Common etiology of muscle loss in the upper extremity includes trauma, Volkmann’s ischemic contracture, chronic nerve injury, electrical burns, and posttumor excision. Functional reconstruction of the upper extremity involves tendon transfer or pedicled muscle transfer. Advancements in nerve surgery have enabled reconstruction using nerve transfer.

Free functional muscle transfer (FFMT) reconstruction is indicated in cases of late presentation or lack of tendon donor site secondary to injury or excision of potential donor muscle. FFMT is well established as a reconstructive option for functional restoration of finger flexion secondary to trauma or Volkmann’s ischemic contracture. In particular, the gracilis FFMT remains as an excellent option for restoration of finger flexion.

Our case report describes a free gracilis muscle flap for finger flexor reconstruction and a profunda artery perforator (PAP) flap for overlying soft tissue coverage based on a single donor site following a large sarcoma excision from the forearm.

CASE REPORT

A 35-year-old male patient was diagnosed with left forearm high-grade epithelioid sarcoma with left axillary node involvement. The patient underwent neoadjuvant chemotherapy and radiation treatment. Tumor excision involved marginal dissection of median nerve, ulnar nerve, and ulnar artery; complete excision of flexor digitorum superficialis (FDS), flexor digitorum profundus (FDP) muscle bellies from their origins to the distal carpal tunnel, palmaris longus, and pronator quadrates; and 20% excision of ulnar border of flexor pollicis longus muscle bulk. The tumor and the majority part of the forearm skin were resected en bloc. Figure 1 demonstrates the forearm defect postresection.

Analysis of the defect indicated that a myocutaneous gracilis flap was insufficient alone to reconstruct the soft tissue defect. No locoregional flap option to reconstruct the skin defect was possible. A secondary flap, PAP flap, was required for soft tissue coverage. The myocutaneous free gracilis flap harvest involved dissection of the full gracilis muscle belly for finger flexor reconstruction and a profunda artery perforator flap for overlying soft tissue coverage based on a single donor site following a large sarcoma excision from the forearm.
After insertion of the first flap into the forearm, a PAP flap was designed adjacent to the site of gracilis harvest (Fig. 2). After harvest, the flap was then inset in the volar forearm to reconstruct the radial aspect of the defect for coverage of the gracilis muscle, the myotendinous junction, and the FDP tendons. An end-to-side anastomosis of profundus artery perforator artery to distal ulnar artery and end-to-end anastomosis of profundus vein to forearm basilic vein was performed. Figure 3 illustrates the fore- arm before inset, with the gracilis flap located proximally and PAP flap distally. Primary closure of the medial thigh donor site was performed.

Following microvascular transplantation of both flaps, we proceeded with tendon reconstruction of the FDP tendons to the index, long, ring, and small fingers only. Excursion was tested, and correct tension of repair for each of the four flexor tendons was carefully determined such that full flexion would be possible. Following reconstruction of all four flexor tendons, the fingers were put through range of motion (ROM) to assess movement, and digit cascade was noted to be within normal limits.

Forearm reconstruction was concluded with the insertion of the PAP flap to cover the rest of the defect (Fig. 4).

Postoperatively, the wrist and fingers were splinted in 20–30-degree angle of flexion. After a short period of immobilization, the patient started passive (ROM) exercise under the guidance of a hand therapist. The patient learned to regularly stretch the left hand using his right hand to allow full finger extension and flexion. Once spontaneous muscle contraction occurred, the patient was instructed to attempt active ROM throughout the day. When good ROM became evident, resisted grip exercise and strengthening was worked on until maximal function was obtained. Therapy is expected until 15 months postoperatively. At 8-month follow-up, the patient had Musculoskeletal Tumor Score of 22/30 and Disabilities of the Arm, Shoulder, and Hand score of 34/100. Hand sensation (including light touch) completely recovered with normal two-point discrimination. The supplemental video demonstrates active finger flexion with good ROM including both active distal interphalangeal and proximal interphalangeal flexions. (See Video [online], Fig. 2.

Fig. 1. Forearm postresection.

Fig. 2. PAP flap harvest that was designed adjacent to the site of gracilis harvest.

Fig. 3. Forearm defect before inset with the gracilis flap located proximally and PAP flap distally.

Fig. 4. Forearm defect postinset with the insertion of the PAP flap distally.
which displays the patient performing active finger flexion at 8-month follow-up.)

**DISCUSSION**

FFMT remains an excellent option to restore upper extremity function in upper extremity defects where other reconstructive options are not deemed appropriate, including tendon transfer, nerve transfer, and pedicled muscle transfer. The most common areas for reconstruction include elbow flexion and finger flexion.

Our case report outlined FFMT for reconstruction of the upper extremity defects secondary to sarcoma ablation only. Restoration of finger flexion has been described using gracilis, tensor fascia lata, and latissimus dorsi FFMT. Our decision to select the gracilis flap was due to its minimal donor site morbidity, reliable nerve and pedicle anatomy, muscle/tendon length, and appropriate excursion to allow finger flexion. As opposed to the latissimus dorsi flap (in which its fan-like shape with minimal distal tendon prohibits strong weaving of the flexor tendon), the gracilis muscle tapers distally, allowing for strong flexor tendon attachment, and therefore, provides powerful excursion that is more compatible to the flexors in the forearm.

Our patient regained full passive ROM by 6 months postoperatively and active ROM with active thumb to finger pinch test by 8 months, with good functional outcomes overall. Importantly, there was no locoregional sarcoma recurrence reported potentially because FFMT allowed complete compartmental resection of the tumor; however, there is a lack of literature investigating survival and oncologic outcomes to support this finding.

Previous literature is conflicting regarding the appropriate patient age for FFMT. Flaps (including the latissimus dorsi) may lead to donor site weakness that may be noticed in younger, more active patients. From our experience, motivation to remain adherent to the intensive postoperative rehabilitation process and age were a priority during patient selection.

Additionally, we described a novel approach using a single donor-site incision to harvest two free flaps, which provided both functional restoration and adequate soft-tissue coverage for a large forearm defect. This approach appeared reliable when FFMT and large skin reconstruction were required. A second flap allowed for more durable soft tissue coverage and protection of the functional reconstructive site. Furthermore, a second flap offered improved aesthetic results compared with conventional methods, including local flaps and skin grafts.

**CONCLUSIONS**

Reconstruction of the upper extremity after extensive resection of soft tissue for sarcoma treatment remains challenging, given the associated functional deficits. Functional finger flexion was demonstrated from innervated free gracilis transfer. We described a novel approach to obtain a secondary free flap, the PAP flap, through a single donor-site incision to expand soft tissue coverage.

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