Use of a 2/3 Free Vascularized Fibula Flap for Tibiofibular Bone Defect Reconstruction

A Case Report

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Abstract

Case: A 40-year-old man with a tibiofibular bone defect caused by infection was treated using a 2/3 free vascularized fibula flap, which preserved 1/3 of the continuous periosteum and cortex of the fibula at the donor site, allowing for regeneration of fibular bone defect caused by bone harvesting procedure. At 16 months of follow-up, his bilateral lower limb function had recovered well.

Conclusions: A 2/3 free vascularized fibula flap is an effective treatment approach for long-segment bone defects. This technique not only provides sufficient mechanical strength and stability at the defect site but also facilitates regeneration of the donor site fibula.

Free vascularized fibula flaps are typically considered the primary choice for repairing long-segment bone defects because of their sufficient length, high mechanical strength and stability, and morphology that easily integrates with the bone tissue of the recipient site, increasing graft success rates[1]. An essential advantage of these grafts is their intrinsic blood supply, which maintains the viability of the transplanted osteoblasts, facilitating the rapid formation and integration of new bone and thereby increasing the speed and quality of bone healing. However, a significant disadvantage is the resultant defect in the donor fibula. Studies have shown that during weight-bearing and movement, the fibula shares approximately 10% to 20% of the load with the tibia through synergistic action[2-4]. The fibula is crucial for lateral stability and overall structural support of the lower leg and serves as an attachment point for several important muscles and ligaments, playing a key role in maintaining ankle joint movement and stability[5,6]. Defects in the fibula can lead to lower limb dysfunctions, affecting a patient's quality of life.

In this report, we present a case of a tibiofibular bone defect caused by infection in a 40-year-old man treated using a 2/3 free vascularized fibula flap. This technique preserves 1/3 of the continuous periosteum and cortex of the fibula, maintaining the potential for regeneration of the fibular bone defect in the donor area.

The patient was informed that data concerning the case would be submitted for publication, and he provided consent.

Case Report

A 40-year-old man sustained an open fracture of the distal left tibiofibula (Gustilo III) caused by a heavy object crushing injury. Following the initial surgery at a nearby hospital, the patient developed an infection, leading to admission to our hospital 3 months after surgery. Physical examination revealed a sinus tract on the lower lateral aspect of the left leg. Cultures of the sinus tract drainage identified *Pseudomonas aeruginosa* and *Staphylococcus aureus*. Imaging revealed a nonunion fracture accompanied by osteolytic destruction (Fig. 1-A). Extensive debridement of the infection in the lower segments of the left tibiofibular region was conducted, followed by the implantation of antibiotic bone cement at the defect sites. The postoperative wound healed well, and the patient was successfully discharged. Three months after the second surgery, follow-up revealed well-controlled infection, with imaging showing a 5-cm bone defect in the left tibia and a 10-cm defect in the fibula (Figs. 1-B and 1-C). The patient was readmitted for bone defect reconstruction.

Disclosure: The **Disclosure of Potential Conflicts of Interest** forms are provided with the online version of the article (http://links.lww.com/JBJSCC/C483).

Keywords middle age; male; bone defects; 2/3 free vascularized fibula flap

Surgical Technique

The original incisions on the anterior and lateral sides of the left leg exposed the bone layer by layer. All the bone cement was removed, the medullary cavity was cleared, and the Kirschner wire was extracted from the fibula. A distal tibial plate was installed on the medial side using the minimally invasive percutaneous plate osteosynthesis technique with 10 screws for fixation, and a lateral fibula plate was installed using 11 screws. The tibial and fibular defects measured 5 cm and 10 cm, respectively. Simultaneously, the distal and proximal anterior tibial artery and vein pedicles were explored.

Points were marked 8.0 cm above the right lateral malleolus and 5.0 cm below the fibular head to outline the projection of the right fibular shaft. Using Doppler ultrasound, the strongest echo of the fibular artery perforator was marked. A 14 cm × 5 cm flap centered on this point was designed (Fig. 2-A). The required length of the fibula from the right side was determined by the length of the bone defect in the left tibiofibula. The marked perforator was located above the deep fascia and traced to the fibular periosteum (Fig. 2-B). Dissection was used to expose the flexor hallucis longus muscle, preserving key vascular structures. The fibula flap was designed to maintain the continuity of the anterior-lateral 1/3 of the periosteum and cortical bone while retaining the intact posterior-medial periosteum connected to the fibular artery. During osteotomy, a 1.0 Kirschner wire was used for continuous irrigation to protect the bone tissue. After the anterior-lateral and proximal-distal ends were cut, the fibula was rotated to expose the vascular pedicle, which was ligated and cut at the osteotomy ends (Figs. 2-C, 2-D and 2-E). A drain was placed at the donor site, and the wounds were closed layer by layer.

