Intramedullary Nail Fixation for Tibiotalocalcaneal Arthrodesis

42

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42.1 Introduction

Tibiotalocalcaneal arthrodesis is used to treat severe arthrosis, deformity, and malalignment of the hindfoot and ankle. This may be accomplished by the utilization of crossed lag screws, plates, external fixation, or an intramedullary nail.[1] With a tibiotalocalcaneal arthrodesis, the goal is to create a solid fusion that corrects the deformity, maintains anatomic alignment, and allows the patient to function independently while relieving pain and providing a plantigrade foot and ankle that is shoeable or braceable.[2] Often the severity of the deformity affects not only the ankle but also the subtalar joint, thereby warranting fusion of both joints.

Intramedullary nail fixation, often termed IM nail, has been described in the literature for over 100 years. In 1906, Lexer described tibiotalocalcaneal arthrodesis in the form of an implanted cadaver bone "skewered" through the hind foot.[3,4] In 1915, Albee used a fibula as a makeshift IM nail.[5] The technique and hardware for this procedure have continued to be modified over the years.[6-19] Modern forms of the IM nail allow for a reproducible technique that provides stable fixation for tibiotalocalcaneal arthrodesis without extensive soft tissue damage.[20]

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42.2 Indications and Contraindications

Appropriate utilization of an intramedullary nail in the hindfoot and ankle is limited to those patients who suffer from severe pathology of both the subtalar and ankle joint or those patients who have a nonviable talus. Tibiotalocalcaneal arthrodesis via an intramedullary nail is indicated in a number of situations. Indications include marked ankle and subtalar joint instability and severe deformities of rheumatoid, primary degenerative, and posttraumatic arthritis of both the ankle and subtalar joints. The procedure is also indicated for a talectomy and a tibial-calcaneal arthrodesis, for avascular necrosis of the talus, pseudoarthrosis, revision of failed ankle and subtalar joint arthrodesis, crush injuries, and severe deformity secondary to neuromuscular disease, cerebral vascular accidents, and residual or neglected clubfoot.[1,4,21] The use of an IM nail is also a powerful tool that can be very effective for the correction of severe Charcot deformities and after failed total ankle replacement.[2,22]

Charcot arthropathy is a very serious complication related with diabetic peripheral neuropathy (Fig. 42.1). The problem is most severe when the hindfoot and ankle are a major concern because of instability and progressive distortion which can lead to ulceration, infection, osteomyelitis, limb loss, and death. Indications for the surgical reconstruction of Charcot arthropathy of the ankle and hindfoot are the result of failure of conservative treatment to properly address the following: chronic recurrent ulcerations, osseous deformities, unstable joints, a non-braceable foot and ankle, acute displaced fractures, and malalignment.[2] Inadequate stabilization of the existing disease process may result in further breakdown and

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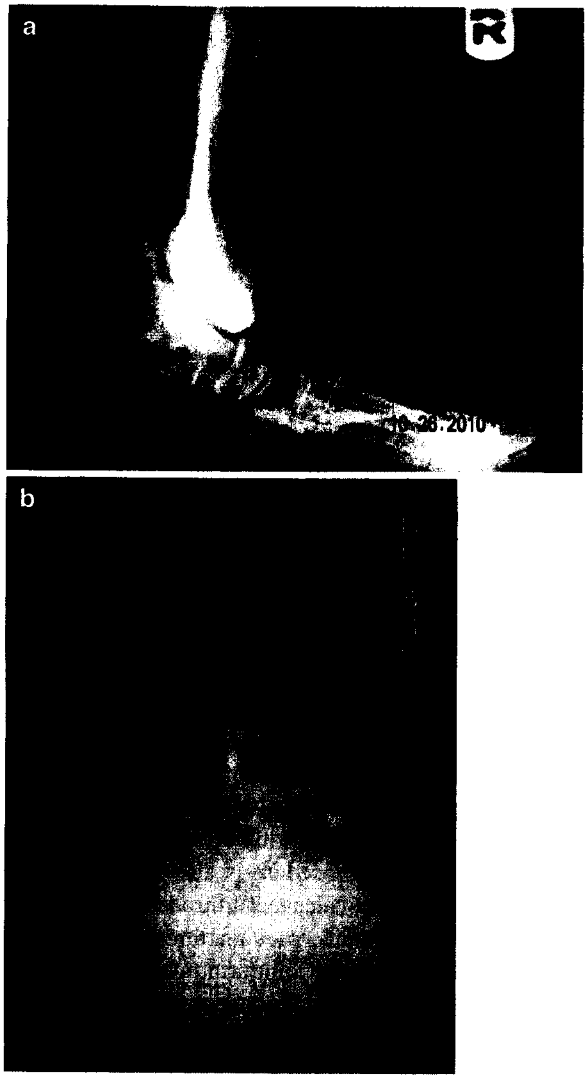


