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Single Tau-Shaped Anterolateral Thigh Free Flap on Bimalleolar Defect Acquired by Osteomyelitis in Lower Extremity Trauma: A Case Report

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Abstract

Soft tissue defects can cause serious issues in traumatic lower extremity injuries when limb salvage is the goal, especially when complicated by osteomyelitis. The distal lower extremities lack redundant soft tissue, necessitating free tissue transfer for complex injury reconstruction. For bimalleolar defects, a chimeric or double flap is an option, but harvesting such flaps can be challenging, and multiple arterial anastomoses risks distal limb ischemia. We present a case of a large bimalleolar defect with associated osteomyelitis covered with a single anterolateral thigh (ALT) free flap. Preoperative mapping identified perforator distribution allowing design of a single tau-shaped flap from the left thigh to minimize morbidity. The defects were covered successfully with no permanent complications. Given the ALT flap's consistent anatomy, this case could guide future approaches for typical bimalleolar defects, including those with osteomyelitis.

Keywords: Ankle; Osteomyelitis; Free tissue flaps; Case reports

Introduction

In Korea, the lower extremities are among the most frequently injured body parts, accounting for nearly 18.5% of all reported injuries [1]. Soft tissue defects can cause serious issues in traumatic lower extremity injuries. Limb salvage is critical not only for preserving ambulatory function, but also for maintaining limb length, preventing further trauma and soft tissue damage, and allowing for potential reconstruction or prosthetic fitting when amputation becomes unavoidable. Ambulatory ability is a crucial aspect for patient quality of life and medical prognosis, as a non-ambulatory status can lead to pneumonia, deep vein thrombosis, falls, and other complications that can deteriorate the patient's general condition.

The paucity of soft tissue in the distal part of the lower extremities is well known, and soft tissue reconstruction with free tissue transfer is the preferred modality for complex injury resurfacing [2]. For smaller defects, pedicled local flaps can be employed by utilizing adjacent soft tissues for coverage. In large defects, inappropriate local flap transposition can lead to flap failure, donor site problems, and extended length of hospital stay.

While various free flap donor sites have been reported in the literature, only a select few are commonly utilized for lower extremity reconstruction. These include the anterolateral thigh (ALT) flap, radial forearm flap, latissimus dorsi flap, and lateral arm flap. Among these, the ALT free flap is particularly advantageous due to its consistent anatomical features, reliable vascular supply, long pedicle length, and potential for

Case Report

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harvesting large flap dimensions [3]. This flap can cover defects as large as 20×30 cm and is thus considered a good choice for severe, complex distal 1/3 lower extremity reconstruction [3]. However, harvesting a large-sized flap can lead to donor morbidities, such as sensory problems, decreased range of motion, decreased muscle strength, and poor esthetic outcomes. More severe complications, such as compartment syndrome and muscle necrosis, can also influence the recipient site when both donor and recipient sites are on the same limb [4].

In bimalleolar defects, a chimeric or double flap is an option to minimize donor and recipient morbidities. However, harvesting such flaps is generally both challenging and time-consuming, as in harvesting the significant pedicle length required for a chimeric flap in cases of large, separated bimalleolar defects. Moreover, double free flaps pose a risk of distal limb ischemia since the sacrifice of two recipient arteries could be required for most of the cases [5]. We present a case where a single ALT free flap was successfully utilized to reconstruct an extensive bimalleolar defect. In presenting this case report, we strictly adhered to the ethical guidelines for research involving human subjects. Prior to the surgical procedures and participation in this report, informed consent was obtained from the patient.

Case

A 39-year-old man with no significant medical history was referred to our plastic surgery department for a soft tissue defect in the right distal lower leg. The patient initially had a small defect on the lateral portion of the lower leg right above the ankle and two distinct moderate size defects in the anteromedial tibial area. Two months prior, he had sustained traumatic injuries from a fall while intoxicated, dropping from a third-floor height. Initially evaluated at the nearest emergency room, he was subsequently transferred to a local secondary hospital in his hometown region. There, he underwent emergency surgery for an open pilon tibial fracture. However, 10 days after the procedure, signs of infection manifested in the right lower leg, prompting his admission to our facility for intensive care management of this right lower extremity infection.

