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## Case Report

## Extended Abdominal Pedicled Flap Using a Modified Abdominoplasty Incision for Reconstruction of an Extensive Forearm Defect



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Extensive upper extremity traumatic defects are challenging to reconstruct. Regional flaps are often too small or have pedicles in the zone of injury. Free microvascular flaps are not ideal options in the presence of extensive vascular injuries and in patients who cannot tolerate long procedures. We present a case featuring an extended abdominal flap using abdominoplasty-like incisions that facilitated simultaneous abdominoplasty and soft tissue coverage of an extensive, traumatic defect of the forearm and hand in a patient who was not a candidate for free flap.

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Coverage of extensive upper extremity traumatic defects poses several reconstructive challenges. Large soft tissue defects are often accompanied by the need for tendon, neurovascular, and/or bony reconstruction, which requires reliable soft tissue coverage. Coverage over the arm should be thin and pliable for tendon gliding and desirable contours. Regional flaps have limitations in surface area coverage and pedicles likely within the zone of injury. Free microvascular flaps (eg, latissimus dorsi or anterolateral thigh flap) are often chosen for reconstruction of larger defects. However, free flaps are not ideal in the presence of extensive vascular injury, patients who cannot tolerate long procedures, or settings in which microsurgery staff and equipment are not available. Moreover, muscle flap adhesions can prevent tendon gliding. In such cases, distal pedicled flaps should be strongly considered. Groin and abdominal pedicled flaps have long played an important role in upper extremity reconstruction.<sup>1</sup> When appropriately designed and raised, abdominal pedicled flaps offer a well-vascularized and versatile option.

We present a case of a patient with a traumatic, extensive upper extremity defect with segmental neurovascular loss and tendon injury. The patient also had a pulmonary embolus and was not an

ideal candidate for free flap. The defect was reconstructed using an extended abdominal pedicled flap with simultaneous abdominoplasty-like closure during single-step pedicle division, a departure from previously described extended abdominal flaps.<sup>1,2</sup> This procedure can provide excellent soft tissue coverage of extensive upper extremity defects while creating a pleasing donor site without skin grafts or wound dressing changes.

## Case Report

A 37-year-old, right-handed woman presented with a large defect in the volar aspect of the forearm sustained from a motor vehicle accident 1 month prior. She was initially managed at an outside hospital and underwent serial debridement, pinning of comminuted proximal ulnar diaphysis and right thumb metacarpal fractures, and wound vacuum-assisted closure therapy. However, the tendons and neurovascular structures were left in their injured state with no soft tissue reconstruction. Computed tomography angiography revealed a long-segment ulnar artery injury but intact brachial and radial arteries. She also had a provoked, large, main-stem bronchus pulmonary embolus, for which she was on therapeutic anticoagulation therapy.

On our initial examination, her fingers were found to be perfused. The thumb was immobilized using a Kirschner wire. She did not have any finger flexion but otherwise had intact wrist and finger extension, wrist flexion, supination, and pronation. Sensation was intact in the radial sensory nerve distribution but not in the median and ulnar nerve distributions. Surgical exploration and final debridement revealed a 40 × 20-cm<sup>2</sup> soft tissue defect (Fig. 1).

