CHAPTER **31**

INTRAMEDULLARY NAIL FIXATION FOR RECONSTRUCTION OF THE HINDFOOT AND ANKLE IN CHARCOT NEUROARTHROPATHY

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INTRODUCTION

Charcot neuroarthropathy (CNA) involving the foot and ankle is a rather challenging clinical entity for the foot and ankle surgeon. Although nonoperative therapy is most often effective in maintaining a stable and ulcer-free limb, there are times when surgical management is often necessary for limb-salvage. This article will deal with surgical management of CNA involving the hindfoot and ankle. The use of intramedullary nail fixation will be presented in detail. A review of indications, contraindications, technical execution, postoperative management, and complications are presented.

PREOPERATIVE CONSIDERATIONS

Those diabetic patients undergoing CNA reconstruction require an extensive preoperative evaluation. This should include cardiac assessment since these patients often have silent cardiac disease. Cardiology consultation or thorough cardiac evaluation by the primary treating physician, including an echocardiogram or stress thallium scan, is often necessary to ensure that these patients are safe candidates to undergo a complex reconstructive procedure.

The soft tissue envelope should be thoroughly evaluated for wounds or poor quality tissue. It is most prudent to operate with a closed soft tissue envelope. There is clear evidence that elective surgery in the presence of an open wound increases the incidence of postoperative infection.[1] However, there are times when surgery may be necessary in the presence of an open wound. It is important to ensure that there is no evidence of clinical infection within the wound site in these situations. Serial debridements, local wound care, off-loading, and antibiotic therapy may be necessary before proceeding to any type of advanced surgical reconstruction.

Some patients may require a social services consultation prior to undergoing surgery. There is a relatively long period of convalescence following surgical intervention that will include nonweightbearing and limited mobility. Therefore, patients will be nonambulatory for an extended period of time. They may require postoperative deep venous thrombosis prophylaxis or have other special needs that are difficult to meet in a home environment. Unfortunately, these patients may have very little family support or are unable to manage themselves. It is often beneficial to have these patients placed in a subacute or rehabilitation facility to assist them during the initial period following surgery.

Advanced imaging may provide some benefit prior to surgical management. CNA often results in avascular bone that is difficult to ascertain on standard radiographs. Avascular bone will require extensive debridement in order to obtain a healthy cancellous substrate that will proceed to primary union. Advanced imaging, such as magnetic resonance imaging may provide insight as to whether or not avascular necrosis is present and will help with surgical planning. Scintagraphy may also be of benefit in situations where osteomyeliits is a possibility. This is especially so in patients with long-standing open wounds that have failed to heal. It is important to ensure that osteomyelitis is not present prior to surgical reconstruction.

One of the most important preoperative considerations is to thoroughly evaluate the patient’s existing deformity. These patients need to be evaluated both clinically and radiographically. The majority of patients with CNA involving the hindfoot and ankle that have failed nonoperative care usually have frontal plane deformity. Unfortunately, frontal plane deformity, whether grossly unstable or fixed and nonreducible, is often difficult to manage with bracing or shoe therapy. Additionally, a frontal plane deformity is difficult to manage with percutaneous techniques in the presence of a nonreducible deformity. These patients usually require open surgical management. The authors often employ long-leg axial radiographs to evaluate the deformity.[2,3] These radiographic views demonstrate the relationship of the tibia, talus, calcaneus, ankle joint, and subtalar joint relative to one another. These views specifically show which anatomic sites are involved and whether one is dealing with a translational versus an angulational deformity (Figure 1).

CONTRAINDICATIONS

There are some specific contraindications to CNA reconstruction of the hindfoot and ankle. Uncontrolled diabetes mellitus or malnutrition is an obvious

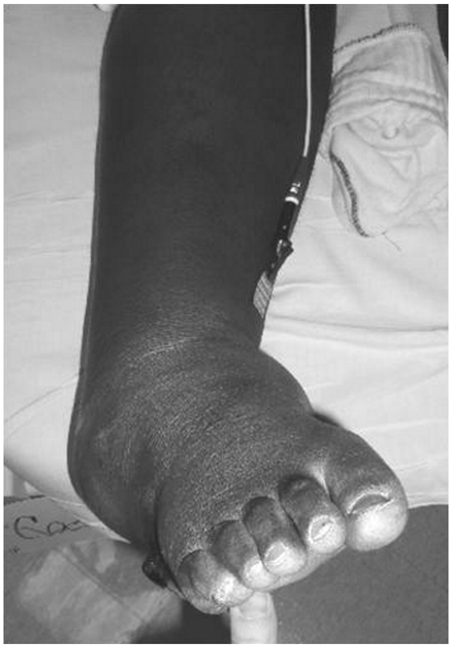

Figure 1A. Charcot foot demonstrating fixed hindfoot varus.

