Palmar Hand Wound Coverage with the Free Flaps

Si Young Roh*, Kyung Jin Lee, Dong Chul Lee, Jin Soo Kim, Jae-Won Yang[1]

Department of Plastic and Reconstructive Surgery, Gwangmyeong Sungae Hospital, Gwangmyeong,
[1]Gangnam Jaejun Plastic Clinic for Hand and Plastic Surgery, Pyeongtaek, Korea

Palmar soft tissue defects are best reconstructed using a replacement flap of proper size with adequate soft tissue stability for mechanical resistance as well as with protective sensation. Reconstructive approaches are dictated by injury mechanism, defect size and location, and the status of the wound bed and tendino-skeletal structure. While uninjured portions of the hand can be used as a source for local flaps, the use of free flaps allows for maximal access for selection of the most ideal replacement tissue for the defect to be restored as close to the initial state as possible. Here, we review the garden variety of free flaps used in reconstruction of palmar soft tissue defects.

Key Words: Microsurgery, Reconstruction surgical procedure, Hand, Free flap

INTRODUCTION

While tissue defects vary greatly in presentation, all successful attempts at reconstruction share a singular character. In all such examples, the reconstructive surgeon had chosen a donor that is most similar to the tissue lost to an injury or pathologic process. This fundamental character delineates between beautiful and ugly and divides what is functionally sound to what is painful, stiff, frail, and consequently useless. Nowhere in the human body is this fundamental principle of reconstruction more obvious–and its violation more treacherous–than in the management of hand reconstruction.

Palmar defects are notoriously difficult to manage if the reconstructive surgeon believes the glabrous skin to be a passive envelope, which exists solely to cover the underlying tendino-skeletal framework. The successful reconstruction begins with appreciation of three functional sets of the palmar tissue: 1) The provision of a tactile surface towards the outer world; 2) soft tissue of smooth surface for the tendons gliding within; and

3) sensory recovery. Upon this recognition, the surgeon must now decide on the donor site with minimal morbidity and maximal function.

Local flaps perform admirably but with a couple of caveats. First, the defect cannot be too great of a size. An injured hand can only give up so much donor tissue before there is no more of the hand left. Second, the defect cannot be in a location that requires prolonged immobilization. Unfortunately, these caveats place a significant limit on the types of palmar defects that can be address with a local flap reconstruction.

Setting aside the reimbursement issue and technical demand of microsurgery, free flaps provide an expansive set of reconstructive options with which to repair the wide variety of palmar defects. Name a palmar defect of any size, shape, or location.

SECOND TOE PULP FREE FLAP

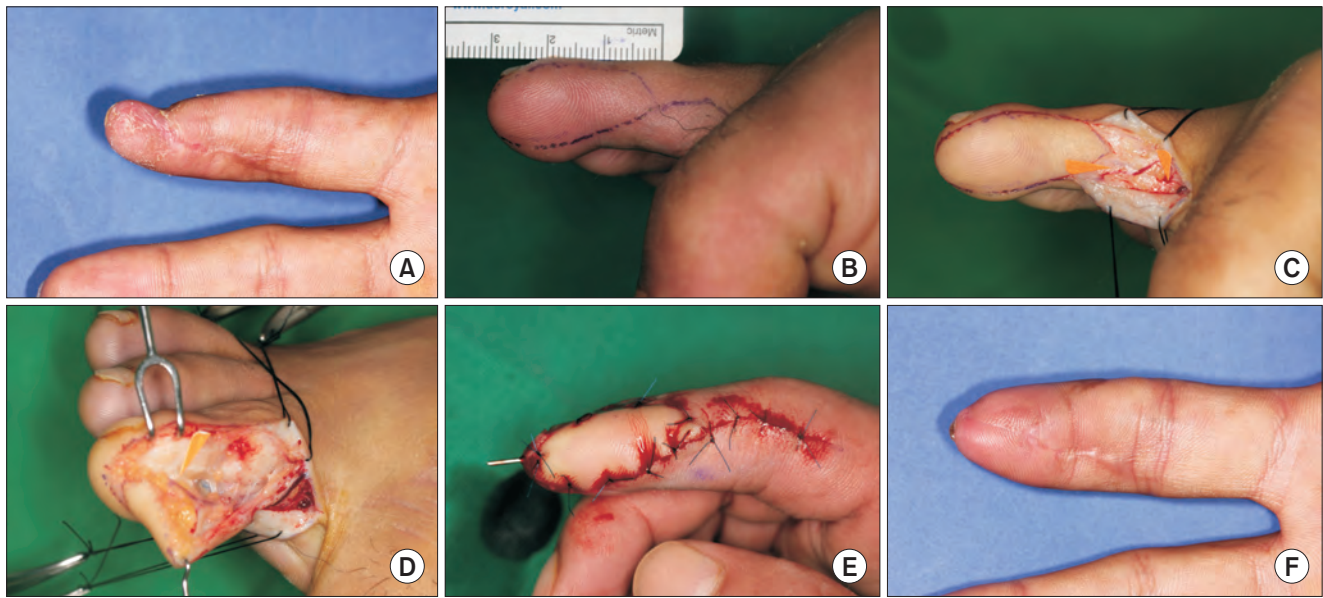The second toe pulp free flap has mean dimensions of 2.7 by