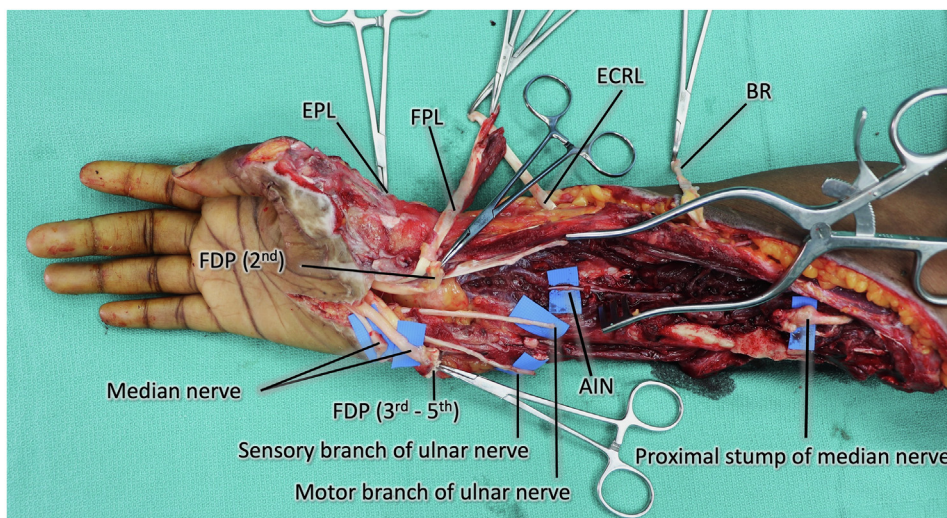
**Declaration of interests:** No benefits in any form have been received or will be received related directly or indirectly to the subject of this article.

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**Figure 1.** A 40 × 20-cm<sup>2</sup> soft tissue defect of the volar aspect of the forearm with large gaps in the ulnar and median nerves and in the ulnar and anterior interosseous arteries as well as injury to multiple tendons, including flexor pollicis longus, extensor pollicis longus and brevis, extensor carpi radialis longus portions of flexor digitorum profundus and superficialis, brachioradialis, pronator teres, and flexor carpi ulnaris. AIN, anterior interosseous nerve; BR, brachioradialis; ECRL, extensor carpi radialis longus; EPL, extensor pollicis longus; FDP, flexor digitorum profundus; FPL, flexor pollicis longus.

There were large gaps in the ulnar (40 cm) and median nerves (25 cm). The ulnar and anterior interosseous arteries were avulsed to elbow level. Most of her flexors and thumb extensors were ruptured.

Reconstruction was performed 4 days after our debridement, approximately 1 month after her injury. Despite her recent pulmonary embolism, expeditious timing for reconstruction was favored to salvage motion and function. The patient received an inferior vena cava filter and was admitted 1 day prior for bridging onto a therapeutic heparin drip because of her high risk of developing another thrombus. The large segmental ulnar and median nerve defects were reconstructed using cabled sural nerve grafts. Alternatives to sural nerve grafts were considered; however, their calibers were considered too small or they would have led to motor deficits and, therefore, were not used. Protective pinch sensation was achieved by transferring the radial sensory nerve to the index finger, radial digital nerve, and thumb ulnar digital nerve. Tendon reconstructions were performed as follows: brachioradialis to the flexor pollicis longus; extensor carpi radialis longus to the flexor digitorum profundus of the index, long, ring, and small fingers; and extensor pollicis longus repair using a tendon graft from the flexor digitorum superficialis.

This patient was a poor candidate for free microvascular flap because of her extensive vascular injury and high risk of thrombus formation. Therefore, we designed an extended pedicled abdominal flap for large, durable coverage over the reconstructed structures. This option helps avoid anastomoses and reduces operative time. Furthermore, the donor site was closed in an abdominoplasty-like fashion, which is a desirable effect. The abdomen was marked using a template shaped to the size and contours of the wound. The inferior aspect of the template was placed by following a curvilinear outline typical of an abdominoplasty inferior incision. A transverse incision was made just inferior to the umbilicus from anterior superior iliac spine to anterior superior iliac spine (Fig. 2A), and it approximately bisected the template. The abdominal flaps were developed in the subscarpal plane (Fig. 2B). The superior dissection was carried to the costal margin, and the inferior dissection was carried to the pubic tubercle. The superior abdominal flap was pulled caudally, and the inferior flap was pulled cephalad, with excess