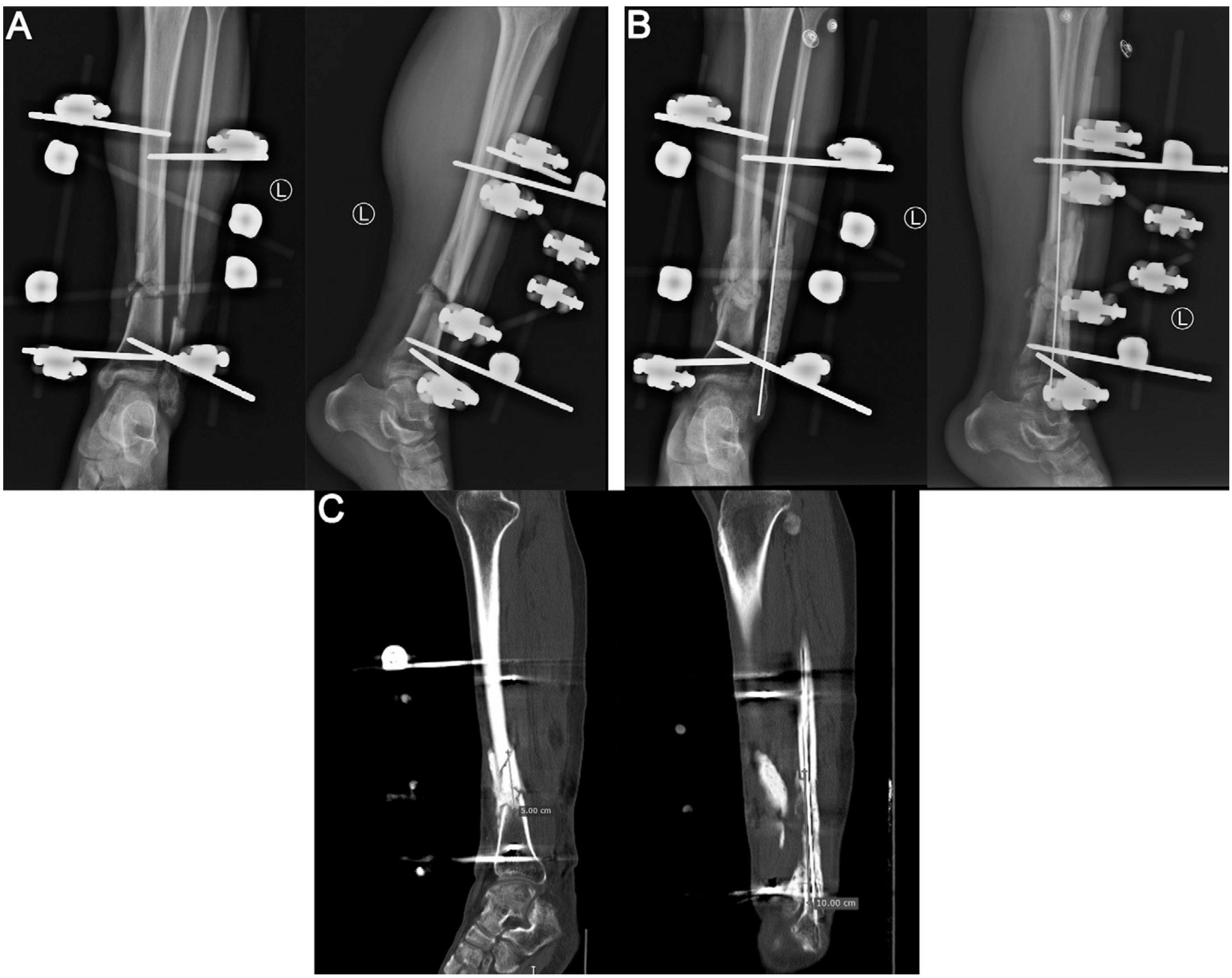

Fig. 1

Anteroposterior and lateral radiographs of the left tibiofibula showing the fracture nonunion and osteolytic destruction caused by infection (**Fig. 1-A**). Radiograph obtained 3 months postoperatively showing a 5-cm defect in the left tibia and a 10-cm defect in the fibula (**Figs. 1-B and 1-C**).

