CHAPTER 40

PRIMARY ANKLE ARTHRODESIS WITH EXTERNAL RING FIXATION

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INTRODUCTION

For over 100 years, arthrodesis of the tibiotalar joint has been the treatment of choice for end-stage ankle arthrosis resulting from multiple etiologies. The foot and ankle surgeon has several choices of techniques and methods of fixation. These include fusion without compression, internal fixation with a lag screw and external fixation. The key to a successful outcome of any ankle arthrodesis is to obtain and maintain rigid bone-to-bone contact in a correct position. The current mainstay in the initial surgical management of end-stage inflammatory and post-traumatic degenerative joint disease is compression arthrodesis using internal fixation.[1,2,3,4] With such a technique, compression is achieved intra-operatively and cannot be adjusted once the wound is closed. Historically, external fixation employed for ankle arthrodesis has been in complex situations and salvage procedures that preclude the use of internal fixation.[5] Such situations include active infection, poor bone quality, altered anatomy, inadequate soft tissue coverage and patient size. Its use in these circumstances has achieved very satisfactory results. More recently, however, external ring fixation has been used in simple situations of ankle arthrosis that require fusion. Extremely successful results have been reported.[5] The purpose of this paper is to provide the rationale for the use of external ring fixation as the procedure of choice for primary arthrodesis of the tibiotalar joint, regardless of the indication.

ARTHRODESIS AND EXTERNAL FIXATION

In 1951, Charnley described the concept of compression arthrodesis of various joints of the lower extremity by using a combination of transfixation bone pins and external clamps.6 Since that time, many devices have been described for arthrodesis of the ankle joint. These include Hoffman, Muller four-pin, Muller two-pin, Monolateral, Hybrid and Calandruccio.[7,8,9,10] All of these fixators are uni-planer in design and require the use of large diameter pins for fixation to bone. A uni-planar design, by nature, dictates that the patient remains non-weight bearing during the healing process. The benefit of using large diameter pins is that fewer are required for rigid fixation. The downside is that if one is removed from the construct, the stability of the frame is placed in jeopardy.

The use of rings, however, as developed by Ilizarov, allows the creation of a modular system that is multi-planar in nature. This type of design enables the device to be individualized to a particular patient's anatomy, thus facilitating the placement of wires. The wires used for fixation to bone are 1.5 mm and 1.8 mm. Eight to ten are normally necessary for an ankle fusion. If one of these wires necessitates removal, the frame would lose a minimum of stability. The compression created by the external ring construct and the multi-planar design provides excellent stiffness and shear rigidity to the ankle joint while allowing significant axial motion. This enables the patient early, functional weight bearing.[5,11] This device, through its modular design, also allows for progressive and uniform inter-fragmentary compression across the tibiotalar joint while sparing the subtalar joint. Adjustments to compression can be made postoperatively as needed. If necessary, adjustments may also be made during the treatment period to correct problems of angulation, rotation and or translation.[5,8,12,13]

SURGICAL PROCEDURE

Through a lateral approach, a section of the fibula is removed roughly 5-6 cm proximal to the ankle joint. The distal portion of the fibula is dissected and the articular surface removed. The articular surfaces of the ankle joint are then resected. Next, a 4.0 mm partially threaded cancellous screw is used to compress the denuded fibula against the tibia and talus. In so doing, the fibula acts as a sliding lateral strut to provide additional stability once fusion is achieved.[14] Finally, the position of the joint is

inspected under intra-operative fluoroscopy while it is temporarily stabilized with two crossed 5/64" Steinman pins. The external fixator is then applied.

Prior to the surgery, three appropriately sized rings and one footplate are selected and assembled (Figures 1 & 2). The pre-assembled apparatus is placed onto the extremity while the position of the foot and leg are maintained at 90° to one another. At the level of the most proximal ring, an axial wire is driven through the tibia. Another axial wire is driven through the calcaneus at the level of the footplate (Figure 3). The tibial wire is secured to the ring with 100 – 130 kg of tension and the calcaneal wire to the footplate with 60 – 80 kg. Additional wires are then passed through the two proximal tibial rings, for a total of two wires per ring. At the most distal ring, which is placed at the level of the talus, two wires, one from anteromedial to posterolateral and the second from anterolateral to posteromedial, are passed through the body of the talus. Care must be taken to avoid the neurovascular bundles in this region. Additional wires are passed through the calcaneus and midfoot, secured to the footplate and given tension, as previously described (Figures 4 & 5). Next, the tibiotalar joint is placed under compression by decreasing the distance between the middle and distal rings via the four threaded rods that connect them. The external ring fixation device stabilizes

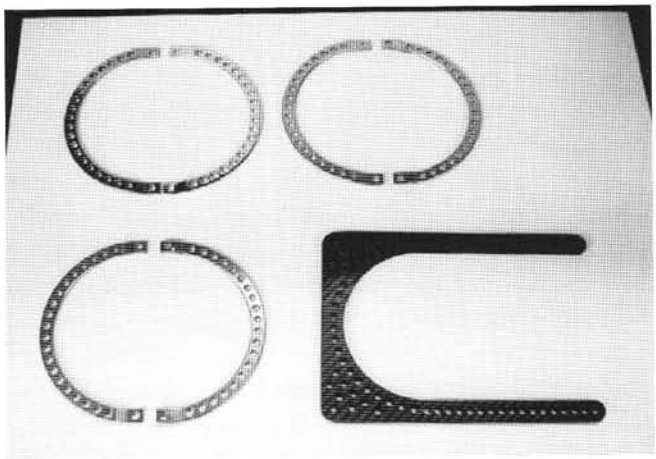


Figure 1. Six composite half-rings and one footplate, prior to assembly.

