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Case Report

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The abductor hallucis muscle flap - a viable surgical solution for treating first ray soft tissue defects

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Abstract

Long-standing wounds are at high risk for infection. Therefore, it is critical to achieve wound healing in a timely manner; however, some complex wounds remain recalcitrant and difficult to treat. Local muscle flaps are an underutilized technique with great utility in the reconstruction of complex foot wounds. Providing a healthy bleeding base that promotes wound healing, these muscle flaps can greatly benefit the patient and prevent amputation. In this present report, we demonstrate the use of the abductor hallucis muscle flap in the reconstruction of a complex wound following bunion surgery.

Keywords: Muscle flap, abductor hallucis, forefoot wound, limb salvage, flap reconstruction, soft tissue coverage

INTRODUCTION

Hallux abducto valgus (HAV), also known colloquially as a bunion, is one of the most common foot deformities. A systematic review and meta-analysis reported that approximately a quarter of individuals between 18 and 65 years of age have HAV and is even more prevalent in individuals greater than 65 years old[1]. Its prevalence increased with age, with a higher predilection for females. Numerous reports have linked HAV to impaired gait, instability and poor balance, falls in the elderly, and general foot pain[2-6].

Surgical management usually involves an osteotomy in the first metatarsal or an arthrodesis of the first tarsometatarsal joint. Over 350,000 bunion procedures are performed annually, making it one of the most common elective foot surgeries[7]. Despite the generally high success rate, complications from bunion surgery can occur.

There is wide variation in the reported incidence of complications following bunion surgery, but most are due to delayed wound healing and infections[8-11]. Interestingly, the need for revisions secondary to complications was estimated between 2.1% to 9%[12,13]. A retrospective review of 72 court decisions related to hallux valgus surgery revealed that 70% of verdicts were in favor of the plaintiff, and more than 30% of plaintiffs' main reason for complaints included postoperative infection[14]. This data underscores the importance of appropriately addressing elective surgical complications. The purpose of this case report is to present the use of the abductor hallucis muscle flap in the reconstruction of a complex wound following bunion surgery.

CASE REPORT

Patient demographics

A 47-year-old female with a history of coronary artery disease, hypertension, hyperlipidemia, prediabetes (hemoglobin A1c: 6.2%), and smoking underwent a distal first metatarsal chevron osteotomy for correction of a bunion deformity to her left foot in December 2020 that was complicated by persistent wound dehiscence and infection. Bone cultures of the first metatarsal were positive for *Staphylococcus aureus* and *Pseudomonas aeruginosa* (last culture collected September 2021). She completed two 6-week courses of IV antibiotics. Prior to presenting to our clinic, the patient underwent a total of 14 surgeries to reconstruct the site, including several debridements of the soft tissue, bone, and reconstruction with local tissue rearrangement. The last surgery was an advancement flap, which failed, requiring a return trip to the OR for debridement. Of note, negative bones were not obtained prior to attempts at reconstruction. She presented to our clinic in August 2022 with a draining wound to the dorsal medial aspect of the first metatarsal-phalangeal joint measuring 1 cm in diameter and exposed bone [Figure 1]. Notably, she failed prior negative pressure wound therapy and multiple skin allografts (Integra bilayer, Epifix, Kerecis, PuraPly, Apligraft, Grafix).

Physical examination revealed palpable pedal pulses and minimal range of motion (< 10°) to the first metatarsal phalangeal joint. The periphery of the wound consisted of indurated scar tissue extending circumferentially for approximately 2 cm from the skin deficit. A CT angiogram was obtained for preoperative planning, which revealed no major evidence of vascular disease and, specifically, a patent medial plantar artery.

Surgical technique

The patient underwent the first part of a staged procedure on August 26th, 2022. A handheld Doppler was used to trace and mark the perforators to the abductor hallucis muscle [Figure 2]. The wound and peripheral scar tissue were excised using cautery with a Colorado microdissection needle until healthy viable bleeding tissue was achieved [Figure 3]. The abductor hallucis muscle belly was then carefully divided from the flexor hallucis muscle [Figure 4]. The muscle origin was left intact at the calcaneus, but all perforators except the most distal two were then ligated. A non-adherent petroleum gauze was interposed between the muscle belly and the tissue bed to minimize scar tissue formation during the delay before the insetting of the flap. Next, the first metatarsal bone was debrided until bleeding bone was obtained. This bone was sent for pathology and microbiology. A 2.0 mm drill bit was then used to fenestrate the head of the metatarsal from medial to lateral. A mixture of gentamicin and CERAMENT® was used to fill in any bone deficits following

Figure 1. Preoperative appearance. Wound probed to bone with continued drainage.

