The Volar Forearm Fasciocutaneous Extension: A Strategy to Maximize Vascular Outflow in Post–Burn Injury Hand Transplantation

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Summary: Patients with circumferential extremity burns may have a deficiency of cutaneous veins, which presents a challenge for both autologous reconstruction and vascularized composite allotransplantation. The authors present a 44-year-old, left-hand-dominant man with metacarpal level amputation of his left hand secondary to burn injury. Extensive prior débridement and skin grafting resulted in nearly total absence of cutaneous veins in the forearm. The patient underwent unilateral left hand transplantation with an allograft designed to include a volar forearm fasciocutaneous extension supplied by the radial artery and including the basilic vein to permit augmented venous drainage by means of anastomosis at the antecubital fossa. The volar forearm fasciocutaneous extension can increase vessel caliber and possibly improve reliability in the setting of hand transplantation and should be considered following severe burn injury. (*Plast. Reconstr. Surg.* 134: 731, 2014.)

CLINICAL QUESTION/LEVEL OF EVIDENCE: Therapeutic, III

Vascularized composite allotransplantation is an option for the treatment of devastating extremity and facial injuries.[1–5] Circumferential extremity burns present particular clinical difficulties, as autologous microsurgical reconstruction is challenging[6,7] and patients may have a paucity of cutaneous veins because of the initial injury or prior surgical intervention. A level of transplantation below the elbow is most common,[8–11] although distal transplantations are preferred to minimize the time required for reinnervation. In this context, the absence of cutaneous veins in the recipient stump makes achieving adequate venous drainage a concern.

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Although the history of vascularized composite allotransplantation is short, it is conventional for repair of components during hand transplantation to be performed within a relatively narrow zone, with osteosynthesis, tendon repair, vascular anastomoses, and neurorrhaphies performed at the same anatomical level. Ideally, performing proximal vascular anastomoses and distal neurorrhaphies would combine the benefit of large-caliber, high-quality vessels for perfusion with minimal distal axonal length to expedite functional recovery. To our knowledge, hand transplantation with volar forearm fasciocutaneous extension has not been described. We report

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Fig. 1. Pretransplant status of dominant left hand, with metacarpal level amputations, fixed flexion deformity at the wrist, and circumferential skin grafting in the forearm. Gross appearance (*above*) and anteroposterior (*below*, *left*) and lateral radiographs (*below*, *right*).

such a case, combining proximal anastomoses of the radial artery and basilic vein, with distal osteosynthesis, neurorrhaphies, tendon repair, and anastomoses of the ulnar artery and vena comitans.

CASE REPORT

A 44-year-old, left-hand-dominant man presented who had sustained 50 percent total body surface area burns in 2003. This resulted in a metacarpal level amputation of his left hand with a truncated thumb, contracture of the first webspace, and a 45-degree flexion contracture of his wrist (Fig. 1). In prior operations, the patient's forearm was débrided extensively to fascia or deeper and covered circumferentially with a skin graft.

Preoperative Planning

Given the patient's preoperative deformity affecting both upper extremities, he was offered bilateral hand transplantation. Ultimately, he decided to pursue unilateral left hand transplantation, as his right hand functioned as a helper limb, a function that he did not wish to jeopardize. The patency of the patient's cutaneous veins was a substantial preoperative concern given his extensive injury and surgical history, and ultrasound studies demonstrated an absence of cutaneous veins distal to the elbow suitable for anastomosis to donor veins during transplantation. To provide greater vessel caliber and more reliable venous outflow, a volar forearm extension was designed for the allograft to include the proximal basilic vein and larger vena comitans for outflow.

Intraoperative Technique

The patient underwent unilateral left hand transplantation in October of 2012. A cutaneous extension, incorporating the volar forearm fasciocutaneous paddle, was included with the allograft (Fig. 2). The basilic vein was included with the fasciocutaneous extension, as it was confirmed to be patent, whereas the cephalic vein within the donor forearm was thrombosed. The forearm skin paddle was 8 cm in greatest width and designed immediately overlying the radial artery. Osteosynthesis was performed 3 cm proximal to the radiocarpal joint. The ulnar artery and vena comitans anastomoses were performed in the distal