Fig. 1. (A) Patient with pulp defect in the right index finger. (B) Flap design on the right 2nd toe. (C) Skin elevation for subcutaneous vein. Arrow indicates subcutaneous vein. (D) Elevated flap above the paratenon. Arrow indicates digital artery. (E) Immediate postoperative photograph. (F) At 3 months after operation.

1.7 cm with a mean pedicle length of 2.5 cm. For pulp defects less than half the width of finger, there is no better substitute tissue because the free flap is histologically similar–if not identical–to the lost finger pulp tissue.

The flap is composed of the soft toe pulp tissue, medial planter artery, digital nerve, and subcutaneous vein. The pedicle is dissected via a zigzag or lateral incision on volar finger. Great care is taken to preserve the subcutaneous veins located on joint crease. A teardrop flap incision is made over the medial or plantar side of second toe. Subcutaneous veins range between 0.8 mm and 2.0 mm in size. Two such veins ensure adequate venous drainage, although small single subcutaneous veins are often sufficient enough to mitigate the need for leech therapy (Fig. 1).[1]

GREAT TOE PULP FREE FLAP

For pulp defects that cannot be addressed by the second toe pulp flap, the great toe is the most logical donor site. The great toe pulp free flap has all the characteristics of the second toe flap except that the great toe pulp usually yields donor tissue that is thicker than necessary.

Operative steps are similar to that of the second toe flap. A longer vascular pedicle is possible with the first dorsal

metacarpal artery and dorsal subcutaneous veins. The donor site defect is often significant and is closed by secondary intention or with a skin graft (Fig. 2).

SECOND TOE PLANTAR FREE FLAP

The second toe plantar free flap is appropriate for more proximal volar defects with tendon exposure as well as injuries to the neurovascular bundle. This free flap usually incorporates an interphalangeal crease and accommodates flexion-extension motion better than any other donor tissue. The neurovascular bundle can be interpositioned to allow reintroduce blood flow and sensory signal to the distal finger.

The flap pedicle is harvested from the lateral aspect of second toe. Its dimensions are decided by the size of defect, with the proximal interphalangeal joint crease as the middle of flap. The plane is dissection is above the adipofascial level, with the neurovascular pedicle harvested for interpositional anastomoses if necessary. The donor site usually requires skin graft for closure (Fig. 3).[2]