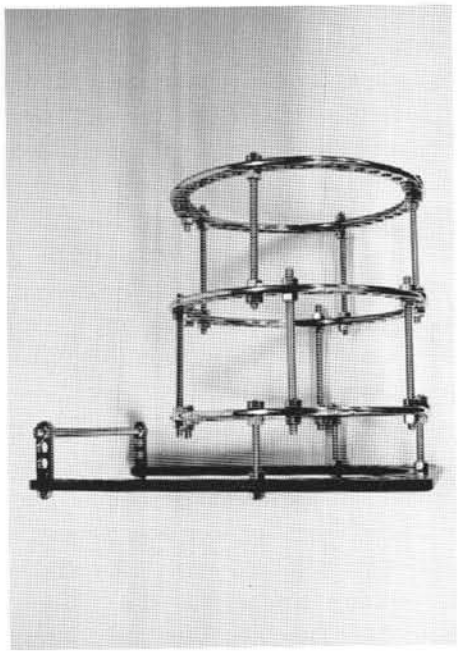


Figure 2. The apparatus, consisting of three rings and footplate, is pre-assembled prior to the surgery.

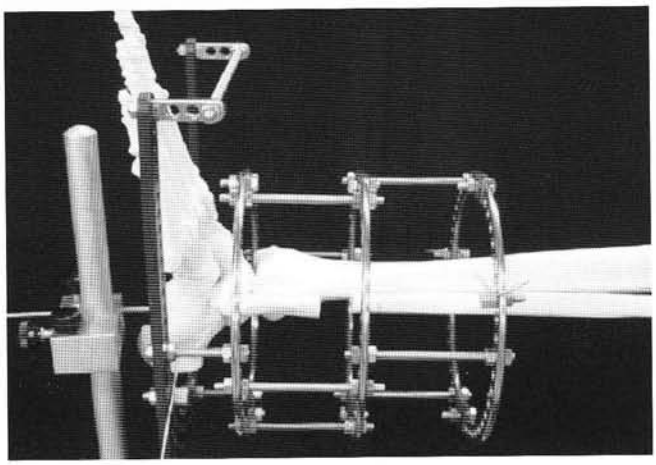


Figure 3. The first two wires attached to the frame are the axial tibial wire and the calcaneal wire. These help to maintain the position of the foot and leg within the frame while the remaining wires are thrown.

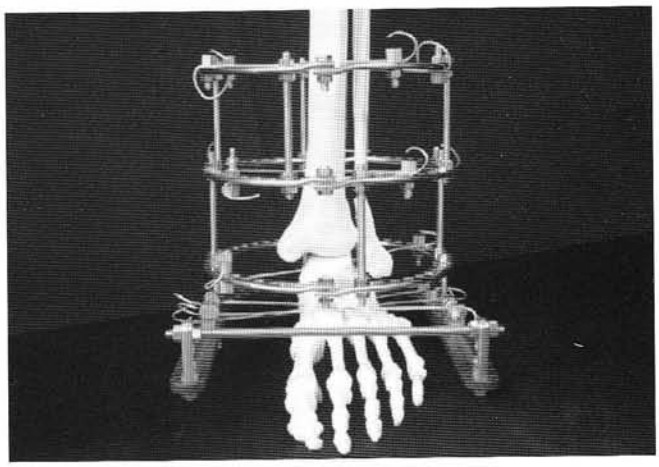


Figure 4. Final AP view of the frame assembly with all wires in place.

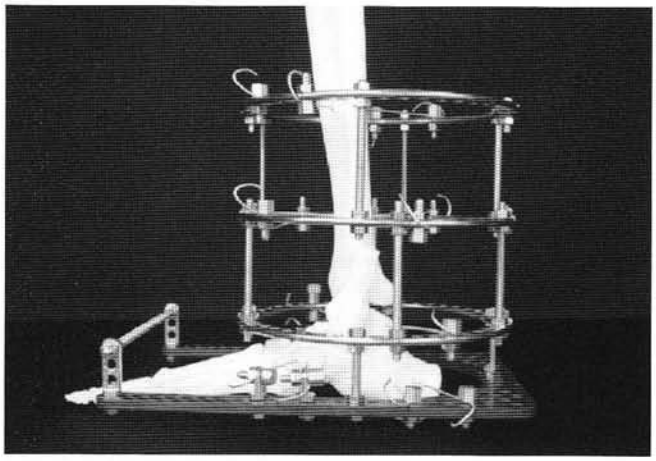


Figure 5. Final lateral view of the frame assembly with all wires in place.

