

Chapter 43

Neurocutaneous Toe Free Flap with Pulp

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Soft tissue reconstruction of the fingers poses a reconstructive challenge when there may be a need for glabrous skin and/or nerve and/or arterial inflow. A partial toe transplant permits a one-stage solution for complex losses of a digit in an unprecedented way as compared to any nonmicrovascular method. Various compound flaps can be harvested from the toe, and rarely does the donor toe need to be sacrificed (Fig. 43-1). The main drawback that limits the widespread use of these flaps lies in the fact that familiarity with vessel handling in the ultra-microsurgery (0.5 mm or less) range is required. Although many surgeons avoid this procedure, it is quite safe; in my practice, the survival rate for toe transfers is 99.3% of 450 procedures.

Attention should be paid to avoid stretching the indications because local methods can also yield good results in a simpler way. Briefly, I limit this flap's use to "important" fingers: defects in the thumb, radial side of the index and perhaps the ulnar side of the small finger.

In central defects, the indication is for cases where lack of inflow is combined with a soft tissue defect, as this flap allows top-quality matching vessels for revascularizing the digit and soft tissue restoration in a single stage.

RELEVANT ANATOMY

All flaps of the toe are based on the same vascular system: the plantar digital artery. Rarely do I keep dissecting more proximal than that, but the pedicle can be elongated proximally via the first dorsal metatarsal artery up to the dorsalis pedis. When the first plantar metatarsal artery is dominant, only a couple more centimeters can be dissected before you

get into troublesome dissection under the first metatarsal shaft. Distal dissection has the advantage of minimizing foot morbidity, but it has its own set of problems regarding the vessels. The artery has anatomical variations and it is not uncommon for a dominant dorsal branch to curve in a palmar fashion and become the digital artery proper (Fig. 43-2).

I tend to use flow-through configurations in most of these small flaps. This configuration enables us to carry out easier end-to-end anastomoses and restore the flow to the finger (Fig. 43-3).

Regarding the veins, for the most part I use a dorsal vein; rarely is it necessary to rely on a palmar vein for drainage (Fig. 43-4). Because of local variations, alternative routes of inflow or outflow should be preserved until the dominant vessels have been clarified.

INDICATIONS

Pulp flaps are indicated in major defects in the thumb, in the radial hemi-pulp of the index finger or in the ulnar part of the small finger. For the thumb, the flap is elevated from the peroneal side of the homolateral hallux. In the index finger, it depends on whether the flap is revascularized so as to avoid dangerous vessel crossings (Fig. 43-5).

Second toe tibial neurocutaneous flap (or the like) is indicated in traumatic defects in the same locations as above. It can be used in any finger when a painful neuroma can be solved in one stage.

Flow-through free flaps are indicated in any finger with a soft tissue defect and an arterial defect. Normally the flap includes the nerve, but in some cases this is not needed. As in

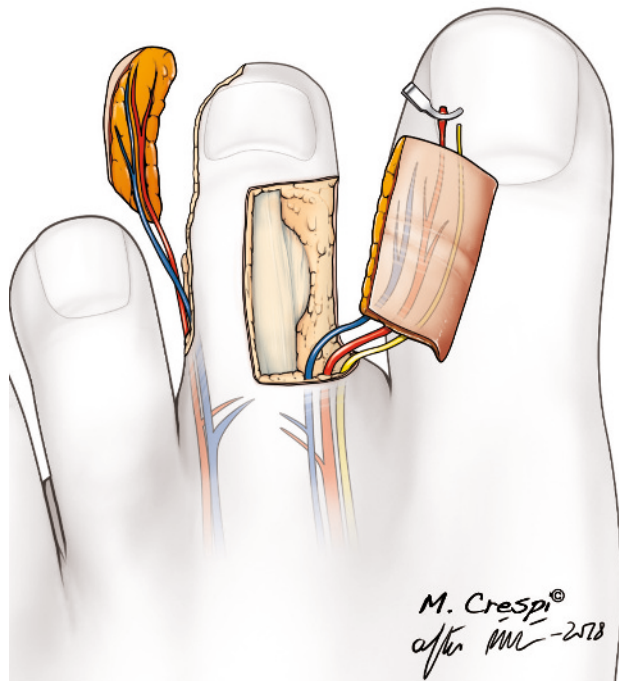


FIGURE 43-1
Multiple combinations can be harvested from a single toe. On the right, a pure neurocutaneous flap. On the left, a chimeric flap: pulp-osteocutaneous flap (see Chapter 44).