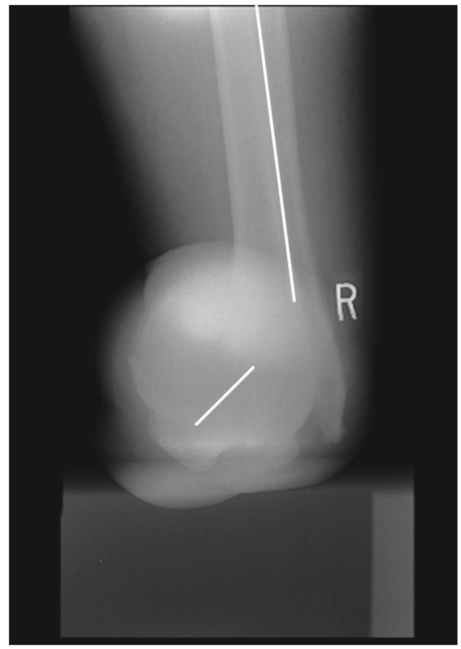

Figure 1B. Long-leg axial radiograph demonstrating severe angulational deformity between the calcaneus and tibia.

Figure 1C. Long-leg axial radiograph demonstrating severe lateral translation of the calcaneus relative to the tibia.

Figure 1D. Charcot foot with fixed hindfoot valgus secondary to severe translation demonstrated in Figure 1C.

contraindication. Those patients demonstrating elevated hemoglobin A1c levels or long standing hyperglycemia are precluded from undergoing surgical management. Patients who are medically unfit for any reason, including cardiac, renal, etc., should not be undergoing any extensive surgical reconstruction. Active infection of either soft tissue or bone is an absolute contraindication to surgical reconstruction. Any soft tissue or osseous infection should undergo thorough debridement, antibiotic therapy, and complete resolution before proceeding to any complex reconstruction. Patients and their families must thoroughly understand what is required during the postoperative period. A patient's inability to comply or comprehend is an obvious contraindication to surgery. Complications, extended convalescence and return visits to the hospital and operating room are not uncommon following surgery. These patients must be thoroughly evaluated to ascertain whether they understand what is required following surgery.

Traditional literature has described the acute inflammatory phase of CNA as a contraindication to surgical reconstruction. Sydney Eichenholtz has stated that "an arthrodesing procedure to stabilize a Charcot joint during the stage of development is doom to failure." Furthermore, he states "the optimal time for surgery is at the completion of the reconstruction stage."[4] More recent literature however, has shown that operative intervention during early stages of CNA produces good outcomes. Shibata presented his results of ankle arthrodesis in Leprotic neuroarthropathy. Twenty-six ankles were reviewed at an average of 9.5 months following ankle arthrodesis. Four of the patients who underwent surgery were early-stage CNA that went on to primary union. However, seven of the 22 patients who were late-stage CNA developed a nonunion. He concluded that arthrodesis was more successful in earlier stages of CNA.[5]

Simon et al presented 14 patients undergoing midfoot arthrodesis for CNA. All patients had stage-1 midfoot involvement. All procedures were successful with no report of ulcerations or complications. They concluded that early operative intervention may expedite the reversal of the destructive CNA process.[6] Although the timing of surgical intervention is traditionally recommended in the quiescent stages of CNA, it remains somewhat controversial and should be based on the patient's unique set of circumstances.

INDICATIONS

Indications for surgical reconstruction of CNA involving the hindfoot and ankle include a nonreducible deformity with increased plantar pressure resulting in a nonhealing wound (Figure 2). This includes patients with wounds that proceed to heal when offloaded, but recur when weightbearing resumes. Surgical intervention to off-load an at-risk foot is warranted when bracing and shoe therapy have not been effective or have failed to maintain these patients ulcer-free.

Figure 2A. Fixed varus with secondary neurotrophic ulcer along the fifth metatarsal base area.

Figure 2B. Fixed varus.

Figure 2C. Fixed varus.

Figure 2D. Fixed varus.

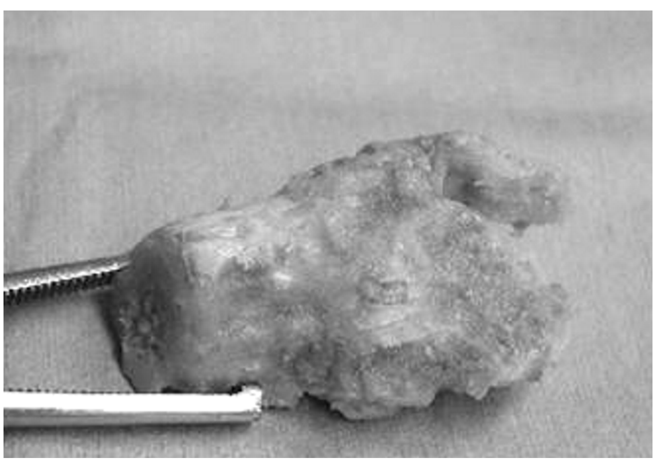

Figure 3A. Autogenous fibula can be used as a structural bone graft.

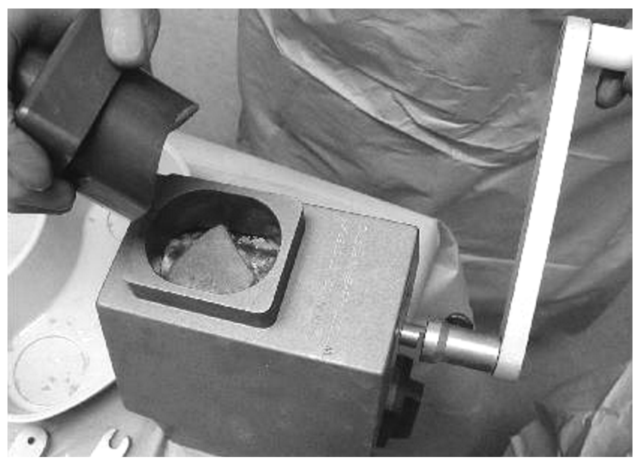

Figure 3B. The fibula can also be morselized with a bone mill and mixed with an orthobiologic substrate to enhance arthrodesis.

