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Vascularized iliac crest reconstruction of the distal fibula after trauma: Technical notes and long term follow up

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ABSTRACT

Background: Large post-traumatic defects of the lateral malleolus are uncommon but present major reconstructive challenges, particularly in the presence of segmental bone loss, infection, or soft-tissue compromise. The lateral malleolus is essential for ankle stability, and its absence leads to mechanical imbalance and early degenerative changes. Traditional solutions—including non-vascularized grafts, allografts, arthrodesis, or fibular transfers—may be inadequate when biological conditions are poor or when three-dimensional reconstruction is required. Vascularized bone flaps offer improved union rates and enhanced resistance to infection. The vascularized iliac crest flap, although well-established in limb reconstruction, remains infrequently reported for distal fibula restoration.

Methods: Three patients with severe post-traumatic lateral malleolar defects were treated between 2002 and 2015 at two microsurgical centers. Reconstruction was performed using free vascularized iliac crest flaps based on the deep circumflex iliac artery. Flap configuration (osteo-muscular or osteo-cutaneous) was adapted to defect size and soft-tissue requirements. Technical details—including flap harvest, shaping of the iliac crest segment, fixation, and vascular anastomoses—are described. Clinical and radiographic outcomes were evaluated over 8–14 years.

Results: All flaps survived without major postoperative complications. Radiographs demonstrated consistent osseous union between the iliac crest graft and tibia. All patients achieved full weight-bearing and stable ankle function. Mild-to-moderate radiographic osteoarthritis occurred at long-term follow-up but remained asymptomatic. Soft-tissue coverage was reliable, and no secondary flap procedures were required.

Conclusions: The free vascularized iliac crest flap is a dependable and versatile reconstructive option for extensive lateral malleolar defects. It provides stable ankle restoration, predictable union, and durable function, and should be considered when conventional grafting or fibular transfers are unsuitable, particularly in complex post-traumatic or infected environments.

1. Introduction

Segmental defects of the lateral malleolus are rare but pose significant reconstructive challenges. They typically arise after high-energy trauma, oncologic resections, or failed surgical procedures complicated by septic nonunion. Because the lateral malleolus plays a key biomechanical role in ankle stability and force transmission between the leg and foot, its loss results in marked ankle instability, mechanical axis deviation, and early degenerative changes.[1–3]

Multiple reconstructive options have been described, including non-vascularized autografts,[4] allografts,[5] tibiotalar arthrodesis,[5] proximal fibular transfer,[4] and pedicled or free vascularized bone flaps.[6–7] However, in cases of large bone defects, active infection, or combined soft-tissue loss, these techniques may yield suboptimal results in terms of union and functional recovery.[5]

Vascularized bone flaps, both simple and composite, are increasingly

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Fig. 1. Clinical and radiographical appearance of first patient. a) Preoperative condition, b) Postoperative appearance, c) X-ray at 3 months, d) X-ray at 14 years, e) Donor site at 3 months, f) Functional outcome at 14 years.

used in limb reconstruction. Although the vascularized fibula is a well-established solution for extensive long-bone defects, its application in lateral malleolus reconstruction is restricted by geometric limitations and technical complexity—especially when restoration of bone volume, joint stability, and adequate soft-tissue coverage must be achieved simultaneously.[8,9,7] In these circumstances, a vascularized iliac crest flap represents an effective yet underreported alternative.

This case series describes three complex post-traumatic reconstructions of the lateral malleolus using a free vascularized iliac crest flap. Surgical technique, technical nuances, postoperative course, and mid-to long-term radiographic and functional outcomes are presented.

2. Case series

Three patients treated at two high-volume microsurgical centers (2002, 2008, 2015) were included. All required lateral malleolus reconstruction following severe trauma.