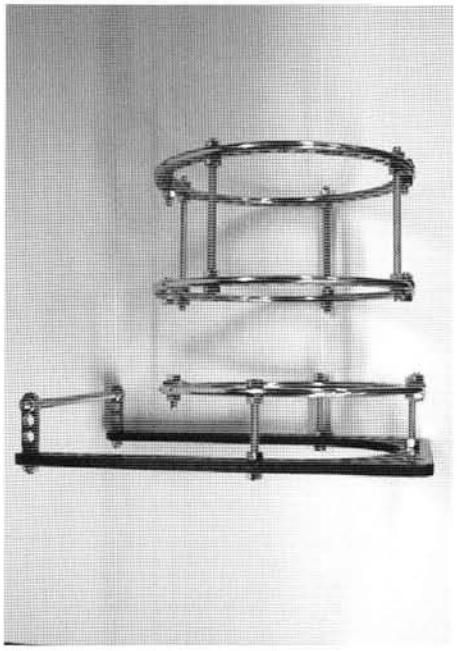
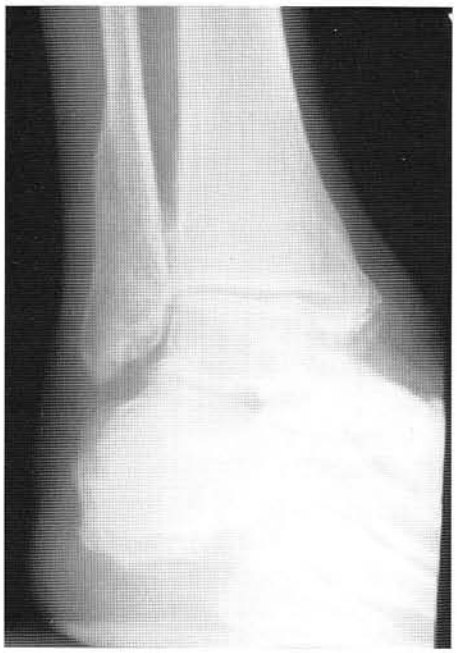
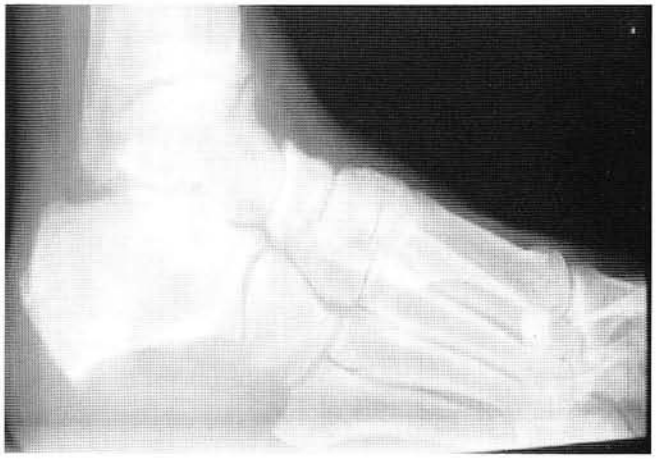
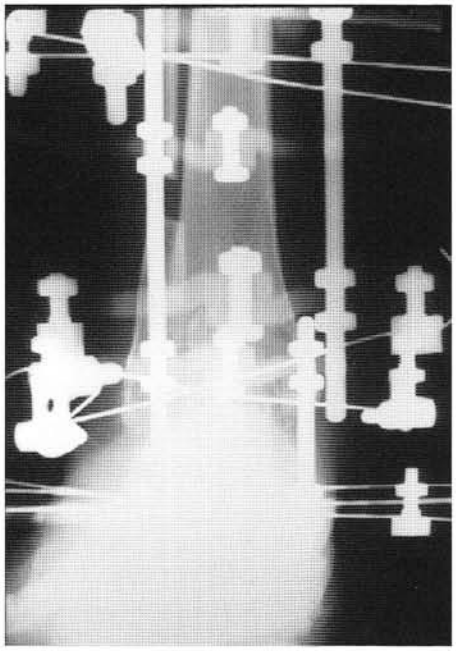


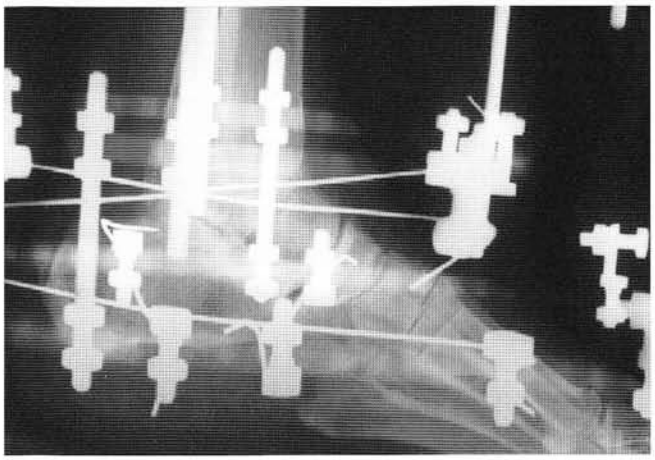
Figure 6. The ring system is both multi-planar and modular in nature. This photo shows that the apparatus is comprised of two units, which will ultimately act as one device.





Figures 7A, 7B. Pre-operative mortise and lateral radiographs demonstrating signs of advanced arthrosis.





Figures 8A, 8B. The ring fixator in place as seen on the AP and Lateral radiographs of the ankle. Note the crossing of the wires in the talus.

the fusion site is through its ability to apply continuous, static inter-fragmentary compression. Any adjustments to the amount of compression or the position of the arthrodesis can be made postoperatively. The modular nature of this fixator (Figure 6) enables the calcaneus, which is fixated to the footplate, to be separated from the area of compression. This avoids compressive forces to the subtalar joint, thus allowing its preservation.