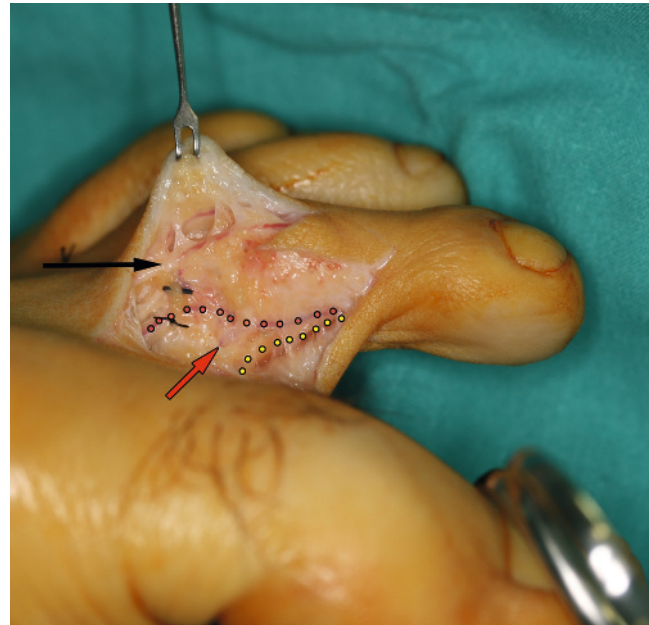


FIGURE 43-2
Hypoplasia of the plantar digital artery at the proximal phalanx level. Notice that the nerve (dotted in yellow) is not accompanied by the digital artery until after the point at which the dominant dorsal digital artery (dotted in red) curves toward the plantar at the level of the proximal interphalangeal joint. The sole contribution of the plantar system is a small twig (red arrow).

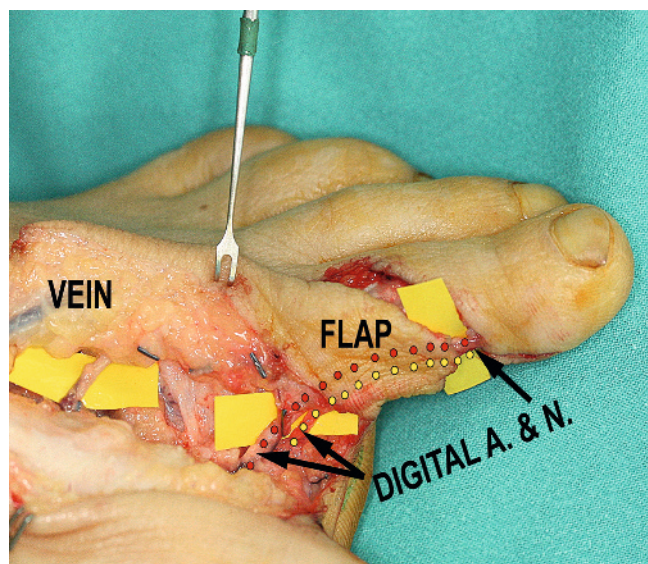


FIGURE 43-3
Dissection of the artery distally allows restoration of the arterial inflow and easier end-to-end anastomoses.

the case of the neurocutaneous flap, it can also be harvested from the neighboring hallux or from other areas in order to match the existing defect(s) (Fig. 43-6).

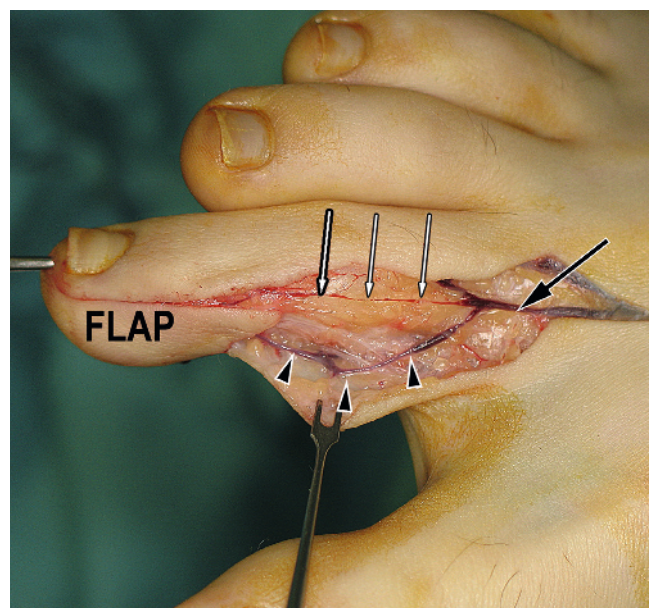


FIGURE 43-4
In this patient (same as in Figure 43-5), the dorsal vein was quite hypoplastic (small white arrows) as to entrust the venous drainage to it. Both the dorsal and a compensatory overdeveloped plantar vein (arrowheads) were harvested in a proximal dorsal vein (large black arrow). As a rule, connections from this plantar system occur in the vicinity of the web.