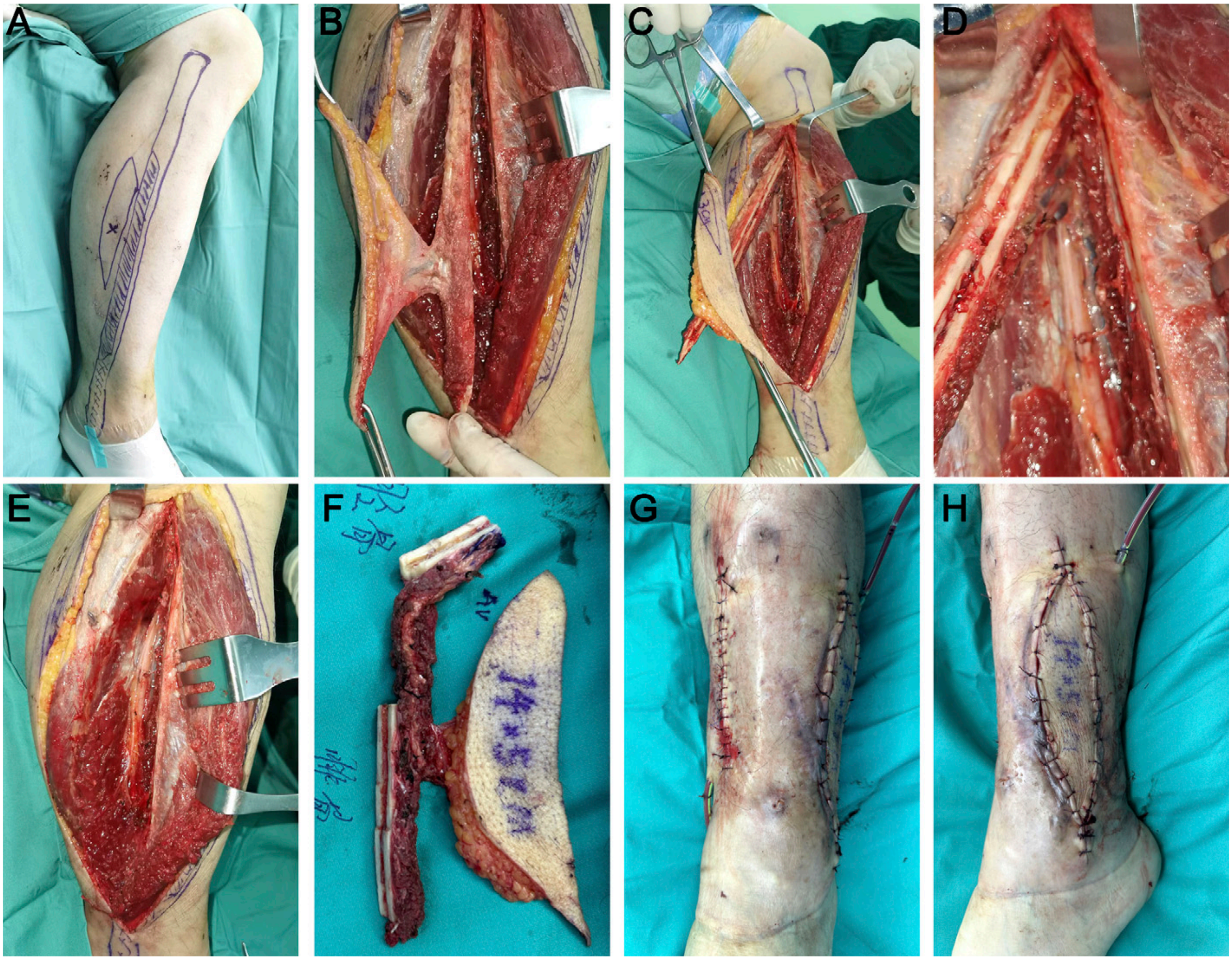

Fig. 2

Surgical markings of 2/3 free vascularized fibula flap (**Fig. 2-A**). Harvest of 2/3 free vascularized fibula flap (**Figs. 2-B through 2-E**). Double-barrel fibula flap design for tibiofibular bone defect (**Fig. 2-F**). The skin flap sutured in the recipient site (**Figs. 2-G and 2-H**).

Fig. 3

Active range of motion including bilateral ankle and knee flexion/extension and load-bearing and squatting for both lower extremities at 10-month follow-up.

Fig. 4
Anteroposterior and lateral radiographs of bilateral tibiofibula obtained 1 month, 3 months, 5 months, 10 months, and 16 months postoperatively.

