CHAPTER **14**

Masquelet Technique for Reconstruction of the Ankle Following a Traumatic Infected Nonunion: A Case Presentation

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INTRODUCTION

Treating segmental bone loss after trauma, avascular necrosis, nonunion, tumor, or infection can be arduous. The most common approaches for the treatment of large bone deficits include vascularized free bone transfer and Ilizarov bone transport method. In recent years, Masquelet introduced the concept of combining induced membranes and cancellous autografts for reconstruction of significant bone loss (1-4). This case study presents our technique for reconstruction of large bone deficits in the foot and ankle, in which standard bone grafting techniques are inadequate.

LITERATURE REVIEW

The Masquelet technique was introduced in 1986 (1). The technique is a 2-stage procedure utilized for the repair of bone defects (1-4). In the presence of an infection, a thorough debridement of the infected site is necessary in order to obtain a clean cavity (5). Utilizing polymethylmethacrylate (PMMA), a cement block is then fashioned in the form of the defect, which serves as a spacer to maintain the space for grafting and later reconstruction, and induces a synovial-like membrane (3-4). The induction of the fibrous tissue membrane around the bone defect is accomplished by taking advantage of the foreign body reaction to the presence of the PMMA spacer (6-7). The purpose of the membrane is to avoid resorption of the bone graft and to secrete growth factors, including vascular endothelial growth factor, transforming growth factor beta-1, bone morphogenetic protein 2, and bone progenitor cells, which contribute to osteoinductive properties, in order to promote revascularization of the graft (4, 6). The inner portion of the membrane is a synovial-like epithelium and the outer portion is composed of fibroblasts, myofibroblasts, and collagen (4, 6). The spacer is then removed after 6-8 weeks by incising the formed induced membrane (1, 6). At this point, the bone graft, which is typically autologous and harvested from the iliac crest, is inserted into the defect as morcellized cancellous chips (3). When the amount of autograft is not sufficient, or to preserve the iliac crest, bone substitute is added to the cancellous bone in a ratio 1:31. The membrane is then closed over the graft (1).

There has been abundant literature published on the Masquelet technique (1-7). However, the published articles mostly pertain to the femur and tibia, as the Masquelet technique involves long bone segmental deficits. This technique has been utilized successfully for diaphyseal bone loss up to 25 cm in length, without the need for a vascularized free bone graft transfer (4, 6). There has been limited focus in the foot and ankle literature for the use of this technique.

CASE STUDY

A case is presented of a 58-year-old man with type II diabetes mellitus. He has a remote adolescent smoking history, and a 5.5 cm deficit of the distal tibia following an infected nonunion of a trimalleolar ankle fracture. The severely comminuted open ankle fracture was sustained in the water after hitting a submerged boulder. The patient was initially treated at a trauma center, were he underwent several surgeries including application of an external fixation device, multiple irrigation and debridements, removal of external fixator, and open reduction internal fixation of the right ankle. The patient was placed on oral augmentin and ciprofloxacin in the emergency department. He then received intravenous ceftaroline for 2 months, despite being told he was "not infected." The patient then choose to follow-up at our facility due to a long-term history of treatment, after having sustained a calcaneal fracture with later subtalar joint arthrodesis in 2009 on the contralateral limb.

At this point, the patient presented to us with painful right residual ankle dislocation, with an associated open ulcer, which probed to hardware. In December 2012, a debridement was performed with removal of infected hardware and bone biopsies. We consulted infectious disease, who changed the patient to ertapenem and daptomycin due to his repeated positive bone cultures. The patient continued intravenous antibiotics via PICC, routine wound debridements, as well as, hyperbaric oxygen treatment to close the wound (Figure 1). Surgical debridement of the tibia and talus was performed followed by insertion of a PMMA spacer (Figure 2). Due to the lingering infection,

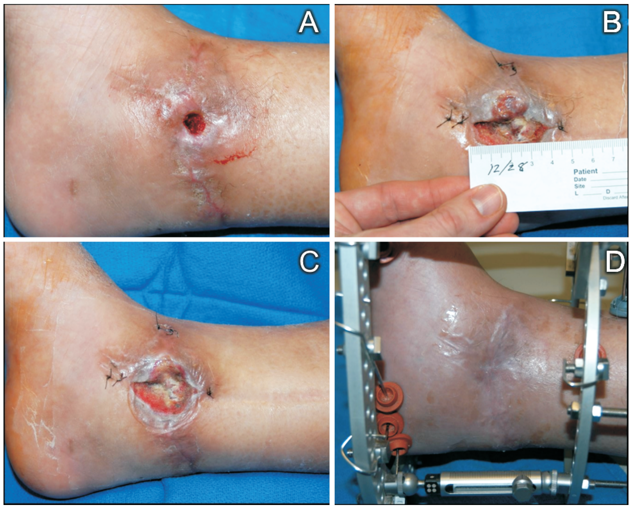

Figure 1A and B. Draining sinus tract. C. Wound after debridement with partial closure and VAC. D. Complete closure of the medial ankle wound.

