Local Fasciocutaneous Sliding Flaps for Soft-Tissue Defects of the Dorsum of the Hand

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IMPORTANCE Appropriate coverage of defects that expose tendon, joints, and/or neurovascular structures is necessary to preserve optimal hand function. Local, random-pattern flaps and skin grafts may be inadequate because of the hand’s finite skin reservoir or the presence of a poorly vascularized and mobile wound bed. Described herein is a novel method of dorsal hand reconstruction.

OBSERVATIONS A fasciocutaneous sliding flap and the underlying vascular anatomy of the dorsal hand are described. The flap takes advantage of the distinct fascial layers of the hand by raising the skin and fascia with bilevel undermining.

CONCLUSIONS AND RELEVANCE The proposed single-stage, bilevel undermined fasciocutaneous sliding flap based on the perforating vessels running through fascial septae recruits pliable, easily mobilized skin, preserves neurosensory innervation, and facilitates early hand mobilization with reduced postoperative care. This flap, and its proposed variations, are ideal for use when paratenon is exposed and immobilizing the hand would be necessary for graft survival or when tension at the wound precludes reconstruction with primary closure or a traditional flap.

Report of a Case

After resection of a squamous cell carcinoma on the dorsal hand of a woman in her 70s, a 3 × 2-cm defect extending to the dorsal intermediate fascia was repaired with a novel fasciocutaneous sliding flap based on the perforating arteries of the dorsal arterial system of the hand. The patient provided consent for this publication.

Flap Design

This flap may be used to repair superficial defects, as well as defects that extend down to tendon and bone that are situated on the dorsal surface of the hand between the metacarpophalangeal joints and the extensor crease of the wrist. Flap design should account for the size and site of the defect, as well as the mobility of the donor skin. The defect should be measured by instructing the patient to “make a closed fist.” This provides a conservative estimate of the size of the flap necessary to tolerate the anticipated postoperative tension generated with hand motion. The lateral borders of the flap may then be designed proximally off of the defect as 2 lateral limbs that arise from the widest portions of the defect. A third limb should connect the 2 lateral flap limbs. The length of the lateral limbs should be at least 1.5 to 2.0 times the defect diameter to incorporate a sufficient number of dorsal perforating arteries. These lateral flap limbs may parallel one another to create a rectangular flap, or they may gently diverge from one another so that an arciform or keystone shape is created. For defects that will be under tension, the keystone design allows for easier recruitment of skin with the V-Y closure at the proximal corners (Figure 1A). Because the abundance of the dorsal hand blood supply is derived from the dorsal metacarpal arteries and their perforators that run between the carpal bones, flaps designed centered over and incorporating multiple intercarpal spaces are more likely to have greater vascularity. Doppler ultrasound was not used in our clinical practice but may be helpful to locate perforating arteries preoperatively.
Surgical Technique
Once the flap is designed, all 3 flap limbs are gently incised through the dermis and superficial subcutaneous fat to the level of the dorsal superficial fascia (Figure 1B). This layer is readily identified by its glistening white color and the veins that it invests. To access the deeper undermining plane and gain additional mobility, 1, 2, or 3 limbs of the flap are further incised through the dorsal superficial and dorsal intermediate fascia to the level of the dorsal deep lamina immediately superficial to the paratenon and dorsal deep fascia (Figure 2). Frequently, only 1 lateral limb is incised to the deeper plane initially, undermining is performed, and flap mobility is assessed prior to incising through additional flap limbs. As more limbs of the flap are released, more mobility may be gained, but flap vascularity grows more tenuous, especially if the flap is not centered over a generous supply of perforating arteries.
Undermining that occurs in the plane above the para-tenon and dorsal deep fascia should be done bluntly to pre-serve perforator arteries when possible (Figure 1C). The perforating arteries have a small diameter of 0.1 to 0.3 mm, so they are not readily visible. However, their presence can often be intuited by a focal restriction on the ability to reflect the flap back or by a focal point of restriction on advancement of the flap. When perforator arteries are severed, the surgeon will note both bleeding and a sudden increase in flap mobility as a vertically oriented vascular “tether” is released.