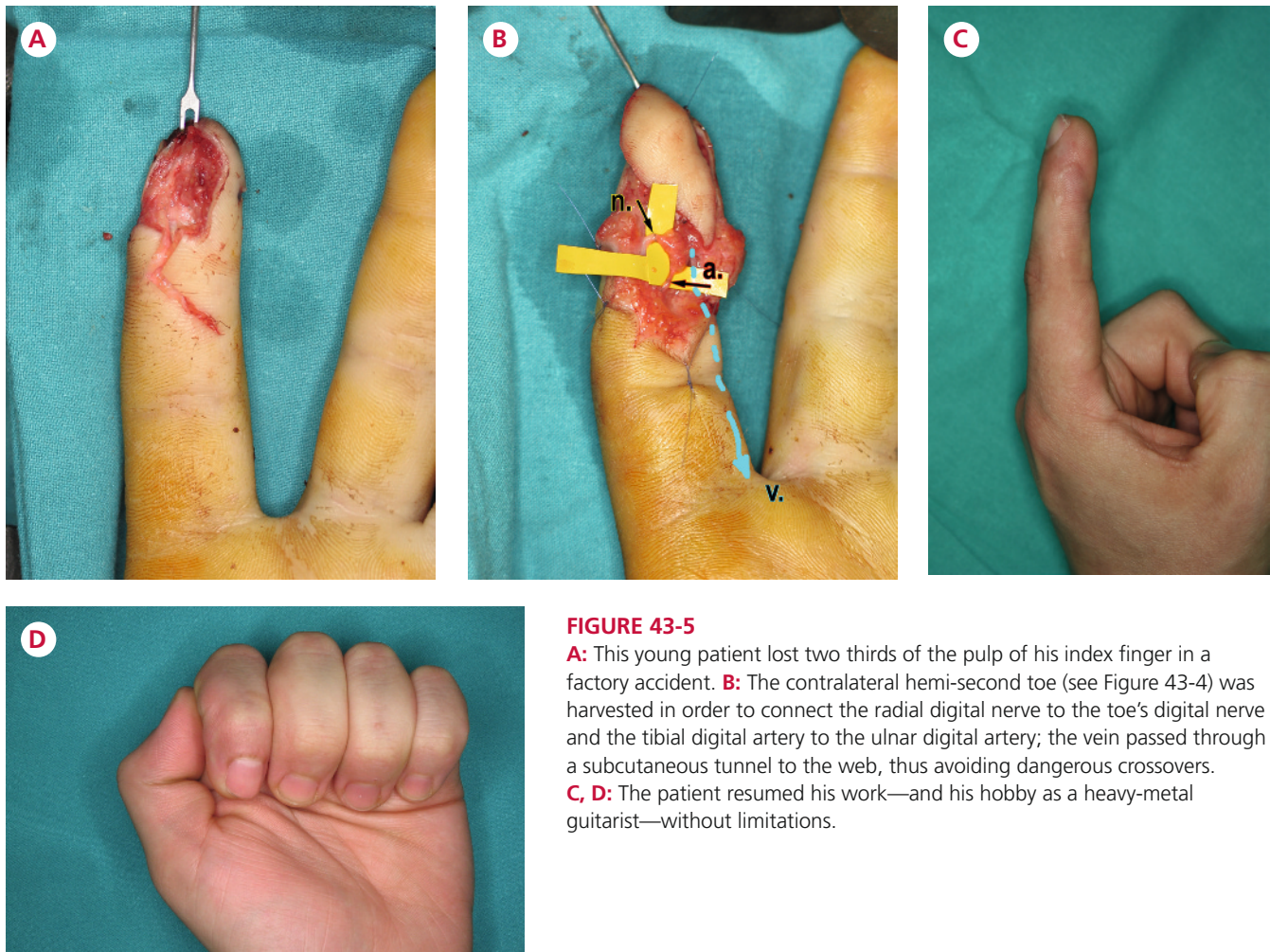


FIGURE 43-5

A: This young patient lost two thirds of the pulp of his index finger in a factory accident. **B:** The contralateral hemi-second toe (see Figure 43-4) was harvested in order to connect the radial digital nerve and the tibial digital artery to the ulnar digital artery; the vein passed through a subcutaneous tunnel to the web, thus avoiding dangerous crossovers. **C, D:** The patient resumed his work—and his hobby as a heavy-metal guitarist—without limitations.

