Plate Fixation in Midfoot and Ankle Charcot Neuroarthropathy

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KEYWORDS

• Plate fixation • Midfoot • Ankle • Charcot neuroarthropathy

KEY POINTS

- Healthy resection of diseased bone is necessary/mandatory to provide a healthy environment for bone healing. When the surgeon is attempting a surgical repair, he or she must resect/remove the diseased pathologic bone to good healthy bleeding bone.
- Anatomic alignment should be the goal of the reconstruction. With larger deformities with Charcot reconstruction, it is necessary to achieve a close-to-anatomic alignment with the construct.
- Stable rigid internal fixation is needed for a successful outcome to assist with stabilizing the diseased bone.

INTRODUCTION

Charcot neuroarthropathy (CN) of the foot and ankle is most often observed in the midfoot. Classifications laid out in the early literature began by focusing on broad radiographic findings—development, coalescence, and reconstitution—such as those of Dr Sidney Eichenholtz.[1] Shibata and colleagues recommended a prodromal phase or "stage 0," which is associated with warmth, swelling, and erythema before radiographic changes.[2,3]

Another widely used classification is the Brodsky classification. This system is based on anatomic location affected with types arranged from most common to least commonly identified: type 1, tarsometatarsal joint; type 2, Chopart or subtalar or both; type 3a, ankle; and type 3b, calcaneal tuberosity[1,2] (**Figs. 1–3**).

CN was originally identified by Jean Martin Charcot in patients with peripheral neuropathy from tertiary syphilis. At present, the vast majority of cases are commonly

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Fig. 1. Radiograph of a diabetic patient who suffers from a midfoot Charcot arthropathy.

associated with long-standing peripheral neuropathy in diabetic patients.[4,5] Although it can be agreed upon that neuropathy is present in the development of CN, diabetes is one comorbidity that stands out in the literature.[5] The association between CN and diabetes was first made by William Riely Jordan in 1936. Since then, given the rise of diabetes, studies highlight its evolution in this population.[4–9] A 5-year retrospective study of 1050 patients revealed 18.8% with diabetes alone died, 28.3% with diabetes and Charcot arthropathy of the foot and/or ankle died, and 37% with diabetes and an ulcer died. The development of an ulcer or CN in a diabetic patient is best thought of as marker of severe disease rather than precursor to demise.[7]

The clinician and surgeon should be aware of the many other causes of peripheral neuropathy that can propagate Charcot joint disease, including disorders such as idiopathic sensorimotor neuropathy and alcoholism.[5]

Conservative measures to treat a CN event begin with offloading—whether with a cast, Charcot restraint orthotic walker (CROW), brace, and, in the case of skin breakdown, total contact casts.[10,11] When a patient presents with a CN that has progressed to a rigid deformity and/or with a wound resistant to healing, additional steps may be

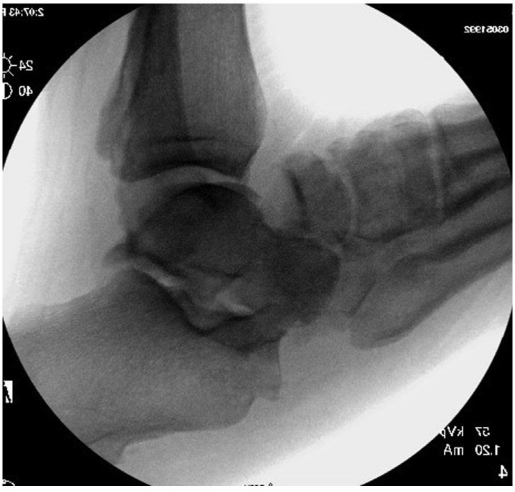

Fig. 2. Radiograph of a diabetic patient who experienced a proximal midfoot fracture dislocation with Charcot arthropathy.

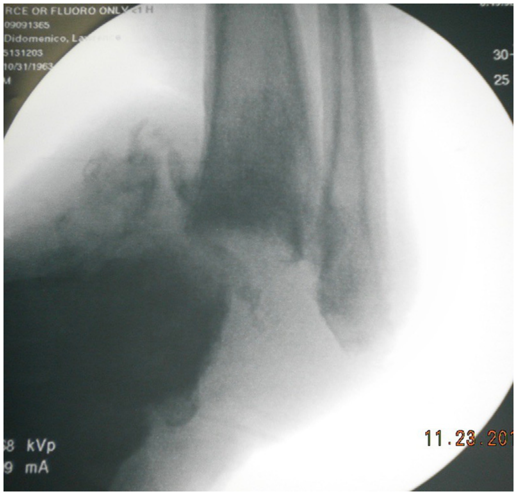

Fig. 3. Radiograph of a diabetic patient who experienced an ankle fracture dislocation with Charcot arthropathy.

warranted. With a rigid deformity and chronic wound, a patient is at great risk for infection and amputation as well as reduced quality of life.[7,12]