For flaps on the dorsal hand, the midpoint between the carpal bones should be preserved whenever possible because the underlying dorsal metacarpal artery and its perforators emerge along this line. For flaps based on the second through fourth web spaces, the area immediately distal to the juncturae tendinum, which is approximately 1 cm proximal to the metacarpal heads, should be preserved to protect the Quaba’s perforators. The fascial pedicles of the bipedicled and sling variations of this flap may provide sufficient random blood supply, even if the perforators under the flap have been severed.

Once the flap has been adequately released to the para-tenon on the desired limb(s), the remaining attached limbs are undermined in a more superficial plane immediately in the subcutaneous fat to mobilize the fascial pedicle (Figure 1D). Once the flap has been sufficiently released and undermined, it should easily move into the defect without undue tension (Figure 1E and 1F). A layered repair should be able to secure the flap in a tension-free manner with preserved function and range of motion just after closure (Figure 1G and 1H).

Discussion
Successful reconstruction of hand defects must allow patients to avoid postoperative hand dysfunction and quickly return to daily activities and work. Second intention healing may desiccate vital tissue such as tendon, and layered side-to-side repairs may compromise hand function because of closure tension. In the absence of a well-vascularized bed in defects that expose bony prominences and tendon, skin grafts are unreliable and fail to provide a gliding surface for the underly-ing mobile structures. Adhesions and fibrosis may ensue, potentially compromising tendon motion. Commonly used local cutaneous flaps for reconstruction of larger defects on the dorsal hand may be limited by a finite reservoir of adjacent donor skin and can lead to substantial donor site morbidity, prolonged rehabilitation, or ischemia.

A novel approach to repairing dorsal hand soft-tissue de-fects is proposed whereby the distinct anatomic layers of the dorsal hand anatomy are mobilized to create a vascularized sliding flap. The strategy for mobilization of this flap and other variations was extrapolated from the anatomic investigation of cadaver hands of Bidic et al. They elegantly described the distinct fascial layers and accompanying structures via anatomic dissection, Doppler ultrasound, and lead oxide injections. Whereas Bidic et al sought to improve cosmetic hand rejuvenation, we believe that their findings are particularly sa-lient for reconstruction after skin cancer resection. The reliable and reproducible fasciocutaneous sliding flaps may be implemented to cover defects with exposed tendon and re-move the likelihood of ischemia that may be seen with grafts and random-pattern cutaneous flaps. In addition to preservation of hand neurosensory function, use of adjacent tissue allows sensory discrimination to remain intact through the avoidance of skin grafting. This novel flap is ideally suited for moderately sized defects with a wound bed that is mobile with hand movement, increasing the risk of graft failure, or where tension is high and full flexion would have a high risk for de-hiscence of a linear closure.

Axial, paddled flaps of the dorsal hand and wrist that are based on perforators of the dorsal metacarpal artery are often used to cover defects on the dorsum of the hand and fingers. These flaps and their corresponding blood supply have been reviewed comprehensively elsewhere. The sliding fasciocutaneous flaps described herein are not truly axial, but their blood supply is robust. Consistent cutaneous perforator vessels from the parallel arrangement of the dorsal arterial network permit these sliding flaps to be raised and mobilized with a reduced risk of ischemia when compared with random-pattern flaps based on the dermal plexus. Often, there is a communication between the palmar and dorsal systems, which may further reinforce blood flow to these flaps.

The fasciocutaneous sliding flaps derive their primary blood supply from a series of perforating arteries from the dor-sal and palmar arterial systems of the hand (Figure 3). The skin of the proximal two-thirds of the hand is supplied by the dor-sal metacarpal arteries, which run parallel to the metacarpal bones within the fascia of the dorsal interosseous muscles deep to the extensor tendons. Each of the dorsal metacarpal arteries supplies blood to the dorsal skin of the hand via 4 to 8 cutaneous perforator vessels (diameter, 0.1-0.3 mm) that arise
along its length. The number and diameter of perforators are larger at the level of the distal third of the metacarpal compared with the proximal and central thirds.