The free vascularized fibular flap was trimmed to the lengths of the tibial and fibular bone defects, forming a double-barrel fibular flap (Fig. 2-F). The long segment bone flap and skin flap were used to fill the fibular defect, and the short segment was placed at the tibial defect and secured with 3.5-mm locking screws and Kirschner wires. The distal and proximal peroneal arteries of the fibular flap were anastomosed end-to-side with the anterior tibial artery, restoring blood flow in 1 attempt. A drain was inserted, and the wound was closed in layers (Figs. 2-G and 2-H).

Results

Postoperative imaging revealed a nondisplaced fracture in the right donor fibula. Early advice included active joint function training for the right knee/ankle and passive training for the left knee/ankle without weight-bearing for 1 month. Subsequent images at 1, 3, 5, and 10 months demonstrated progressive healing and callus formation at both the right fibula and left tibiofibula graft sites. By 5 months, the patient could walk on flat surfaces using both limbs. At 10 months, slight thickening was observed at the donor site and transplanted fibula, with only a minor left ankle dorsiflexion limitation (Fig. 3). By 16 months, significant thickening of the right fibula was observed (Fig. 4).

Discussion

A traditional free vascularized fibula flap requires harvesting the entire fibula, which shares load-bearing duties with the tibia. Removing the entire fibula can affect the mechanical stability of the donor site's lower limb, potentially causing postoperative fatigue and affecting leg and ankle movement. Preserving the potential for fibular regeneration at the donor site offers the potential for maximum functional recovery[7]. Violas et al. used minimally invasive methods to harvest nonvascularized fibulas for pediatric bone defects, observing fibular regeneration at the donor site while preserving the periosteum[8]. Greenblatt et al. identified periosteal stem cells within the periosteum and mechanisms for intramembranous ossification, showing that retaining the periosteum and cortical bone benefits regeneration[9]. The periosteum and cortical bone maintain the blood supply, crucial for osteoblast growth, repair, and new bone formation.

Based on the above content, we developed a surgical method that involves resecting a 2/3 free vascularized fibula flap to repair bone defects while maintaining continuity of 1/3 of the periosteum and cortical bone in the donor site of fibula to facilitate regeneration. We used a double-segment 2/3 free fibula flap with the same vascular pedicle to simultaneously repair the left tibiofibular bone defect. The transplanted 2/3 free fibula flap healed with the left tibiofibular bone within 3 months postoperatively. The patient was able to fully bear weight and walk, effectively returning to daily life. This outcome demonstrates that the mechanical strength of the 2/3 free vascularized fibula flap is sufficient to repair load-bearing bone defects. Moreover, the 2/3 free vascularized fibula flap provides a larger fresh osteotomy surface, increasing the contact area between the transplanted bone and the recipient bone and promoting bone healing. Interestingly, 10 months after surgery, the transplanted fibula flap not only healed but also exhibited the phenomenon of "fibularization" where it thickened and integrated with the recipient fibula. At 5, 10, and 16 months after surgery, the retained 1/3 of the fibula at the donor site gradually thickened, indicating that the fibula regenerated, and the function of the right lower limb at the donor site recovered well. During the harvest of the 2/3 free vascularized fibula flap, we preserved the anterolateral 1/3 of the fibula and resected the posteromedial 2/3, maximizing periosteum retention and minimizing interosseous membrane damage while better isolating and exposing the vascular pedicle. Anatomical characteristics indicate that at least 5 cm of the fibula above the lateral malleolus is necessary for ankle stability. In this case, only 3 cm remained after debridement, prompting concurrent fibular and tibial reconstruction. Follow-up assessments confirmed that the patient's ankle function recovered well. Traditional free vascularized fibula flaps require retaining 10 cm of fibula above the ankle. Our case observations indicate that the 2/3 free vascularized fibula flap could provide longer segments of the fibula to repair extensive bone defects under the condition of preserving the structural tissues associated with the stability of ankle.

Conclusion

This report shows that 2/3 free vascularized fibula flaps can effectively repair long-segment bone defects. These flaps not only provide adequate mechanical strength and stability at the defect site but also enable potential regeneration of the donor site fibula by preserving the continuity of 1/3 of the periosteum and bone cortex, thus avoiding the adverse effects on donor site function associated with traditional complete fibula harvesting. This innovative method ensures effective bone defect repair while preserving the potential for maximal functional recovery of the donor site, indicating broad clinical application prospects. ■

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