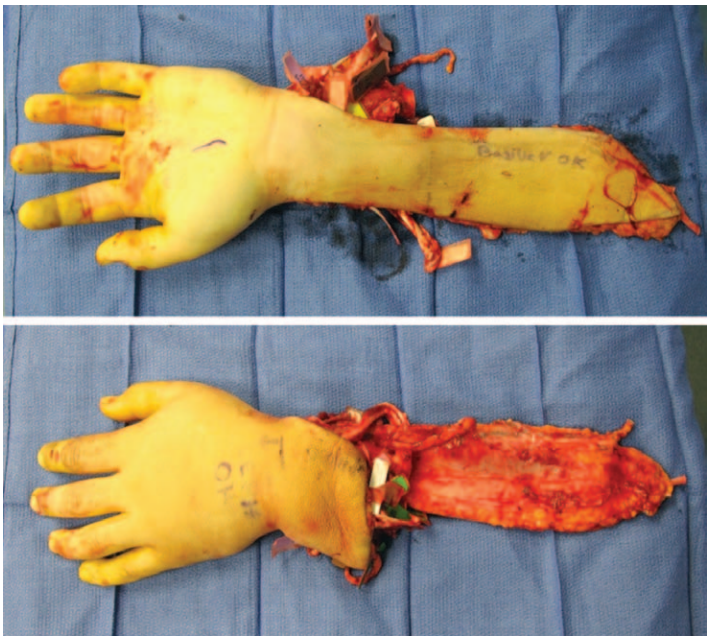


Fig. 2. Left hand allograft with volar forearm fasciocutaneous extension. Volar (*above*) and dorsal (*below*) views of donor hand before transplantation.

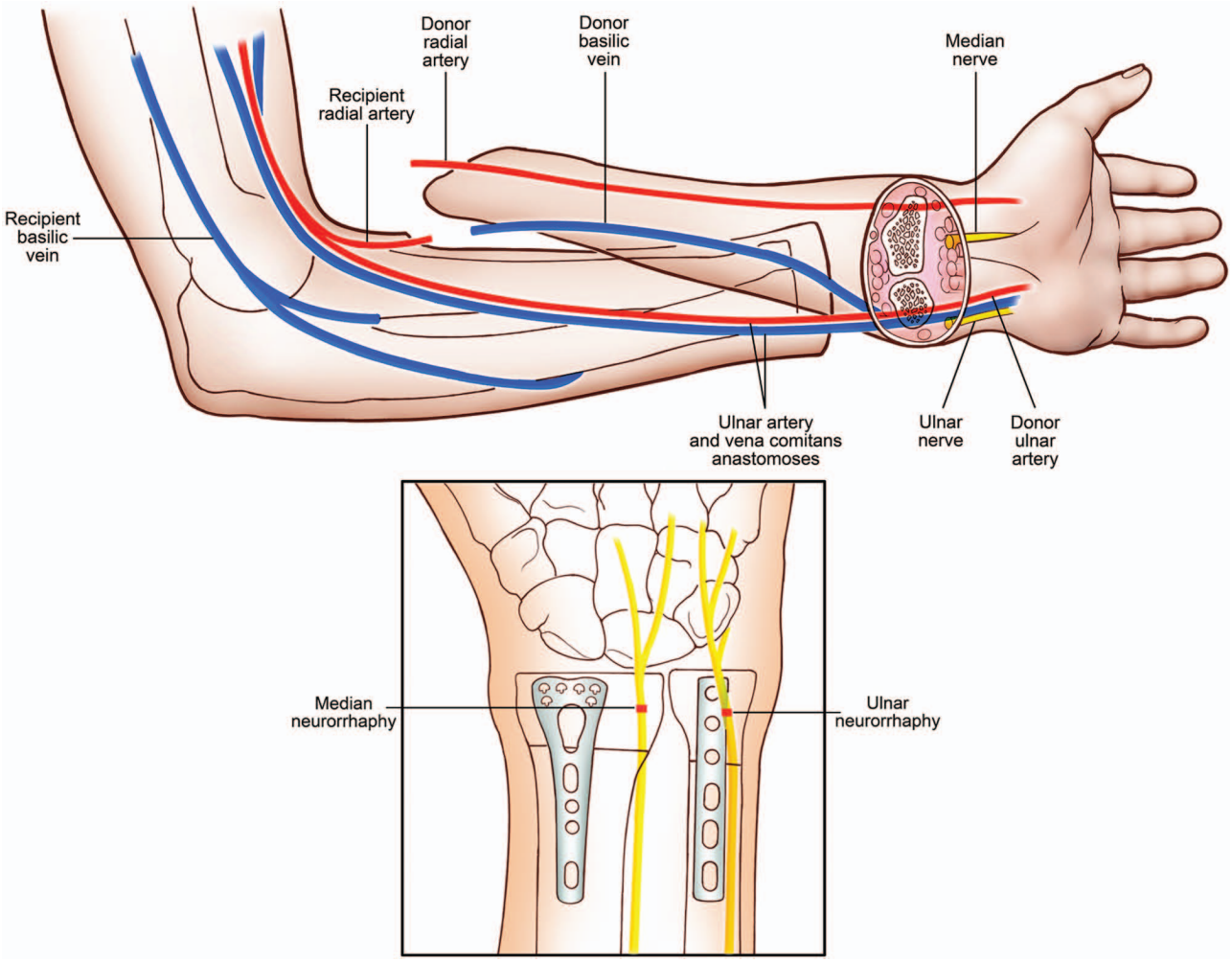


Fig. 3. Distal upper extremity transplantation with volar forearm fasciocutaneous extension combines reliable, proximal vascular anastomoses with distal neurorrhaphies. Illustration demonstrates location of key structures.

