CHAPTER **19**

REVISION ANKLE ARTHRODESIS

Kieran T. Mahan, DPM
Jarrett Cain, DPM

Ankle fusions have been the procedure of choice for a variety of deformities of the ankle. In the appropriate conditions, the procedure can be quite successful in alleviating pain and deformity.[1] This technique, which is designed to create a bony union across the tibiotalar joint, has a goal of creating a painless, plantigrade, and stable joint.[2,3] The indications for this procedure include a wide span of diseases such as post-traumatic arthritis, rheumatoid arthritis, talar collapse, drop foot, tumors with joint invasion, neuromuscular deformities, failed ankle joint prostheses, paralytic deformities, avascular necrosis of the talus, septic destruction of the joint, and crush injuries.[2] The most common indication for an ankle fusion is post-traumatic arthritis following a malleolar or pilon fracture.[4] Though severity of ankle joint destruction varies from disease to disease, the underlying indications for ankle arthrodesis are significant pain, severe deformity, and severe instability of the ankle joint while subjective indications include daily pain, significant limitation of activity, the desire to function free of braces, or the desire to reduce the need for specialized shoes.[2]

APPROACHES

Surgeons have developed a spectrum of approaches and techniques. No single procedure is the universal standard operation in achieving arthrodesis of the ankle. There are two anterior approaches: a transverse anterior approach and a midline longitudinal approach. The transverse anterior approach was initially described by Charnley[5] and was designed for the talus and the lower surface of the tibia. This approach provides excellent exposure but is likely to cause interruption of neurovascular structures. The midline longitudinal approach gives good exposure over the anterior aspect of the joint, particularly the lower end of the tibia, but not the posterior aspect of the joint. It also provides limited visualization of the malleoli.

Glissan[6] described a medial malleolar approach that gives good exposure to the medial, anteromedial, and posteromedial aspects of the joint. Furthermore, the medial malleolus can be repaired, used for bone graft in fusion of the ankle joint, or discarded. Anteromedial and anterolateral approaches have been described to provide good exposure of the anterior ankle and the respective malleoli.[7] A posterior approach to ankle joint resection provides poor visualization of the ankle joint and may cause unintended harm to the subtalar joint. This approach should be reserved for patients with poor anterior skin coverage and when performing a subtotal fusion.[8]

The lateral approach begins with a hockey-stick incision over the lateral aspect of the fibula, crossing over the lateral aspect of the neck of the talus, and ending at the base of the fourth metatarsal.[9] This approach, which may require an ancillary medial incision for removal of cartilage of the medial malleolus, may be combined with osteotomy and reflection of the fibula and provides excellent exposure of all aspects of the ankle joint.

The surgical approach chosen by the surgeon is predicated on the exposure needed to achieve complete removal of the joint, visualize the alignment of the ankle, and achieve fixation.

TECHNIQUES

Techniques for fusion can be grossly simplified into the following categories: articular wedging (with or without bone grafting), articular wedging combined with malleolar osteotomy, anterior arthrodesis with inlay grafting, dowel and other subtotal fusions, compression arthrodesis, arthroscopic resection, and other miscellaneous techniques. The standard by which a technique can be measured against is Glissan's four requirements for successful fusion: 1) complete removal of all cartilage, fibrous tissue, and any other material that may prevent bone to bone contact; 2) accurate and close fitting of the fusion surfaces; 3) optimal position of the ankle joint; and 4) maintenance of the bone apposition in an undisturbed fashion until the

fusion is complete.[6]

The simplest technique, arthrectomy, involves excision of all cartilage in the joint. The goal of this technique, which may or may not involve packing of the bone graft as a supplement technique, is to achieve bone-to-bone contact. Goldthwait[10] performed this technique through a U-shaped incision and Hallock[11] added the use of the tibial graft. Chuinard and Peterson[12] inserted autogenous iliac crest graft to create distraction compression without causing damage to open epiphyses in children.

Another technique utilizes the anterior bone graft across both sides of the ankle to facilitate fusion.[13] The most common technique is using a graft slid down from the distal metaphysis. Although the graft does not provide stability, the quality of bone is very good.