Figure 2. Handheld Doppler (8MHz) was used to mark the perforators to the abductor hallucis muscle from the medial plantar artery.

debridement. The skin was closed over the abductor hallucis muscle belly. The soft tissue defect was covered with a 2 cm × 2 cm Dermal Regeneration Template (Integra®). Petroleum gauze and a Xeroform bolster dressing were then applied over the wound bed.

Given the patient's extensive smoking history and diabetes, the decision was made to delay the insetting of the flap in order to allow the distal perforators time to adjust to the increased demand placed on them. The patient was discharged after the first stage and returned to the OR 4 days later to inset the flap [Figure 5] to reduce medical fees. The wound bed was debrided again to bleeding tissue and covered with PriMatrix® Dermal Repair Scaffold (Integra®). Next, the abductor hallucis muscle was transected proximally and reversed to cover the first metatarsal phalangeal joint. The deep fascia of the muscle belly was scored to gain additional length and cover the distal aspect of the soft tissue defect [Figure 6]. The flap was secured with sutures of Monocryl. A split-thickness skin graft was harvested from the medial left calf at a thickness of 0.018, meshed 1:1.5 and secured over the muscle flap using skin staples [Figure 7]. A Xeroform bolster

Figure 3. Excision of non-healing chronic wound to healthy bleeding margins. This is necessary prior to any attempts at reconstruction.

Figure 4. The abductor hallucis muscle belly is carefully dissected free from the medial head of the flexor hallucis brevis muscle. Vessel loops allow gentle manipulation of the muscle belly for dissection.

dressing was applied over the skin graft. The donor site was closed with skin staples.

The patient was instructed to avoid weight bearing until staples were removed at 2 weeks following surgery, then transitioned to weight bearing in a surgical shoe. There was partial skin graft loss, which was treated with local wound care. The patient had complete closure of the site by 3 ½ months. The final pathology of the bone sample revealed no osteomyelitis and bone cultures were negative.

DISCUSSION

With such a high prevalence of HAV, surgical correction is one of the most common elect foot procedures performed, with over 350,000 cases annually[7]. These complications from surgery can include recurrence of the deformity, nerve injury, metatarsalgia, delayed or nonunion, hallux varus infection, hardware irritation or wound healing complications[8].

Figure 5. Patient returns for insetting of the flap. The wound base is covered with Dermal Regeneration Template (Integra®).

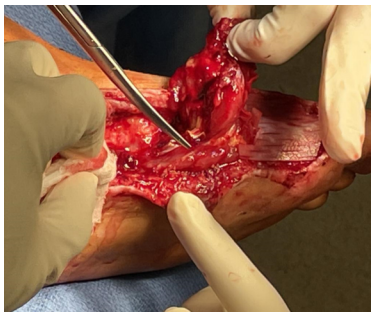

Figure 6. The deep fascia is cut to increase the reach of the flap. This allows coverage of the distal aspect of the defect without tension on the flap.

Figure 7. A split-thickness skin graft (0.018 in) was harvested from the ipsilateral medial calf and secured to the wound bed with skin staples.

In a study, Barg and co-authors conducted a systematic review with a meta-analysis of 229 studies on the unfavorable outcomes following surgical treatment of hallux valgus deformity[8]. The average infection rate

in analyzed studies was 2.6%, though it was difficult to clarify vague terms such as "wound infections" *vs.* "wound complications." Importantly, this group analyzed surgical considerations but no patient demographics.

To this end, another group sought to identify patient demographics as it relates to wound healing in HAV surgery. This group identified 155 consecutive patients in a multi-center retrospective study following a midshaft osteotomy (Scarf) for correction of hallux valgus[9]. In their study, a majority of their patients had multiple comorbidities, with the most common being hypertension, hypothyroidism, and diabetes. A history of smoking was reported in 23 patients (14.8%). Complications occurred in 30 patients (19.4%), 17 of which had comorbidities and 13 did not. 6 patients (3.9%) had superficial surgical site infections that were treated with a course of oral antibiotics. 13 patients (8.4%) had partial wound dehiscence. Interestingly, this study could not find a statistically significant difference in complication rates between healthy patients and those with comorbidities.