forearm proximal to the wrist crease. The radial artery, vena comitans, and basilic vein anastomoses were performed in the proximal forearm immediately distal to the antecubital fossa, providing inflow and reciprocal outflow through the volar forearm skin to and from the hand. The radial artery diameter in this region was approximately 2.5 mm and the basilic vein diameter was approximately 3.5 mm. Single-weave, "Brown" side-to-side tenorrhaphy was performed for all tendons.[12] Median and ulnar neurorrhaphies were performed distally at the wrist flexion crease (Fig. 3). Immunosuppression was induced with rabbit antithymocyte globulin, 75 mg administered intravenously; mycophenolate mofetil, 1000 mg administered orally; and methylprednisolone, 500 mg administered intravenously. Total cold ischemia time was 5.5 hours, and following vascular anastomosis, the hand was perfused without evidence of ischemia or venous congestion.

Postoperative Care

The patient recovered uneventfully and began supervised rehabilitative exercises the day after surgery. Maintenance immunosuppression was continued with tacrolimus, prednisone, and mycophenolate mofetil, with target tacrolimus levels of 8 to 14 ng/ml during the first 6 months to maximize nerve regeneration.[13] Levels were subsequently tapered to 8 ng/ml. The patient has not experienced any episodes of rejection up to 1 year following transplantation. He has protective sensibility to the level of the distal fingertips, with static two-point discrimination of 10 mm in the median and ulnar nerve distributions, and has had return of both extrinsic and intrinsic hand function, with grade 3+/5 power in intrinsic muscles at 1 year (Fig. 4). (**See Video 1, Supplemental Digital Content 1**, which demonstrates intrinsic function of the transplanted hand 14 months postoperatively, ***http://links.lww.com/PRS/B91.***)

DISCUSSION

To our knowledge, this is the first hand transplantation performed with a volar forearm fasciocutaneous extension. This technique provides the benefits of combining a proximal vascular anastomosis with distal osteosynthesis, neurorrhaphy, and tenorrhaphy to expedite and maximize functional recovery. There are many plausible benefits of this technique, specifically, the larger vessel caliber for anastomosis and the