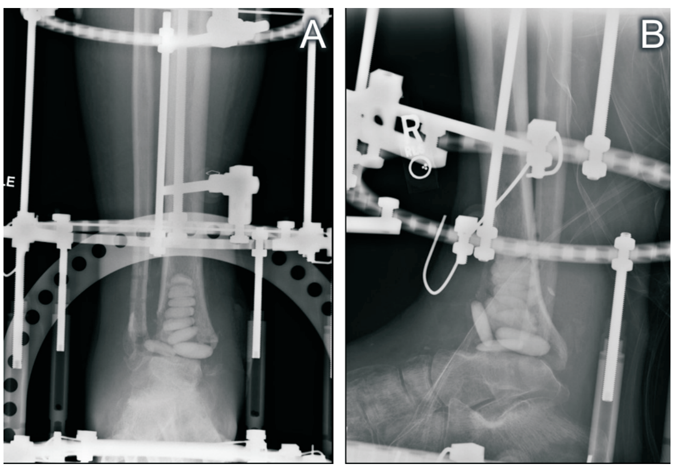

Figure 3A and B./ Antibiotic wafers for induced membrane after treatment of infection.

the final spacer used for the Masquelet technique was not inserted until a clean cavity was obtained (Figure 3).

In June 2013, the antibiotic wafers shown in Figure 4 were completely removed and the induced membrane visualized. Definitive reconstruction included revisional ankle arthrodesis with modification of the external fixator and harvest of an autologous iliac crest bone graft. The iliac crest bone graft was mixed with 5 ml of a cryopreserved stem cell demineralized bone matrix, 15 ml of cancellous allograft bone chips, and platelet rich plasma, which was then packed tightly into the membrane (Figure 5). The membrane was reapproximated utilizing 2-0 Vicryl in a running interlocking fashion. The deep fascial layer was repaired with 3-0 Vicryl. A 2.5 x 2.5 cm amniotic tissue graft was utilized to reinforce the fragile extensor retinaculum, which had been surgically insulted multiple times. The skin and subcutaneous layers were reapproximated with 2-0 Nylon in an interrupted horizontal mattress fashion.

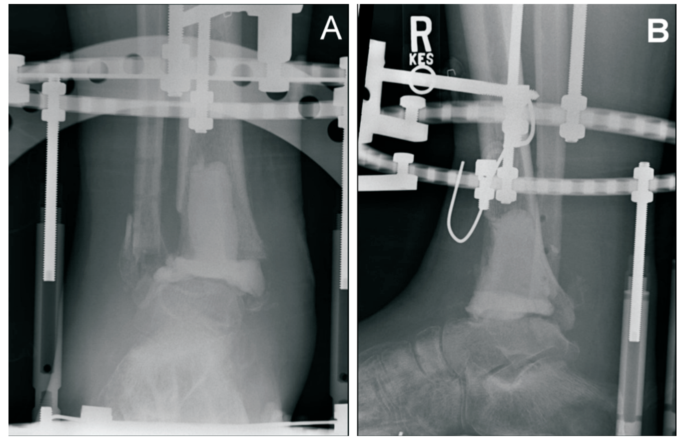

Figure 2A and B. Radiographs of the antibiotic spacer for treatment of infection.

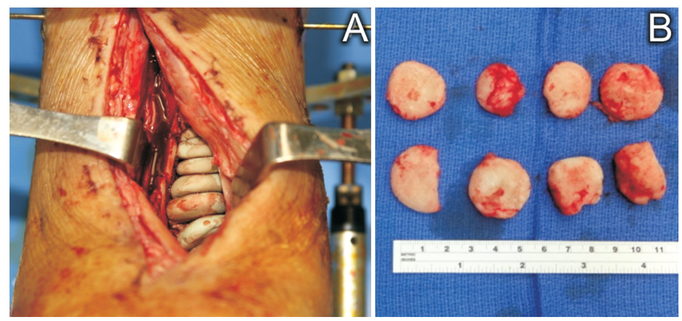

Figure 4A. Induced membrane encircling antibiotic wafers. B. Antibiotic wafers.