During the entire postoperative period, the ankle is maintained in a rigidly fixed position of 90° within the apparatus. Following the procedure, 0.5% Marcaine plain is infiltrated to all the wire sites. Gentamicin ointment is applied to all wire insertion sites. Twox2 gauze pads are cut so they cover the wire site and applied. A foam top-dressing is applied over the gauze and a clip attached to the wire, which holds the dressing in place and provides slight compression. All incision sites receive a compression dressing. An external bone stimulator may then be placed. To make ambulation easier, the patient may wear a modified surgical shoe or bracing can be applied directly to the frame. Standard post-operative analgesic medication is given while the patient is kept for observation for a minimum of 23 hours and up to two or three days.

CASE 1

A 66-year-old white male presented with a chief complaint of significant pain and decreased range of motion in the right ankle joint that has been present for approximately two years. The patient had a past medical history significant for coronary artery disease that required a previous by-pass surgery. At the time of presentation, the patient was taking oral anti-coagulant and anti-hypertensive medication. Radiographic examination of the right ankle revealed marginal osteophyte formation with uneven joint space narrowing (Figures 7A, 7B). Conservative treatment was attempted for two and a half months. This included NSAID therapy, multiple intra-articular steroid injections, pedorthic management with rocker-soled sneaker and physical therapy. Following failure of such treatment, the decision was made to intervene surgically. It was determined that, due to the patients previously mentioned medical condition, he was not a candidate for cast immobilization. Therefore, the patient underwent tibiotalar arthrodesis with an external ring fixator as the method of fixation (Figures 8A, 8B, 8C). On the first post-operative day, the patient was able to bear weight on the right foot and ankle with the use of a walker. On post-operative day two, the patient was able to begin taking steps. By the end of the 4th week, the patient was nearly full weight bearing with the use of a

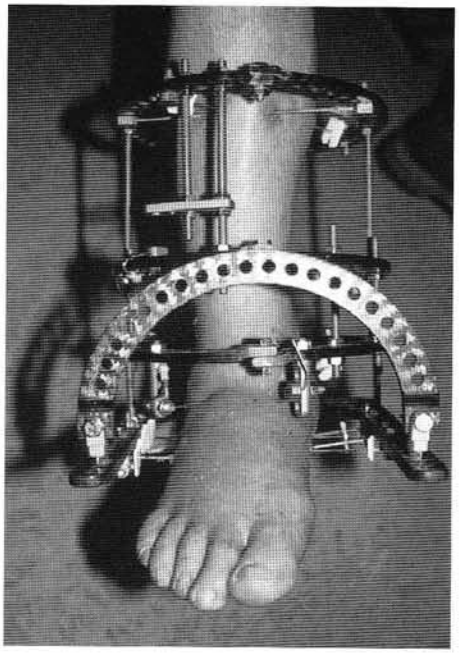


Figure 8C. A clinical photo during treatment.

single crutch. The frame was removed at seven and a half weeks. Radiographic examination revealed bony union in good position (Figures 9A, 9B). The patient was placed in a cam walker for an additional three weeks. Finally, the patient was transitioned into a sneaker. At four-year follow-up, the patient continues to ambulate without pain and maintains his normal activities.

CASE 2

A 41-year-old white female, with past medical history significant for IDDM and hypertension, presented with a chief complaint of "walking on the inside of my left foot and ankle." She related that this 'deformity' had been going on for about two and a half months and had been getting worse. She also related concern over the significant swelling that was present in the foot and ankle. Upon questioning, the patient related that her blood sugars were consistently over 300mg/dl. She had a previous amputation of the left hallux and first metatarsal head. Her medications at the time included insulin, prinivil, verapamil and lasix. She also had a 20-pack year history of tobacco use. Radiographic examination revealed a fibular fracture, severe valgus dislocation of the left ankle and a significant medial clear space. Callus

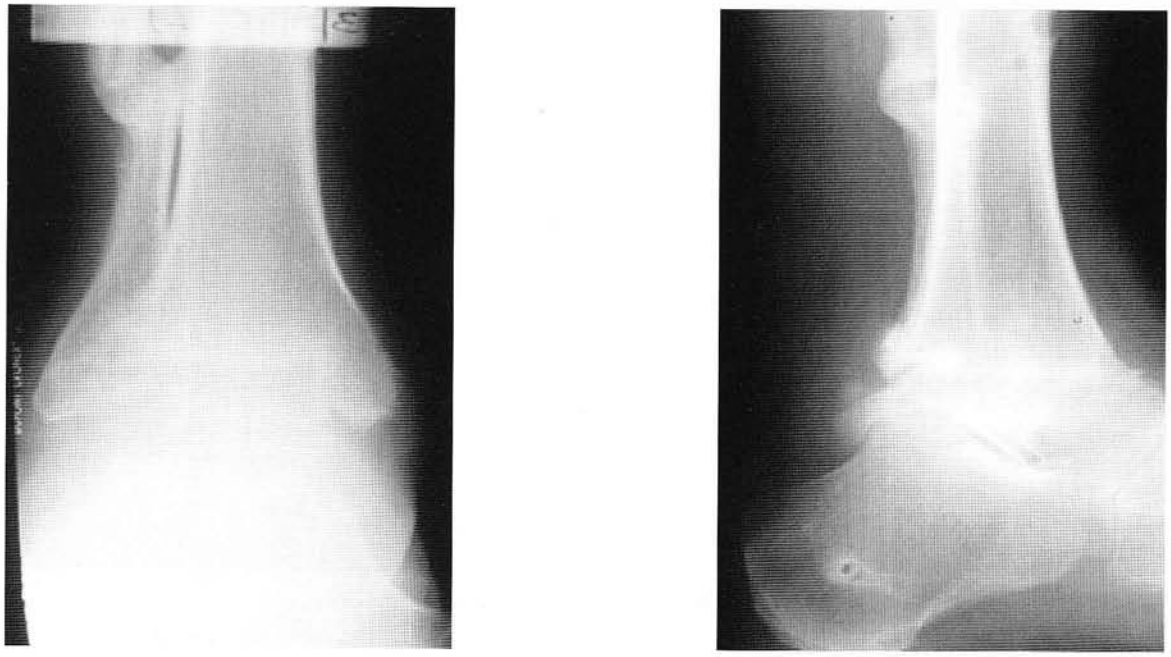


Figure 9A, 9B. AP and Lateral radiographs show consolidation of the tibiotalar joint in proper alignment.