ARTERIALIZED VENOUS FREE FLAP

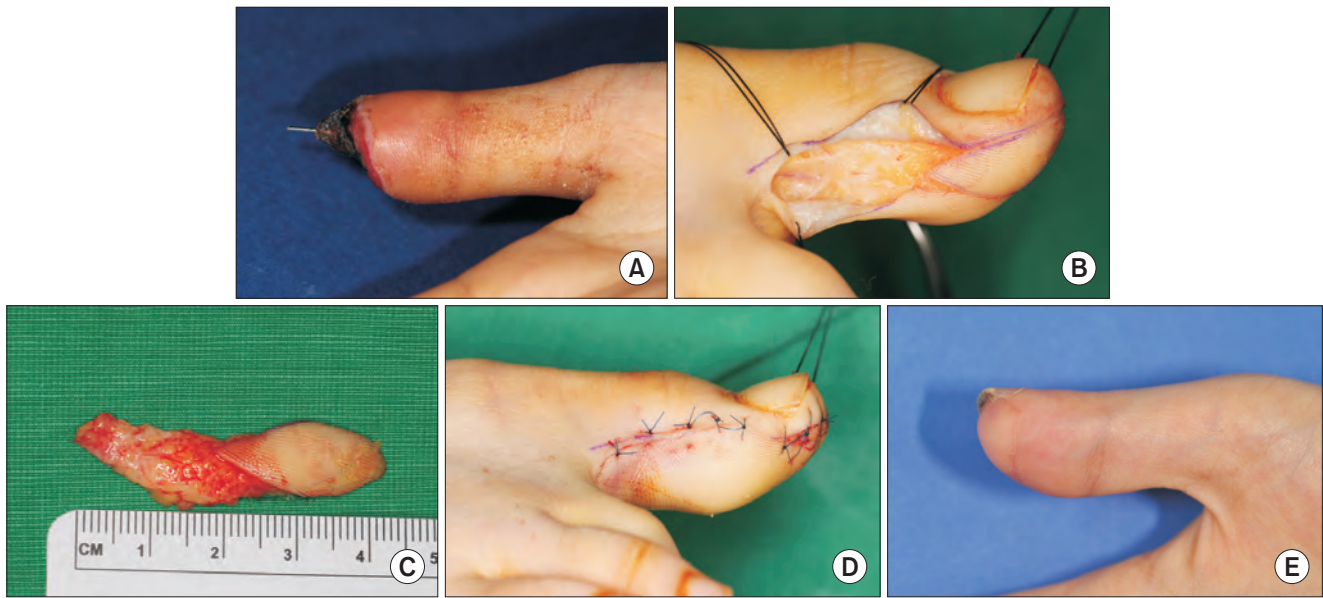First introduced by Yoshimura et al.[3] in 1987, arterialized

Fig. 2. (A). Pulp defect in the right thumb. (B) Flap dissection from the right big toe. (C) Harvested big toe pulp flap. (D) Primary closure was possible in this patient. (E) At 2 months after operation.
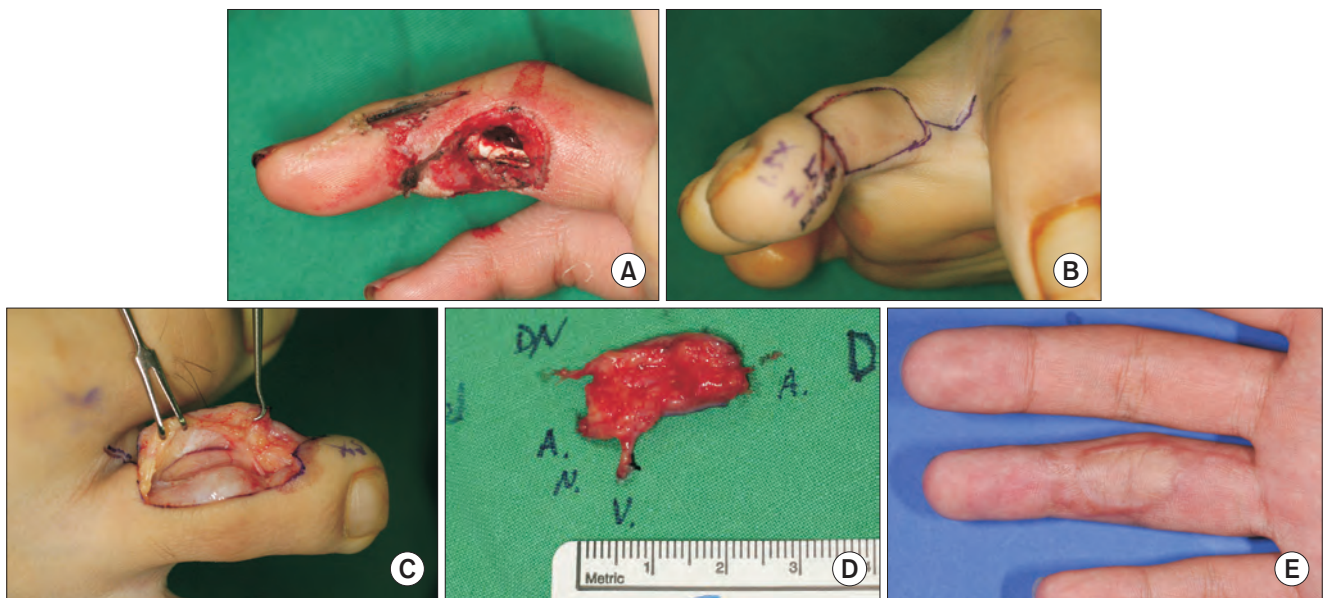

