The Boomerang Flap in Managing Injuries of the Dorsum of the Distal Phalanx


Taipei, Taiwan

Finding an appropriate soft-tissue grafting material to close a wound located over the dorsum of a finger, especially the distal phalanx, can be a difficult task. The boomerang flap mobilized from the dorsum of the proximal phalanx of an adjacent digit can be useful when applied as an island pedicle skin flap. The vascular supply to the skin flap is derived from the retrograde perfusion of the dorsal digital artery. Mobilization and lengthening of the vascular pedicle are achieved by dividing the distal end of the dorsal metacarpal artery at the bifurcation and incorporating two adjacent dorsal digital arteries into one.

The boomerang flap was used in seven individuals with injuries involving the dorsal aspect of the distal phalanx over the past year. Skin defects in all patients were combined with bone, joint, or tendon exposure. The authors found that the flap was reliable and technically simple to design and execute.

This one-step procedure preserves the proper palmar digital artery to the fingertip and has proven valuable for the coverage of wide and distal defects because it has the advantages of an extended skin paddle and a lengthened vascular pedicle. When conventional local flaps are inadequate, the boomerang flap should be considered for its reliability and low associated morbidity. (Plast. Reconstr. Surg. 106: 834, 2000.)

The loss of dorsal tissue at the level of the distal phalanx, along with exposure of the tendon or joint, represents a challenging reconstructive problem because of the lack of locally available tissue. The regimen of surgical treatment includes the use of local, regional, and distant flaps.

The use of local flaps, including transposition and advancement flaps\(^1,2\) with random vascularity, may not be extensive because of the limited range of flap mobility and the limited amount of tissue movable from areas adjacent to the defect. The use of a skin flap mobilized from an adjacent finger, such as the distally based cross-finger flap\(^3\) and the deepithelialized cross-finger flap,\(^4\) requires a staged approach and is associated with limitations, including a considerable period of immobilization with the risk of joint stiffness and a limited arc of transposition.

The reverse digital artery flap\(^5\) and the axial pattern digital transposition flap,\(^6\) based on the proper palmar digital artery, are other options. However, with these flaps, a major artery is killed and an already injured finger might be jeopardized.

Recently, the reverse dorsal digital island flap,\(^7,8\) based on the arterial branches anastomosing the palmar and dorsal arterial networks of the finger, has been developed. The contra-indication to this flap is that the distally dorsal tissue loss extends beyond the midlateral line of the middle phalanx, thus making its vascular integrity uncertain.

The boomerang flap, which was originally described by Legaillard et al.\(^9\) is based on retrograde blood flow through the vascular arcades between the dorsal and palmar digital arteries. It is useful in covering a soft-tissue defect located over the dorsum of the distal phalanx. We used this flap to treat seven patients, and the experience obtained from the management of these cases formed the basis of this report.

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VASCULAR ANATOMY AROUND THE DORSUM OF THE FINGER

The dorsal metacarpal artery bifurcates into two dorsal digital arteries at the level of the metacarpal head. Each of the vessels courses downward along the ulnar or the radial side of the proximal phalanx. The vessel continues distally as the longitudinal subdermal vascular plexus, anastomosing capillaries of the dorsal branches of the proper palmar digital artery. As described by Strauch and de Moura in 1990, the dorsal branches of the proper palmar digital artery in each phalanx are more consistently four in number and demonstrate a regular repetitive distribution. In the proximal phalanx, the largest anastomosing vessels are the dorsal skin vessel and the dorsal branch of the proximal transverse palmar arterial arch. These vessels are located at the middle and the distal one-third of the proximal phalanx. The anastomotic sites of these vessels are considered potential pivot points for the boomerang flap.

Venous drainage of this flap depends on the dorsal venous networks existing between the dermis and the paratenon of the extensor tendons, located in the same tissue plane as the arterial plexus.

DESCRIPTION OF SURGICAL TECHNIQUE

Vascular Pedicle Dissection

The surgical maneuver is based on the principle of lengthening the vascular pedicle by converting two adjacent dorsal digital arteries into one. This is accomplished with the concept of “Y to I.” As the “Y” configuration is divided at the stem (the dorsal metacarpal artery), the two branches (the two dorsal digital arteries) can be straightened and added to form a longer “I” (Fig. 2).

The distal segment of the dorsal metacarpal artery, located at the level of metacarpal head, is visualized by retracting the respective extensor tendon and intertendinous connection. It is transected at the level just proximal to the bifurcation.

Skin Marking and Skin Flap Dissection

A skin marking, with its size determined by the defect of the digit requiring reconstruction, is made over the dorsum of the proximal phalanx of the adjacent digit. The estimated pivotal point, depending on the location of the wound, is also marked on the middle or the distal one-third of the proximal phalanx of the injured digit (Fig. 3).

