Custom Cages in Foot And Ankle Reconstruction

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INTRODUCTION

Revision ankle reconstruction/arthrodesis is particularly challenging when there is severe bone loss secondary to avascular necrosis, bone loss from prior surgery, or trauma creating complex defects. With the complicated geometry of the talus within the mortise there is no straightforward technique that has stood the test of time for anatomic reconstruction that maintains height and does not collapse over time. A reconstruction/arthrodesis with a custom cage filled with morselized autograft, and the addition of allograft products as needed to fill the void, may offer an alternative. To my knowledge this is the first case reported utilizing a custom cage for ankle arthrodesis with a defect fixated with an ankle fusion plate.

I believe that the first case utilizing a cage for reconstruction of the ankle was performed in 2006 (1). There have been well-published outcomes on treating segmental bone loss with cages in the tibial shaft with good results (2-4). Henricson reported a series of 13 patients using a trabecular metal implant for ankle arthrodesis after failed total ankle replacement, and described good bone-to-implant interface with healing (5). The approach to reconstruct the ankle utilizing spinal cages or other metal structural implants have all been performed in conjunction with an arthrodesis nail (1,5,6). There has been very little long-term follow up, and few results with this approach in the foot or ankle have been published.

CASE PRESENTATION

A 56-year-old male presented to our emergency department 4 days after a fall from a rooftop and subsequent surgery that included open reduction and screw insertion of a talar body fracture, application of a delta frame external fixator, pinning across the subtalar and ankle joints, and open fracture soft tissue debridement with closure. The patient had a history of coronary artery disease, myocardial infarction, and hepatitis C.

The patient was appointed to the orthopaedic clinic where his physical examination revealed a delta frame across the ankle and subtalar joint with percutaneous pin through the heel. His vascular and neurological examinations were abnormal. Pulses were non-palpable secondary to severe edema but were audible per Doppler examination. There was diminished sensation along the course of the sural nerve. His radiographs and computed tomography (CT) scan showed the ankle mortise to be adequately aligned with external fixation, percutaneous pin crossing the subtalar and ankle joints, a nonunion or malunion of an old fibular fracture, and 2 screws in body of the talus fixating a talar body fracture (Figures 1, 2). With adequate alignment of the fracture and external fixator, no further surgical reduction was needed at that time, but the percutaneous pin was pulled at his initial visit.

Ten weeks after the external fixator was applied, it was removed in the operating room. After the external fixator was removed, the patient did not follow up and missed several appointments. Twenty-one months after the injury and initial surgery, the patient came to the clinic, complaining of increasing swelling and pain with ambulation. Radiographs were taken, which showed a loss of the ankle and subtalar joints as well as lucencies within the talus and distal tibia (Figure 3). The patient was instructed by orthopedics to follow up in 3 weeks for further evaluation and treatment and to be non-weightbearing on

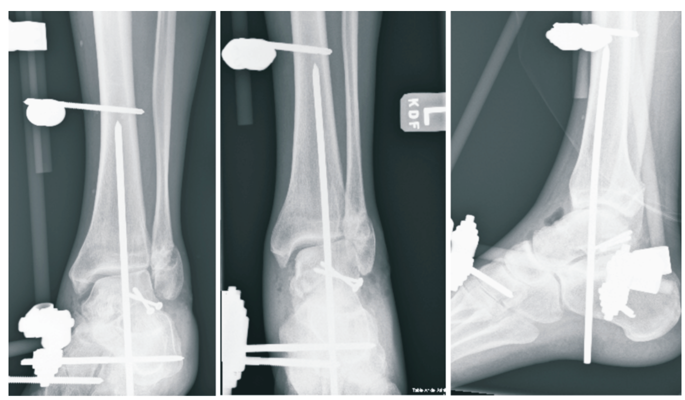

Figure 1. Radiographs from a different hospital, showing the initial injury after the talar fracture fixation with external fixation, and a pin across the subtalar joint and ankle. Note the old fibular fracture.