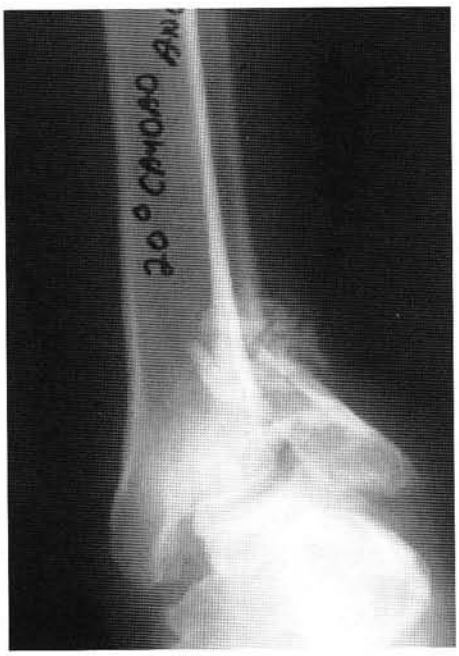
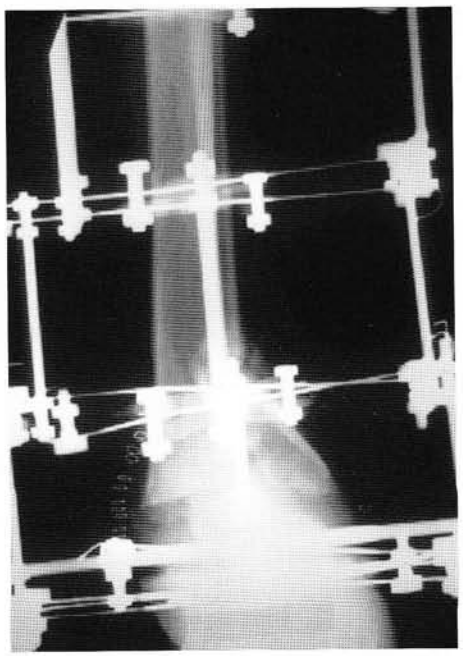
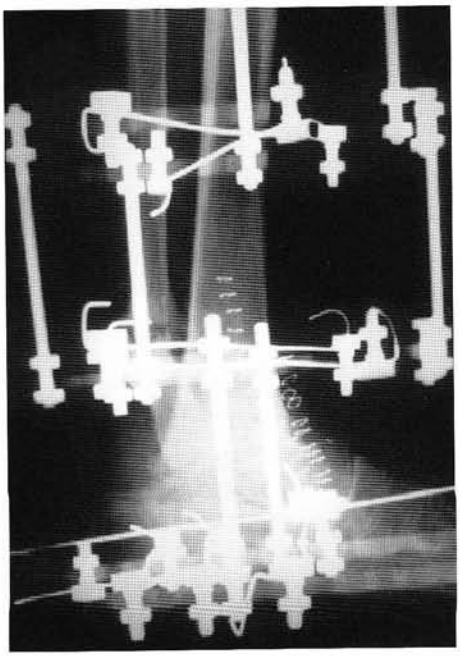


Figure 10. An AP radiograph of how the patient presented to the office approximately two and a half months after this "deformity" occurred. Significant valgus dislocation of the ankle and fibula are present. Note the callus formation at the fracture site.

formation was evident at the fracture site (Figure 10). She was diagnosed with Charcot ankle deformity and surgical intervention was recommended. The goal of the surgery was to realign the dislocated joint as best possible to enable the patient to ambulate with a stable extremity. An ankle arthrodesis was performed and an external ring fixator was used to realign and stabilize the joint for arthrodesis (Figures 11A, 11B). The use of external ring fixation allowed the patient immediate post-operative weight bearing thus enabling her to apply equal stress to both lower extremities. On the first post-operative day, the patient was partial weight bearing and full weight bearing by the 3rd day. During the third post-operative week, she was able to return to work. Due to the history of the patient, it was decided to keep the external fixation device on longer than usual, 13.5 weeks. Final radiographs revealed a consolidated fusion in good position (Figures 12A, 12B). Following removal of the frame, the patient was placed in a below knee walking cast for two weeks. At six-year follow-up, the patient is functionally weight bearing on a stable lower extremity. She continues to be very satisfied with her outcome (Figures 13A, 13B).





Figs 11A, 11B. Radiographs showing external fixation in place, aiding in the realignment and stabilization of the displaced ankle joint.