Figure 3C. The fibula is moreselized.

The other primary indication for operative intervention is significant deformity with gross instability that is not amenable to brace treatment. Some patients may have significant difficulty tolerating brace therapy. Surgical management should be considered to impart stability to the limb such that brace therapy can be tolerated when gross instability is present. The primary goals of surgical management are to maintain the patient's ability to transfer or remain a short distance ambulator. Surgery should restore stability and alignment such that footwear and bracing can be effective.

ANCILLARY PROCEDURES

It is important that a completely plantigrade foot be obtained at the time of the surgery. Therefore, bony resection or realignment must be sufficient to completely reduce any existing deformity. Structural bone graft is rarely necessary in the majority of patients. The authors have found that patients tolerate limb shortening quite well, as long as the foot is plantigrade. Bone graft or bone graft substitutes are often used to enhance arthrodesis. The authors typically use regional bone graft such as the fibula. A bone mill or reamer can be used to morselize the fibula. Morselized autogenous bone can be combined with an orthobiologic substance such as demineralized bone matrix to provide an excellent enhancer to arthrodesis. Additionally, the fibula can serve as a source of structural bone graft should the need arise (Figure 3).

Posterior muscle group lengthening in the form of gastrocnemius recession or Achilles tendon lengthening is required in virtually all patients undergoing CNA reconstruction. This is especially important where there is complete loss of calcaneal inclination. Restoration of calcaneal inclination is difficult without some type of posterior muscle group lengthening.

INTRAMEDULLARY NAIL FIXATION

Intramedullary (IM) nail fixation is preferred when possible. An IM nail with interlocking screws will maintain alignment, length, and stability when bone loss or osteopenia is present. This is often the case in CNA involving the hindfoot and ankle. Additionally, delivery of an IM nail results in minimal disruption of soft tissue relative to fixation devices such as large plates. The proximal and distal interlocking screws impart excellent stability. Additionally, an IM nail serves as a rigid, load-sharing device. This is especially advantageous in CNA patients with poor quality bone.

There are some contraindications to using an IM nail in CNA patients. An insufficient heel pad or a heel with previous ulceration is often a contraindication. These nails are delivered through the plantar aspect of the heel and soft tissue problems may result if the fat pad is insufficient or of poor quality. Any proximal deformity in the tibia is also a contraindication to use of an IM nail. Proximal deformity often results in delivery of an IM nail that is too short. Short nails are to be avoided because there is an increased incidence of tibial stress fractures. Lastly, the inability to obtain collinear reduction between the tibia, talus and calcaneus is an obvious contraindication. A straight IM nail cannot be delivered without collinear reduction of all osseous components.

The IM nails used in hindfoot and ankle reconstruction have evolved to provide greater compression and rotational stability. The first IM nails used in foot and ankle surgery were distal femoral nails designed for supracondylar femur fracture fixation.[7,8] The interlocking screws were directed from lateral to medial. Second generation nails added calcaneal locking in the posterior-to-anterior direction to provide rotational stability. In addition, these IM nails allowed compression across the arthrodesis site. Second generation nails have been shown to provide excellent biomechanical stability. The biomechanical strength can be attributed to the dense bone purchased near the sustentaculum tali and by neutralizing sagittal plane forces at the ankle joint.[7-10] Humeral nails have also been evaluated in foot and ankle surgery. The curve in the distal portion of the humeral nail allows for insertion of the nail without medialization of the foot.[11] This eliminates the necessity of an additional medial incision and partial resection of medial malleolus or extensive medial malleolar dissection to achieve medial translation.[8,11,12]

In several biomechanical studies, the IM nail has been shown to provide stability similar to other forms of fixation. Investigations of primary stability following tibiotalocalcaneal (TTC) arthrodesis with various implants have not proven one implant more superior to another.[13,14] Comparative studies between IM nail fixation and blade plate has shown varied results.[15,16] Since all implants are similar, factors such as osteopenia, quality of soft tissue envelope, and surgeon preference should determine the choice of implant.

IM nails have become a useful device to obtain stability in the foot and ankle. Pinzur et al reported on 21 CNA ankle fusions with retrograde locked IM nails. They showed 20 cases achieved fusion at 12-31 months when talectomy was not required. Overall, they describe their results to be satisfactory.[17] The authors prefer to use an IM nail supplemented by a static external fixator whenever possible (Figure 4).

Figure 4A. Preoperative AP radiograph.

Figure 4B. Preoperative lateral radiograph.

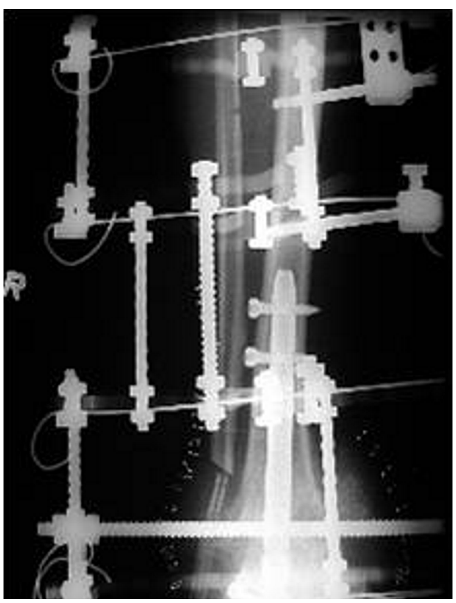

Figure 4C. Immediate postoperative AP radiograph.

