Orthoplastics Tips & Tricks: Case Report: Orthoplastic Limb Salvage in a Patient with Chronic Nonunion, Infection, Deformity, and Wound

Ashleigh Bush, MD[1]
Stephen Kovach, MD[2]
Samir Mehta, MD[1]

[1]Department of Orthopaedic Surgery
University of Pennsylvania

[2]Department of Plastic Surgery
University of Pennsylvania

Introduction

There are various types of soft tissue coverage options including skin grafting, local tissue rearrangement, rotational flaps such as a gastrocnemius or soleus or a microvascular free flap. For large soft tissue defects in these injury patterns, rotational muscle flaps or free flaps are generally the first choice for soft tissue coverage in the leg. There continue to be, however, some clinical situations in which these flaps are often not possible or the best option for the patient.

Another option for soft tissue coverage is the cross-leg flap. The cross-leg flap was first described by Hamilton in 1854. The cross-leg flap was used extensively for lower extremity trauma prior to the introduction of the free flap in 1970.[1] Since its introduction, the free flap has become the gold standard for post traumatic lower extremity soft tissue reconstruction. While infrequently performed, the cross-leg flap plays a unique role in orthoplastic limb salvage.

This case study describes a patient with a severe initial open tibial fracture which was subsequently complicated by malunion, osteomyelitis, erosion through soft tissue reconstruction, and delayed presentation for and consideration of a cross leg flap for orthoplastic limb salvage.

Case Report

The patient is a male 70-year-old male with a PMH of smoking, coronary artery disease status post stent placement, hyperlipidemia, and AAA status post stent who sustained an open, high-energy left tibial fracture in 1984. This was initially treated with open reduction and internal fixation. Since that time, the patient developed a chronically infected malunion/nonunion. This was complicated by exposed hardware with a chronically draining sinus tract, broken instrumentation, and a significant varus deformity of his left lower extremity. In addition, he had hypertrophy of his fibula.

At the time of his initial visit at our center, the patient had been suffering from this problem for many years prior to referral. The patient wished to have a limb reconstruction rather than amputation. He was seen and evaluated both in the Orthopedic Surgery Clinic and Plastic Surgery Clinic regarding his suitability for limb salvage. At the time of initial evaluation in each clinic, the patient was advised to quit tobacco smoking due to the unacceptably high risk of adverse events.

The patient returned to clinic approximately one year later having quit smoking tobacco. Again, he preferred attempts at limb salvage rather than amputation. Both surgeons had a lengthy conversation with the patient about the risks involved in reconstruction including the very real risk of an amputation. He was seen and counseled on multiple occasions regarding the potential for limb salvage.

To treat this limb, a staged reconstruction was planned to address both the bony and soft tissue challenges. The goals of this reconstruction would be getting the limb straight, allowing him to clear his infection with provisional fixation, getting definitive soft tissue reconstruction, and ultimately reconstructing the bone in a delayed fashion. From a bony standpoint, he had significant loss of length, alignment, and chronic infected nonunion/malunion. From a soft tissue

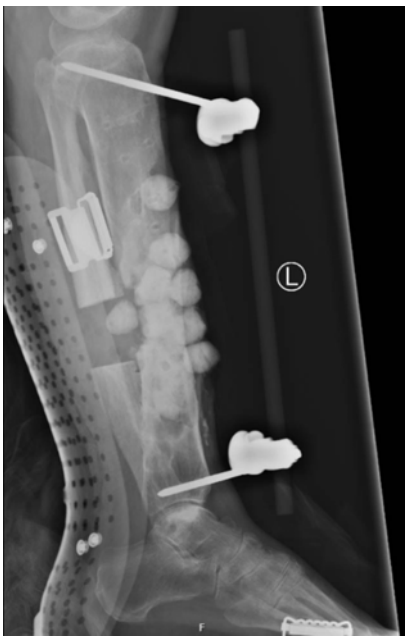
Image 1. Limb at the time of initial presentation to our medical center.

Images 2 and 3. AP and Lateral Xrays of the Left Tibia at the time of initial presentation to our medical center.