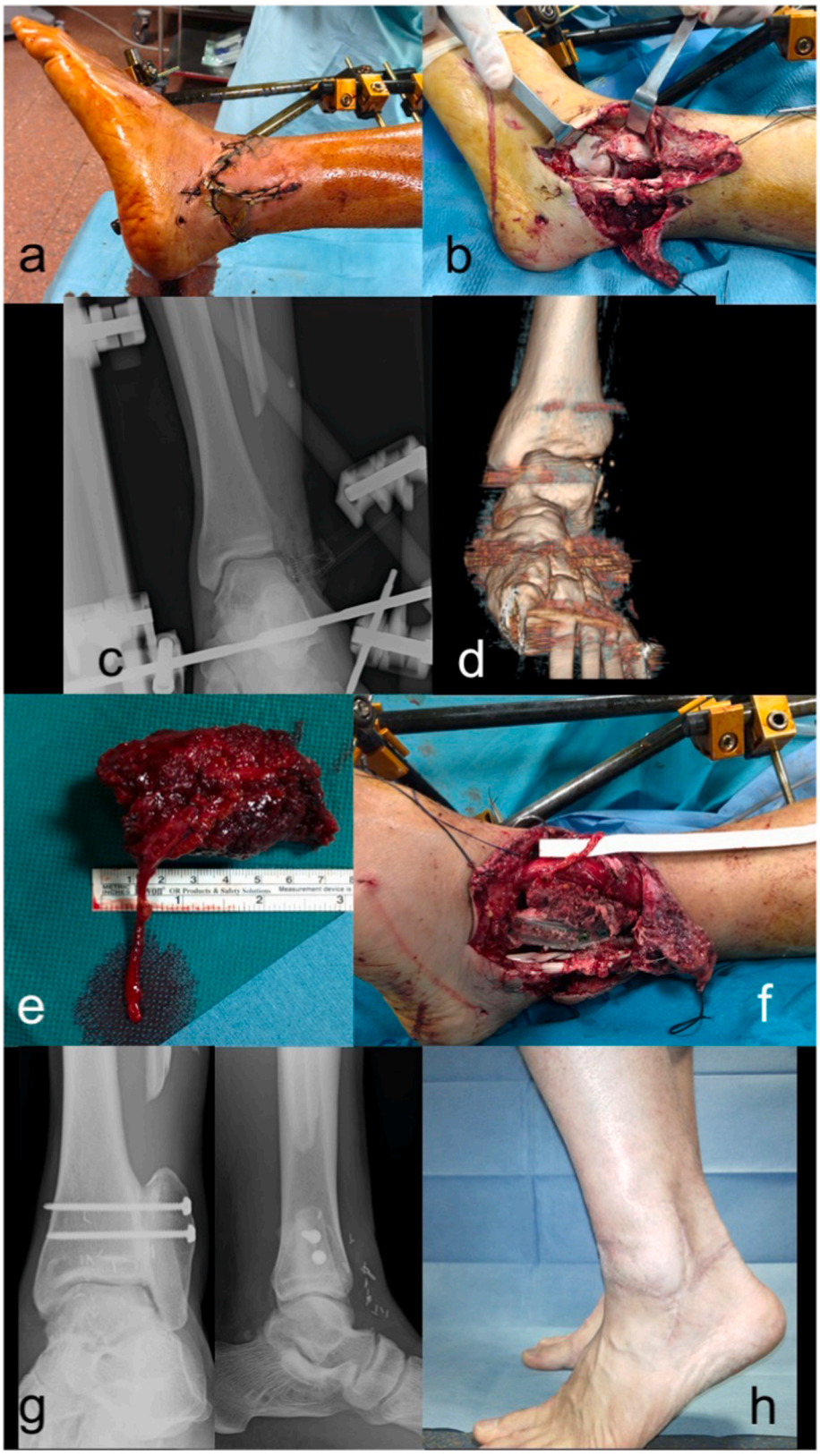

Fig. 2. Clinical and radiographical appearance of patient 2. a) Soft tissue condition before debridement b) intraoperative picture of bone defect c and d) pre operative x-ray and CT scan showing lateral malleolus defect e) harvesting of the iliac crest flap with the vascular pedicle clearly visible, f) Positioning of the vascularized bone graft with screw fixation and end-to-end microvascular anastomosis to the anterior tibial artery g) Radiographic and h) clinical appearance 8 years after reconstruction.