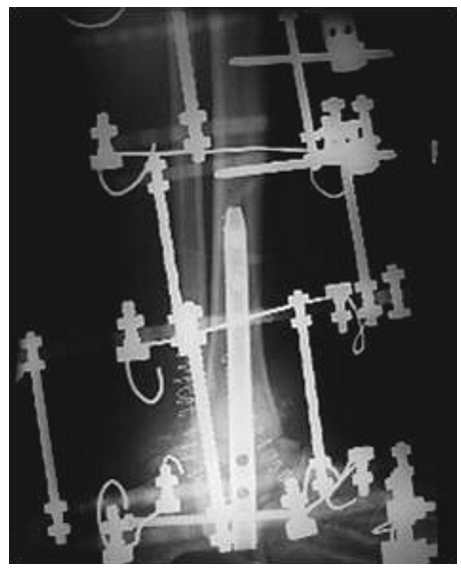

Figure 4D. Immediate postoperative lateral radiograph.

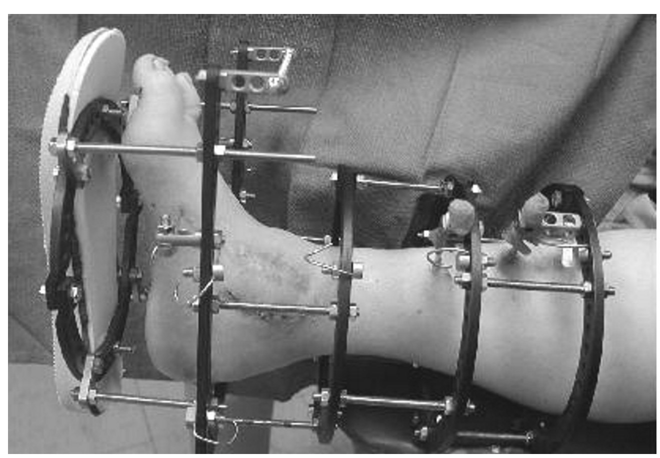

Figure 4E. Postoperative clinical picture.

Figure 4F. View at 9 months postoperative.

Figure 4G. Postoperative view.

Figure 4H. Postoperative view.

Figure 4I. Postoperative view.

TECHNICAL EXECUTION

Surgery is performed under general inhalation or spinal anesthesia. The authors typically employ a pneumatic thigh tourniquet until osteosynthesis has been achieved. Thereafter, the pneumatic tourniquet is released and hemostasis is achieved prior to a closure. There should be a sandbag or blankets placed under the ipsilateral hip such that the foot can be easily accessed and manipulated from medial to lateral. The foot is usually suspended over a large sponge block or a set of blankets to enhance intraoperative imaging.

The procedures are performed through a combination of medial and lateral incisions. The lateral incision extends from the distal one-third of the fibula to the sinus tarsi. Full thickness dissection is typically employed. All soft tissues are completely elevated and the fibula is resected and saved for possible use as a bone graft. All soft tissues are dissected from the anterior and posterior aspect of the ankle and subtalar joint. Depending on the nature of the deformity, the subtalar joint is thoroughly denuded of all cartilaginous tissues. Small osteotomes can be used to methodically break the subchondral plate. This can also be performed with a side-cutting burr. Attention is then directed to the medial aspect of the ankle where an incision is made along the anterior aspect of the medial gutter. Care must be taken to tie off vessels that are part of the anterior ankle capsule. The incision is then carried down through the ankle joint capsule and all soft tissues are elevated from the ankle. This gives complete visualization of the ankle joint. The joint is then resected with the use of a sagittal saw. Joint and bony

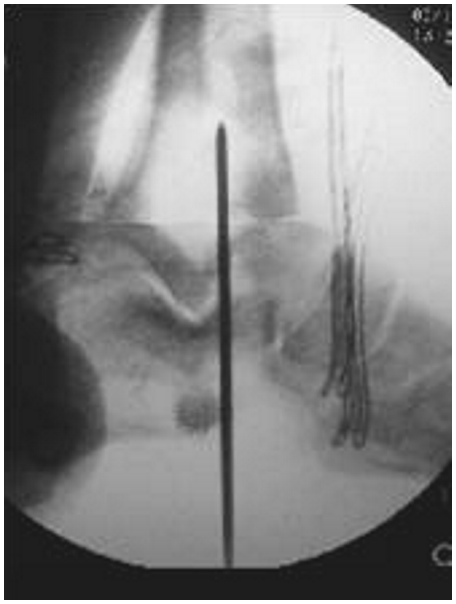

Figure 5A. Intraoperative imaging demonstrating advancement of intramedullary nail guide pin on lateral images.

Figure 5B. Intraoperative AP image.

resection depends upon the nature and extent of the deformity. One must thoroughly evaluate this area for avascular bone or fibrotic soft tissue. Avascular bone and diseased soft tissue must be thoroughly evacuated. It is important to carry out debridement down to a level of healthy cancellous bone to enhance primary union between bony segments.