In combination with joint resection, a malleolar osteotomy of either the fibula or the tibia can be used as a strut graft across the joint or as a filler bone graft to promote bone-to-bone contact. Glissan[6] demonstrated the use of the medial malleolus to achieve ankle fusion. Horwitz[9] described dividing the fibula malleolus into halves longitudinally and using the anterior half as a graft for fusion and the lateral half as an onlay graft to the lateral side of the talus and the tibia. Wilson[14] used a bimalleolar approach with the tibial graft medially, and the lateral half of the longitudinal hemisection of the fibula as an onlay graft anterolaterally. Complete removal of the distal fibula was described by Verhelst et al.[15] Modifications involving malleolar osteotomies have been performed by different surgeons using this approach.

There are situations where the joint can be fused without total resection of the joint itself. These procedures, known as subtotal fusion techniques, are indicated in patients who cannot tolerate long surgeries with extensive joint resection. This procedure does not allow for correction of position. Pridie[16] demonstrated this technique through a medial approach and a medial malleolar osteotomy to visualize the ankle joint. Once the central portion of a joint was removed, bone chips were used to fill in the space.

One of the most popular techniques for achieving ankle fusion is compression arthrodesis. Charnley[5] advocated the use of the procedure through the use of external fixation. Charnley concluded that there are two advantages in the use of compression arthrodesis: elimination of shearing strains and prevention of gap formation at the fusion site. Morgan et al[17] demonstrated compression arthrodesis through internal fixation by crossing screws into the talus, one from the medial malleolus and one from the lateral malleolus. Compression arthrodesis in one form or another has become a standard technique.

Arthroscopic ankle technique has become a well-described procedure for certain indications in the ankle joint.[18-20] Myerson and Allon[21] describe this technique as an attractive alternative to open techniques. However, this operation method is limited in its ability to correct significant preoperative deformity.[22,23] This approach has been modified by Yee,[24] Wang,[25] and Paremain.[26]

Another procedure that is utilized is the Blair tibiotalar arthrodesis for injuries to the talus.[27] This procedure involves a sliding anterior tibial graft. Urquhart et al[28] utilized this method in three patients with a vascular necrosis of the talus. Haverstock, Barth, and Jacobs[29] modified the method by using an autogenous iliac bone graft in a patient with systemic lupus erythematosus who developed avascular necrosis of the talus.

Although it is important to eliminate the cartilage and tissue from the ankle joint, it is equally crucial to maintain bone-to-bone contact. This is mainly achieved by three methods. The first method is bone graft stabilization through cancellous or cortical grafts. Although cancellous bone lacks the mechancal strength to resist forces in any direction, cortical bone does posses mechanical strength, but begins its healing phase by reabsorbing that will result in the initial decline in mechanical strength.[2] These methods provide little stability and must be used in combination with another form of fixation. Bishop, Wood, and Sheetz[30] performed arthrodesis of the ankle with free vascularized grafts in patients with massive loss of bone. Stranks, Cecil, and Jeffery[31] performed arthrodesis with the dowel grafting technique in combination with another form of fixation.

Another method of fixation that exists is external fixation. Devices that have been reported in the literature are the Charnley, Hoffman, Muller four-pin, Muller two-pin, and the Ilizarov external fixators. Charnley[5] described using an external fixator frame for ankle arthrodesis by placing a Steinmann pin in the talus and in the tibia between bilateral bars to apply compression. His fixation device shows little consideration for biomechanical

principles and is unstable with any rotation.[32] Berman et al[33] modified the Charnley frame by placing a pin through the first metatarsal and attaching this to the pins in the tibia, resulting in a triangular configuration, thus creating a triangular external fixator. The Hoffman external fixator[34] places two pins in the tibia and across the talus and has been indicated for ankle fusion. Carlsson, Montgomery, and Besjakov[35] utilize the Hoffman external fixator as the dominant method for arthrodesis of the ankle in failed ankle arthroplasties. The four-pin Mueller and Calandruccio devices also require two pins across the talus.[36] Thordarson, Markolkf, and Cracchiolo[37] found that the Calandruccio clamp configurations caused tibiotalar motion when subject to plantar flexion-dorsiflexion bending moment. The small two-pin Mueller device doesn't provide much rigid stability since it has alignment in only one plane.[38] The Ilizarov external fixator has become useful in complex foot and ankle deformities because of its stability, adaptability, and weightbearing characteristics.[39-41] The Ilizarov frame utilizes tensioned small diameter Kirschner wires to stabilize bone and is an excellent option for fusion of the ankle joint.[42,43] The Ilizarov frame has the ability to adapt to any situation however extensive the deformity and is useful in multiplanar deformity.[44-46] With any external fixation device, it is important that the pins be placed parallel to each other and at an angle of approximately 15 degrees of external rotation. The fixators are removed under anesthesia (general or local) and are kept in for approximately 6-10 weeks under careful monitoring and cleansing to prevent pin-tract infection. External fixators provide static compression perpendicular to the fusion site and that compression that is created can be adjusted during the postoperative period. However, the major complications that accompany external fixators are pin-track infections, pin-track loosening, infection of the fusion site, and delayed wound healing.[45]