Fig. 3. (A) Soft tissue defect in the right ring finger. The digital artery and nerve is missing in the radial side. (B) Flap design on right second toe. (C) Flap elevation. (D) Harvested flap (A, digital artery; N, digital nerve; D/V, dorsal vein; V, subcutaneous vein). (E) At 9 months after operation.

venous flap can provide a thin vascularized tissue that can be as large at 10×12 cm. The physiological basis for its survival is not entirely understood, but the 'artery in-capillaries-venous out' blood flow is replaced by 'the venous in-capillaries-venous out' flow. The non-physiologic vascular current results in arterial pressures reaching venous valves, which subsequently results in vein dilatation and stagnation of interstitial fluid. Because of this, the flaps can exhibit remarkable edema, congestion, desquamation, and multiple bullae in the early postoperative period, which can ultimately leaded partial necrosis. This potential downside is offset by the fact that harvesting of this flap does not sacrifice a major artery at the donor site.

The arterialized venous flap can easily be harvested from any location but are usually taken from the hand dorsum, forearm,

and foot. The skin flap can incorporate tendon (palmaris longus or extensor digitum brevis) and nerve (sural nerve). When considering this flap, the following recommendations should be followed as much as possible: 1) the supply of largest possible arterial flow; 2) either an efferent veins (artery-vein anastomosis) or an artery (artery-artery anastomosis) (Fig. 4) for inflow; and 3) a flap design that places the afferent vein next to recipient artery.[4]

THENAR FREE FLAP

The thenar free flap was first reported by Kamei et al.[5] in 1993. It is supplied by the superficial palmar branch of the radial artery and used to resurface relatively larger volar defect than 2nd toe pulp free flap and big toe pulp free flap.

The superficial palmar branch is palpated immediately above the tubercle of scaphoid bone at the volar wrist crease. A skin incision is made from the volar wrist crease proximally along the superficial palmar branch, which is confirmed to bifurcate of the radial artery. The venae comitante or a subcutaneous vein should be preserved for venous drainage. The flap has a variable pattern of innervation, and one of these nerves can be incorporated for fingertip reconstruction. The flap width is around 2 cm, and most donor sites could be closed primarily.

iRASP FREE FLAP (INNERVATED RADIAL ARTERY SUPERFICIAL PLAMAR BRACH FREE FLAP)

This innervated modification of the thenar free flap exploits the anatomic finding that palmar cutaneous branch of median nerve hitchhikes onto the vascular pedicle consistently (Fig. 5).[6] The flap can be used an innervated interposition graft by including the superficial palmar branch of radial artery for flow-

Fig. 4. (A) Soft tissue defect in right index finger. (B) Flap elevation. (C) At 6 months operation.
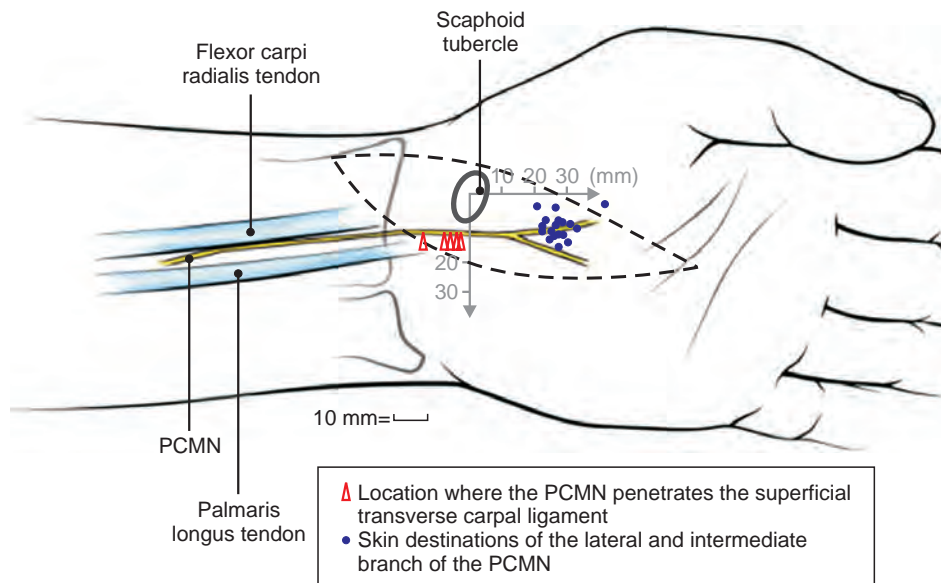