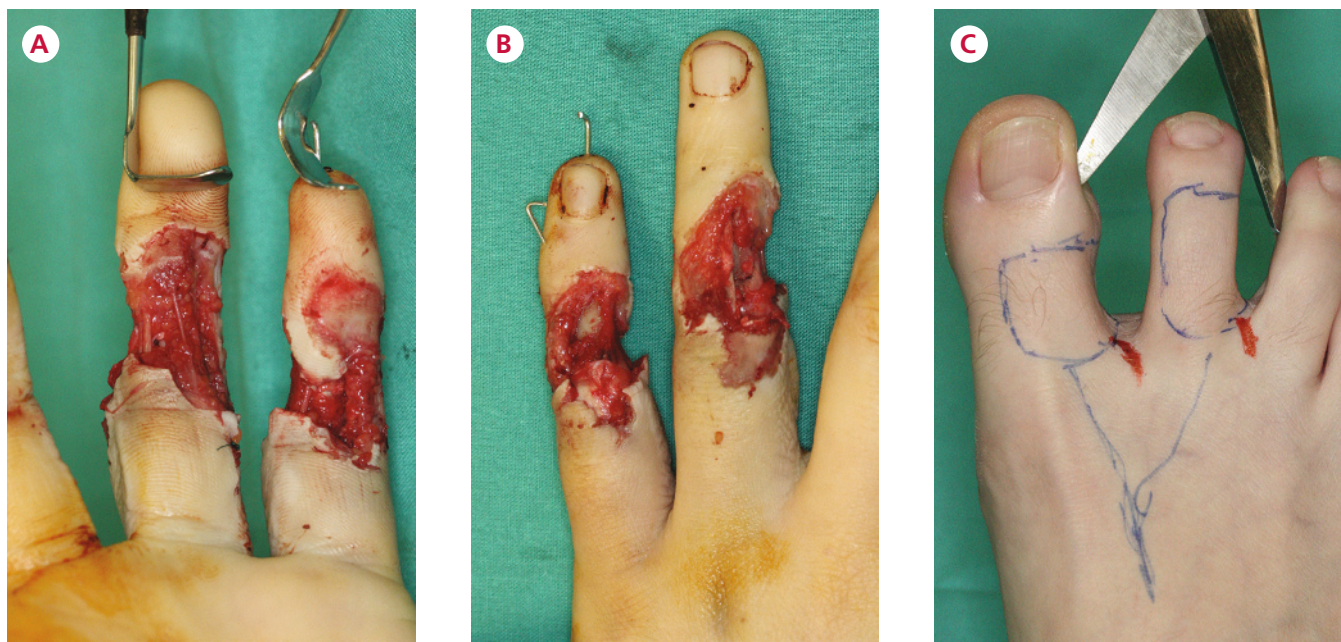


FIGURE 43-6 continues...

A, B: This patient sustained compound fractures and finger devascularization.