Figure 2. Computed tomography scan from the initial treating hospital 2 days after open reduction internal fixation of the talus. Good reduction of talus fracture fragment and good ankle alignment are shown.

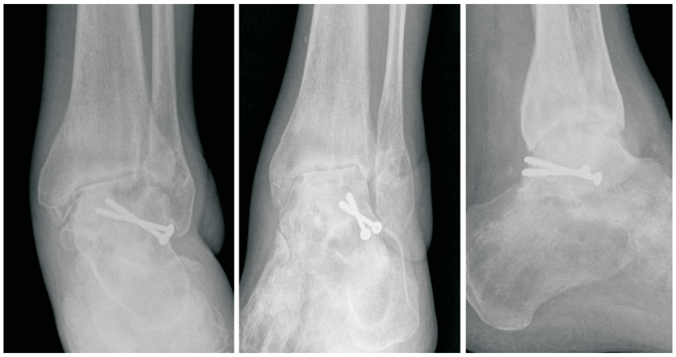

Figure 3. Radiograph showing total loss of the ankle joint and subtalar joint.

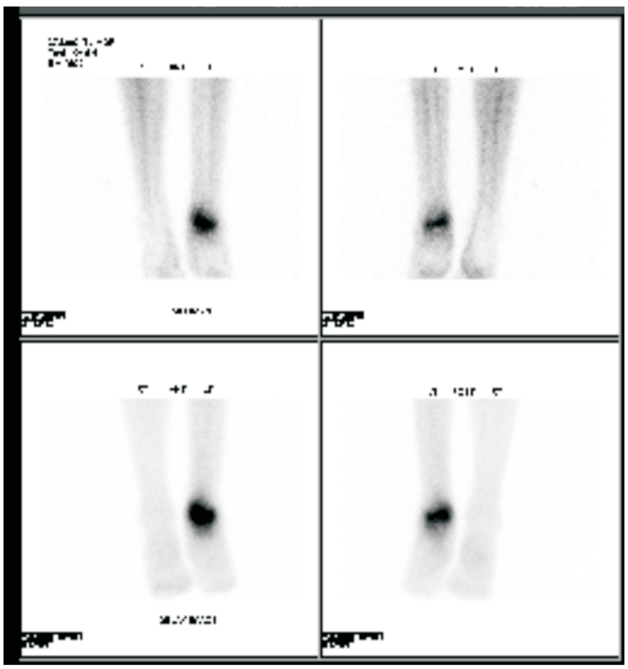

Figure 5. Triple-phase bone scan and white blood cell labeled scans with increased uptake at the left ankle. The findings are consistent with osteomyelitis.

crutches until that appointment. Once again the patient missed several appointments and presented to the clinic 5 months after the last clinic appointment ambulating on the foot. Radiographs at this time showed further lucencies and collapse of the ankle and subtalar joint as well as the talar body (Figure 4). A triple-phase and white blood cell labeled scan were ordered at this time to aid in the differentiation of avascular necrosis versus osteomyelitis. The radiologist reported that both the triple-phase scan and the white cell labeled scan were consistent with osteomyelitis (Figure 5). Orthopedics treated him with a course of 12 weeks of intravenous antibiotics recommended by infectious disease and non-weightbearing.

The patient was then referred to the foot and ankle clinic from the orthopedic trauma clinic for evaluation and treatment. On his initial visit, an ankle arthrocentesis and joint fluid analysis and full blood work up was performed.