Following bony resection and joint preparation, the osseous segments are aligned in a collinear fashion. The talus and calcaneus must be translated medially for proper positioning because the position of the calcaneus is about 1-cm lateral to the distal tibia. Failure to medially translate the foot may result in fracture of the medial cortex of the calcaneus or damage to vital neurovascular structures. Positioning of the foot under the leg to achieve optimal alignment is the most critical aspect of the procedure. Failure to medially translate the foot may result in placement of the IM nail in a valgus angle, which can lead to a stress riser along the cortex of the tibia. At times it may be necessary to resect a portion of the medial malleolus to allow for adequate translation; however, this is uncommon. After translation has been achieved, evaluation of rotational (transverse plane) deformity must be evaluated to ensure the ankle is not in excessive internal or external position. Alignment should be confirmed with image intensification including AP and lateral view of the ankle and a calcaneal axial view (Figure 5). These 3 views are usually adequate to ascertain reduction of the osseous segments. Provisional fixation can be obtained with Steinmann pins. An IM nail is then delivered in standard fashion. The exact steps for nail delivery will depend on the type of the nail that is being utilized. Placement of the IM nail should be anterior to the weightbearing aspect of the calcaneus and slightly lateral to avoid neurovascular structures. Sequential reaming is required for preparation of the intramedullary canal. Most IM nail manufacturers recommend reaming one-half millimeter larger than the nail diameter being inserted.

The nail is then delivered with the amount of countersink into the plantar calcaneus depending on placement of lateral-to-medial screws. Orientation of the screws will be lateral-to-medial at the level of the calcaneus and talus. A posterior-to-anterior screw is also available in some nails, which have been shown to offer better rotational stability (Figure 6).[8] The tibial screws are inserted and can be placed in a medial-to-lateral or lateral-to-medial direction. The nail is inserted in an internally rotated position to bring the interlocking screw holes to a position anterior to the fibula. Every attempt should be made to obtain complete bone to nail interface. This can be difficult due to the small calcaneal bone at the site of insertion and the medially placed nail. A medially placed IM nail may not leave adequate bone for purchase with the lateral-to-medial screws. Compression can be achieved after the proximal screws have been inserted through a mounting device. The distal screws are then inserted in either a lateral-to-medial (LM) or posterior-to-anterior (PA) direction. Although the PA screw may provide additional torsional stability to the construct, the surgeon should consider complications of the screw as well. Soft tissue breakdown at the screw head in this area of poor soft tissue coverage can occur. This entire process is performed under image intensification to ensure appropriate alignment, cortical screw purchase and appropriate screw length. The

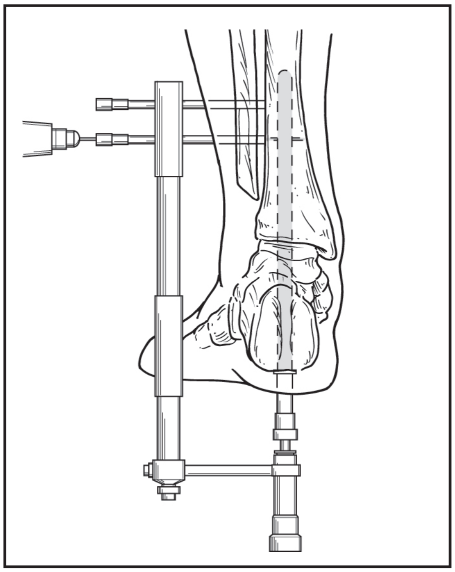

Figure 6A. Diagrammatic demonstration showing delivery of interlocking screws in a lateral to medial direction.

Figure 6B. Intraoperative demonstration.

Figure 6C. Intraoperative demonstration.

Figure 6D. Radiographic demonstration.

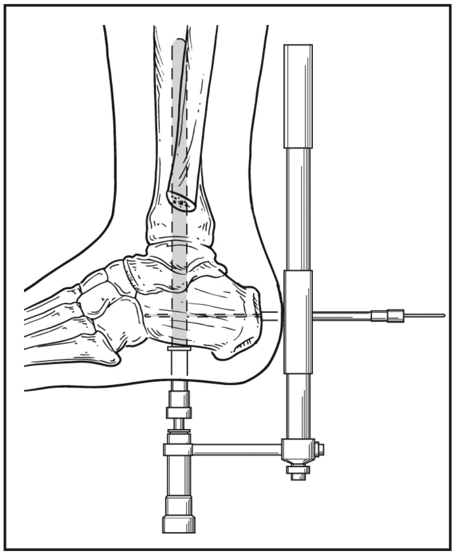

Figure 6E. Diagrammatic demonstration showing delivery of interlocking screws in a posterior to anterior direction.

authors will sometimes supplement this construct with large-diameter screws to increase stiffness. The pneumatic ankle tourniquet is then released and hemostasis achieved. Bone graft is then placed to augment arthrodesis or provide structural support. A close suction drain is beneficial. A static external fixator, which serves as a neutralization frame, is often applied.