Severe osteomyelitis was confirmed on right leg magnetic resonance imaging, and wound cultures revealed methicillin-resistant *Staphylococcus aureus.* Extensive intravenous antibiotic therapy including vancomycin was initiated. Initial management involved debridement, vancomycin-impregnated cement bead insertion, and subsequent application of negative-pressure wound therapy. Following 1 month of intensive conservative care, during which the infectious signs were resolved, the orthopedic surgery department planned for further surgical intervention, and also consulted our department for free flap coverage. The orthopedic surgery team made a 5-cm skin incision over the lower anterior aspect of the wound for necrotic tissue debridement, and after removing the previously placed vancomycin beads proceeded with osteosynthesis by fixing an allogeneic bone graft onto the right tibia using a distal tibia titanium plate (Zimmer Biomet).

Prior to the definitive orthopedic surgery, due to the need for flap reconstruction of the separated bimalleolar defects, we performed preoperative lower extremity computed tomography angiography and LOGIQ P9 ultrasound mapping to preliminarily assess perforator anatomy for a potential tau-shaped flap design. This initial mapping identified a perforator arising from the descending branch of the lateral circumflex femoral artery, and also provided mapping data of the more distal branches spreading out from this perforator. After the orthopedic team's surgery, the anterior tibial and lateral site defect were enlarged to 6×20 cm and 6×13 cm, respectively (Fig. 1). Since the two defects were separately placed about 6 cm apart, the conventional method of excising the tissues lying between the two recipient sites and covering the ensuing total defect with a single oval-shaped free flap would require harvesting a very large-sized (18×20 cm) flap. To minimize recipient and donor morbidity, we planned to harvest a single tau (τ)-shaped flap from the left thigh. Using a τ-shaped template, we optimized the flap design and site on the right ALT so that adequate pedicle distribution could be reflected. Flap elevation was then performed. After confirming the pedicle distribution inside the

Fig. 1. Bimalleolar defects of the patient just before flap surgery. (A) Lateral view. (B) Anterior view.

flap both visually and with intraoperative Doppler (Fig. 2), we cut the flap half across the midline to make a τ-shape without injuring the pedicle branches. The remaining normal tissue between the defects was minimally excised to accommodate the planned τ-shaped flap design. The bone exposure sites were reconstructed with the τ-shaped ALT free flap. The flap size was insufficient to cover the entire defect area, but the wound bed of the area not covered by the flap was muscle and therefore successfully covered with a split-thickness skin graft (STSG) (Fig. 3). Inset of the ALT flap was performed with end-to-side anastomosis of one artery (descending branch of the lateral femoral circumflex artery to the posterior tibial artery) and end-to-end