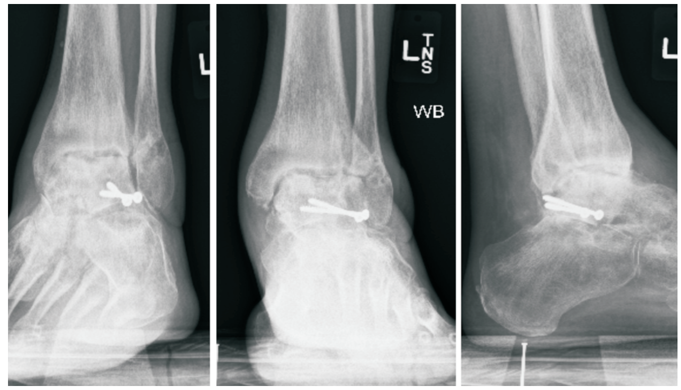

Figure 4. Radiograph showing collapse of the talus.

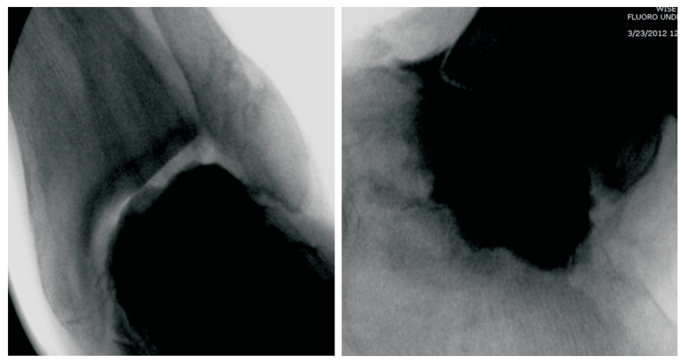

Figure 6. Fluoroscopy of ankle with debridement of non-viable bone and insertion of antibiotic impregnated cement.

His ankle joint fluid analysis showed no white cells and his hematology laboratory values were all within normal limits. After a lengthy discussion with the patient concerning his 50-60% chance of a below-the-knee amputation, he was scheduled for surgery. His scheduled surgery was bone biopsy of the talus, tibia, calcaneus, and fibula with excision of all non-viable bone. The surgical approach was through an 8-centimeter anterior incision. The talar head and neck were firm and appeared to be viable but the talar body was soft and not viable. An osteotomy through the talar neck was performed utilizing a large osteotome and the talar body was removed and sent to pathology. The distal tibia was also soft and non-viable so an osteotomy was performed utilizing the osteotome, and all soft non-viable bone was removed and sent to pathology. Punch biopsies of the dorsal calcaneus and the fibula were harvested and sent to pathology.

The surgical site was then flushed with 6 liters of saline and examined for any remaining non-viable bone, of which none was found. Palacos cement, which contains tobramycin, with the addition of vancomycin and gentamycin was inserted to fill the void of the removed bone while awaiting the pathology results (Figure 6). Postoperatively 2 weeks after debridement and insertion of antibiotic impregnated cement, the wound was healing well with no edema or sign of infection. Pathology results of the bone biopsy samples were negative for osteomyelitis. The distal tibia was read as

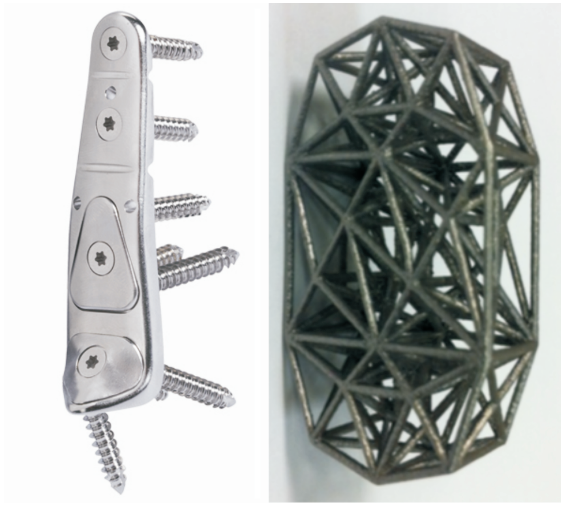

Figure 7. Image of the anterior ankle fusion plate and trabecular cage.