Fig. 5. Red triangles denoate the location where the palmar cutaneous branch of median nerve (PCMN) penetrates the superficial transverse carpal ligament, which is at a mean of 6.08±3.52 mm proximal to the scaphoid tubercle.

Location where the PCMN penetrates the superficial transverse carpal ligament
Skin destinations of the lateral and intermediate branch of the PCMN

through anastomosis. It has the following advantages:

1) The durable, glabrous skin provides excellent texture for volar finger defect.
2) The arterial anatomy is constant with reliable direct skin perforator.
3) Pedicle vessel is compatible in size to digital arteries.
4) The flap can be innervated.
5) Flap harvesting is just superficially over the palmar aponeurosis.
6) The donor site morbidity is low.

ANTEROLATERAL THIGH FREE FLAP

The anterolateral thigh (ALT) flap was first introduce by Song et al.[7] and was popularized by Koshima et al.[8] This fasciocutaneous flap is based on either a septocutaneous or musculocutaneous perforator from the lateral femoral circumflex artery. Depending on the patient, this composite tissue is of varying thickness and usually requires debulking for applications in palmar tissue reconstruction—either at the time of reconstruction or as a secondary procedure. The subcutaneous bulk of fat is removed from the entire flap except for a 2 to 3 cm cuff of connective tissue around the main perforator, and the resulting flap can be as thin as 3 mm. The ALT flap has many advantages, including a long pedicle with a suitable vessel diameter, large skin area, and the possibility of primary closure for flaps less than 6 cm in width.[9]

FASCIAL FREE FLAP WITH SKIN GRAFT

In obese patients, most fasciocutaneous flaps contain too much subcutaneous fat interposed between the fascia and skin. Fascial free flaps with skin grafts are an option for these patients with moderate-to-large palmar defects.

Most readily accessible fascia (serratus,[10] lateral arm,[11] radial forearm, temporoparital, and anterolateral thigh) can be harvested with a reliable perforator supply. The flaps are extremely thin and, therefore, pliable. The fascial free flaps provide the gliding surface, whereas the skin graft cover the whole wound.

Donor-site morbidity is twofold—an incisional scar at the site of fascial donor site and post-skin graft pigmentation changes.

If needed, a small island of skin can be used as a proxy means to postoperative monitoring.[12]

MEDIAL PLANTAR FREE FLAP (INSTEP FREE FLAP)

The plantar surface of the foot has the same glabrous skin and septated connective tissue found in the palm and is an accurate match in function. Of all the flaps incorporating glabrous skin, the medial plantar free flap is the largest. Because of this, it is also the only glabrous flap that is capable of resurfacing volar surfaces of multiple skins in a bridge fashion.

The flap is designed from the non-weight bearing surface of the medial plantar surface to the tuberosity of navicular bone. The skin perforator emerges between the center of heel posteriorly and the medial seasamoid of great toe. A flap can be taken with dimensions up to 9 by 10 cm.

The medial part of the flap is elevated with the perforator of the medial plantar artery and venae comitante. The distal portion is dissected in a plane superficial to the abductor hallucis muscle. Only the superficial portion of the plantar vascular arcade is sacrificed; plantar muscle functions are preserved. The donor site is covered with a skin graft, and is associated with discomfort in the early recovery period.[13]

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