The goal of reconstruction in a patient with an ankle joint affected by CN is to restore alignment and stability to the ankle and hindfoot in an effort to provide a functional limb. The senior author's staged algorithm for the management of these patients begins with addressing the patient's medical status and ensuring a multispecialty approach (medicine, vascular surgery, infectious disease, physical therapy social work, and so on) before pursuing definitive surgical reconstruction.[10]

When nonoperative care has failed and the patient presents with wounds, infections, and instability, surgical intervention is warranted. Studies have demonstrated compromised successes and increased complications in CN reconstruction alongside patient comorbidities.[2,9] McCann and colleagues[9] noted in 151 cases that those who underwent ankle or subtalar reconstruction were 70% less likely to return to walking than those undergoing medial column reconstruction. These patients were also 3.3 times more likely to require amputation within 3 years after surgery. Rehabilitation following either a below-knee amputation or CN reconstruction is not a small task. The ultimate decision of whether to pursue surgical intervention for reconstruction versus a below-knee amputation is up to the patient with expert input from the surgeon.

Unlike healthy bone, the bone in the patient with CN is often diseased and noted to be weak, osteoporotic, and fragmented. Bone may exhibit decreased density as well as an overabundance of osteoclasts.[5,13] The role of treating bone affected by the disease pharmacologically is still unclear.[14,15] Well-accepted and traditional methods of internal fixation, including lag screws with plates, are usually insufficient to meet the demands of stabilizing bone commonly exhibited by CN. Surgical reconstruction in CN is commonly staged in the presence of infection and may include a combination of internal fixation, external fixation, and/or hybrid constructs.

Plate Fixation in Ankle Charcot

Given the severe deformities and the altered bone biology seen in CN, traditional constructs used for fusions such as screws alone in most scenarios should be replaced or supplemented by stronger, more rigid constructs.[16,17]

When addressing ankle joint destruction due to CN, intramedullary nail fixations for tibiocalcaneal (TC) and tibiotalocalcaneal (TTC) fusions have proved to be successful constructs.[18,19] Intramedullary nail fixation is not without potential complications including malpositioning, malunion, nonunion, hardware fracture, implant failure, and fracture. Desirable positioning of an intramedullary nail is often difficult especially the entrance point into the calcaneus. In addition to this, the integrity of the soft tissues and the ability to establish anatomic alignment must be taken into consideration by the surgeon. The calcaneus, which characteristically has a thin outer bony cortex and an abundance of cancellous bone, has weaker holding ability, therefore precise entrance is paramount for this type of fixation. In patients with nonpathologic anatomy, the calcaneus lies lateral to the tibia. In the senior author's experience, in seeing and performing revision surgeries in patients who have experienced ankle and hindfoot CN and a previously attempted arthrodesis with intramedullary nail fixation, he has often found that the intramedullary nail appears in good position on the lateral radiographs many times misleading the surgeon. In these cases, he has frequently identified failure in the appropriate placement of the intramedullary nail. Routinely the nail has been inserted more medially on the calcaneus thus not purchasing the body of the calcaneus leading to failure. In the senior author's experience the vast majority of failures of intramedullary nails occur in the calcaneus (**Figs. 4** and **5**).

The difficulty of precise placement and other postoperative complications associated with intramedullary nail fixation for TTC and TC fusions have encouraged the use of locking plate constructs for the rearfoot and ankle.[20–22] A cadaveric study by O'Neill and colleagues in 2008 demonstrated that screw fixation augmented with a lateral locking plate versus augmentation with an intramedullary nail may provide similar rigidity required for a TTC fusion.[23]

Early studies showcase the use of blade plates for the surgical treatment of tibiotalar (TC) or TTC fusions, which were originally designed for use in subtrochanteric femur fractures.[24] In addition, surgeons have used locking plates created for humeral and femoral fractures.[22] Modern technology now includes anatomic plates specifically for rearfoot and ankle fusions (**Figs. 6** and **7**).

A condylar blade plate with a fixed 90° to 95° angle has been used in TC or TTC arthrodesis. Originally described by Alvarez and colleagues[23] in 1994, it is placed laterally and tamped into the calcaneus just beneath the angle of Gissane (see Surgical Techniques section). In a biomechanical cadaver study, this construct was found to

Fig. 4. Radiograph of a diabetic patient who underwent an attempt of a tibiotalocalcaneal arthrodesis with an intramedullary nail. The nail failed within the calcaneus.

Fig. 5. Preoperative surgical view of a diabetic patient who had previously had an attempted tibiotalocalcaneal arthrodesis with an intramedullary nail that failed. The nail is now protruding through the calcaneus and is resulting in an infection.

Fig. 6. An intraoperative lateral radiograph projection demonstrating a diabetic who had a tibiotalocalcaneal arthrodesis performed using a lateral-based plate along with fully threaded large cancellous screws. Note the multiple holes of fixation within the calcaneus, the talus, and the tibia.