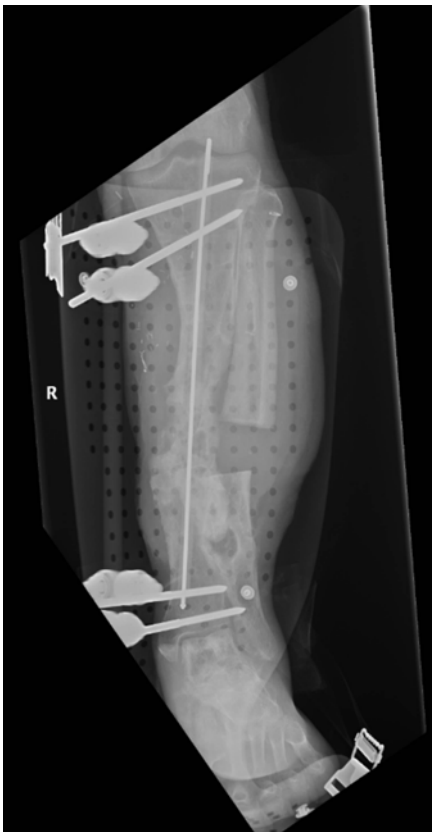
standpoint, he had severely fibrotic tissue as well as exposed hardware and soft tissue damage. The chronically infected bone and unstable soft tissue envelope needed to be removed. The surgeons anticipated large tibial intercalary defect and a large soft tissue defect after the removal of the infected bone and unstable soft tissue envelope. After this, the surgeons planned to pursue microvascular free tissue transfer to reconstruct his soft tissue envelope and temporizing fixation to provide stability and bony opposition while continuing to treat his osteomyelitis. Once his bony infection was cleared and he had achieved appropriate alignment, rotation, and soft tissue coverage, he then would undergo bony reconstruction to restore length to the limb.

In the first series of operations, he first underwent removal of hardware, excision of the infected tibia and fibula with sequestrum debridement, osteotomy of the tibia and fibula, external fixator application, and antibiotic spacer placement. Five days later, he underwent antibiotic spacer removal, tibial debridement and washout, and antibiotic nail and bead placement. Intraoperative cultures at this time demonstrated methicillin-sensitive Staph Aureus, for which infectious disease was consulted. This patient also had an anaphylactic reaction to cephalexin, thus infectious diseases recommended he be treated with six weeks of intravenous vancomycin therapy.

At this time, he had undergone resection of his fracture, retained hardware, and his limb was provisionally stabilized



Images 4 and 5. AP and Lateral Xrays after removal of hardware, excision of the infected tibia and fibula with sequestrum debridement, osteotomy of the tibia and fibula, external fixator application, and antibiotic spacer placement.



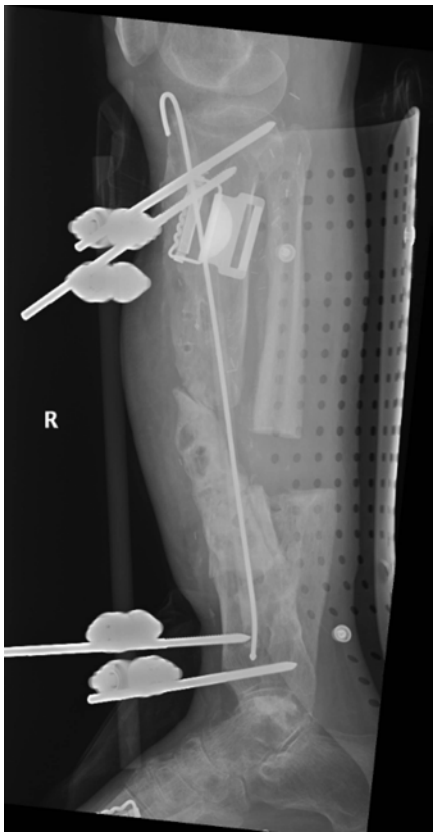


Image 6 and 7. Ap and Lateral Xrays after excision of his infected bony tissue, removal of broken hardware, restoration of alignment and rotation, provisional fixation in the form of an antibiotic nail and external fixator, and free flap reconstruction.

with alignment and rotation restored. However, he still had large, intercalary defect and a massive soft tissue defect overlying his anterior lower extremity. To reconstruct this, microvascular reconstruction was planned. In his preoperative work up, a CT angiogram demonstrated single vessel run off via the posterior tibial artery which emanated high in the popliteal fossa. His anterior tibial and peroneal vessels were occluded in the mid aspect of the lower extremity. This in addition to his severe fibrosis of the affected extremity made soft tissue reconstruction incredibly challenging.