Internal fixation has become a standard technique for ankle fusion. Scranton[47] described the use of a T-plate compression device, which is applied medially by placing two screws to attach the plate to the talus and three screws to attach the plate to the tibia. Morgan[17] described crossing screws that are overdrilled through the tibia and the fibula. Monroe et al[48] described the use of multiple 6.5mm cancellous screws to gain solid fixation without removing the subchondral tibial and talar bone. Braly et al[49] Used two 6.5mm cancellous bone screws and a lateral T plate as a modification of internal fixation compression. Moore[50] and Pinzur[51] utilized retrograde locked intramedullary nail as a procedure for fusion of the ankle. Internal compression provides stabilization of the fusion site and allows early mobilization of adjacent hindfoot and midfoot joints.[52] Pfahler et al[53] found in a study comparing both internal and external fixation that internal fixation achieved fusion earlier. No matter what kind of fixation is used, the biologic events that lead to bone growth across the arthrodesis site and the ability of whatever method utilized to hold these bony surfaces together are important considerations when performing an ankle arthrodesis.[54]

The literature indicates a high rate of complications for ankle fusion.[55] There are a diversity of factors that influence successful fusion of the ankle such as non-union, malposition, loss of fixation, wound complications, deep infection, and adjacent joint pain.[56,57] Vogler found that planar malposition can cause severe long-term problems for patients.[57] Frey et al reviewed 78 ankles, reporting an overall complication rate of 56% and a higher complication risk of non-union in patients with a history of major medical problems and those with open injuries. The reported complications include non-union 41%, delayed unions 12%, infection 9% and malunion 3%. The authors found no significant correlation between the incidence of non-union and the technique used for fixation. Perlman and Thordarson[56] evaluated 67 fusions and found that high risk factors for non-union are: history of open trauma, tobacco use, alcohol use, illegal drug use, a history of psychiatric disorders or diabetes. The authors also found that patients who present with one or more of these risk factors have a high rate of non-union after ankle fusion. Cobb et al[58] reported that cigarette smokers have a 3.75-times greater risk of non-union in ankle fusion than non-smokers. Stuart and Morrey[59] reported a 62% complication rate in diabetic neuropathic patients. Lidor et al[60] reported stress fracture of the tibia after arthrodesis of the ankle as a differential diagnosis in patients with pain months after a solid fusion of the ankle joint. Complications can be frustrating and present a challenge to the surgeon.

When a bony union is not achieved in primary fusion procedures, additional surgery is required to accomplish union. Very little has been reported in

the literature to describe repair of failure after a primary ankle arthrodesis. Edelman and Fisher[61] reported the success of tibiocalcaneal arthrodesis in a patient who had two previous attempts at ankle fusion. Kirkpatrick et al[62] treated 9 of 11 patients with pseudoarthrosis after failed tibiotalar arthrodesis. The authors combined the use of supplemental bone graft with internal fixation, and postoperative cast immobilization. Kitaoka[63] used external fixation, internal fixation, and percutaneous pin fixation in patients who had a non-union following total ankle arthrodesis. He reported a success rate of 78%. Kitaoka et al[64] evaluated 26 patients who underwent revision of an ankle arthrodesis with external fixation. The authors used a supplemental bone graft and the success rate was reported as 77%. Anderson et al[65] reported a success rate of 85% in revision ankle fusions for non-unions and malunions by using internal compression arthrodesis with screw fixation. Mann and Rongstad[66] performed revisonal procedures in 12 ankles that were referred with a diagnosis of non-union of an ankle fusion. The authors performed a takedown procedure of the arthrodesed site and repeated rigid internal fixation and obtained a success rate of 75%. Though revision operations present challenges to the surgeon, the literature reports good success rates.

We will examine two cases of revisonal ankle arthrodesis.