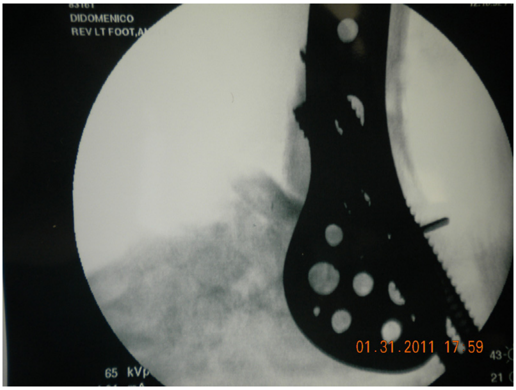

Fig. 7. An intraoperative lateral radiograph projection demonstrating an femoral locking plate prepared for fixation. Note the multiple holes of potential fixation in the "weaker" cancellous calcaneal bone.

have lower plastic deformation and higher stiffness than an intramedullary rod.[24] In addition, the plate offers more points of fixation distally. The use of a locking plate construct provides a rigid, stable construct while also respecting the biological demands of bone healing. With locking and nonlocking screws, surgeons can achieve compression and stability through the same plate. In a retrospective review of 30 patients (26 of whom had CN), fusion occurred in 28 patients by an average of 16 weeks. Of note, patients were non-weight-bearing for 3 months in a below-knee cast and progressed to weight-bearing the following 3 months[25] (**Fig. 8**).

Early on, proximal humeral locking plates provided a potential upgrade for the TC or TCC fusion construct. In 2007, Ahmad and colleagues reported successful union in 17 of 18 patients using the Proximal Humerus Internal Locking System (PHILOS) by Synthes, Paoli, Pa.[26] A cadaver study by Chodos and colleagues[27] compared a laterally based blade plate to a laterally placed proximal humeral locking plate. The investigators reported higher initial stiffness, torsional load to failure, and lower construct deformation than a blade plate for a TTC fusion construct; they also noted that placement of a blade plate is technically more difficult than that of locking plates and does not allow for screws in divergent orientations.[27] Another study by Shearman and colleagues[16] noted that 18 of 21 patients achieved fusion over an average 4.8 months (**Fig. 9**).

Like humeral locking plates, femoral locking plates, primarily intended for femoral condyle fractures, provide a suitable contour for TC and TTC fusions. In the senior author's experience, using a femoral locking plate for a TC or a TTC fusion provides a nicely contoured plate to the lateral tibia, calcaneus, and/or talus. One can place multiple locked or nonlocking bicortical screws into the calcaneus, which exhibits a thin cortex and an abundance of porous cancellous bone. The proximal holes in the plate allow for a combination of locking and/or nonlocking screws.[22]

Modern plating technology is specifically designed to contour ankle and rearfoot anatomy. It has been the senior author's experience to use 2 or 3 fully threaded large cancellous screws as positional screws. It is important to use the cortex-cortex technique allowing the fully threaded screws to act as positional screws and maintain length, strength, and stability. For example, a screw can be inserted from the posterior inferior cortex of the calcaneus into the distal anterior tibial cortex. In addition, these fully threaded cancellous screws provide fixation from a different anatomic location providing more stability. Also these fully threaded screws can be long and near the

Fig. 8. Radiograph of a diabetic patient who suffers from diabetic peripheral neuropathy and a history of previous trauma and Charcot arthropathy. A previous attempt of a TTC arthrodesis failed. In this lateral radiograph a lateral-based blade plate was used in the surgical revision of the TTC arthrodesis.

length of an intramedullary nail. Based on what system the surgeon is choosing to use, the fully threaded screws can have a length of 100 to 150 mm. In addition, if the surgeon uses 2 or 3 fully threaded screws from cortex to cortex, the added diameter will often be equal to or larger than the diameter of the intramedullary nails on the market providing excellent stability. Arguably the multiple long fully threaded screws may provide more stiffness when compared with an intramedullary nail (Fig. 10).

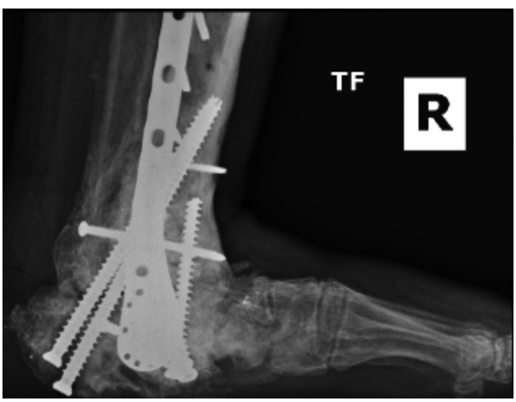

Fig. 9. Radiograph of a diabetic patient who suffers from diabetic peripheral neuropathy and a history of Charcot arthropathy and previous history of osteomyelitis. In this lateral radiograph a lateral-based humeral locking plate was used in the surgical reconstruction of a TTC arthrodesis.