Ten days after his initial operation, he underwent soft tissue debridement and wound excision, antibiotic spacer placements, and Free anterolateral perforator flap to the left lower extremity with right saphenous vein graft harvest

Image 8. Lateral aspect of ALT flap 2 months post operatively.

Image 9. Lateral aspect of ALT flap 2 months post operatively.

and for vascular inflow and outflow as interposition arterial and venous grafts. Intraoperatively, the initial plan was to explore the anterior tibial vessels and attempt and end-to-end anastomosis. However, this compartment and his anterior tibial artery were found to be severely scarred in and unable to be dissected for this end. In this case, the posterior tibial artery was identified high in the infrageniculate popliteal fossa and dissected free for microvascular anastomosis with its accompanying veins. With inflow and outflow vessels identified, the skin paddle and its dominant perforator were dissected and prepared. It became clear that the patient would need vein graft to bridge the donor site for his recipient vessel inflow and outflow. Thus, the saphenous vein was harvested from the contralateral side to be used as interpositional vein graft. Prior to leaving the operating room, the flap was found to have excellent arterial inflow, venous egress, and doppler signals.

Having undergone excision of his infected bony tissue, removal of broken hardware, restoration of alignment and rotation, provisional fixation in the form of an antibiotic nail and external fixator, and free flap reconstruction of the affected extremity, the patient was discharged with six weeks of culture directed intravenous antibiotics.

Three months after the index operation, having healed the soft tissue, and being treated with a course of IV antibiotics, he returned to the operating room for placement of a NuVasive magnetically-driven nail for bone transport to definitively manage his limb length inequality and nonunion. The Plastic Surgical Service was consulted regarding management of the soft tissue as well as elevation of his previous free flap reconstruction in order to allow for removal of his existing antibiotic spacer, placement of this intramedullary construct to allow for bone transport.

During this operation, the surgeons found his antibiotic spacer eroded through the soft tissue resulting in a formal defect in the setting of a terribly fibrotic limb and additional soft tissue defect. This residual wound overlying the medial right lower extremity that could not be closed even with his previous free flap reconstruction, therefore negative-pressure wound therapy was placed while preparing to return to the operating room for soft tissue coverage of his underlying bony defect and NuVasive nail.

Planning for soft tissue coverage in his case was challenging given the dense scar burden, one vessel inflow in the form of the posterior tibial artery high in popliteal fossa, and limited veins that could be used for interpositional vein grafts. Thus, the possibility of cross-leg flap was introduced.

He returned to the operating room to undergo a cross leg flap. A random pattern flap was then designed based proximally overlying the medial and posterior aspect of his right lower extremity, taking into account his previous incision and scar from his saphenous vein harvest site. This was raised full-thickness through the deep fascia on top of the gastrocnemius muscle as well. Intraoperatively, the distal flap did appear to perfuse well after being raised, but the surgeons were concerned that they did not want to formally inset this in case there was any chance of distal flap necrosis as this was a portion of the flap that would be necessary. Thus, a decision was made to delay this flap. A sheet of Integra skin substitute was placed on top of the gastrocnemius muscle so that the flap would have no deep tissue contact to the underlying wound bed.

Post operatively, the cross-leg flap was nonviable in the distal aspect and began to necrose. A long discussion was had with the patient regarding pursuing limb salvage and the likelihood of success versus amputation. Extensive discussions were had given the nature of the surgery including the potential for partial or complete flap loss and/or inability to achieve reconstruction based on the amount of available vein graft. He understood the nature of the anticipated surgical procedure as well as the attendant risks and benefits and he wished to proceed with a trial of limb salvage with a second free flap and vein grafts. The patient again wished to pursue limb salvage. He was indicated for a second free flap in the form of an anterolateral thigh flap with interposition vein grafts.