The nail length should extend beyond the distal isthmus of the tibia. The surgeon should consider using a nail that is as long as possible in the majority of these cases. Longer nails provide for additional stability, particularly in neuropathic patients. Additionally, the use of a longer nail often reduces the incidence of stress risers. Noonan et al performed a biomechanical analysis of nail length on cadavers, which included a strain gauge analysis of cadaver tibiae. They performed an analysis of standard length IM nails versus longer nails. The standard length nails increased strain of the posterior tibial cortex at the level of the proximal interlocking screw 5.3 times that of the longer nail. They concluded the longer retrograde nails may be more appropriate in patients with neuropathy or osteopenia.[18]

The primary goal is complete reduction of frontal plane deformity. Ultimately, a plantigrade foot should be obtained at the time of surgery. Often times this requires extensive bony resection and secondary shortening of the extremity. Shortening is usually acceptable and well tolerated in the majority of the patients. However, there are unique situations where shortening may be rather extensive and a structural bone graft may be necessary. The fibula provides an excellent source of structural autograft

Figure 6F. Radiographic demonstration.

Figure 6G. Intraoperative demonstration.

if it is viable. The authors also use frozen femoral head allograft, which is osteoconductive and provides volume (Figure 7). This provides an adequate source of structural bone graft. Otherwise, the authors will morselize the fibula and combine it with an orthobiologic substance such as demineralized bone matrix. The IM nail is delivered following resection and realignment. The foot segment is then distracted distally over the nail until adequate length is obtained. Interlocking screws are then delivered and the structural bone graft is placed into the deficit (Figure 8). However, this is rarely necessary. More often than not, shortening is well tolerated and will be easily accommodated with postoperative bracing and shoe therapy (Figure 9).

Figure 7A. Preoperative radiograph showing Charcot deformity.

Figure 7B. Preoperative radiograph.

Figure 7C. Immediate postoperative radiograph demonstrating intramedullary nail with frozen femoral head as structural graft following complete evacuation of talar body.

Figure 7D. Postoperative radiograph.

Figure 7E. Lateral radiograph at 7 months post-operative demonstrating consolidation bone graft.

Figure 7F. AP radiograph.

Figure 8A. Preoperative clinical radiograph and demonstration of Charcot deformity with absence of the talar body.

Figure 8B. Preoperative view.

Figure 8C. Preoperative view.

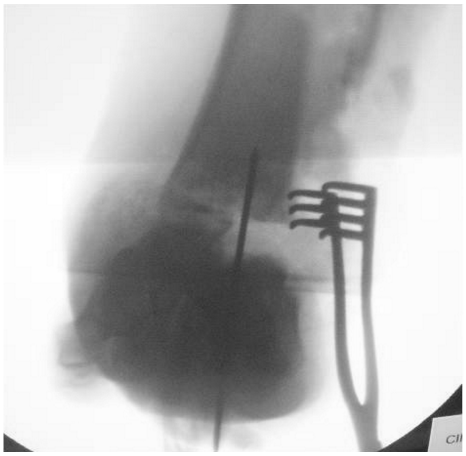

Figure 8D. Intraoperative AP image demonstrating guide pin placement and delivery of the intramedullary nail while maintaining length. A structural bone graft will be placed into the deficit.

Figure 8F. Frozen Femoral Head.

Figure 8E. Intraoperative image.

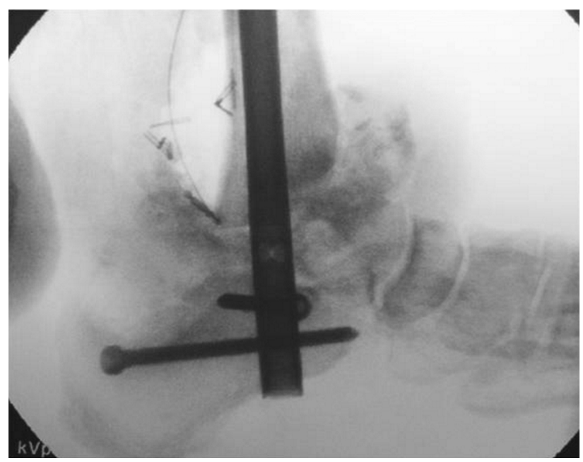

Figure 8G. Intraoperative image.

Figure 8H. Application of static external fixator as a supplement to provide neutralization.

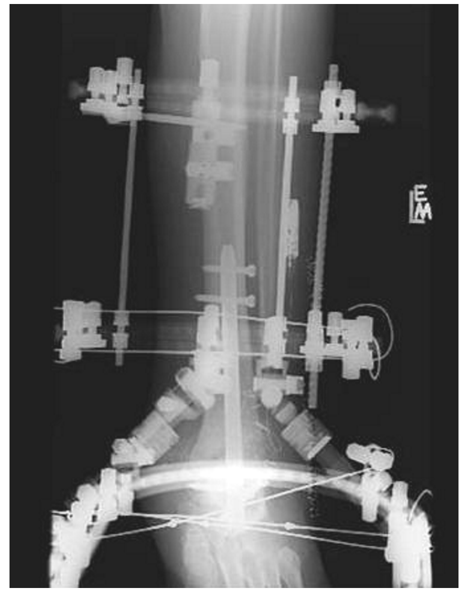

Figure 8I. Static external fixator.

Figure 9A. Clinical picture demonstrating severe Charcot deformity with gross instability.

Figure 9B. Radiographic view.

Figure 9C. Radiographic view.