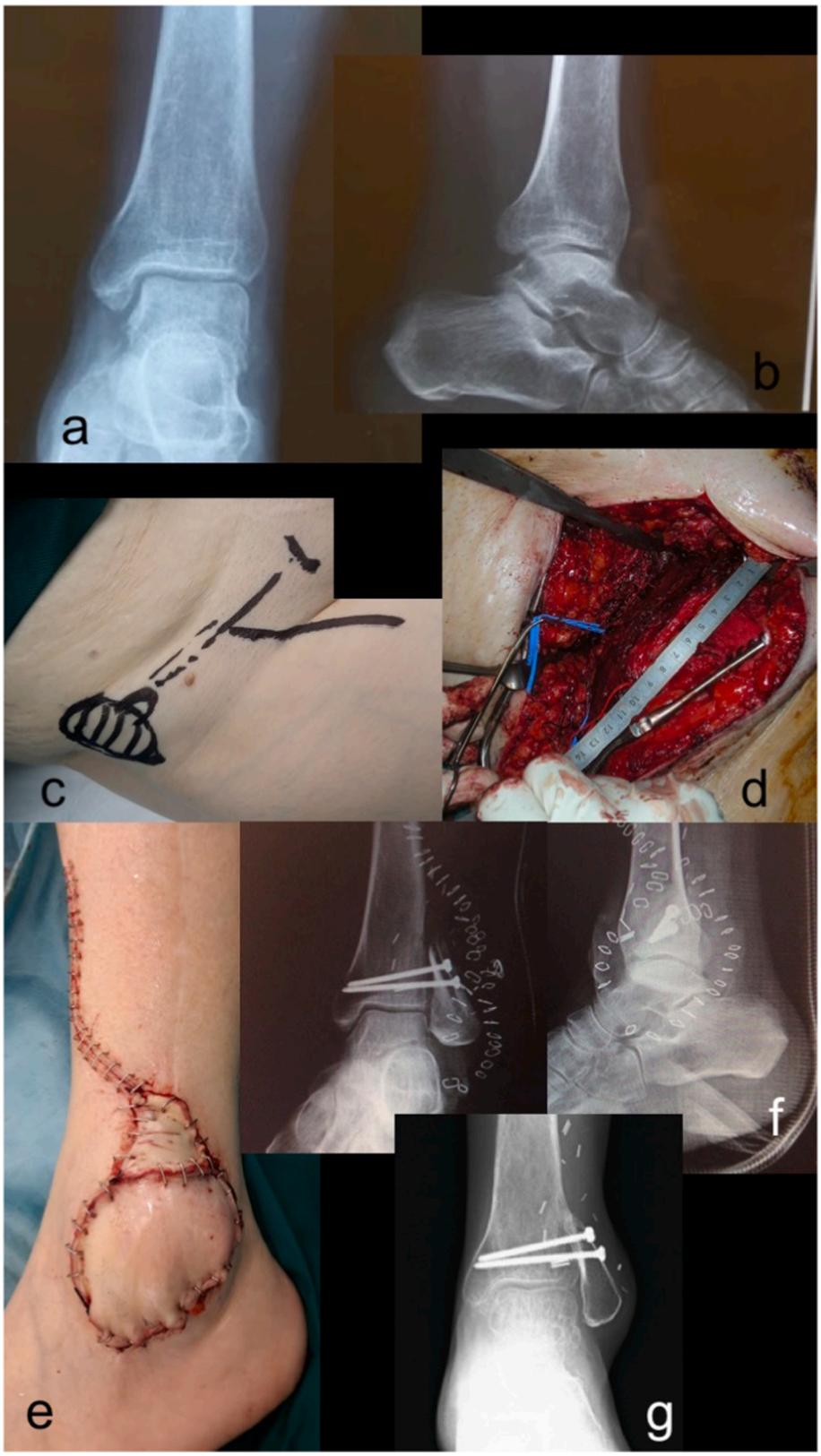

Fig. 3. Clinical and radiographical appearance of patient 3. a and b) Preoperative radiographic assessment, b and c) Flap design and dissection including the skin paddle, d) Final appearance at the end of surgery, e) Postoperative x ray, f) Five-year radiographic follow-up.

2.1. Patient 1

A 25-year-old man presented with a subtotal defect of the left lateral malleolus and a 10 × 6 cm skin loss after a motorcycle accident. Reconstruction consisted of a combined free iliac crest and iliacus muscle flap with split-thickness skin grafting. End-to-end anastomoses were performed on the peroneal vessels. Owing to intraoperative ankle instability, two cortical screws were placed to reconstruct the tibiofibular syndesmosis, and removed after 90 days. At 5 months, MRI demonstrated good restoration of ankle contour. At 13-year follow-up, radiographs showed tibiofibular arthrodesis without symptomatic arthritis, and functional range of motion was comparable to the contralateral side (see Fig. 1).

2.2. Patient 2

A 33-year-old man sustained a motorcycle injury with complete loss of the lateral malleolus and severe skin damage. After debridement, reconstruction was performed with a composite iliac crest–iliacus flap. Fixation used two cannulated screws. Vascular anastomoses were performed end-to-end on the anterior tibial artery at ankle level. At long-term follow-up, the patient showed radiographic ankle osteoarthritis but remained asymptomatic and returned to normal daily and sporting activities (see Fig. 2).