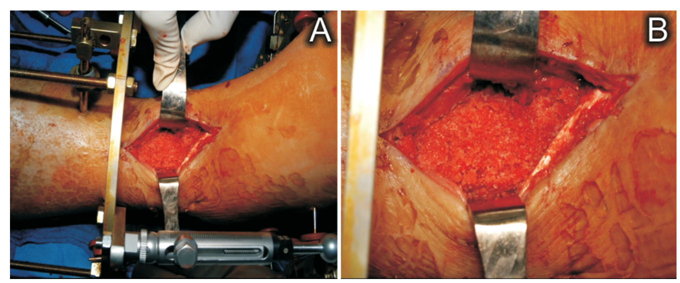

Figure 5A and B. Arthrodesis site packed with autogenous iliac crest bone graft, stem cell DBM, allograft cancellous bone chips, and platelet rich plasma.

The frame was gradually compressed and remained on for another 6 months.

Trimethoprim/sulfamethoxazole and ciprofloxacin were continued as warranted over this time period due to the history of chronic infection, as well as the presence of 1 pin tract infection, which resolved without further complication. The patient was non-weightbearing throughout the entire process.

At 17 months follow-up after definitive reconstruction with iliac crest bone graft and external fixator frame modification, clinical and radiographic assessments of the ankle revealed consolidation of the ankle joint, resolution of all wounds, and no further signs of infection (Figure 6). The patient has returned to full activity, and is now ambulating as tolerated without assistance.

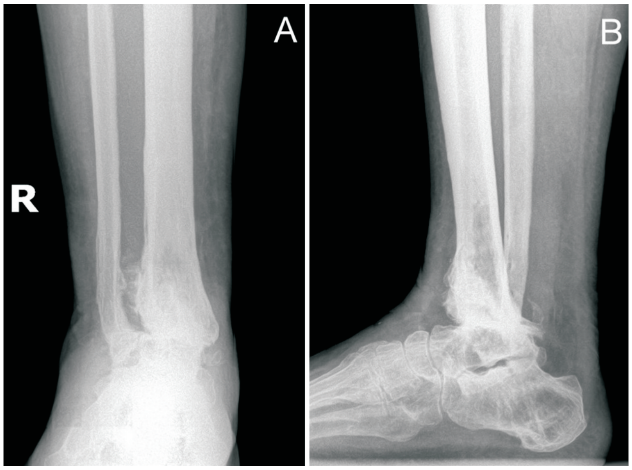

Figure 6A and B. Consolidation of the arthrodesis site.

DISCUSSION

This case study details the use of the Masquelet technique for the treatment of large segmental bone loss in the foot and ankle. The goal of this technique is to restore bone deficits in which standard bone grafting techniques would fail. With the evolution of orthobiologics, including growth factors and stem cells, there is room for variations on our technique. We have utilized this technique in another patient with success; the only difference being another allograft comprised of cancellous bone with viable osteogenic and osteoprogenitor cells was utilized. However, the second patient is still in follow up and final radiographic ankle consolidation has yet to occur.

The Masquelet technique is a effective method for the treatment of bone loss. This technique should not be untaken lightly. Both the physician and patient should be mentally and physically prepared for multiple surgeries and potential complications along the way. However, when used in the appropriate patient and setting, this technique can provide an alternative to loss of limb.

REFERENCES

1. Masquelet AC, Begue T. The concept of induced membrane for reconstruction of long bone defects. Orthop Clin North Am 2010;41:27-37.
2. Pelissier P, Masquelet AC, Bareille R, Pelissier SM, Amedee J. Induced membranes secrete growth factors including vascular and osteoinductive factors and could stimulate bone regeneration. J Orthop Res 2004;22:73-9.
3. Karger C, Kishi T, Schneider L, Fitoussi F, Masquelet AC. Treatment of posttraumatic bone defects by the induced membrane technique. Orthop Traumatol Surg Res 2012;98:97-102.
4. Giannoudis PV, Faour O, Goff T, Kanakaris N, Dimitriou R. Masquelet technique for the treatment of bone defects: tips-tricks and future directions. Injury 2011;42:591-8.
5. Assal M, Stern R. The Masquelet procedure gone awry. Orthopedics 2014;37:e1045-8.
6. Yin Q, Sun Z, Gu S. (Progress of Masquelet technique to repair bone defect). Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi. 2013;27:1273-6.
7. Aho OM, Lehenkari P, Ristiniemi J, Lehtonen S, Risteli J, Leskela HV. The mechanism of action of induced membranes in bone repair. J Bone Joint Surg Am 2013;95:597-604.