CASE STUDY 1

A 42-year-old female presented to the Foot and Ankle Institute of the Pennsylvania College of Podiatric Medicine for severe pain in her left ankle joint. Her initial injury was sustained in a car accident. The patient had surgery to repair the ankle after the injury. On the initial visit, the patient was taking Naprosyn twice a day for pain, Dynacert for hypertension, Albuterol for asthma, and Seldane for allergies. She denied any allergies, any family history of diseases, and any relevant social history. Due to the severity of pain in her ankle, she was not employed.

The history is as follows: an ankle arthrodesis using a Blair procedure was performed 17 years after the accident on her left ankle. Less than a month later, closed reduction and removal of hardware with percutaneous pinning of the left ankle was performed. A year later on physical examination, patient presented with very significant swelling around the entire aspect of the left ankle with a slightly hypertrophic anterior incision. The patient experienced pain on palpation of the central, medial and lateral aspects of the ankle. Also on physical exam, excessive motion was present and a collapsed talo-navicular joint on the left foot was noted. The patient was not in any excessive valgus or varus on weightbearing and she is close to her right ankle with the foot loaded.

Radiographs revealed a lucency and a non-union at the ankle joint along with the presence of a palpable screw on the lateral aspect of the ankle joint. Stress-radiographic x-rays were performed and revealed significant motion at the talo-navicular joint with some spurring at the talar head.

A revisional ankle arthrodesis with external fixator, implanted bone stimulation, and autogenous bone graft from the iliac crest was performed under general anesthesia. The talo-navicular joint was fused at the same time. During her 3-month postoperative visit, her external fixator frame was removed under anesthesia and the patient was placed in a removable cast and allowed light partial weight bearing. The radiographic examination continued to show excellent alignment and very good consolidation of the ankle fusion site. During her 4-month postoperative visit, an osseous bridge in the anterior aspect of the ankle was present and in good alignment. The fusion site of the talo-navicular joint was consolidating well although it was not complete. Her visits continued at 5, 6, 7, 9, 11, and 12-month postoperative with progressive consolidation of the ankle joint and removal of the electrical stimulator through surgery 13 months postoperative. During the 9-month post-op visit, complete consolidation of the ankle joint was seen and the 13-month postoperative visit showed both fusion of the ankle joint and the talo-navicular joint. She successfully returned to most activities.

CASE STUDY 2

A 37-year-old woman presented to the Foot and Ankle Institute of the Pennsylvania College of Podiatric Medicine for treatment of a history of a very severe open fracture dislocation of her right ankle that had occurred 6 years prior. Her original injury consisted of a high fibular fracture as well as a fracture of the medial malleolus and the lateral aspect of the tibial mortise of the right ankle, con-

sistent with an open pronation external rotation stage IV based on the Lauge Hansen classification. On the date of the injury, the patient had irrigation, debridement, and open reduction with internal fixation. It was noted that the patient had an anterior subluxation, that led to revisional surgery of closed reduction of the ankle followed by open reduction with a transfixion screw across the calcaneus into the tibia. Appropriate alignment of the ankle joint was still not restored and the patient had trouble ambulating on her right foot. Because of her persistent inadequate reduction and continued pain, the patient underwent an ankle fusion with iliac bone graft 2 months later. After 9 months, the patient underwent a revisional right ankle fusion with bone graft from the iliac crest on the lateral side of the joint and a 6.5-mm cannulated screw.

On physical examination at presentation, to the Foot and Ankle Institute, the patient had significant tenderness to palpation on the lateral aspect of the sinus tarsi, elevated medial column, and limited range of motion of the first MPJ. The patient's ankle was fused in a significant valgus position, which caused her to roll over the medial column and first MPJ. The patient complained of ongoing medial knee pain, which correlated with the valgus position of her ankle fusion.

Standard radiographs revealed a complete fusion of the ankle joint. Significant narrowing of the subtalar joint was present. On the AP ankle view, the talus was in a valgus position.

Approximately, 8 months later, a subtalar joint fusion was performed with hydroxyapatile bone substitute and autogenous marrow to remove the valgus position along with a McBride bunionectomy. Fixation was accomplished with a 6.5mm screw.

After 5 months postoperative, the patient was improving in consolidation since the surgery and was continuing in her CAM walker, but attempting to wear a regular shoe. The patient was still experiencing pain in the first MPJ range of motion.