With the aid of tourniquet control and loupe magnification, the operation is performed under general, axillary block, or regional anesthesia. The skin incision is begun from the side opposite the intended vascular pedicle, and the flap is raised. Care is taken to leave the paratenon undisturbed to ensure the “take” of a skin graft and the free gliding of the tendon. No attempt is made to visualize the vessels. Instead, dissection must be strictly subdermal to raise the entire thickness of the fibrofatty tissues surrounding the vessels, and it is continued to the level of the metacarpal head to meet the dorsal metacarpal artery bifurcation.

In breadth, half the dorsal fibrofatty tissues of the proximal phalanx are raised, and they include the dorsal cutaneous vein. The vascular
Pedicle dissection is continued caudad in the recipient digit to the pivot point, where the flap can easily reach the defect without tension and reverse blood flow can be preserved (Fig. 4). The tourniquet is released, and vascular flow to the flap is ascertained.

The thickness of the vascular pedicle forbids any tunnelling at the digital level because of the risk of ischemia or secondary venous stasis. The lateral aspect of the middle phalanx is therefore incised, and the fatty pedicle is placed and covered with a partial-thickness skin graft. When the width of the flap exceeds 1 cm, a full-thickness skin graft from the groin is applied on the donor site and secured with a tie-over bolster dressing.

The involved digit is splinted for 7 days; after this time, a pressure garment is worn and active mobilization is begun, except in cases of tendon reconstruction. In our experience, these supportive treatments can reduce the bulky pedicle and restore digital appearance and motion quickly.

**Patients**

During the past year, seven digits in seven patients who had soft-tissue loss over the dorsal aspect of the distal phalanx underwent reconstruction using the boomerang flap. Two of these patients are shown in Figures 5 and 6. In all patients, grafting was contraindicated because of the exposure of joints and/or extensor tendons. Trauma and infection were the causes of tissue loss. In five patients, the skin overlying the distal interphalangeal joint was avulsed. In two, the bone became exposed because of loss of the nail bed. The associated procedure of extensor tendon reconstruction was included in one patient. The size of the skin flap harvested from the dorsum of the proximal phalanx of the adjacent finger varied. The largest flap was $4 \times 3$ cm, and the smallest was $2 \times 1$ cm. The donor defect was grafted with a full-thickness skin graft in six individuals and closed primarily in one. No flap necrosis occurred, and no patients underwent secondary revision. Morbidity in the donor digit was minimal. The only complaint of the patients was graft discoloration.

**Discussion**

The task of closing an open wound located around the dorsum of the distal phalanx can be difficult. The conventional mode of wound management, such as wound closure per primum or skin grafting, may not be feasible be-
cause of bone, joint, or extensor tendon involvement.

A boomerang flap\textsuperscript{9,12} is an island skin flap mobilized from the dorsum of the proximal phalanx of the digit next to the injured one. The flap receives its vascular supply from the remnant of the dorsal digital artery and the capillary anastomosis existing between the dorsal digital artery and the dorsal branches of the proper palmar digital artery. The vascular pedicle is lengthened surgically by dividing the dorsal metacarpal artery at a point just proximal to the bifurcation, thus making two branches of the dorsal digital arteries, one to the ulnar side and the other to the radial side of two neighboring fingers, into a single arterial vessel. Despite the rheologic alteration created surgically by dividing the dorsal metacarpal artery, the vascular supply to the skin flap remained intact in our patients.

Although the created length of the vascular pedicle could cover the dorsum of the distal phalanx, the actual length can be limited by the location of a capillary anastomotic site be-
tween the dorsal branch of the proximal transverse palmar arterial arch and the dorsal digital artery. This area is located at the distal one-third of the proximal phalanx, which is the pivot point for the vascular pedicle as the flap is transferred to cover the wound around the nail bed.

The venous congestion that can develop in a skin flap without definite venous channels was not observed in any flap in this study, although no distinct venous system exists in the boomerang flap. The numerous venules contained in the fibrofatty tissues around the vascular pedicle appeared to be sufficient for venous drainage from the skin pedicle.7,8

Surgical dissection of this flap is designed to maintain the integrity of its vascular structure. However, the dorsal digital nerve is not included in the design of this island pedicle skin flap. In practice, lack of skin sensitivity in and around the site of reconstruction was not the primary concern of this group of patients. The procedure is a single-stage operation that preserves the proper palmar digital artery. The size of the mobilized skin flap is ample for covering soft-tissue defects located around the

![Fig. 6. (Above, left) Complex injury to the dorsal aspect of the distal phalanx of the index finger with destruction of the nail matrix and partial loss of the terminal tendon. (Above, right) Reconstruction of the terminal tendon with a tendon graft. (Below, left) The exposed tendon and phalanx were covered with the boomerang flap. (Below, right) View at 4-month follow-up.](image)
tip of the finger. The texture is thin, and early mobilization of the finger is possible unless primary joint structure reconstruction and/or tendon repair is involved.

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ACKNOWLEDGMENT
The authors would like to thank Dr. Ted T. Huang for his invaluable suggestions and reviews of the manuscript.

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