The Use of a Neurotized Arterio-venous Flow-through Flap for Concurrent Pulp Revascularization and Reconstruction

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Summary: Digital fingertip soft tissue defects requiring both reconstruction and revascularization pose challenges to the reconstructive surgeon. Traditional options, including terminalization, vein graft and cross-finger flap, and free flow-through flaps, maybe unsuitable or unavailable, with potential for significant donor site morbidity. Venous free flaps rely on venous circulation alone, with no sacrifice of an artery. We present a unique case of a self-employed tradesman with Raynaud’s disease, with four-finger injury, and three-finger ischemia for whom we performed a neurotized arterialized venous flow-through flap to revascularize and reconstruct a pulp defect (with a concomitant vessel gap of 2 cm). After allowing for a period of intrinsic delay, the neurotized arterialized venous flow-through flap was inset after 10 days. The flap survived and the patient began to return to his activities within a month of the injury. (Plast Reconstr Surg Glob Open 2021;9:e3894; doi: 10.1097/GOX.0000000000003894; Published online 2 November 2021.)

CASE REPORT

A 39-year-old, right-hand dominant self-employed tradesman, with a background of Raynaud’s disease, sustained a circular-saw injury. This resulted in devascularization of his left middle, ring, and little fingers, with a 3 × 1.5 cm significant soft tissue defect of his left middle finger pulp with exposed flexor digitorum profundus tendon at its insertion and laceration to the left index finger (Fig. 1). He had also sustained a comminuted fracture of the distal inter-phalyngeal joint of his left ring finger. A neurotized arterialized venous flow-through flap from volar forearm was used to simultaneously revascularize and reconstruct the defect in a two-stage procedure.

In terms of patient-reported outcomes measures, we used the validated, quick disability of the arm, shoulder, and hand score (qDASH). At 2 months postoperative, the patient had a qDASH disability/symptoms score of 31.8 and qDASH work module score of 31.3, where 0 represents no disability, and 100 represents total disability. Postoperatively, the patient was able to return to work by 5 weeks and was performing activities of daily living by 6 weeks. (See video [online], which displays optimal healing of the pulp defect and the partial return of sensation at 10%–20%.)

DISCUSSION

This case illustrates a multidimensional problem: (i) devascularized digit, (ii) pulp loss of the left middle finger with exposed flexor tendon, (iii) background of Raynaud’s disease, (iv) a need to return to work quickly, and (v) a desire to preserve digit length. This necessitated a flow-through flap that was thin and neurotized, which the anterolateral thigh, radial forearm, and superficial circumflex iliac artery flow-through variants did not satisfy. The venous flap was chosen based on this.

Although the use of venous flaps is not new, its use has been hampered by a relatively high rate of partial flap necrosis, which has been shown to reduce with arterialized venous flow-through flaps (AVFTs). They facilitate single-stage revascularization and reconstruction with thin and pliable tissue, with a compromise of only a subcutaneous vein and, therefore, minimal donor site morbidity. They are ideal when grafts, local flaps, or other conventional flaps are not available or suitable. In this patient with a

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defect over the pulp with exposed flexor tendon and a devascularized digit, the AVFT flap option satisfied the requirements to provide a sensate, well-padded pulp that also provided coverage of the tendon. The digit was also revascularized through the flow-through flap.

**Technical Pearls**

**Flap Choice**

A Type III H-configuration flap\(^1\)\(^,\)\(^2\) was utilized with a proximal arterio-venous anastomosis (ulnar digital artery and flap vein anastomosis) and distal veno-venous (flap vein and periosteal vein of 0.7 mm diameter anastomosis) (Fig. 2). Adventitial stripping was performed for 2 cm to account for the Raynaud’s disease.\(^3\)

**Surgical Technique**

An arteriovenous anastomosis was facilitated using the knight’s move technique, proposed by the senior author (RYK).\(^4\) This is based on a near-parallel angle of entry into the lumen before exiting perpendicular as per conventional microsurgical methods. All digits and pulps were salvaged, and flap inset was performed at 10 days. The technique allows the safe anastomosis of very small vessels. Once the needle has passed through the proximal vessel wall, its tip is rotated 90 degrees and passed through the opposite vessel wall to avoid catching the back wall.

**Reduce Risk of Flap Necrosis**

We delayed the flap inset by 10 days, facilitating a process we coined “intrinsic flap delay” to reduce the risk of partial flap loss (Fig. 3). We hypothesize that if the flap is tightly sutured at the peripheries, this would increase peripheral vascular resistance, and blood would shunt through the center of the flap. This would result in partial flap necrosis at the flap periphery due to a tight inset.\(^7\) By delaying the inset, it would allow peripheral channels to open and encourage neovascularization. Other mechanisms of flap survival have been proposed in the literature, however, and peripheral neo-angiogenesis may be supported by arteriovenous shunting or capillary bypass flows.\(^8\)

**Restore Sensation**

In terms of neurotization, although a cutaneous nerve was found, no nerve was identified within the flesh of the pulp for coaptation. Instead, the nerve was laid upon the

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**Fig. 1.** Preoperative image of the devascularized middle, ring, and little fingers, wherein there was a 3 × 1.5 cm volar pulp defect with an ischemic fingertip.

**Fig. 2.** A type III H-type venous flap was harvested from the volar forearm and anastomosed to the proximal digital artery while distally, it was connected to a periosteal vein.
Pacinian corpuscles, which, by 6 weeks, demonstrated sensory recovery. This has been previously described. Because the patient was White, we did not employ the use of a vein-finder. This is a device we routinely use, especially for darker skin types to identify the venous patterns before flap/vein graft harvest and encourage the readers to employ in their own practices.

In summary, when grafts, local flaps, and conventional flaps are unsuitable or unavailable, a neurotized arterIALIZED venous flow-through flap can be used, optimized by using a Type III H-configuration, using a vein-finder, employing the knight’s move technique for supermicrosurgery and “intrinsic AVFT delay” for 10 days before trimming and in-setting. The steps have been listed below.

**Step 1:** Identify the suitable patient, requiring revascularization-reconstruction, where grafts and local or conventional free flaps would be unsuitable.

**Step 2:** Prepare the pulp vessels.

**Step 3:** Use the vein-finder and select the AVFT flap configuration needed.

**Step 4:** Raise a neurotized AVFT (essentially a thick full-thickness skin graft with cutaneous veins/nerves).

**Step 5:** Use the knight’s move to facilitate the supermicrosurgery.

**Step 6:** Employ intrinsic flap delay for 10 days before trim and inset.

**CONCLUSIONS**

Fingertip injuries are common, and where both revascularization and reconstruction is required in a single-stage operation, arterialized venous flow-through flaps provide a viable option when grafts, local flap, or conventional free flaps are unavailable or unsuitable. They should form part of the armamentarium of a reconstructive hand surgeon attending or resident.

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