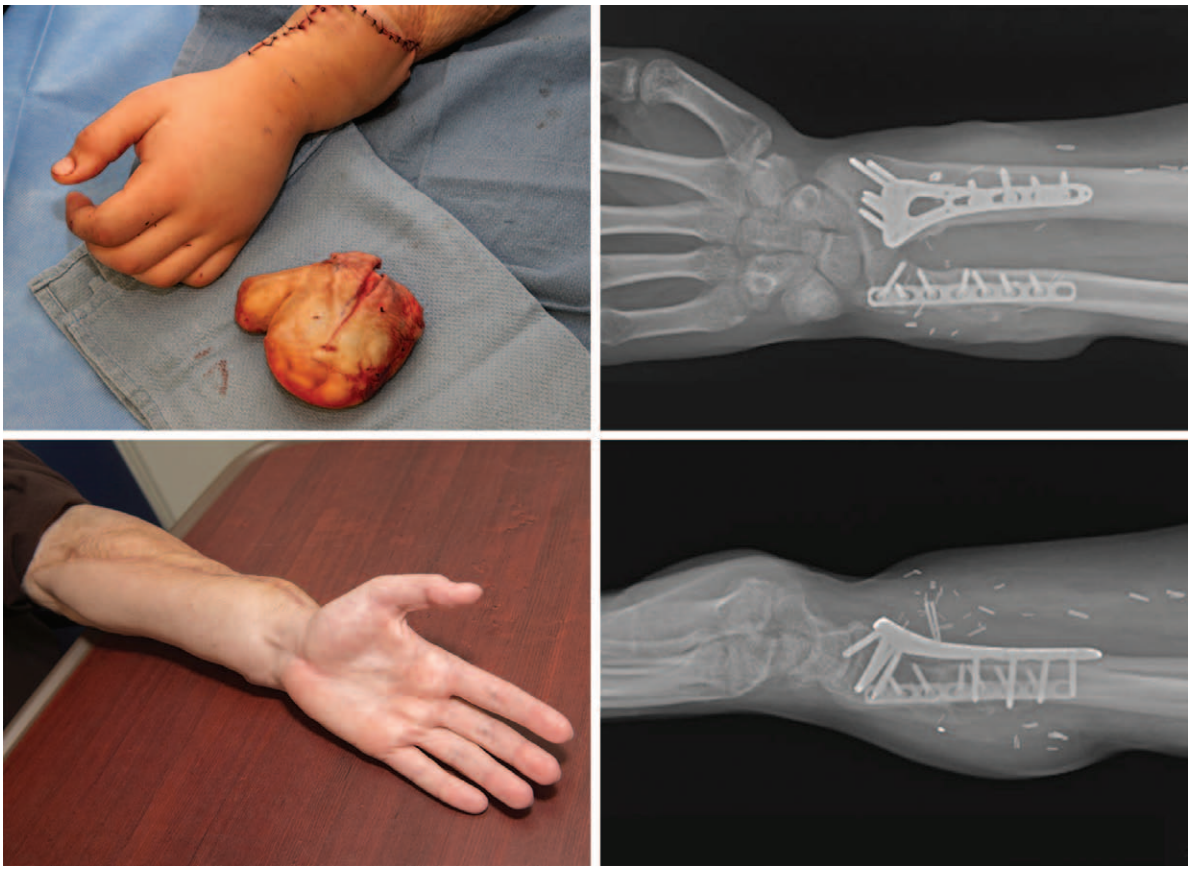
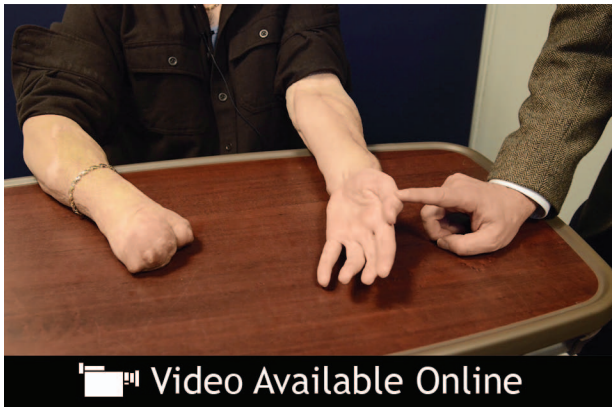


Fig. 4. Postoperative appearance immediately after reperfusion with amputated recipient hand shown for comparison (*above*, *left*), and 12-month postoperative photograph (*below*, *left*) with posteroanterior (*above*, *right*) and lateral radiographs (*below*, *right*).

provision of additional soft-tissue bulk to provide a more optimal milieu for tendon gliding. It combines the anatomical understanding of this commonly used angiosome[14] with the principle of vascular reliability using large vessels. This patient's prior burn injury and extensive skin graft reconstruction had left him with a paucity of cutaneous veins; the use of a volar forearm extension ensured reliable venous outflow of the allograft. Theoretically, the basilic or the cephalic vein could be used for this purpose, but in this case, the donor cephalic vein was thrombosed. Interestingly, when flushed following procurement, the dominant drainage of the allograft appeared to be through the ulnar vena comitans rather than the larger diameter basilic vein. However, following reperfusion, both vessels were draining freely. Importantly, with this technique, the volar forearm skin, fat, and fascia are included with the accompanying radial artery, vena comitans, and cutaneous veins. This is in contrast to the dissection of an extended length of skeletonized radial and brachial artery performed in some upper extremity transplant cases to facilitate large-caliber proximal arterial anastomoses. Some of these recipients have developed posttransplant vascular intimal hyperplasia; although initially considered analogous to the chronic allograft vasculopathy observed in



Video 1. Supplemental Digital Content 1 demonstrates intrinsic function of the transplanted hand 14 months postoperatively, ***http://links.lww.com/PRS/B91***.

cardiac transplantation, this may in fact reflect the presence of ischemic vascular segments.[15]

Risks of this technique are few, but it should not be used if the radial artery provides singular inflow into the distal native stump or if there is occlusion of the proximal radial artery. The impact on donor harvest is minimal; dissection of the volar cutaneous extension is straightforward and can be completed rapidly. We believe that this technique should be considered during upper extremity transplantation for patients in whom reliable venous outflow through the recipient veins is uncertain. Indeed, even without a significant soft-tissue deficit of the recipient's volar forearm, a thin (approximately 2 cm) strip of skin overlying the radial artery and vena comitans can be included to harness the benefit of larger caliber inflow for the allograft.

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