINTS

- The increase in knowledge of vascular anatomy, including the concept of the perforasome theory and perforator hot-spot versus cold-spot anatomy, has led to significant advances in reconstructive options.
- Pedicle perforator flap (PPF)–based reconstruction benefits patients by using autologous tissue for reconstruction and decreases operative morbidity by limiting transfer of tissue on perforators.
- Freestyle PPF allows greater degrees of freedom in operative planning, because flaps can be based on any dominant perforator.
- Keystone perforator island flap is a multiperforator advancement flap based on musculocutaneous or fasciocutaneous perforators with high rates of flap survival, decreased donor site morbidity and pain, and quick patient recovery.

INTRODUCTION

Initial descriptions of perforator flaps in 1989 by Koshima and Soeda,[1] by using a musculocutaneous flap with an inferior epigastric artery–based skin island for reconstruction of defects involving the floor of mouth and groin, have led to significant additional advancements in the understanding of perforator flaps and vascular anatomy. Kroll and Rosenfield[2] reported that perforator flaps had vascular reliability comparable with musculocutaneous flaps, but limited donor site morbidity by avoiding muscle harvest. The transfer of tissues therefore is not limited by the requirement to include muscle or underlying deep fascia for adequate tissue perfusion. Milton[3] showed that the inclusion of a pedicle with a large vessel was critical for flap survival, and also dictated the viable length of harvest for islanded flaps.

Further modifications of the perforator flap led to the advent of the propeller flaps, first introduced in 1991 by Hyakusoku and colleagues,[4] with later modifications by Hallock[5] and Teo.[6] Propeller flaps allow significant tissue reconstruction with ideal like-for-like tissue, and maintain similar complication rates to free flap reconstruction.[7–12] Recent advances in the understanding of vascular anatomy have led to significant advancements and freedom in perforator-based reconstruction. Taylor and Palmer[13] introduced the angiosome concept, which was further detailed in many additional studies evaluating the static vascular territories of every source vessel and their perforators.[13–26] Further anatomic studies by Saint-Cyr and colleagues[27–29] and other investigators[30–34] introduced the perforasome concept of distinct vascular territories of individual perforators, which

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are dynamic and have significant interactions with adjacent perforating vessels or perforasomes.

The keystone perforator island flap (KPIF) is a versatile flap that was originally described by Behan[35] for reconstruction of defects after excision of skin cancer, and has since been used for the reconstruction of defects located on the head and neck, trunk, and extremities.[35–38] Modifications in planning, design, and execution of the KPIF by relying on a sound understanding of vascular anatomy and the perforasome theory by Saint-Cyr and colleagues have allowed large defect reconstruction after tumor resection, with high rates of flap survival, low risk of significant complications, decreased pain, and quicker postoperative recovery.[39]

PERFORASOME PRINCIPLES

The ability of a single arterial perforator to adequately vascularize large volumes of soft tissue for reconstruction can only be understood with a comprehensive understanding of the perforasome theory. A perforasome is described as the unique vascular territory of a single arterial perforator from an underlying source vessel. Four major principles elucidate the ability of a single perforator to sustain a large volume of soft tissue, and the consistent preferential direction of vascular flow.[29,40]

1. Perforasomes are linked with adjacent perforasomes by direct and indirect linking vessels (**Fig. 1**). Direct linking vessels are larger vessels that directly connect one perforator to another in the suprafascial plexus, whereas indirect perforators connect one perforator to another through the subdermal plexus.[29] In addition, there are communicating branches that connect direct linking vessels to indirect linking vessels. Interperforator flow is bidirectional, with directionality of flow dependent on perforator perfusion pressures. With adequate perfusion pressure, a single perforator can vascularize multiple perforasomes via interperforator flow.
2. Design of the flap and orientation of the skin paddle should be in the same direction as the linking vessels, which are axial in the extremities and perpendicular to the midline in the trunk. Linking vessels allow for interperforator communication between perforators from the

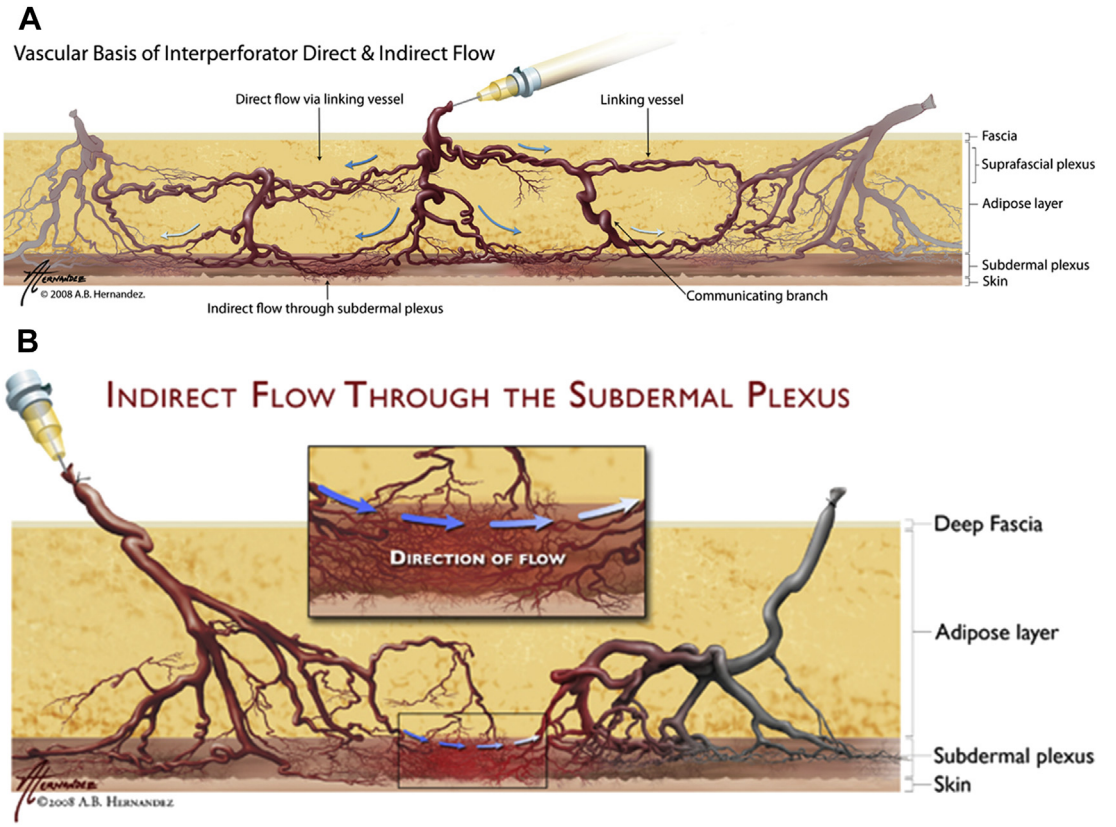

Fig. 1. (*A*, *B*) Linking vessels, direct and indirect. (*Courtesy of* Alexandra B. Hernandez, M.A. of Gory Details Illustration; with permission.)