At 21 months following the fusion of the subtalar joint, the patient still complained of pain on the lateral side of her foot and pain in the first MPJ. Radiographic exam showed complete consolidation of the subtalar joint, but an arthritic first MPJ. The patient also demonstrated excessive pronation on ambulating and a wedge type callous formation on the medial side of the heel.

Approximately 2 months later, the patient underwent a Koutsgiannas procedure with an opening wedge graft to take the heel out of valgus and put it in a more rectus alignment along with a Keller bunionectomy to address the arthritic MPJ.

After 10 months, the patient had significantly increased her ability to be standing and weight-bearing for longer periods of time. Her alignment was excellent. It was then recommended that the patient get a soft orthosis to provide shock absorption on her right foot and to accommodate for the multiple surgeries that caused a limb length discrepancy.

DISCUSSION

When approaching the foot and ankle that requires revisional surgery, it is very important that the surgeon have a balance in management of the patient, the surgical problems that exist, and the factors that may have a significant impact when doing an additional surgery. These problems may be more precedent in doing a revisional surgery than in doing a primary procedure.

Although there are similarities in doing a primary or revisional ankle fusion surgery, differences exist in their application and outcomes. As stated earlier, one of the major complications in doing a primary ankle arthrodesis is non-union. This was the primary concern in case study 1. The patient presented with signs and symptoms of a non-union one-year after the primary procedure was performed. Plain radiographs confirmed the presence of a non-union in the left ankle. Many studies have shown that the rate of non-union is the highest in patients treated for posttraumatic arthritis and in those with open injuries to the ankle due to high energy of the original fracture.[67] Another cause for concern was the presence of excessive motion and collapse that was present in the talo-navicular joint in the left foot. Plain radiographs revealed spurring located at the talar head. The excessive instability present in the talo-navicular joint needed to be addressed. Addressing the biomechanical forces that exist in adjacent joints, primarily the subtalar, talo-navicular, and calcaneal-cuboid joints, is important in planning an arthrodesis of the ankle.[67] The revision surgery that was performed addressed the non-union of the ankle with an external fixator, implanted bone stimulation, and autogenous bone graft from the iliac crest. Along with the revision ankle surgery, fusion of the talo-navicular joint was

performed. Treatment of non-union by means of revisional surgery is best accomplished by multiple modalities.

Another complication that exists in primary ankle arthrodesis is malunion. This can cause an abnormal gait and weightbearing in the patient. In case study 2, the patient went on to have a revisional ankle fusion with iliac bone graft without the alignment ever being restored. Upon physical examination, the patient's ankle was in significant valgus position, which had a significant impact on the medial column. The subtalar fusion improved the alignment but not completely. To take the heel out of valgus, a Koutsgiannas procedure was performed with an inverting opening wedge graft. Myerson states that position failures largely result from either technical intraoperative errors or failure to appreciate the magnitude of the preoperative deformity.[68] Alignment of the ankle joint in an ankle arthrodesis is important in that any excessive varus or valgus deformity causes pain on ambulation in the patient and arthritis in adjacent joints because of the increase in mechanical load and stress.

Revisional ankle fusion may require multiple modalities to address the biologic and mechanic etiologies of an initial non-union. Alignment problems require a thorough understanding of the patients' limb alignment at multiple levels not simply the subtalar and ankle joints.

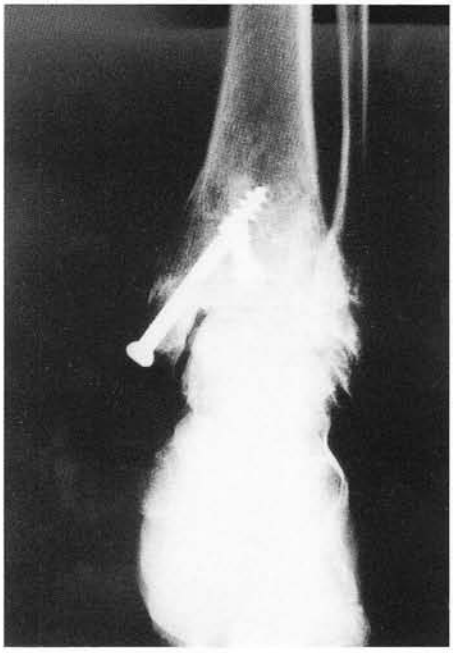

Figure 1. AP ankle view shows severe degenerative joint disease (Case 1).