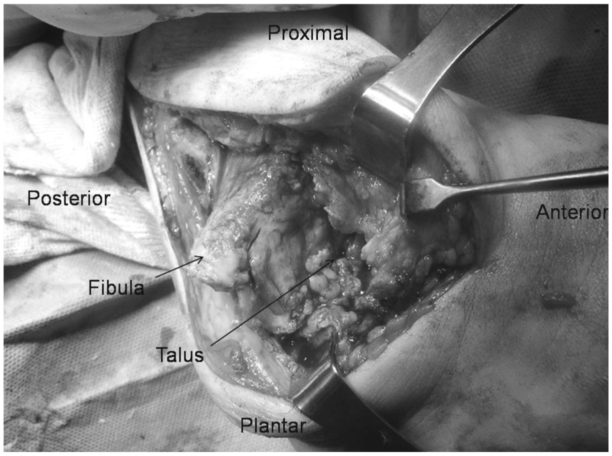

Figure 9D. Intraoperative view of the ankle and subtalar joint demonstrating severe degeneration.

Figure 9E. Note generous resection of distal portion of fibula.

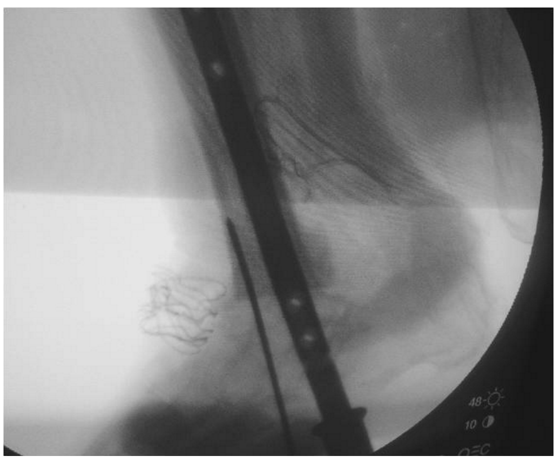

Figure 9F. Lateral intraoperative imaging demonstrating delivery of intramedullary nail.

Figure 9G. Preoperative clinical picture.

Figure 9H. Eight month postoperative clinical view.

Figure 9I. Postoperative view.

Figure 9J. Significant shortening.

Figure 9K. Shortening.

Figure 9L. Significant shortening.

Figure 9M. Accomodation with appropriate bracing and footgear.

Figure 9N. View of bracing.

POSTOPERATIVE MANAGEMENT

These patients require an extended period of nonweightbearing during the postoperative course. Patients are maintained in a static external fixator or a modified total contact cast following surgery. They must be completely offloaded until the hindfoot and ankle undergo complete consolidation. Patients are evaluated with serial radiographs and with clinical assessment. Patients are permitted partial weightbearing in a pneumatic fracture brace or Charcot Restraint Orthotic Walker if the extremity demonstrates limited edema and minimal warmth.[19] Edema and temperature should be compared with the contralateral extremity. Some patients may require placement in a subacute or extended care facility depending on their social situation. An implantable bone growth stimulator can be inserted at the time of surgery or an external bone growth stimulator can be utilized over the cast. However, if the surgeon is considering a static frame to supplement the IM nail, an implantable bone growth stimulator is preferred. All patients are ultimately placed into some type of permanent bracing. The combination of casting, external fixator and weight bearing transition device usually extends up to 8 months.

COMPLICATIONS

Complications are not uncommon following CNA reconstruction of the hindfoot and ankle. Infection is always a concern. These patients should be given prophylactic antibiotics and the authors will consider an extended course of antibiotics if a wound is present at the time of surgery. Patients should be seen at frequent intervals following surgery so that early signs of infection can be identified and addressed. Alternatively, home nursing can provide evaluation and treatment of surgical wounds, pin sites, and ulcers. Additionally, if patients are placed into a cast, the cast should be changed frequently so that the postoperative wounds can be frequently inspected and to ensure that the cast has not caused iatrogenic wounds.

Tibial stress fractures can develop with the use of an inadequate length IM nail (Figure 10). Short IM nails are often delivered when there has been inadequate frontal plane reduction of the osseous segments, the foot is not adequately translated in a medial direction, or the nail is delivered at an angle to the long axis of the tibia. The most common site of stress fracture is at the proximal interlocking screw (Figure 11). Therefore, the use of long IM nails is recommended in these diabetic neuropathic patients.

Malunion and nonunion are also possible complications. Malunion is especially difficult to address. Malunion or residual deformity will result in a fixed nonplantigrade foot with the potential for wounds to develop at some point in the future. It is imperative to obtain a plantigrade foot at the time of surgery. Nonunion is typically addressed in standard fashion with bone growth stimulators, extended nonweightbearing immobilization and sometimes surgical management. Nonunion can also result in broken hardware that can be difficult to retrieve.

Wound problems can develop with overzealous retraction or when excess tension results following realignment. This can lead to wound necrosis that requires serial debridement, wound care and antibiotic therapy. These problems can be addressed with vacuum assisted closure, delayed primary closure, secondary intention healing, and plastic surgery intervention (Figure 12).