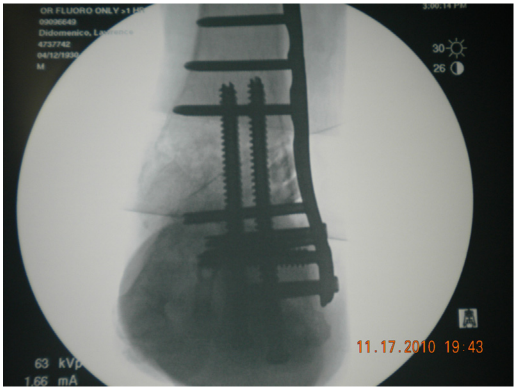

Fig. 10. An intraoperative anteroposterior view in a patient with Charcot arthropathy treated with 2 fully threaded cancellous screws and a lateral-based femoral locking plate. Note the multiple points of fixation in the calcaneus.

In cases in which there is compromise to the anterior or lateral soft tissue envelopes a posterior approach with application of locking plate and intramedullary fully threaded bicortical fixation can be used. The posterior approach to the ankle and/or subtalar joint provides a thick and well-vascularized soft tissue envelope and allows excellent exposure to the articular surfaces of the ankle and subtalar joints for TTC arthrodesis. Patzkowski and colleagues[28] found better visualization with a direct posterior approach with splitting of the Achilles tendon versus a posterior lateral approach based on anatomic structures observed. Didomenico and Sann[29] reported the successful posterior use of an anterior locking plate for an ankle and hindfoot arthrodesis. Hanson and colleagues[30] noted a 100% fusion rate in 10 patients with mild to moderate hindfoot and ankle deformity.[31] With the posterior approach awareness of anatomic structures is vital to reducing the risk of potential complications. Complications associated with this approach include injury to the sural nerve, flexor hallucis longus (FHL) tendons, as well as the anterior neurovascular structures during resection of the articular surfaces (Fig. 11).

Midfoot Charcot

In most patients who present with CN the isolated midfoot will be affected. In a systematic review of 1143 cases treated surgically, 59.5% of interventions were for midfoot Charcot arthropathy and 29.3% for ankle.[29,30] In surgical cases in which a patient presents with both ankle and hindfoot Charcot arthropathy, the surgeon needs to work from most straight/stable to less stable/less straight therefore surgically correcting the ankle before surgical repair of the midfoot. Once the ankle/hindfoot has been surgically addressed, the surgeon can better evaluate the midfoot and make appropriate surgical decisions. In cases involving both anatomic locations, the senior surgeon prefers to stage the surgeries because this can be a lot of physiologic stress on the patient and their respected limb. In addition, this can involve a lot of work and can be stressful for the surgeon as well.

Relative to surgical reconstructive efforts of the midfoot in cases with Charcot arthropathy, before the use of internal fixation, the surgical treatment generally included exostectomy, ulcer debridement and/or excision, realignment osteotomies, and possibly amputation.[29,32,33] As discussed earlier, the senior author prefers a staged approach if there is an ankle deformity that needs to be surgically addressed

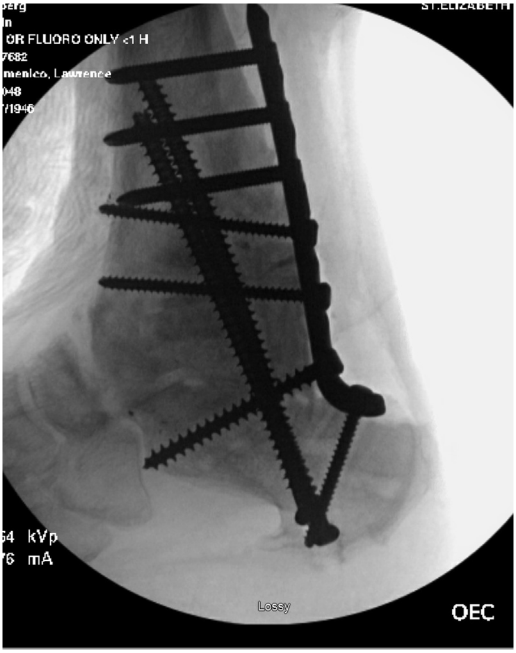

Fig. 11. Radiograph of a diabetic patient who has a history of Chariot arthropathy, positional arthrodesis failure, and a previous history of osteomyelitis. Because of the patient's previous history, a posterior approach was performed because of the healthy soft tissue envelope.

in combination with a midfoot deformity. In cases in which there is an ankle Charcot arthropathy involved, once osseous alignment and stability is achieved, the midfoot can be addressed in the same setting or as a staged approach.