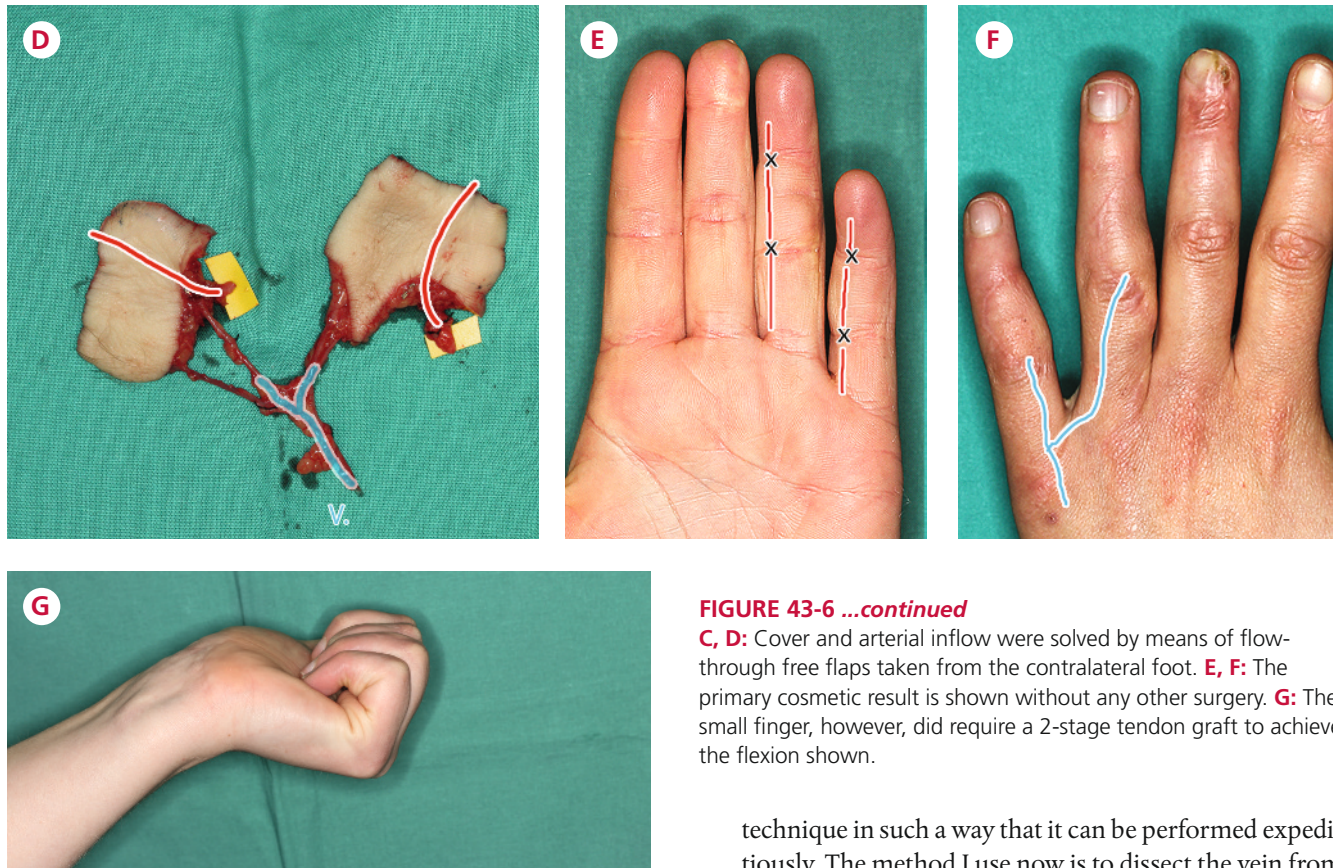


FIGURE 43-6 ...continued

C, D: Cover and arterial inflow were solved by means of flow-through free flaps taken from the contralateral foot. **E, F:** The primary cosmetic result is shown without any other surgery. **G:** The small finger, however, did require a 2-stage tendon graft to achieve the flexion shown.

CONTRAINDICATIONS

Perhaps the most important warning is to avoid over-indicating these sophisticated flaps instead of using simpler reconstructions. In central digits, except for flow carrier scenarios, these flaps are not indicated.

Major vascular conditions are also contraindications. However, patients who smoke, are overweight, or are diabetic are not disqualified, although they are warned that there may be problems at the time of flap raising and the possibility of local spasm.

SURGICAL TECHNIQUE

- Planning is important to avoid dangerous crossover of vessels that may put at risk arterial or venous flow (Fig. 43-7). Rehearsing on paper is strongly recommended.
- For flap elevation, I apply a tourniquet without exsanguination using an Esmarch bandage, but I elevate the leg: it is crucial for veins to contain some blood for identification during dissection. All dissection is carried out with 3.5x loupes.
- Vein harvesting is without a doubt the most difficult part of the whole operation, as the veins are very small and may be easily damaged. I have modified the dissection

technique in such a way that it can be performed expeditiously. The method I use now is to dissect the vein from proximal to distal. I first locate the end of the recipient vein and then track it distally to the edge of the flap. Side branches are ligated with silk if the vein is to be passed under a tunnel; hemoclips will become entangled when passing the vein through a subcutaneous tunnel (see below). Hemoclips can be used, however, for the side

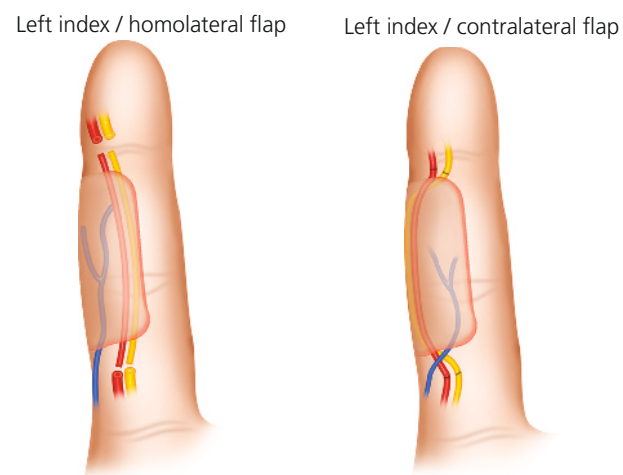


FIGURE 43-7

A: At the time of reconstructing this neurocutaneous defect in a left index finger, all structures match if the ipsilateral tibial second toe neurocutaneous flap is harvested. **B:** Conversely, dangerous crossover of neurovascular structures will occur if the same flap is harvested from the contralateral side. Rehearsing on paper is paramount.

branch away from the pedicle. In most cases, dissection continues until the length of the vein is sufficient to reach the digital web where sizable veins can be found.