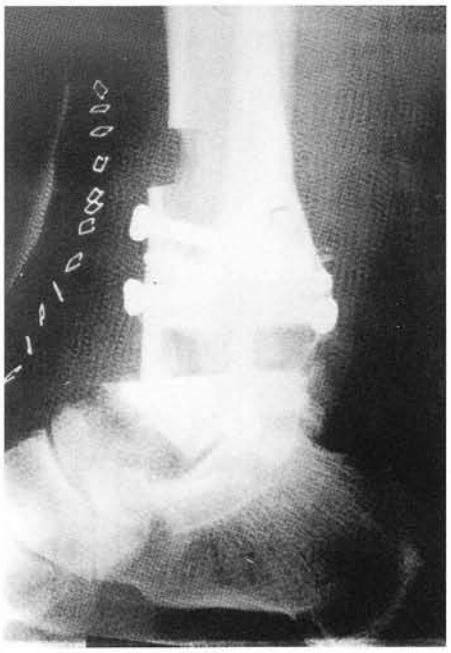

Figure 2. Lateral X-ray shows initial fusion attempt with sliding tibial graft. Note large space between talus and main portion of tibia (Case 1).

Figure 3A. X-ray views of failed primary fusion (Case 1). AP view shows non-union. Note also the horizontal screw that was palpable and painful laterally.

Figure 3B. Lateral view shows some continued separation between tibia and talus. Tibia has failed to fill in anteriorly at the site of sliding graft.

Figure 4. Lateral X-ray postoperatively after revisional fusion. Note external fixation for ankle fusion, anterior bone graft from iliac crest, use of internal bone stimulator at ankle, and screw fixation of talo-navicular fusion (Case 1).

Figure 5. Lateral X-ray shows full consolidation of fusion sites (Case 1).

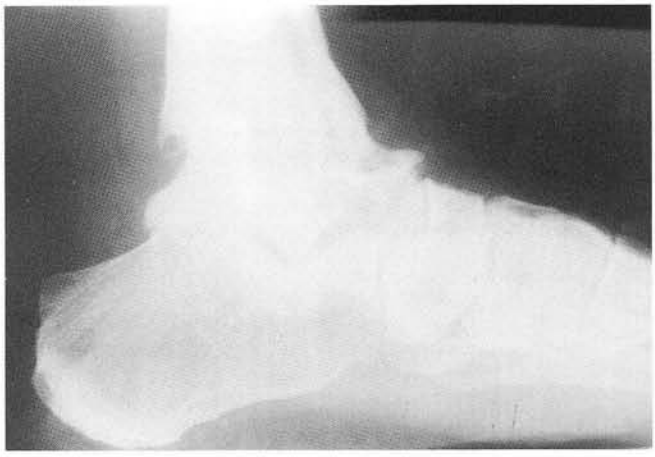

Figure 6A. Lateral X-ray shows severe subtalar degenerative joint disease.

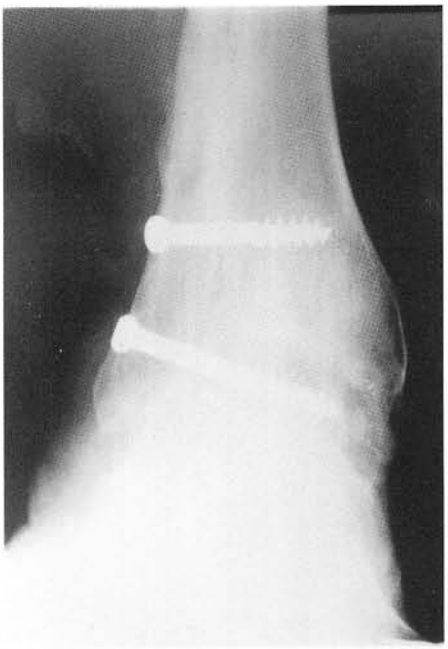

Figure 6B.AP ankle view demonstrates severe ankle valgus after ankle fusion.

Figure 7. Lateral view after subtalar fusion. Note two points of fixation (Case 2).

Figure 8A. X-ray views of Case 2 after calcaneal osteotomy to address valgus hindfoot. Lateral view demonstrates healed calcaneal osteotomy with 7.3mm cannulated screw fixation.

Figure 8B. Calcaneal axial view demonstrates good alignment of hindfoot.

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