In many situations, the CN progression has presented with a broken down foot, ulceration, and often osteomyelitis. The ulcer, infection, and/or osteomyelitis are secondary to the malaligned broken down foot. In scenarios with an infection or contamination, a combination of staged planned reconstruction is necessary. The initial stage consists of lengthening the posterior muscle group with an Achilles tendon lengthening or a gastrocnemius recession based on a Silfverskiöld examination.[33–35] Next, an incision, drainage, debridement of bone, and surgical debridement of the wound along with the bone is performed. Skin graft substitutes can be used in cases in which there is not an acutely infected surgical site. Once the bone debridement is performed (whether a rigid deformity or nonrigid), the surgeon needs to debride, resect diseased bone, and allow the deformity to become reducible. Once the deformity is reducible, it can be realigned using an external fixator, which can provide anatomic alignment and stability; this will also accomplish the offloading of the affected pathologic site. Typically negative pressure therapy is used to assist with wound management and closure. An infectious disease and vascular consults are commonly requested.

Once the wound is closed and the serum markers such as the white blood cell count, erythrocyte sedimentation rate, and C-reactive protein level are normal, the second portion of the planned, staged reconstruction is completed. At the time of the second staged reconstruction the external fixator is removed. This surgical reconstruction consists of additional bone resection removing any remaining diseased

Charcot/chronically infected/avascular bone[10] to the remaining healthy bleeding better-quality bone. For midfoot Charcot, this may include what is termed an “internal amputation, or removal of the remaining bone in the midfoot.

Addressing the midfoot in Charcot with a “superconstruct” approach is well documented in the literature. In short, the “superconstruct” means using plate, beam, or bolt fixation to cross the joints affected and include joints unaffected by CN. This approach also includes removing nonviable tissue or bone to shorten the foot to allow for reduction of the deformity without compromising other soft tissues and placing the strongest internal device accepted by the soft tissues in a biomechanically advantageous position.[36,37] External fixation may also be used as adjunct fixation. Midfoot Charcot primarily presents with disruption to the naviculocuneiform joints or tarsometatarsal joints. In isolated midfoot Charcot, addressing the equinus due to the Achilles tendon is paramount.[38] However, performing a subtalar joint fusion as well to “protect” the midfoot construct is still debated depending on the construct. A recent study suggested that subtalar joint fusion was associated with 80% lower complication rate than beaming of the medial column alone.[39]

Although a variety of screw, beam, and bolt constructs are possible, use of plate fixation in midfoot Charcot may provide a stronger construct offering stability and compression. Isolated plating of the midfoot begins with medial column stabilization or with intramedullary beaming or bolts. Plate application can be applied dorsal, medial (or dorsomedial), or plantar.[40,41] Dorsal plating is not recommended because it is weaker than screw fixation alone. Plantar plating is the most biomechanically sound given the tension across joints. Plantar plating is an effective fixation option for sagittal plane correction in the rocker-bottom deformity, especially at Lisfranc joint. However, placing a plantar plate presents a challenge to the surgeon in terms of dissection and placement of a contoured plate.[41] Simons and colleagues[42] showed no statistical difference between dorsal medial versus plantar plating with regard to stiffness and cycles to failure. Their constructs encompassed the navicular to the first metatarsal[42] (**Fig. 12**).

Surgical Techniques

In the author’s experience, surgical reconstruction of an ankle and foot affected by CN that presents with an open wound and/or infection should be treated in a staged fashion. When the patient presents with an open wound and/or infection the first stage generally focuses on infection control, aggressive resection of the diseased or infected bone, specific identification of the pathogen, followed by reduction of the deformity, and wound care. The unstable deformity is reduced, put into anatomic alignment,

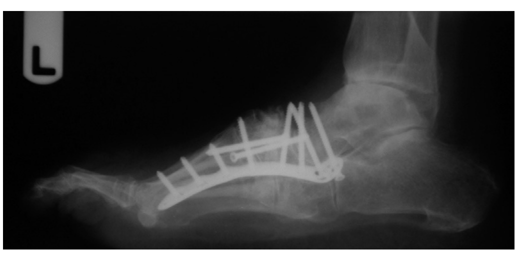

Fig. 12. A postoperative lateral radiograph demonstrating a plantar plate applied to the tension side of the Lisfranc and midfoot deformity. Note the positional screws inserted outside of the plate extending to the lateral aspect of the foot.

and stability is maintained with the use of a pin-to-bar external static multilevel external fixator until the reconstructive procedure.