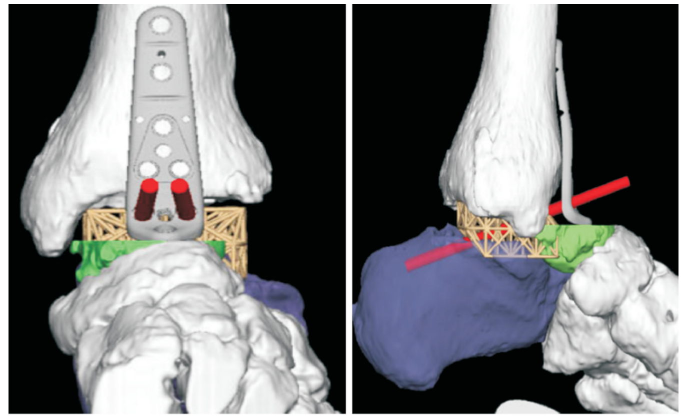

Figure 8. Three-dimensional computerized reconstruction of the hindfoot with anterior plate computer diagram and planned custom cage design.

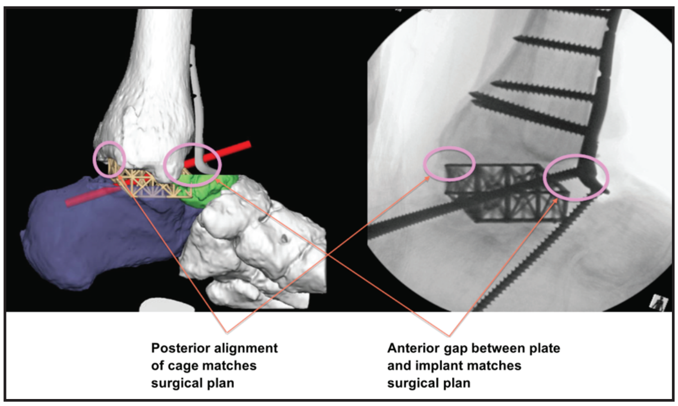

Figure 9. Computed tomography scan of reconstruction with cage and plate compared to postoperative lateral radiograph with cage and plate inserted.

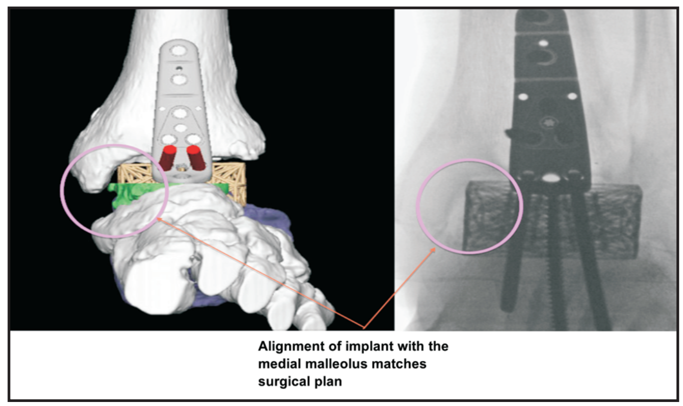

Figure 10. Computed tomography view of reconstruction with cage and plate compared to postoperative anterioposterior radiograph with cage and plate inserted.

severe degenerative joint disease with cystic changes, and the talus was diagnosed with severe osteonecrosis.

In planning for surgical reconstruction, the decision was made to use a custom designed cage from Four Web Medical (Dallas, TX) to fill the void as well as to maintain the length of the limb. The site would be fixated with the Stabilis anterior ankle arthrodesis plate (Tornier, Inc) (Figure 7). A CT scan was done of the ankle and hindfoot and the images were sent to engineers for both companies. The custom cage was designed to accommodate the screws that would pass through the cage and into the calcaneus for fixation. The digital computerized images were sent to me for approval from the engineers (Figure 8).