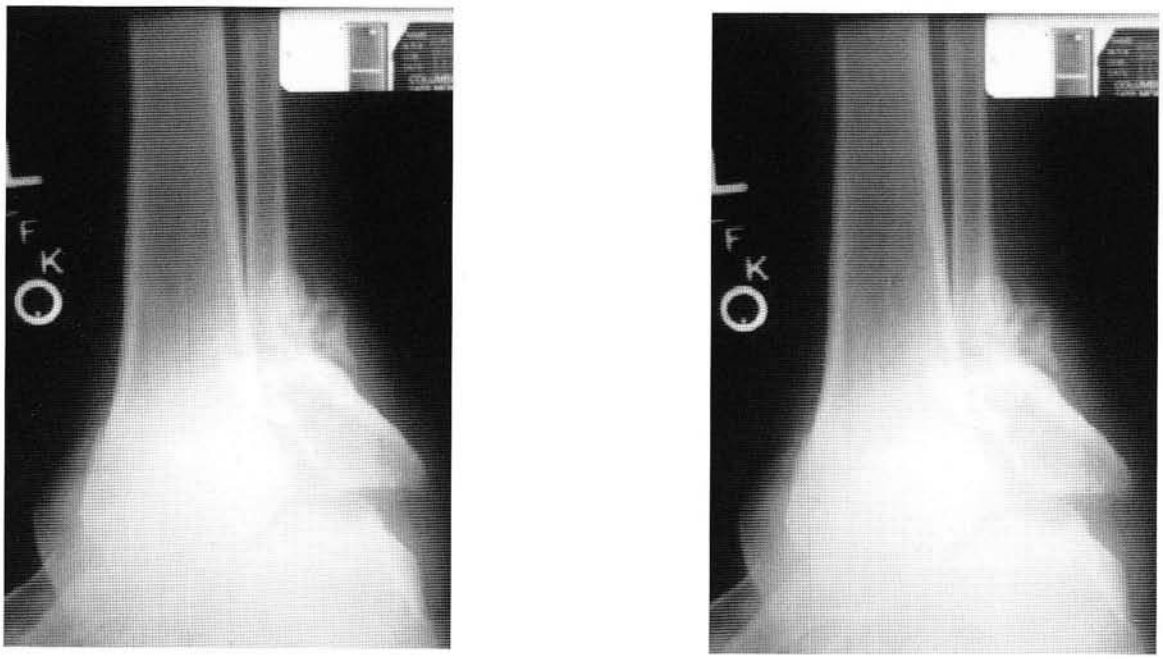


Figure 12A, 12B. Post-operative Radiographs demonstrate consolidation of the tibiotalar joint.

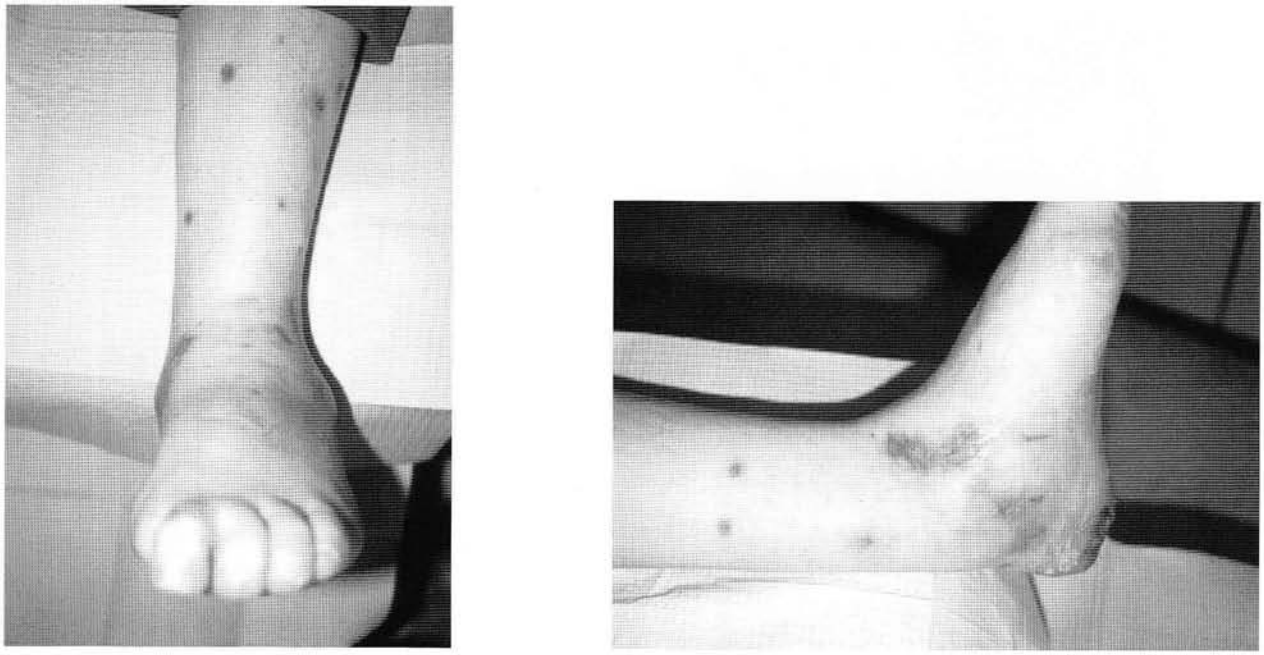


Figure 13A, 13B. Clinical photos, showing the position of the foot and ankle.