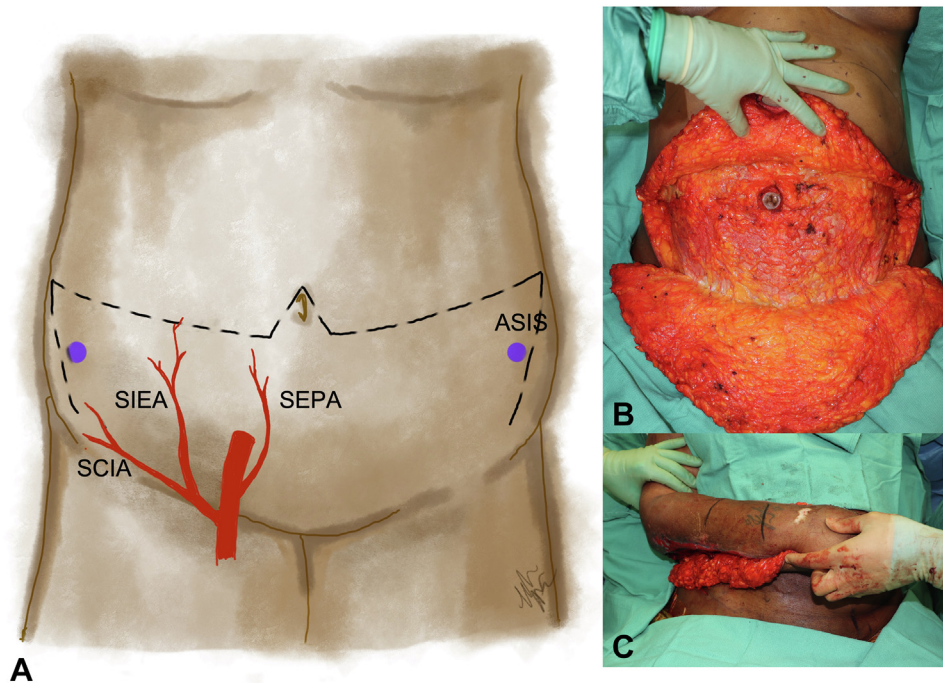
tissue reflected outward. The volar aspects of the forearm and hand were placed on top of the overturned flaps and secured to the abdominal flap bases, and the skin edges were approximated (Fig. 2C). Dead space was obliterated using quilting sutures.

The pedicle was divided 4 weeks later. The flap was viable throughout, except for a small area of marginal necrosis over the base of the thumb (Fig. 3), which was debrided. The flap was minimally defatted prior to closure, and a completion abdominoplasty without rectus plication was performed (Fig. 4). Plication was omitted because of her recent pulmonary embolus. The excess discarded abdominal tissue from the complete abdominoplasty was used as a full-thickness skin graft for the debrided area at the base of the thumb. There were no intraoperative complications. After division, the patient required debridement of partial fat necrosis of the deep surface of the flap, facilitated by thinning of the flap. Although some areas of the deep surface of the flap had fat necrosis, the skin and remaining flap parts remained viable, without exposure of vital structures. She also had central dehiscence of the abdominal incision, which was debrided and healed well with wound vacuum-assisted closure therapy. At her 8-month postoperative visit, the flap in her right forearm and the abdominal donor site were well healed and had good contours (Fig. 5). She did not engage in hand therapy because of ongoing treatment for other injuries, such as those for her spine. Therefore, she has finger joint stiffness but not shoulder stiffness. She has no active range of motion in her interphalangeal joints but has good motion at the metacarpophalangeal joints and the thumb. She has sensation in her thumb but no sensation in the tips of the other fingers. Most importantly, she has ample soft tissue coverage over the fully reconstructed structures.

Written informed consent was obtained from the patient for the publication of images and/or recordings.

## Discussion

We showed that the extended abdominal flap with simultaneous abdominoplasty closure is an acceptable option for soft tissue coverage of large defects of the forearm. There were several functional, aesthetic, and safety considerations that led



**Figure 2.** A) Planned extended abdominal flap marking. The extended abdominal flap is loosely based on the superficial circumflex iliac, superficial inferior epigastric, and superficial external pudendal. B) Subscarpal dissection of abdominal flaps. The inferior flap was raised from anterior superior iliac spine to the other anterior superior iliac spine and inferiorly to the pubic tubercle. The superior dissection was carried to the costal margin. C) The volar aspect of the forearm was placed on top of the overturned flaps and secured to the base of the abdominal flaps, and the skin edges were approximated. ASIS, anterior superior iliac spine; SCIA, superficial circumflex iliac; SEPA, superficial external pudendal; SIEA, superficial inferior epigastric.