2.3. Patient 3

A 54-year-old woman presented with a chronic post-traumatic defect 7 years after a road accident, complicated by infected nonunion and osteomyelitis. Resection of septic bone resulted in total loss of the lateral malleolus and the distal two-thirds of the fibula. Due to limited soft-tissue mobility, an osteocutaneous iliac crest flap was required. At 5-year follow-up, radiographs confirmed complete bone healing (see Fig. 3).

2.4. Surgical technique

Following radical debridement, bone and soft-tissue defects were assessed to determine flap size. Flap harvesting followed the technique described by Taylor.[10] Three osteotomies were performed to obtain a 6 × 3 cm bone segment, with particular care during the anterior osteotomy, which lies beneath the vascular pedicle. When required, skin paddles were harvested with meticulous preservation of delicate perforators.

In two patients, only the osteo-muscular flap was necessary, whereas one required an osteo-cutaneous flap for adequate coverage.

The iliac crest segment was shaped to approximately 6 cm to allow secure proximal fixation to the distal tibia and to recreate the tibiotalar mortise. Anastomoses were performed on the anterior tibial artery in two cases and on the peroneal artery in one, depending on vessel quality. No intraoperative vascular complications occurred.

The flap was positioned with the muscular surface outward; in the osteocutaneous case, the segment was rotated 180° to restore malleolar prominence. Fixation used two cortical screws. No lateral ankle ligament reconstructions were performed.

3. Results

Clinical follow-up was 14, 10, and 8 years, respectively. All patients showed radiographic evidence of solid union between the iliac crest graft and the tibia. No late soft-tissue or skin-related complications were observed.

Patient 1 returned to regular running and remained pain-free, despite mild radiographic degenerative changes.

Patient 2 resumed normal daily activities and sports with no limitations.

Patient 3 achieved full weight-bearing without significant pain; moderate radiographic osteoarthritis was present but asymptomatic.

4. Discussion

Reconstruction of the lateral malleolus is technically demanding due to the biomechanical complexity of the ankle mortise and the frequent coexistence of bone and soft-tissue loss. Early approaches relied on non-vascularized bone grafts, including proximal fibular transfers. Herring et al.[4] reported long-term success in an adolescent undergoing proximal fibular transposition. Non-vascularized autografts remain suitable for limited defects due to their availability and osteogenic potential; however, their use in terminal positions carries a high risk of resorption and failure.

Microsurgical advances expanded reconstructive options. Vascularized fibular grafts were first described for lateral malleolus reconstruction in the 1990s[8] and later replicated by Gao.[7] Others used the proximal fibula as a free flap.[9] Although ideal for physeal reconstruction in children, the proximal fibula has unfavorable geometry for malleolar reconstruction and is less suitable for composite defects.

The vascularized deep circumflex iliac artery (DCIA) flap offers a robust and versatile alternative. It has been employed for reconstruction of large defects of the distal tibia, talus, midfoot, and—more rarely—the distal fibula.[10] Its advantages include strong osteogenic capacity, rapid revascularization and incorporation, resistance to infection, and the option to harvest composite flaps incorporating muscle, fascia, or skin.[10,11] It also provides a substantial amount of bone that can be precisely tailored to the defect, unlike the narrower proximal fibula, whose harvest may require collateral ligament repair and carries a risk of peroneal nerve injury.

Another option, propesed by Faure[12], is the scapular tip flap, which can be a valid alternative but requires more demanding patient positioning, unlike the DCIA flap, which allows a simpler, supine, two-team approach.

Limitations of the DCIA flap include donor-site morbidity, technical complexity—particularly when harvesting a skin paddle—and lack of growth potential, restricting its use in pediatric patients. Nonetheless, these drawbacks are acceptable in adults and in cases of large defects.[11]

In this series, vascularized iliac crest flaps—osseous or osteocutaneous—provided reliable stability, consistent union, and durable functional recovery, even in the setting of chronic infection and extensive bone loss. No cases of nonunion or late flap-related complications occurred. Moderate long-term osteoarthritis likely reflects the severity of the initial trauma rather than the reconstruction itself and remained clinically silent.

5. Conclusion

For major lateral malleolar defects with substantial bone and soft-tissue loss, the vascularized iliac crest flap is a dependable and biologically advantageous solution, offering superior consolidation and function compared with non-vascularized grafts. Reconstruction should be individualized, but our experience supports the DCIA flap as a key method in complex post-traumatic cases.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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