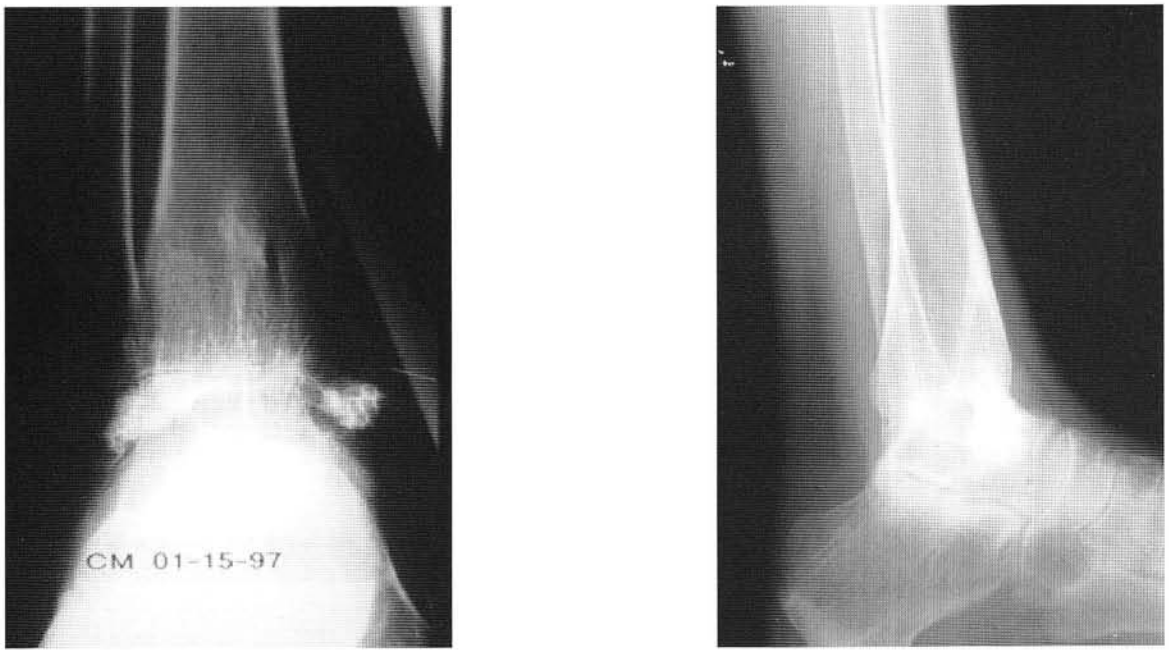


Figure 14A, 14B. Radiographs demonstrate significant arthrosis of the tibiotalar joint.

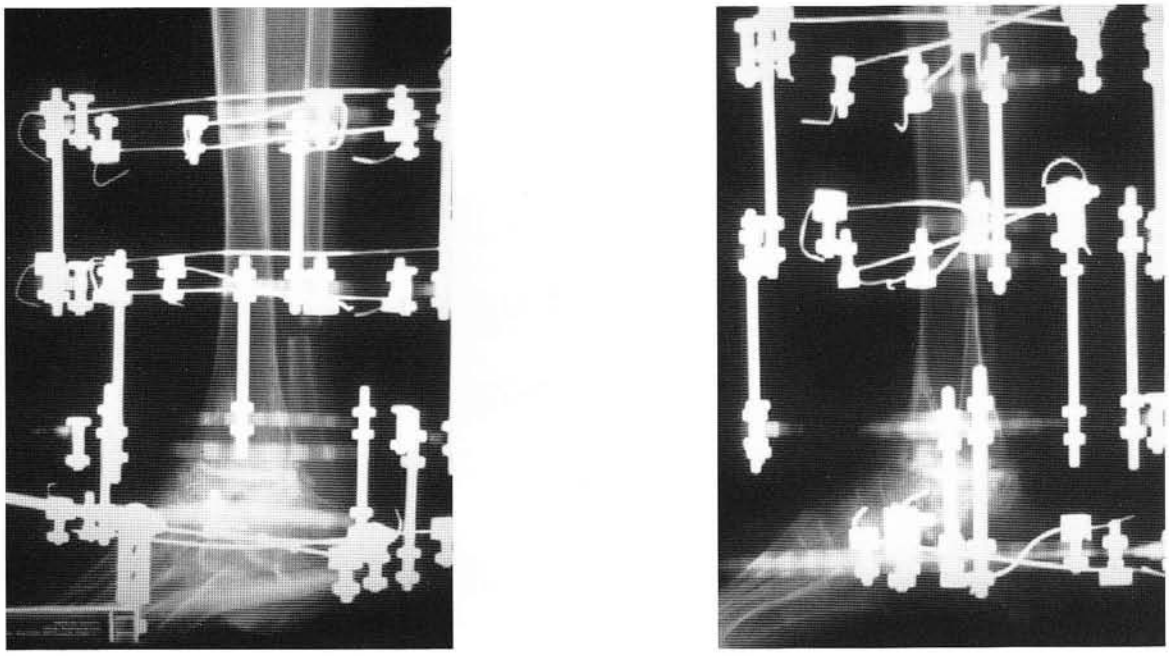
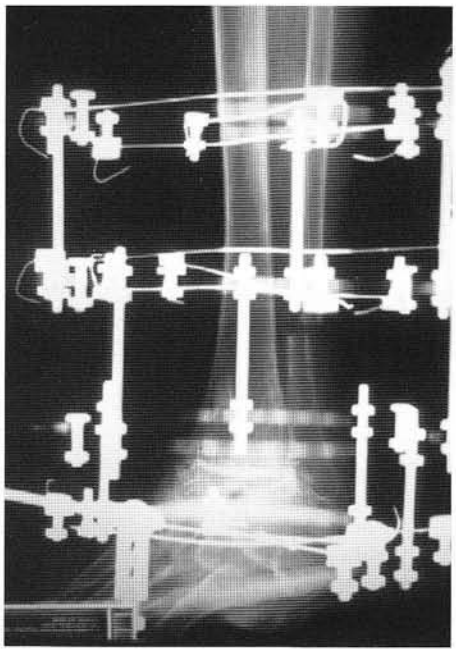


Figure 15A, 15B. Radiographs showing external fixator providing compression and stability across the tibiotalar joint.