- The artery is located by incising the proximal aspect of the flap. The corresponding artery and nerve (if needed) are isolated from that point and dissected proximally. Utmost care should be taken to ligate the small branches that take off from the artery, particularly those directed to the bone, as they are tiny and will cause unrelenting spasm if avulsed. Microdissecting them and ligating with 9-0 nylon is recommended. This process is time consuming, but it is only needed for 1 or 2 side branches—and the benefit of immediate flap reperfusion once the tourniquet is released far outweighs those additional minutes. On the other hand, the remaining branches can undergo bipolar coagulation or be clipped.
- Once the vessels are isolated, elevation of the flap itself is carried out expeditiously by following the periosteum and flexor sheath plane with a knife.
- In any circumstance, rough dissection of the small arteries, or traction from side branches, or bipolar coagulation too close to the digital artery digital artery proper are to be avoided as these maneuvers may cause unremitting spasm.
- The tourniquet is released and, after allowing time for reperfusion at the foot, the flap is transferred to the hand.
- Once the flap is fitted into position, the anastomoses are carried out. Our preferred suture technique is running suture with 10-0 nylon in a 100 μ needle for both artery and vein. Two or 3 epineural stitches with the same material are placed in the nerve.
- To transpose the veins to the web or proximally into the finger, rather than opening the skin that will scar the finger, we prefer the following technique: A channel is made bluntly with Metzenbaum scissors, and a silicone tube (taken from an intravenous line) is inserted on the scissors tip and passed through this subcutaneous tunnel. Then, by attaching the vessel to the end of the tube with a suture and pulling through, the vein will pass dorsally, thus permitting a comfortable venous anastomosis in a healthy environment without the need to create a scar (Fig. 43-8).
- After completion of the anastomoses and just before tourniquet release, a bolus of 1500 U heparin is injected intravenously. Thereafter, a continuous infusion of heparin diluted in saline at a rate of 500 U per hour is given for 2 days, which is reduced by half on the third day. Patients are discharged on the fourth or fifth day, receiving low molecular weight heparin for an average of 2 more weeks.
- The donor toe is never sacrificed. A skin graft applied to the periosteum is all that is required in the soft tissue variants flaps. In some cases, closure can be performed primarily if the flap is small (Fig. 43-9).

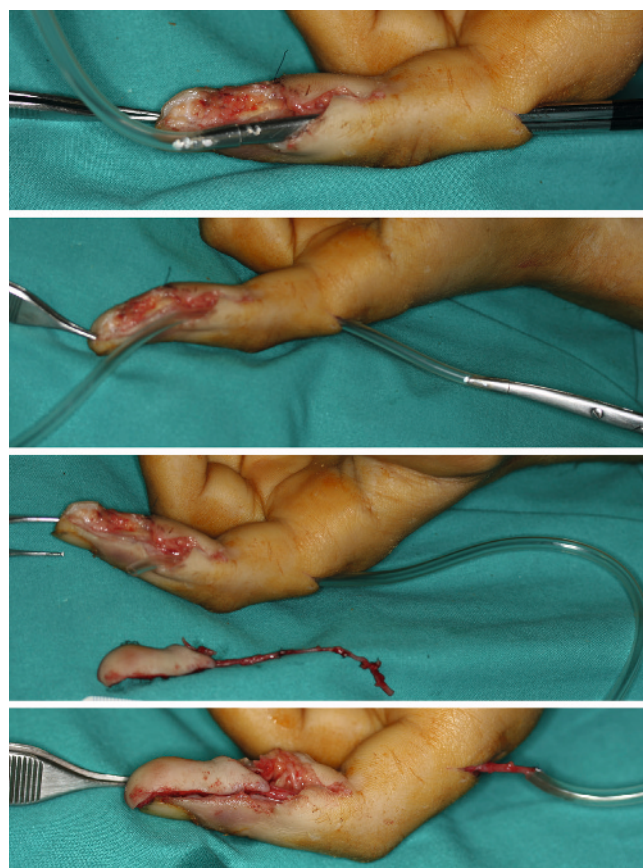


FIGURE 43-8

To transpose the veins to the web or proximally rather than opening the skin (which will scar the finger), we prefer the technique presented in our 2007 paper. A channel is made bluntly with Metzenbaum scissors, and a silicone tube (taken from an intravenous line) is inserted on the scissors tip and passed through this subcutaneous tunnel. Then, by attaching the vessel to the end of the tube with a suture and pulling through, the vein may pass dorsally, thus permitting a comfortable venous anastomosis in a healthy environment without the need to create a scar.



FIGURE 43-9

Donor site following stitch removal.

- Postoperatively, the flaps are monitored through the use of a Doppler probe and visually checked for color by nursing personnel on an hourly basis for the first 48 hours and every 2 hours thereafter except at night (when the flaps are checked every 3 hours) for 2 more days.

See Video 43-1 for a case example using this technique.