The skin of the distal third of the hand and proximal digits is supplied by perforating arteries from the palmar arterial system. The common digital arteries, which arise from the superficial palmar arch, branch at the web space to connect with the dorsal metacarpal arterial system. The palmar metacarpal arteries, which arise from the deep palmar arch, also anastomose with the dorsal metacarpal artery at the web space and give off perforators to the dorsal skin. Skin perforators, called the Quaba perforators, consistently arise 1 cm proximal to the metacarpal head immediately distal to the juncturae tendinum, then ramify in retrograde fashion to supply blood to the skin of the distal dorsal hand.

Our proposed flap design has several distinct advantages compared with other methods of dorsal hand reconstruction. First, the bivelar undermining creates a highly vascularized flap based on both vertical perforating arteries and a vascularized sling pedicle. This robust vascular supply facilitates rapid, reliable wound healing and reduced postoperative care restrictions, which allows early hand mobilization with prompt return to unrestricted hand function. Second, the broad flap design benefits from mobilizing distant tissue reservoirs situated circumferentially around the wound; this permits diffuse distribution of the tension vectors necessary for wound closure and allows for recruitment of skin from several distinct tissue reservoirs that are less likely to “compete” with one another. This flap design broadly distributes the secondary motion required for flap closure, so limitations on joint mobility are less pronounced. Third, this single-stage reconstruction produces minimal donor site morbidity and delivers nearby pliable skin with good color and texture match to the recipient area. Using adjacent tissue with an intact neurovascular supply and avoiding skin grafts or dermal substitutes allows the defect to be repaired with sensitive tissue, thereby preserving sensory discrimination.

Over the past 18 months, 2 of us (J.F.S., C.J.M.) have performed a variation of this flap on 15 dorsal hand defects. We categorize the 4 versions of the dorsal fasciocutaneous sliding flap as follows: (1) bivelar bridge, (2) 2-sided sling, (3) 1-sided sling, and (4) keystone. All 4 variations similarly take advantage of the distinct fascial layers of the hand by raising the skin and fascia with bilevel undermining (Table and eFigures 1-3 in the Supplement). The complication rate for this flap is low. Patients often experience transient, self-resolving distal hand edema. Distal edge ischemia occurred in 2 patients. We believe that this can be minimized by observing the following precautions: (1) designing the flap 1.5 to 2.0 times the defect diameter when the hand is closed as a fist; (2) centering the flap over the intercarpal spaces, where perforating arteries abound; and (3) limiting the number of flap limbs that are deepened to the dorsal deep lamina.

Conclusions

A variety of local and regional flaps exist for soft-tissue defects of the dorsal hand, many of which can lead to substantial donor site morbidity and prolonged healing. Ideal reconstruction of soft-tissue hand defects should allow patients to avoid postoperative hand dysfunction, quickly return to daily activities, and preserve sensory discrimination. The proposed novel bilevel undermined fasciocutaneous sliding flaps based on the dorsal intermediate lamina and its investing fascial layers create highly vascular and mobile tissue for reliable coverage of soft-tissue defects on the dorsal hand. These flaps are ideal for use when paratenon is exposed and immobilizing the hand would be necessary for graft survival or when tension at the wound precludes reconstruction with primary closure or a traditional flap.