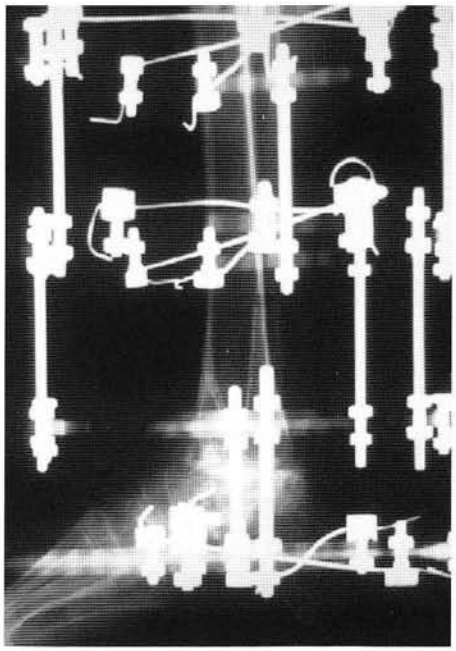


Figure 16A, 16B. Post-operative radiographs show a consolidated arthrodesis.

CASE 3

A 44-year-old white female presented with a chief complaint of significant pain in the left foot and ankle, especially while walking and standing, of approximately one and a half years duration. Radiographic examination revealed significant ankle arthrosis as evident by osteophyte formation, virtual elimination of the joint space and subchondral sclerosis (Figures 14A, 14B). The patient related having undergone conservative treatment at another office that was unsuccessful. Physical examination of the patient's left ankle revealed a decrease in dorsiflexion and plantar flexion accompanied by crepitus. She also expressed significant pain with range of motion. The patient underwent an ankle fusion with the use of an external ring fixator (Figures 15A, 15B). She was full weight bearing within the first post-operative week and went on to heal uneventfully. The frame was removed at the 8th week. Radiographs revealed a consolidated fusion in good alignment (Figures 16A, 16B). She was placed in a cam walker for an additional two and a half weeks, then a rocker bottom sneaker. At six-year follow-up, the patient continues to be pain free and performing normal activities.

On the first postoperative day, the patient is encouraged to bear weight to tolerance using either a walker or crutches. The first follow-up visit is 3-4 days following discharge from the hospital for a dressing change. The patients are then seen in the office at one-week intervals until complete frame removal. Following the second post-operative week the patient may bathe, swim and perform any tolerable activity. Sutures or skin staples are removed at three weeks. Generally, between 6 – 8 weeks the apparatus is removed either in the office or in the operating room. It often depends upon the comfort level of the patient. Likewise, anesthesia may or may not be administered. Following the removal of the frame, the patient is placed in a cam-walker for 2 – 3 weeks. Finally, the patient is transitioned into a sneaker.

DISCUSSION

From 1993 to present, 138 primary tibiotalar arthrodeses (104 male, 34 female) were performed using an external ring fixator. The indications included primary arthrosis, post-traumatic degenerative joint disease, dropfoot secondary to paralytic conditions and Charcot arthropathy. One hundred and twenty eight out of 138 patients (93%) achieved clinical fusion in an acceptable position within 8 weeks. By the second post-operative day, all patients had begun at least partial weight bearing with a walker or crutches. The longest follow-up to date is 9 years.

The most commonly observed complications were infection and pain at the wire insertion site. While there can be a multitude of reasons for their occurrence, the key one is a loose wire. This also makes the wire susceptible to breaking. Therefore, it is imperative to ensure that all wires receive proper tension and that all fixation bolts are tightened. These should be checked at each postoperative visit. Another possible complication with external fixation is excessive tension at the skin-wire interface. The cause of this is improper manipulation of the skin during the insertion of the wires. Other complications were nonunion (7%), malalignment (4%), continued pain (4%) and chronic edema (2%).

CONCLUSION

Three cases were illustrated to demonstrate some unique advantages of external ring fixation over other the techniques for primary ankle arthrodesis. The circular apparatus provides rigid immobilization of the ankle and foot and resists shear and torsion stress. It allows axial loading to progress without having detrimental effect on the arthrodesis site. In addition, the use of the ring system along with tensioned wires allows excellent fixation of the arthrodesis even in situations where the wires need to be placed away from the fusion site.[5] The system allows postoperative adjustments to be made to be made as needed. All patients were allowed to ambulate to tolerance from the first postoperative day. This has proven to be very beneficial to them. Overall, the patients to whom this procedure was performed demonstrated a high rate of compliance.

While the use of any type of fixation requires experience, the use of the external ring fixator is no exception. This procedure requires continuous patient follow-up in order to achieve satisfactory results. Nevertheless, the advantages of this procedure for primary arthrodesis of the tibiotalar joint justify its use and make it an excellent alternative over the many other techniques.

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