He was taken to the operating room for the second anterolateral thigh flap. The wound overlying his medial and

Image 10 and 11. Ap and Lateral Xray after removal of external fixator, removal of antibiotic intramedullary nail, placement of Precice magnetically-driven nail.

anterior left lower extremity was then excised. The proximal posterior tibial artery and large, proximal posterior tibial vein were identified, dissected, and prepared for inflow. For vein graft, the saphenous vein overlying the left thigh was dissected free and prepared from his knee up to his groin crease. Then, the free flap was procured from his right thigh and saphenous vein graft was used as an interposition graft to anastomose the flap to the posterior tibial vein and artery. Finally, the site of the previous delay of an attempted cross-leg flap was debrided and negative pressure wound therapy was initiated. At this time, the patient is approximately six weeks post-operative from second free flap reconstruction.

Discussion

The modern definition of orthoplastics is: "the principles and practices of both specialties applied to clinical problems simultaneously, either by a single provider, or team of providers, working in concert for the benefit of the patient." [2,3,4,5] The combined orthoplastic approach to patients with severe injuries to the lower extremities requiring lower limb salvage has been shown lead to better outcomes including quicker time to bone union, more durable soft tissue coverage, less pain, better function, fewer complications, shorter hospital stays, and higher patient satisfaction. [6]

This is a patient with a complicated extremity who suffered from osteomyelitis, nonunion/malunion, wound, and varus deformity of this extremity for years prior to referral to our orthoplastic limb salvage center. This case demonstrates the importance of early referral to a specialized orthoplastic center with the expertise and facilities to handle the challenges of this case.

The management of long bone defects rely on the principles of distraction osteogenesis which were pioneered by Ilizarov. [7] Newer intramedullary nails which allow surgeons to lengthen magnetically have drastically changed the ability to perform distraction osteogenesis without the need for a bulky ringed external fixator. The PRECICE Intramedullary Limb Lengthening System (Ellipse Technologies Inc., CA, USA) is the nail that was used in this patient. It is a is a remotely controlled, magnetically driven, implantable limb lengthening intramedullary nail system. [8] It has been reported to achieve accurate and precise limb lengthening. [9,10,11,12]

Once a free flap has failed, there are limited options available for soft tissue coverage. Attempts to salvage these extremities can be undertaken with split thickness skin graft or local flaps. However, in these cases, intermittent wound breakdown and drainage of these extremities remain major problems. Thus, these situations indicate that the loss of a free flap significantly affects the overall potential to salvage a lower extremity.[13] Additionally, studies show after failed free flap, the rate of amputation of the affected extremity can vary from 22 to 57%.[14-16]

The cross-leg flap is generally reserved for use when surgeons or medical centers do not have the ability to perform microsurgery. The use of cross-leg flap has previously been limited by the incidence of necrosis, difficulty of immobilizing both legs for 2–3 weeks, joint stiffness, chances of thromboembolism, and concern about donor site cosmetic deformity especially in women. The use of external fixator for immobilization circumvents many of the previous problems with both-leg immobilization. The addition of external-fixator stabilization aids greatly in wound care, as well as for general ease of patient mobility and positioning.[17]

In this patient, had he received a cross leg flap, external fixation would have been used for immobilization. The construct that would have consisted of two pins in the contralateral tibia, one pin in the ipsilateral femur, and one pin in the ipsilateral calcaneus to create a trapezoid-shaped construct. This would avoid placing any pins in the tibia given the magnetically lengthening intramedullary nail as well as the cross leg flap that would have been in place.

The technique of delaying a flap is to allow for enhanced flap length and viability in reconstruction. This has been used nearly 500 years in reconstructive surgery for reliably transferring a greater amount of harvested tissue than one would be able to otherwise.[18] This involves incising the borders of the flap with or without partial subcutaneous elevation and leaving it in situ for a duration of time, usually 10–14 days. After the period of delay, the flap is fully elevated and transposed. Delayed flaps have been shown to have better survival than similar flaps that are raised and transposed primarily.[19]

Conclusion

This is a patient with a challenging limb deformity presenting for limb salvage after a remote history of high energy trauma. His case demonstrates the importance of integrated orthoplastic care, considerations in soft tissue coverage, and restoring length and alignment in a severely shortened and maligned limb.