The previous anterior incision was utilized for the procedure. The cement filler was removed and the void was flushed with 6 liters of saline. Following copious flush, the dorsal calcaneus, distal tibia, lateral side of the medial malleolus, and the medial side of the distal fibula were debrided of all tissues. Drilling of all the surfaces was then performed with a 2.5 mm drill bit. An orthopedic resident harvested over 20 ccs of cancellous bone from the iliac crest. This bone was then packed firmly into the entire cage until it was filled.

The cage was then placed into its planned site as close as possible to the computerized images for easy insertion of the anterior fusion plate. The anterior fusion plate was then applied, placing screws through the tibia and through the cage into the calcaneus. Intra-operative images were taken to confirm placement and alignment of the cage (Figures 9 and 10). Ten ccs of Grafton bone putty with cancellous bone chips was then inserted to fill any remaining defects.

At his first postoperative appointment following the insertion of the cage and plate, the patient had minimal edema, rectus alignment of the ankle, and the incision was intact and appeared to be healing well. The patient was seen at 3 weeks postoperatively and his sutures were removed. He was then placed in a non-weightbearing below-the-knee cast. He was seen at 7 weeks postoperatively and everything appeared to be healing well and he was placed back into another non-weightbearing below-the-knee cast. At his 12-week postoperative appointment, radiographs showed good alignment of the ankle with trabeculation crossing both the

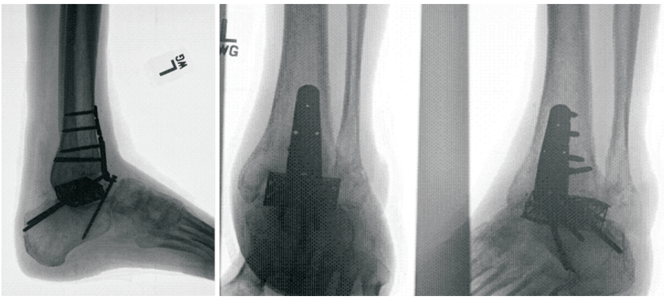

Figure 11. Radiograph at 12 weeks postoperative, showing good alignment and bone healing.

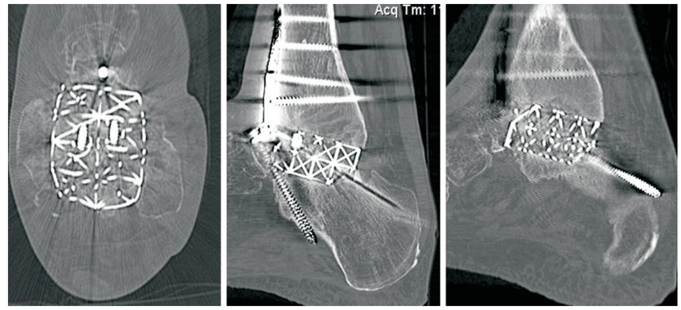

Figure 12. Computed tomography scan at 5 years postoperative showing good alignment of the hindfoot and bone growth throughout the cage and both fusion sites.

dorsal and plantar fusion sites (Figure 11). The patient was then allowed to begin progressive weight bearing in a fracture boot for 6 weeks, then was released to normal shoe gear.

At 5 years postoperative, the patient came into the clinic with an unrelated issue affecting the other foot. He reported no pain and normal gait on the reconstructed side. A CT scan was ordered of the ankle and hindfoot, which showed good alignment and bone growth throughout and around the cage and fusion sites (Figure 12).

DISCUSSION

Reconstruction of the ankle and hindfoot with bone defects poses a challenge at the revision surgery. A key to success is to find a way to obtain anatomic alignment and to prevent long-term collapse of the graft used. Utilizing a custom cage packed with autograft, and an anterior ankle fusion plate provides for a rigid construct and an implant that will not subside or collapse over time. I believe that custom cages being utilized in the right cases are a viable option for reconstruction.

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