Free Skin Flap Coverage of the Upper Extremity

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KEYWORDS

• Free flap • Upper extremity • Reconstruction • Cutaneous • Coverage • Vascularity

KEY POINTS

- Soft tissue reconstruction for the hand must provide coverage and restore function.
- Early debridement and early flap coverage is important to allow mobilization.
- Many good options for free flap coverage in the upper extremity provide versatility and low donor site morbidity.

INTRODUCTION

In the injured upper extremity, goals of reconstruction encompass not only soft tissue coverage but also restoration of form, function, and sensation. Both patient- and injury-related factors create unique requirements for restoring function and contour of the hand.[1–3] Adequate early debridement and soft tissue coverage allowing early mobilization of the hand are important for improving clinical outcomes.[4]

This article discusses options for free skin flap coverage of the traumatized upper extremity. Early treatment of these injuries often begins with stable bony fixation first, with repair of injured nerves and tendons along with soft tissue coverage.[2] In many cases, free flap coverage should be selected early in the treatment algorithm to achieve a better functional end result.

DEFINITION AND CLASSIFICATION OF SKIN FLAPS

Skin flaps provide cutaneous coverage, and may be local, pedicled, or free. In traumatic hand injuries, availability of local tissue can be scarce, especially if an extensive zone of injury is present, such as in crush injuries or high-pressure injection trauma.[5] This article focuses on free skin flaps for reconstruction, which have their own blood supply and may include skin along with fascia, muscle, bone, or tendon.

Options for skin flap coverage have increased in recent years, leading to some confusion in developing nomenclature. In one proposed classification system, Nakajima and colleagues[6] separate skin flaps into 5 types, which are cutaneous, fasciocutaneous, adipofascial, septocutaneous, and musculocutaneous. Alternately, Cormack and Lamberty[7] divide skin flaps into 3 groups: direct cutaneous, fasciocutaneous, or musculocutaneous flaps. Here the term *fasciocutaneous* is used more broadly to include any or all tissues between the skin and the deep fascia. In general, fasciocutaneous flaps are based on fasciocutaneous perforator vessels, which form a plexus at the level of the deep fascia, and are ideal for covering shallow wounds because they are thin and able to restore both contour and a gliding surface for tendons.[3]

Hallock[8] describes a pattern for complete flap classification based on the "6 Cs" described by Cormack and Lamberty,[7] which includes circulation (blood supply), constituents (composition), contiguity (destination), construction (flow),

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conditioning (preparation), and conformation (geometry). This system allows for a complete description of any flap, and works toward the goal of developing a common system for communication.[8] This article focuses on free skin flaps, because other types of free flaps are discussed elsewhere in this issue.

FREE VERSUS LOCAL FLAP COVERAGE: INDICATIONS

Local and pedicled flaps work well for coverage of small, isolated defects in the upper extremity, and are technically less demanding than free flaps. However, in mutilating, high-energy injuries, use of a pedicled flap may not be possible because the extensive zone of injury. Free flaps are indicated when local flaps cannot be harvested outside the zone of injury, and also for large soft tissue defects that include exposed bone, tendon, nerves, and vessels.[3] Factors that must be taken into consideration when choosing a flap include the size, shape, location of defect, donor site morbidity, and goals of reconstruction. Soft tissue coverage should be performed as early as possible after adequate debridement.[4,5] If early radical debridement is not possible, then serial debridements should instead be performed before soft tissue coverage.[9]

Free flaps provide the greatest versatility in reconstructive options for the upper extremity. They can include skin, fascia, bone, tendon, or nerve depending on what tissue is needed to cover the defect. Free flaps also have the advantage of bringing their own blood supply along with angiogenic and lymphogenic potential, which improves venous and lymphatic drainage of the traumatized area.[10]

The decision to use a free flap depends on the size and location of the defect, mechanism of injury, exposed structures, structures in need of reconstruction, and the need to restore sensation.[5,9] Goals of free flap reconstruction may include skin coverage, but it can also supply functioning muscle, bone reconstruction, or vascularized nerve grafts if needed. Free flaps have the advantage of providing a large and reliable cutaneous territory with a long vascular pedicle, ensuring that the microvascular anastomosis is well outside the zone of injury.

COMMONLY USED FREE SKIN FLAPS

Venous Free Flaps

Venous flaps are harvested as a skin island with 2 veins. One vein becomes "arterialized" when anastomosed to a recipient artery, and the other vein becomes the flap's outflow. Venous flaps are very thin because they are harvested in the suprafascial plane.[11,12] Arterialized venous flaps can be harvested from the forearm or dorsal foot, and can be useful for resurfacing and revascularizing traumatic defects in the hand, particularly on the dorsal surface.

Woo and colleagues[13] report a 98% success rate in a series of 154 arterialized venous free flaps used for coverage in the upper extremity. The types of flaps in this series included venous skin flaps and tendocutaneous, innervated venous, and conduit venous flaps. The defect sizes ranged from less than 10 cm^2 in 48 cases (31.0%), between 10 and 25 cm^2 in 64 cases (42.0%), and greater than 25 cm^2 in 42 cases (27.0%). Seven cases (4.5%) required emergent return to the operating room: 5 for arterial insufficiency and 2 for venous congestion. Three of these flaps failed.[13] Despite this high success rate, partial flap necrosis is common and can be as high as 5.2% in this series, deserving their description as "reliably unreliable."[2,14]

In a study of 125 flaps for coverage of the dorsum of the hand, Parrett and colleagues[15] compared muscle, fasciocutaneous, fascial, and venous flaps in their aesthetic and functional outcomes; number of secondary procedures; and donor site morbidity. The best aesthetic results were achieved with venous flaps, which were harvested from the volar forearm in the suprafascial plane. The advantages of venous flaps are that they represent a thin and pliable structure, and that they provide a good match for dorsal hand skin without need for later debulking. Furthermore, they do not sacrifice a major artery, and donor site morbidity is minimal. Venous flaps can cover defects up to approximately 40 cm^2 and are ideal for coverage on the dorsal surface of the hand.[15]

Radial Forearm Flap

The radial forearm flap is a workhorse flap in microsurgical reconstruction, and has remained one of the most popular options because of its thin pliable skin, long pedicle, and large caliber vessel. The radial forearm flap was first described in 1978 by a group of surgeons at the Shenyang Military Hospital, and its use for dorsal hand defects with vascularized tendon transfers was initially described by Reid and Moss[16] in 1983. The radial forearm flap represents a fasciocutaneous flap, and can be used as a reverse pedicle flap for dorsal hand reconstruction or an antegrade pedicle flap for olecranon reconstruction.[14] However, this flap also offers additional versatility, in that it can be harvested with the vascularized