References

1. Stark RB. The cross-leg flap procedure. *Plast Reconstr Surg* (1946). 1952 Mar;9(3):173-204.

2. Lerman OZ, Kovach SJ, Levin LS. The respective roles of plastic and orthopedic surgery in limb salvage. *Plast Reconstr Surg.* 2011 Jan; 127 Suppl 1():215S-227S.

3. Levin LS. The reconstructive ladder. An orthoplastic approach. *Orthop Clin North Am.* 1993 Jul; 24(3):393-409.

4. Heitmann C, Levin LS. The orthoplastic approach for management of the severely traumatized foot and ankle. *J Trauma.* 2003 Feb; 54(2):379-90.

5. Tintle SM, Levin LS. The reconstructive microsurgery ladder in orthopaedics. *Injury.* 2013 Mar; 44(3):376-85.

6. Boriani F, Ul Haq A, Baldini T, Urso R, Granchi D, Baldini N, Tigani D, Tarar M, Khan U, Orthoplastic surgical collaboration is required to optimise the treatment of severe limb injuries: A multi-centre, prospective cohort study. *J Plast Reconstr Aesthet Surg.* 2017 Jun; 70(6):715-722.

7. Ilizarov GA. Clinical application of the tension-stress effect for limb lengthening. *Clin Orthop Relat Res* 1990; 250:8–26

8. Dror Paley. PRECICE intramedullary limb lengthening system, *Expert Review of Medical Devices* 2015; 12:3, 231-249,

9. Kirane YM, Fragomen AT, Rozbruch SR. Precision of the PRECICE® internal bone lengthening nail. *Clin Orthop Relat Res.* 2014; 472(12):3869–78.

10. Hammouda AI, Jauregui JJ, Gesheff MG, Standard SC, Conway JD, Herzenberg JE. Treatment of post-traumatic femoral discrepancy with PRECICE magnetic-powered intramedullary lengthening nails. *J Orthop Trauma* 2017; 31(7):369–74.

11. Schiedel FM, Vogt B, Tretow HL, Schuhknecht B, Gosheger G, Horter MJ, *et al.* How precise is the PRECICE compared to the ISKD in intramedullary limb lengthening? Reliability and safety in 26 procedures. *Acta Orthop* 2014; 85(3):293–8.

12. Calder P, McGrath A, Chasseaud M, Timms A, Goodier W. The precice intramedullary limb lengthening system: early results. *Orthopaedic proceedings* 2013; 95-B(SUPP_23):11–11.

13. Benacquista T, Kasabian AK, Karp NS. The fate of lower extremities with failed free flaps. *Plast Reconstr Surg.* 1996;98:834–40.

14. Weiland AJ, Moore JR, Daniel RK. The efficacy of free tissue transfer in the treatment of osteomyelitis. *J Bone Joint Surg Am.* 1984;66:181–93.

15. Swartz WM, Mears DC. The role of free tissue transfer in lower extremities reconstruction. *Plast Reconstr Surg.* 1985;76:364–73.

16. Melissinos EG, Parks DH. Post trauma reconstruction with free tissue transfer: Analysis of 442 consecutive cases. *J Trauma.* 1989;29:1095–102.

17. Mooney JF, 3rd, DeFranzo A, Marks MW. Use of cross-extremity flaps stabilized with external fixation in severe pediatric foot and ankle trauma: an alternative to free tissue transfer. *J Pediatr Orthop.* 1998;18:26–30.

18. Myers MB, Cherry G. (1967) Augmentation of tissue survival by delay: an experimental study in rabbits. *Plast Reconstr Surg* 39(4):397–401).

19. Milton SH. (1969) The effects of "delay" on the survival of experimental pedicled skin flaps. *J Plast Surg* 22(3):244–252)