If reconstruction of the ankle is necessary, this is the first level of deformity addressed once the external fixator is removed. The Silfverskiöld test is carried out to determine whether gastrocnemius or gastrosoleal equinus is present. If a gastrosoleal equinus is present a tendo-Achilles lengthening is performed using the traditional percutaneous hemisection approach.[33] If an isolated gastrocnemius recession is present, then it is preferred to perform an endoscopic gastric recession, and if an endoscopic recession cannot be obtained successfully then an open gastrocnemius recession can be performed.[33]

Plating for Tibiotalocalcaneal or Tibiocalcaneal Arthrodesis

A transfibular approach is used to access the TTC or TC joints. A full-thickness incision is made directly over the fibula. A fibular osteotomy is made about 10 to 15 cm proximal to the distal tip of the lateral malleolus. The syndesmosis is taken down using an osteotome and mallet. The distal portion of the fibula is removed. The most distal 2 cm of the fibula is split and used as a cortical cancellous autograft and used as an inlay graft or onlay graft. Another option is to decorticate the medial aspect of the fibular strut and use this as an inlay graft and as a biological plate.[43] Another option is to use the fibula as an intramedullary nail. In most cases the senior author splits the distal 2 cm and uses this as a cortical cancellous inlay graft to maintain length and anatomic position. The proximal portion of the fibular is put through a bone mill to aid in fusion and is mixed with the patient's blood. At the time of anesthesia, once the patient is induced, the anesthesia team harvests approximately 15 to 20 mL of the patient's blood and the author soaks the fibula grafts in this blood.

Most of the surgical procedure time is spent preparing the joint for fusion. Joint preparation is achieved with rongeurs, curettes, drills, osteotomes, mallets, and a high-speed bur. Again this is critical to resect all diseased, avascular, and necrotic bone along with any invaginated fibrous tissue.

The deformity is then reduced and temporarily fixated with large K-wire fixation. Next, 2 or 3 large fully threaded cancellous screws are placed from the posterior-inferior aspect of the calcaneus to superior-anterior obliquely across the subtalar and ankle and joints. If a third large cancellous screw is used, it is inserted from the anterior/inferior plantar cortex of the calcaneus to the posterior inferior tibia cortex. As previously mentioned, the diameter of a combination of 2 or 3 large fully threaded cancellous screws will typically result in a greater diameter than the largest nail on the market while providing bicortical purchase and maintaining length and position. Next the autogenous bone graft and if needed allograft cancellous bone chips are packed very tightly to the bony deficit. A lateral-based plate is applied to the lateral aspect of the calcaneus, talus (if present) and tibia; this is applied with a combination of locking and nonlocking screws. Nonlocking screws are used first to compress the plate to the bone and then locking the plate in place once anatomically positioned. The senior author's most sturdiest fixation construct includes utilization of a femoral locking plate placed laterally (**Figs. 13–15**).

In cases in which a posterior approach must be used a direct posterior incision is made overlying the Achilles tendon. During TTC arthrodesis the Achilles tendon can be released from its insertion and resected; this will provide excellent visualization and will provide good vascularity during healing because the avascular tendon is now absent. It will also allow for easier closure because there is less strain on the soft tissue envelope. The deep fascia is then incised and the FHL tendon with its muscle belly can now be visualized. The FHL is then retracted and dissection is carried

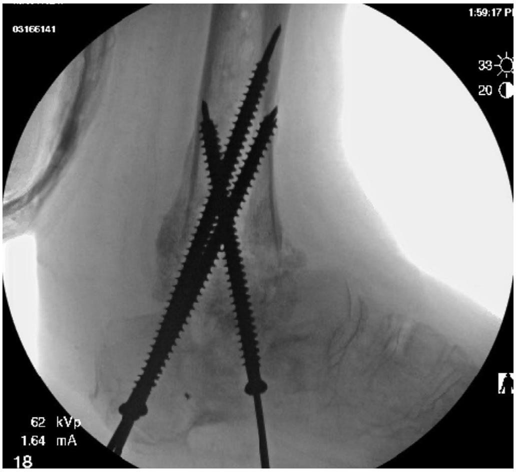

Fig. 13. An intraoperative lateral radiograph demonstrating 3 large cancellous screws inserted from the inferior calcaneal cortex to tibial cortex as positional screws. Note that there is no compression over the bone graft.

down to the posterior tibia, talus, and calcaneus. The articular surface of each joint is removed to healthy bleeding bone. Any deformity that is present is reduced and held in anatomic position with temporary pins and guidewires. Full threaded cancellous screws are then placed into the desired position. A locking plate is then fixated to

Fig. 14. A postoperative anteroposterior radiograph demonstrating good anatomic alignment with excellent fixation following a tibiotalocalcaneal arthrodesis using a femoral locking plate and fully threaded bicortical large cancellous screws.

Fig. 15. A postoperative lateral radiograph demonstrating good anatomic alignment with excellent fixation following a tibiotalocalcaneal arthrodesis using a femoral locking plate and fully threaded bicortical large cancellous screws.

the tibia, talus, and calcaneus using a combination of locking and nonlocking screws.[29] The FHL muscle belly is incorporated in the closure of the deep soft tissue, which provides excellent coverage of the internal fixation.