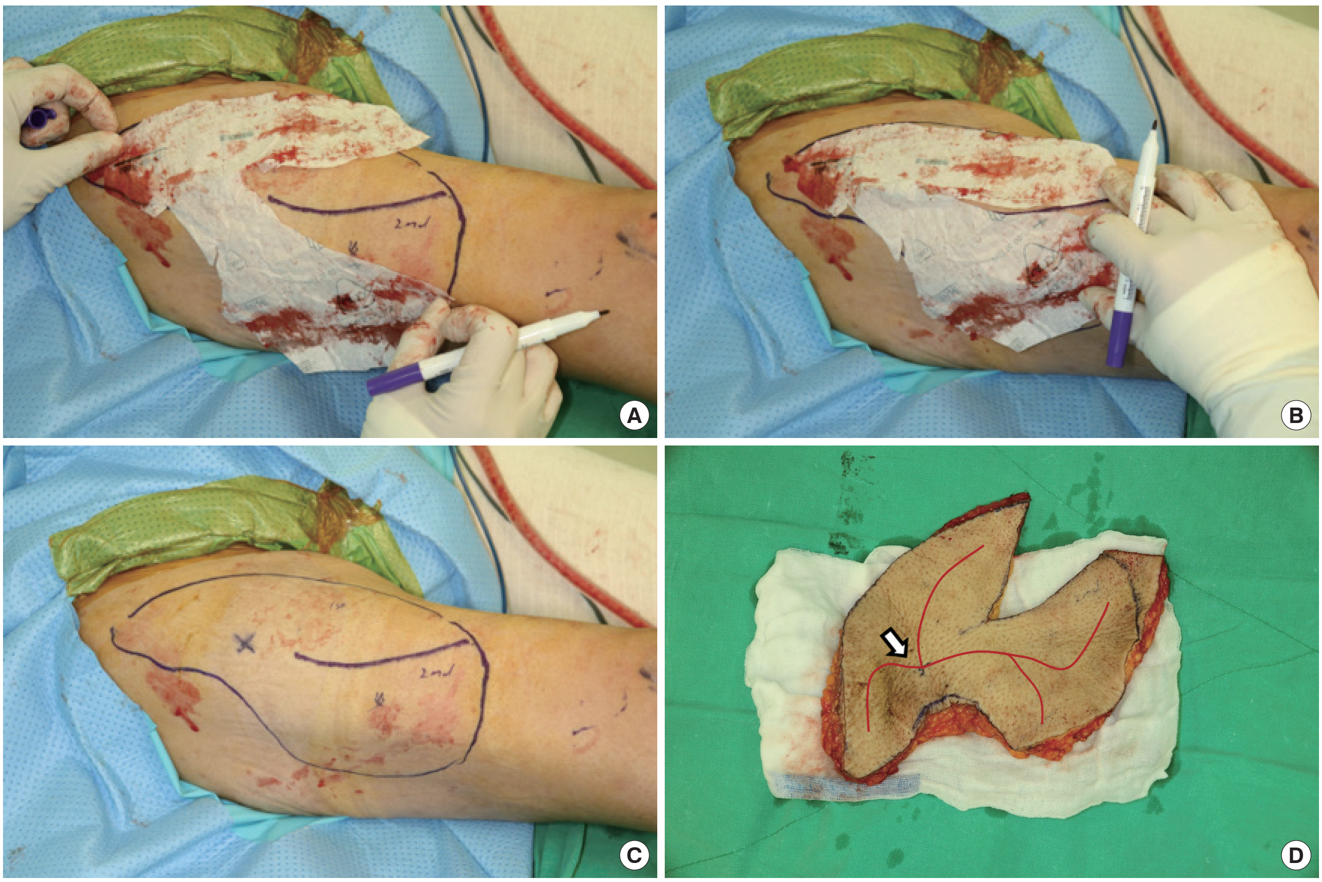

Fig. 2. Detailed depiction of intraoperative procedures. (A) Depicts the use of a tau (τ)-shaped template to guide optimal flap design and positioning, accounting for adequate pedicle distribution within the planned flap dimensions. (B, C) Demonstrate the preoperative marking of two pedicles supplying the flap, denoted by "x" markings on the thigh within the flap design boundaries. (D) Shows the elevated flap after harvesting. The arrow indicates the pedicle distribution markings, confirmed pre- and intraoperatively by ultrasonography and Doppler respectively.

Fig. 3. Postoperative outcome. (A) Lateral, (B) quarter, and (C) anterior views of the immediate postoperative outcome. The arrow in (A) indicates the residual area that could not be covered with the free flap, and was covered with a split-thickness skin graft.

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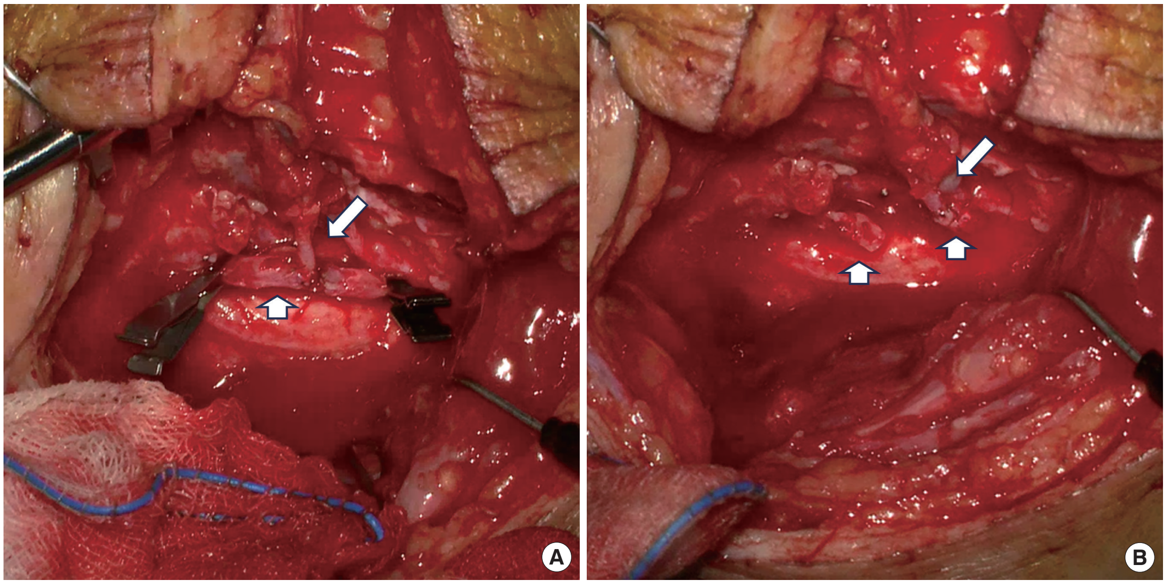

Fig. 4. Emergency re-anastomosis intraoperative photos. The intraoperative images depict the re-anastomosis process. The long arrow indicates the flap pedicle artery, while the short arrow points to the posterior tibial artery. (A) Before revision, the flap artery (long arrow) was markedly collapsed, and to address this, the anastomosis was revised from a side-to-end to an end-to-end configuration, disconnecting the distal part of the tibial artery (short arrow). The subsequent image (B) displays that following this revision, the posterior tibial artery was transected into two (short arrows), allowing for an engorged and well-perfused flap pedicle artery (long arrow) with restored blood flow.