While complications of delayed wound healing and dehiscence are risks following any type of surgery, prompt closure of the wound is especially critical in the foot and ankle where there is already such a high bioburden of bacteria[15]. The distal leg, ankle and foot pose a unique challenge when it comes to soft tissue reconstruction given limited soft tissue laxity, thin skin envelope, and the high number of superficial neurovascular structures and tendons[16,17]. Traditionally, reconstruction of the lower limb is divided into three sections: the pedicled gastrocnemius for proximal third leg defects, the soleus for middle third defects, and free flaps for distal third defects[16-18]. While large defects in the distal third are still preferentially treated with free flaps, there is growing popularity of local pedicled and propeller flaps for the management of small to medium-sized deficits[16,19-22]. Local flaps offer the advantage of having no need for intensive unit monitoring, shorter operative time, simplicity, lower cost, and decreased hospitalization time[21,22]. Given the decreased soft tissue laxity and more tenuous blood supply, adipofascial flaps and local soft tissue rearrangement in the foot are more prone to failure. A rotational flap in the distal lower extremity will not have the same mobility as one in the scalp where significant undermining can be safely performed.

Muscle flaps, on the other hand, are more robust. They can provide reliable soft tissue coverage of bones without sacrificing major vessels[23]. Dissection of intrinsic muscle flaps can be straightforward with minimal donor site morbidity. Indeed, the donor site can usually be closed primarily. All intrinsic foot muscles are classified as Mathes and Nahai type II, with one dominant vascular pedicle and variable distal minor pedicles[24]. Common foot intrinsic muscle flaps include the abductor hallucis (ABH), flexor hallucis brevis (FHB), abductor digiti minimi (ADM), and the extensor digitorum brevis (EDB) muscles[25].

In this present study, our group employed a distally based ABH muscle flap for the coverage of a chronically open wound following HAV surgery. The ABH muscle belly is relatively small, making it ideal for the closure of small defects less than or equal to 3 cm × 6 cm[26]. While its insertion on the calcaneus can offer great reach, care must be taken to avoid iatrogenic damage to the medial calcaneal nerve and calcaneal branch of the posterior tibial artery as the dissection is carried near the calcaneal tuberosity. During flap elevation, perforators will be located at the inferior lateral aspect of the muscle. As dissection is carried distally, the medial head of the flexor hallucis brevis will be just lateral. The similar trajectory of the muscle fibers can make distinguishing between the two muscle bellies difficult, but there is a thin layer of fascia separating them.

Our group previously reported a case series of 5 patients treated with distally based ABH muscle flaps for the treatment of diabetic foot ulcers at the first metatarsophalangeal joint that failed local wound care for

more than 6 months[27]. All the flaps healed uneventfully and provided adequate wound coverage and good tissue contour. Due to socio-economical issues, the patient, unfortunately, could not afford a negative pressure machine, and given her mounting medical costs, she was adamantly opposed to further return trips to the operating room (Integra products were donated). The authors believe graft loss could have been minimized or even avoided with negative pressure therapy. A second reason for partial graft loss could be the insetting of a flap and the subsequent skin grafting over a joint due to the motion of the recipient site. It is the common practice of the senior author to temporarily fixate any joint over which a graft or flap is performed. Unfortunately, this was not an option as the patient traveled from out of state and there was no reliable follow-up for removal of any external fixation or pinning. Despite partial graft loss leading to an extended amount of time until complete recovery [Supplementary Figure 1], the authors would like to highlight the versatility of the muscle flap in restoring vascularity to the zone of injury and allowing the site to heal by secondary intention.

This case report highlights the surgical utility of the ABH muscle flap in the treatment of postoperative complications following a distal bunionectomy. In the setting of a chronically open wound, this patient was at risk for infection and amputation. Our case report demonstrates the importance of considering pedicled intrinsic foot muscle flaps, such as the ABH, in the surgical management of forefoot wounds.

DECLARATIONS

Author's contributions

Made substantial contributions to the concept and design of the study as well as manuscript preparation: Chen S
Made substantial contributions to the concept and design of the study: Rodriguez-Collazo ER
Made substantial contributions to data collection and manuscript preparation: Cheung TP

Availability of data and materials

Not applicable.

Financial support and sponsorship

Not applicable.

Conflicts of interest

The senior author Rodriguez-Collazo ER, speaker bureau consultant of Integra® LifeSciences.

Ethical approval and consent to participate

Informed consent was obtained from all patients, including approval for scientific publication and photographic/video documentation.

Consent for publication

Written informed consent was obtained from the patient.

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