Hardware problems may occur. Interlocking screws can loosen, back out, and require removal. Additionally, IM nails that are not completely flush with the plantar calcaneus can sometimes become a problem when patients begin weightbearing. This is especially an issue if the foot is not completely plantigrade. The authors presented results of tibiotalocalcaneal arthrodesis with retrograde IM nailing in 2004. Interestingly, all major complication occurred in their diabetic patient population.[20]

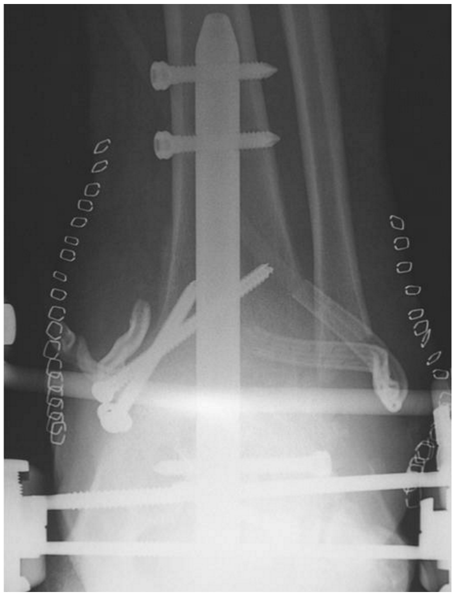

Figure 10A. Three month postoperative radiograph demonstrating consolidation at the arthrodesis site following the use of an intramedullary nail and external fixator.

Figure 10B. Three month postoperative view.

Figure 10C. Three month postoperative view.

Figure 10D. Five months postoperative radiograph demonstrating stress fracture within the midshaft of the tibia. Note the short length and angulation of the intramedullary nail.

Figure 10E. Postoperative radiograph.

Figure 10F.Postoperative radiograph.

Figure 10G. Fracture healing complete after an extended course of immobilization nonweight-bearing.

Figure 10H. Fracture healing complete.

Figure 11A. Intraoperative image demonstrating AP image of the ankle and an axial view. Note the failure to translate the calcaneus and the medial placement of the intramedullary nail within the calcaneus.

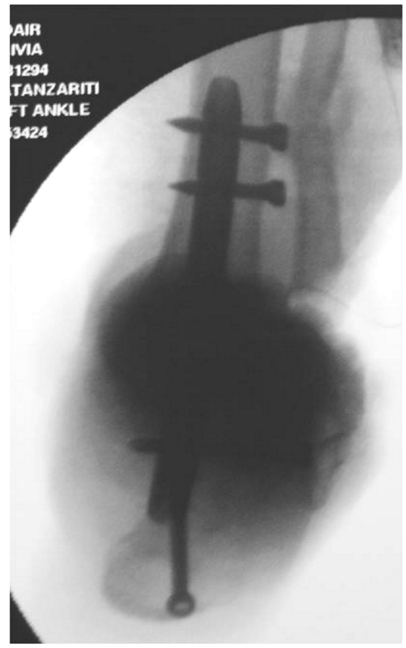

Figure 11B. Intraoperative image.

Figure 11C. Stress fracture noted at the most proximal interlocking screw.

Figure 11D. Stress fracture.

Figure 12A. Predebridement of wound dehiscence along the lateral incision site.

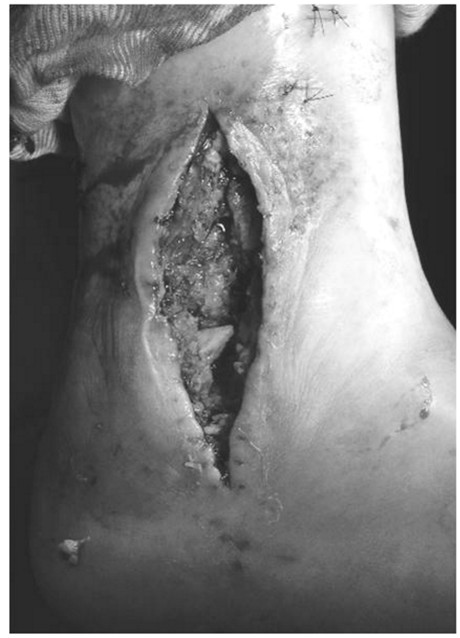

Figure 12B. Postdebridement.

Figure 12C. Free tissue transfer.

Figure 12D. Free tissue transfer.

Figure 12E. Free tissue transfer.

SUMMARY

Ultimately, the surgeon and patient must decide if surgery is the best option to address CNA of the hindfoot and ankle. Watters et al have shown decreased energy expenditure with patients maintaining bipedal gait relative to those patients undergoing below knee amputation. This is especially beneficial in a patient population who already has limited cardiac reserves.

Limb loss can often result in a social situation where patients may be required to give up their home, alter their lifestyle, etc. Limb salvage will certainly maintain independence and quality of life for some patients.

The financial costs of CNA reconstruction of the hindfoot and ankle are high. These patients require multiple visits to the hospital, return visits to the operating room, long-term bracing and casting, etc. The financial costs of these therapeutic interventions can be quite high and more than likely approximate the costs of a below-knee amputation.

Reconstruction of CNA involving the hindfoot and ankle is a reasonable alternative to below-knee amputation in a certain group of patients. These patients will require multiple procedures and hospitalizations. The patient and their family should clearly understand the intensity and burden of postoperative care prior to surgery. Timing of surgical intervention in CNA should probably be reconsidered. The patient's unique needs and circumstances should be taken into account when timing of surgery is being considered. Goals must be realistic for both the patient and surgeon when undergoing a limb-sparing procedure.

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