Table. Review of Fasciocutaneous Hand Flaps

<table>
<thead>
<tr>
<th>Flap Design</th>
<th>Incisions</th>
<th>Vascular Supply</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bipedicled bridge</td>
<td>Incision of proximal limb of flap is carried to level of dorsal deep lamina above paratenon. Lateral limbs of flap are incised to the subcutaneous fat and undermined above dorsal superficial fascia.</td>
<td>Perforator vessels and subcutaneous plexus*</td>
<td>Robust blood supply</td>
<td>Limited mobility</td>
</tr>
<tr>
<td>Two-sided sling</td>
<td>One lateral limb of the flap is incised to the level of the dorsal deep lamina above paratenon. The proximal and remaining lateral limbs are incised to the subcutaneous fat and undermined above dorsal superficial fascia to preserve the sling.</td>
<td>Perforator vessels and subcutaneous plexus*</td>
<td>Robust blood supply</td>
<td>Limited mobility, so releasing incisions to the paratenon may be necessary on each limb of the sling</td>
</tr>
<tr>
<td>One-sided sling</td>
<td>Proximal and 1 lateral arm of flap are incised to the dorsal deep lamina above paratenon. The remaining lateral limb is incised to the subcutaneous fat and undermined above dorsal superficial fascia to preserve the sling.</td>
<td>Perforator vessels and subcutaneous plexus*</td>
<td>Mobile flap; useful for proximal phalangeal defects</td>
<td>Blood supply highly dependent on preservation of perforators</td>
</tr>
<tr>
<td>Keystone</td>
<td>Incision of proximal limb of flap is carried to level of dorsal deep lamina above paratenon.</td>
<td>Perforator vessels</td>
<td>Improved mobility</td>
<td>Blood supply entirely dependent on perforators</td>
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* Extensive or careless undermining may sever the perforating vessels, thereby limiting the blood supply to these flaps.
First Look: Google Glass in Dermatology, Mohs Surgery, and Surgical Reconstruction

Jonathan Kantor, MD, MSCE, MA

Technology continues to revolutionize the practice of dermatology, and the past decades have seen a paradigm shift in the way dermatologists practice medicine and surgery, deliver care to patients, and keep abreast of developments in our field. Google Glass (Google Inc) is a recently developed, first-in-class wearable computer that includes an optical display, camera, microphone, bone-conduction speaker, touchpad, gyroscope, and accelerometer. I have used the Google Glass device in the context of general and surgical dermatology.

Applications in the clinical dermatology setting include lesional and histopathological photography, teledermatology, education, research, and consultation. Live streaming may also be used for teledermatology consultations, although store-and-forward approaches are feasible as well. Applications in the surgical setting include perioperative photography,1 documentation of Mohs stages, Mohs specimen orientation, patient education regarding tumor and defect size and location, and reconstructive options.

An advantage of this technology is the ability to activate the device in a hands-free fashion. In the surgical setting, this permits the dermatologist to record video or still photographs while maintaining a sterile field, and in the clinical setting, it permits recording photographs without the intrusion of using a camera, as photographs may be taken with a wink of the right eye.

Live streaming of procedures may be used for medical and surgical education for medical students, residents, fellows, and colleagues, as well as for patient education. The dermatologist is also able to stream a physician’s-eye view of the skin examination to a monitor in the patient’s room, permitting easy visualization of the back and other difficult-to-

see areas. For some patients, this may also be a useful adjunct in explaining and demonstrating surgical procedures, allowing patients to watch and record their procedures.

There are some pitfalls to this technology, and the central concern relates to privacy. Explaining how the device records and outlining what will and will not be recorded helps a great deal with reassuring patients, and, in my experience, there was no significant resistance on the part of patients to including the device in the context of their care. Moreover, given the ubiquity of smartphones and closed-circuit television monitors, the public has become increasingly accustomed to the presence of recording devices.

Finally, it is important to note that the current version of the software defaults to synchronizing data to Google servers when the device is both plugged in and within Wi-Fi range; therefore, protected health information and patient identifiers should not be recorded unless the Wi-Fi is disabled prior to charging. Future iterations of the device, especially those designed for medical use, will likely include specialized encrypted technologies to obviate privacy concerns and permit easy integration with electronic medical records.

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NOTABLE NOTES