VIDEO 43-1
 Partial toe: Neurocutaneous flap. This video demonstrates the partial toe neurocutaneous flap technique in a patient with scar tissue pain due to nerve defect and limited range of motion. (Copyright Francisco del Piñal, MD, Dr Med, 2017.)
 View online: <https://tinyurl.com/ASSH-FlapsVideos>.

COMPLICATIONS

Lack of inflow of the flap in the foot can occur. Any rough dissection of the small digital artery, traction from side branches, or bipolar coagulation too close to the digital artery may trigger an episode of long-lasting spasm or failure.

If one is faced with an ischemic toe flap at the foot, we recommend exploration for local problems, such as untied branches, and the use of toe warming and topical application of verapamil to relieve spasm—and, if this fails, an adventitia stripping procedure. If all of these measures fall short, we advise proceeding immediately to toe flap transfer to the hand to shorten the already long ischemia time. Alternative paths for arterial inflow should be sought and anastomoses performed to those vessels to supercharge the flap.

Arterial or venous failure appearing several hours after completion of the operation is due to swelling 99% of

the time. Release of stitches in the side opposite the pedicle solves the problem in most cases. Most wounds can be left open and dressed after the swelling subsides; spontaneous closure will occur.

OUTCOMES

In a previous publication (del Piñal et al, 2007), we reported 6 consecutive patients who had a combined soft tissue and digital nerve defect reconstructed by a vascularized neurocutaneous flap from the tibial (medial) side of the second toe. So far, we have done 37 neurocutaneous free flaps in different combinations without a failure.

We also published our early experience in the most useful flow-through toe flap (del Piñal, 2009).

Our initial experience with hemi-pulp transfers (8 thumbs, 11 index fingers and 1 small finger defect, no failures, a recovery in sensibility of 2-point discrimination of 7–9 mm, high patient satisfaction) was reported in the European Congress in Athens (2007).

The procedure should be considered safe when performed by surgeons who have experience in handling small vessels in the range of 0.5 mm or less.

PEARLS AND PITFALLS

- The toes provide skin of similar thickness and durability as a finger. In addition, nerve, artery, or bone can be included to compensate for any defect in the finger.
- The flap can be tailored exactly to match the defect no matter how compound it may be. These flaps permit a one-stage solution for complex scenarios (Fig. 43-10).

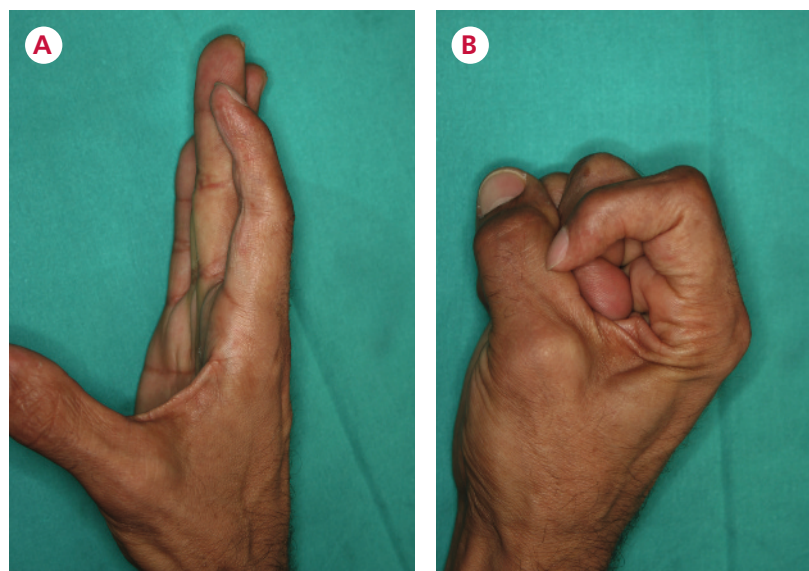


FIGURE 43-10

This cook sustained a laceration on his index finger 3 years before presentation. **A, B:** Because of neuropathic pain, he had undergone several operations and had developed numbness in the ulnar side, hypoesthesia in the radial side, and limited range of motion of the index finger. He was on multidrug therapy for unbearable pain. *continues...*