Fig. 5. Photos on the 50th postoperative day. (A-D) No dehiscence, infectious signs, or discharge was observed.

anastomosis of one vein (vena comitans to vena comitans). The flap donor site was covered with another STSG.

Postoperative anticoagulation therapy was administered with intravenous prostaglandin E1 (5 mg/day) for 5 days, and oral aspirin 100 mg once per day with prostacyclin 20 μg twice per day for 4 weeks. The flap was intensively monitored; on the first postoperative morning, the flap was found to be pale, with faint capillary refill signs and a negative scratching test for bleeding, which led to the decision for an emergency exploration. Intraoperatively, we observed clots in the anastomosed arteries. The pedicle artery anastomosis was revised by changing from side-to-end to end-to-end anastomosis (Fig. 4). Capillary refill and scratch bleeding recovered after revision anastomosis, and no additional vascular or wound complications occurred until discharge. A well-healed ALT flap was observed on the 50th postoperative day in the outpatient department (Fig. 5).

Discussion

The combination of traumatic fractures and lower extremity osteomyelitis presents a formidable surgical challenge. These complex wounds are frequently compounded by the presence of multiple resistant organisms, tissue defects associated with bony nonunion, and excessive perivascular fibrosis stemming from prior interventions. Adequate osseous union cannot be achieved without proper soft tissue support, necessitating concomitant management of soft tissue defects and fractures [2]. In severe trauma cases, providing patients a durable, functional, and acceptable soft-tissue envelope remains a challenge. Traditionally, muscle flaps have been employed to cover osteomyelitis-related defects, supported by studies demonstrating their ability to increase local blood flow and thus antibiotic delivery, oxygen saturation, and immune cell activity [3]. However, since any free flap can increase blood flow to the defect site, fasciocutaneous flaps are also a good approach to cover osteomyelitis defects. Hong et al. [6] demonstrated that fasciocutaneous flaps are not inferior to muscle flaps in osteomyelitis conditions. Consequently, we opted for a fasciocutaneous free flap to resurface the defect. Though options such as thoracodorsal artery perforator and parascapular flaps were considered, the requirement for positional changes during surgery relegated them to secondary choices. The deep inferior epigastric artery perforator flap was ruled out because its bulk was deemed too thick for appropriate lower extremity coverage [7]. After careful deliberation of the available flap options, the ALT fasciocutaneous free flap was selected as the optimal solution.

Advances in comprehension of perforator anatomy have catalyzed the evolution of perforator flap reconstruction. Innovative free flap designs such as chimeric or supercharged flaps have been explored to meet the intricate reconstructive demands encountered in complex clinical situations. Prefabrication of distinct-shaped flaps represents an approach to optimize flap viability, however, this is offset by the requisites of prolonged hospitalization and escalated healthcare costs [3]. The ideal scenario in flap reconstruction remains harvesting a solitary flap without necessitating prefabrication or extensive preoperative preparations. In the present case, we relied only on preoperative computed tomography angiography and Doppler ultrasound to delineate the perforator anatomy. Through judicious intraoperative flap modification, we successfully designed a τ-shaped ALT flap without compromising flap viability.

Reducing flap size is an important factor in minimizing donor site morbidity. Reduced flap size contributes to preserving important structures in donors, such as the lateral cutaneous nerve of the thigh, femoral motor nerve branches, and deep fascia in ALT. The preservation of these structures decreases the risk of donor complications [8]. In our case, these structures were not injured during flap elevation, but the donor site had to be covered with a STSG as primary repair was impossible. However, the patient had no functional and esthetic complaints about his ALT donor and had full strength with an intact range of motion of the left thigh postoperatively.

One limitation of this approach is reproducibility. Not all ALT perforators have the same anatomy; thus, suitable improvisation will be acquired for individual cases. Nevertheless, the ALT perforator flap has relatively constant anatomy with minimal variations. Therefore, if the defect is confined to typical bimalleolar defects, this case could be a reference for further attempts.

Conflict of interest

No potential conflict of interest relevant to this article was reported.

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