When appropriately determined, a drain is used and then the deep tissues are closed using 0-vicryl and skin closed using 2-0 nylon sutures. The surgical wounds are dressed with betadine-soaked Adaptic, 4 × 4s gauze, and kling in a sterile compressive fashion. A univalve below-knee cast with a medial and lateral splint as well as a posterior splint is applied[44] (**Figs. 16** and **17**).

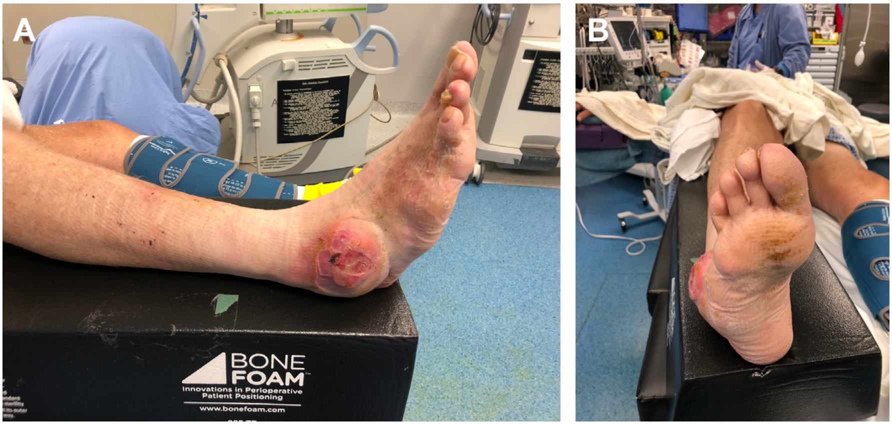

Fig. 16. (*A*, *B*) Preoperative clinical view of a patient who suffered from Charcot arthropathy with a large hindfoot and ankle varus deformity as well as a large bony mass causing a recurrent chronic ulceration leading to soft tissue envelope pathology; this was a staged planned reconstruction surgery. The initial surgery was to remove the large bony mass with culture and biopsy.

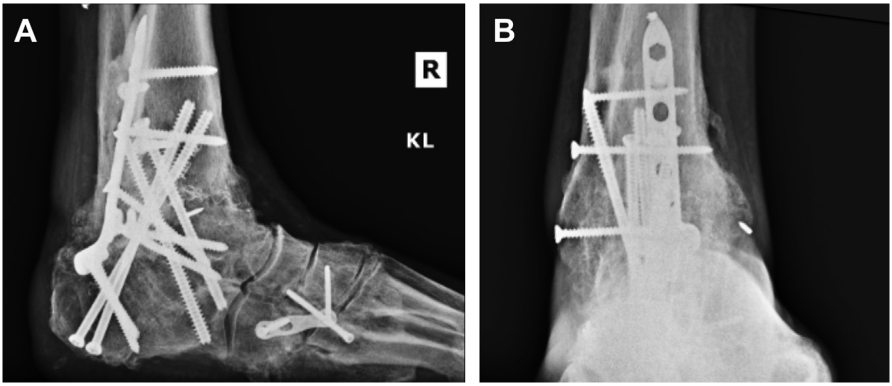

Fig. 17. (*A*, *B*) Postoperative anteroposterior and lateral radiographic views of a patient who suffered from Charcot arthropathy with a large hindfoot and ankle varus deformity as well as a large bony mass causing a recurrent chronic ulceration leading to soft tissue envelope pathology. Once the mass was removed and noted to be benign, a staged planned reconstruction surgery was performed consisting of correction of the tight posterior muscle group and a posterior approach performing TTC arthrodesis through the posterior corridor of the hindfoot and ankle.

Plating for Midfoot Arthrodesis

A medial incision is made overlying the midfoot and deepened down to bone maintaining full-thickness tissue layers. A multiplanar bone resection is performed to correct the underlying malalignment. Common malalignments are abducted, rotated into varus, and dorsiflexion. Typically this bony resection consists of a bone resection with the base being plantar and medial and the apex being lateral and dorsal in most cases; this allows the typical malaligned foot to be adducted, plantar flexed, and rotated into an anatomic neutral position. In scenarios in which the deformity is different, then the appropriate debridement of diseased bone needs to be resected to reduce the malalignment into anatomic alignment. Bone resection consists of diseased midfoot bone excised while also correcting the present deformity. Care is taken not to overadduct the foot and create a metatarsal adducts deformity or a "C"-shaped foot (this can become pathologic). The position is then held with large K-wires temporary fixation. Next, intramedullary screw fixation can be achieved creating good bone-to-bone contact at the plantar surfaces and then a medial base or plantar plate is applied for additional structural support. The other option is to use a plate (preferably a recon plate plantarly or a medial-based plate) using an eccentric loading technique with the plate obtaining compression.[41] Once this is achieved, structural positional screws are inserted outside and around the plate followed by bone grafting of the dorsal bony gaps. When applying the midfoot reconstruction plate it is applied with a combination of locking and nonlocking screws.