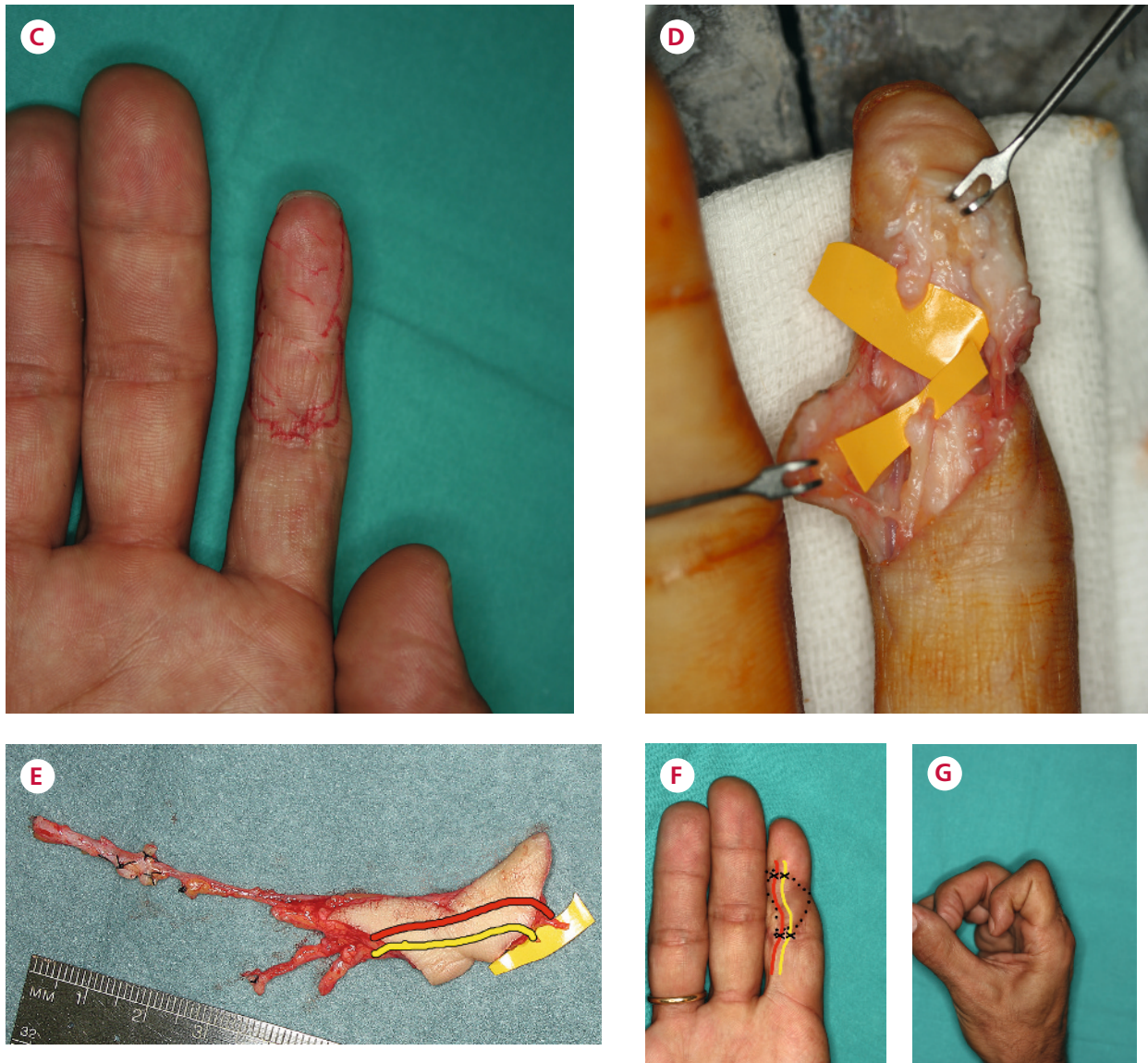


FIGURE 43-10 ...continued

C: The area of neuropathic pain was drawn in red by the patient himself. **D:** At the time of surgery the radial digital nerve was encased in scar tissue although in continuity, while the ulnar nerve was severed and the neuroma trapped in the scar. **E:** The scar tissue was excised and replaced by a well-vascularized flap including the tibial neurovascular bundle of the second toe. The donor site was closed primarily (see Figure 43-9). **F, G:** A painless finger with full range of motion was obtained after, in the patient's words, "three years of misery." All drugs were withdrawn progressively.

- Because spasm is a common occurrence even in the best hands, familiarity with handling spasms is paramount. Avoid vessel desiccation while dissecting by use of frequent irrigation, and keep the patient well hydrated and perfused. Minimize trauma during pedicle dissection.
- Do not confuse spasm (the anastomoses are patent but the flap/toe takes color in a very slow manner with continuous up and downs) with a non-patent anastomoses where waiting will be a waste of time, or with the lack of reperfusion after elevation due to vessel disease.
- Topical application of calcium blockers (verapamil), warm soaks, and control of any side branch or side bleeding may reverse the spasm. In some cases where very slow reperfusion of the transferred flap/toe is taking place, the use of systemic medication may be helpful. We have had some success reversing central spasm by infusing systemically low doses of ephedrine or dopamine at beta effect.

SUGGESTED READINGS

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