**Figure 3.** The abdominal flap remained viable 4-weeks after inset.

to the selection of this reconstructive option. First, there was an irreparable vascular injury to 2 major arteries. Free flap transfer in a predominately single-vessel extremity with inadequate collateral supply to the distal tissue is possible; however, it carries extra risk.<sup>3</sup> Several studies have demonstrated that there is a higher complication rate of reconstruction of single-vessel extremities.<sup>4,5</sup> This can be explained, in part, by vascular changes that occur even in intact vessels within the zone of

injury.<sup>6</sup> Given that the recipient vessel is the sole blood supply to the rest of the limb in single-vessel extremities, a thrombotic event or injury to the vessel would be catastrophic and could result in limb loss. Vein grafts can provide additional length to perform anastomosis outside of the zone of injury but increase thrombotic risk and operative time.<sup>7</sup> Furthermore, compared with muscle, subcutaneous fat is an excellent contact surface for tendon gliding.



**Figure 4.** Pedicle division and completion abdominoplasty 4 weeks after first-stage flap inset. **A)** Extended abdominal flap division and minimal defatting. **B–D)** Inset and closure of abdominal flap on the right forearm. **E)** Complete abdominoplasty without rectus plication.



**Figure 5.** At her 8-month postoperative visit, the patient had ample soft tissue coverage over her fully reconstructed structures, and her abdominoplasty incision was healed.

The second consideration was that the patient already had a large, provoked pulmonary embolus. A shorter, simpler operation was desired to reduce the risk of further development of thrombi. The extended abdominal flap is relatively quicker to perform, taking no longer than what it takes to raise the flaps for abdominoplasty,

and does not require specially trained microsurgery teams or equipment. The flap is loosely based on the superficial circumflex iliac, superficial inferior epigastric, and superficial external pudendal.<sup>1,2</sup> Although the superficial inferior epigastric may not be present in all individuals, the multiperforator vascular supply of this flap

facilitates robust perfusion. A similar approach has been previously described but required division of the flap in 3 steps.<sup>8</sup>

Finally, the patient desired minimal donor site morbidity. Previously described abdominal flaps resulted in large wounds at the donor site, which were closed using skin grafts and/or dressing changes.<sup>1,2</sup> This is less ideal, considering daily dressings and contour irregularities. In our method, the donor site was closed in an aesthetically pleasing abdominoplasty fashion at the time of pedicle division. Thus, a skin graft for donor site coverage is not required. Previously described abdominal flaps used abdominoplasty-like closure but as a subsequent procedure to revise conspicuous scars, not integrated into the initial design of the flap and pedicle division.<sup>9</sup> Our technique combines pedicle division and abdominoplasty, which has the potential to reduce the number of operative trips.

The disadvantages of pedicled abdominal flaps include the need for a second-stage procedure for pedicle division and restriction of shoulder mobility. We shortened the immobilization period by performing division in 1 procedure instead of performing it over several weeks, as previously described in the literature.<sup>1,8</sup> Although the flap remained viable and the reconstructed vital structures were never exposed, the patient did have partial fat necrosis of the deep surface of the flap. This was likely a result of the elevated abdominal flap being too thick. In hindsight, the flap could have been thinned during the first stage given the thick subcutaneous fat layer that created a barrier to adequate perfusion.<sup>10</sup> This may have prevented the need for secondary operations, which is the appealing feature of the combined extended abdominal flap with abdominoplasty.

An extended abdominal flap is a reconstructive option for extensive soft tissue defects of the distal upper extremity, particularly in settings in which free flap reconstruction is not ideal. Although the surgery is not technically complex, meticulous attention to detail and surgical planning are essential for success. The flap can provide coverage for a large surface area, has reliable

vascular supply, and results in an aesthetically pleasing abdominoplasty closure.

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