In cases in which there is both a rearfoot and midfoot deformity it is the authors' preference to perform a percutaneous calcaneal osteotomy using a Gigli saw.[33] When the talonavicular joint is involved, a 6.5 bolt is placed from the posterior lateral talus down the medial column to the proximal aspect of the first metatarsal (**Figs. 18–20**).

Postoperative Care

Postoperatively, the patient is placed in a univalve plaster cast and is non-weight-bearing.[44] This cast is kept intact for 2 weeks following surgery unless the provider

Fig. 18. Preoperative clinical view of a patient who suffered from bilateral Charcot arthropathy and diabetic foot ulcers.

is concerned for a wound complication, deep vein thrombosis, infection, and so on. A fiberglass below the knee cast is then applied for approximately 6 to 8 weeks and based on postoperative radiographs and soft tissue envelope. Following clinical and radiographic consolidation is confirmed via radiographs/and or computed tomographic scan, the transition to a customized CROW boot is facilitated and used for approximately 6 months. Following 6 months of successful use of a CROW walker, the senior author transitions the patients into an ankle-foot orthosis (AFO). The AFO is used for approximately 6 months and then converted to regular shoes or custom-made shoes if needed. If a TTC or a TC arthrodesis was performed, a rocker bottom will be used with the shoes to aid in ambulation. If there are concerns of a delay in the bony union, extended use of below-the-knee casting, contolled ankle motion (CAM) boot, CROW boot, or AFO are indicated and periodically evaluated with CT scans and serial radiographs.

Fig. 19. Intraoperative clinical view of a patient who suffered from Charcot arthropathy, an equinus contracture, a diabetic foot ulcer, and osteomyelitis. A bone debridement and posterior muscle lengthening was performed with application of multilevel external fixator. Anatomic alignment was maintained along with a reduction of the deformity. The patient received intravenous antibiotics with the infectious disease team.

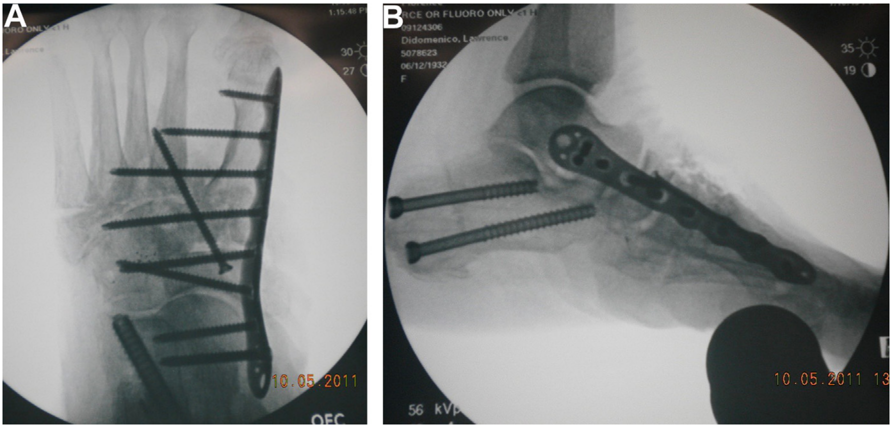

Fig. 20. (*A*, *B*) An intraoperative lateral radiograph demonstrating anatomic alignment an preparation for arthrodesis. A percutaneous calcaneal osteotomy was performed in combination with the midfoot and Lisfranc arthrodesis.

SUMMARY

Plate fixation for reduction and correction of ankle and midfoot CN includes a variety of approaches. The senior author's utilization of plating and treating an ankle and midfoot CN focuses on a staged approach. This approach includes addressing the wound, and infection, and osteomyelitis if present with wide aggressive soft tissue and bone resection before definitive internal fixation, resulting in surgical cure. For the ankle and hindfoot, a lateral approach is generally performed using a rigid construct such as a femoral locking plate. For the midfoot, a plantarly or medially placed plate construct is often performed. Both constructs are supplemented with screws outside of the plate fixation.

Ultimately, the surgeon's approach should address the underlying pathology so the surgeon can fundamentally correct the unbalanced pathologic foot and place it into an anatomic balanced aligned position in efforts of preventing reoccurrence. It is important to use a multidisciplinary approach to ensure the best patient outcome. If this approach presents difficulty or fails, the patient will be facing a significant revisional effort and or possible below-knee amputation.

CLINICS CARE POINTS

- Bone resection and removal of all diseased bone
- Reduction of the deformity to anatomic alignment
- Excellent rigid internal fixation is necessary for successful outcome
- The surgeon must have skills with internal fixation, external fixation, a good understanding of lower extremity vascular disease, and a good understanding of infectious disease and plastic surgical techniques of the lower extremity.

DISCLOSER

Relative to this article, there are no disclosures.

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