Fig. 42.1 (**a, b**) A diabetic neuropathic patient with a neglected ankle fracture. A lateral (**a**) and Anterior- Posterior (**b**) radiograph demonstrating a neuropahtic ankle fracture with mal- alignment in the tibial - talar- fibula joint. This patient wound not benefit from an intramedullary nail as the subtalar joint is in good anatomical alignment and is well maintained

continued progression of the deformity. Oftentimes with multiple joint involvements at the ankle, subtalar joint, and midfoot, it is good appropriate medical care to initiate surgical stabilization and realignment as early as possible in an attempt to avoid the often inevitable severe deformity and skin breakdown. The surgical goal is to create a plantigrade weight-bearing surface free of ulceration and to restore stability and alignment so that shoe gear and bracing are possible (Fig. 42.2).

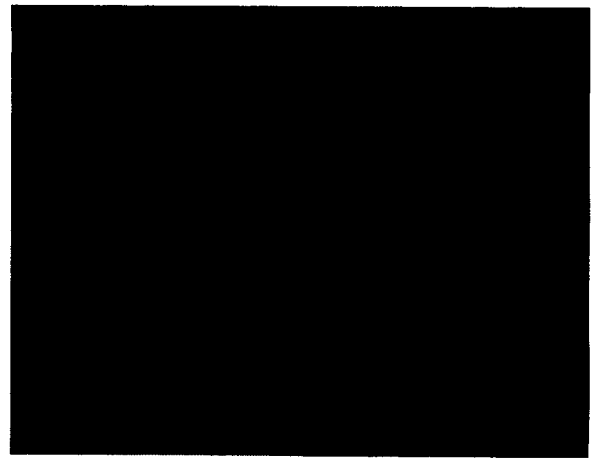


Fig. 42.2 A neuropathic patient with complete instability of the hindfoot and ankle. The radiograph demonstrates complete instability and dislocation of the tibial talar joint

Salvage of a failed total ankle replacement may result in ankle and subtalar arthrodesis which can be associated with such sequelae as marked shortening of the limb. Other options consist of a below the knee amputation or a revisional ankle joint replacement which is technically difficult and potentially challenging for the patient.[23] The former may not be feasible if there is extensive bone loss or an active infection.[8,23,24] The latter is utilized only when limb salvage is considered impossible. Tibiotalocalcaneal fusion, especially in conjunction with an allograft if the talus is unsalvageable, provides an acceptable option after a failed total ankle procedure and decreases the amount of limb shortening.[23]

Contraindications to the use of intramedullary nailing for stabilization and realignment of severe hindfoot and ankle deformities are active infection and a dysvascular limb. Relative contraindications are acute phase Charcot disease, poor glycemic control, and nutritional status. Peripheral vascular disease; insufficient plantar fat pad; a significantly deformed calcaneus; previous infection involving the tibia, talus, and/or calcaneus; and severe comorbidities such as cardiac and renal disease are other relative contraindications.[2,25]

42.3 Advantages and Procedure

There are several advantages of IM nail fixation including maintaining length, alignment, and stability with relatively minimal soft tissue stripping.[4,20,22,25-27]

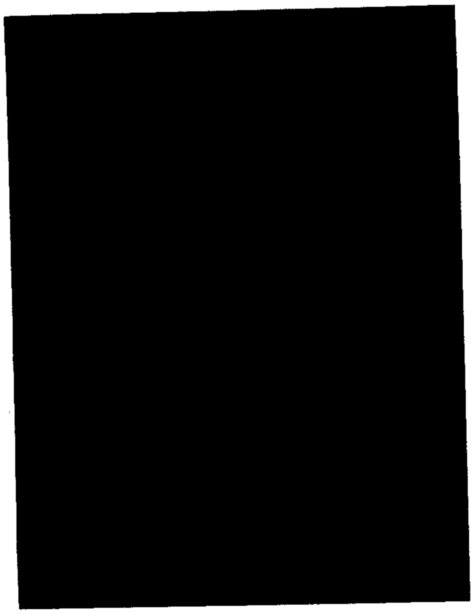


Fig. 42.3 Lateral projection demonstrating a posterior-to-anterior screw placement in the calcaneus

Studies have concluded that the IM nail provides a significantly stiffer and more stable form of fixation for tibiotalocalcaneal arthrodesis when compared with lag screws.[28,29] IM nail fixation has proven successful as a salvage procedure in rheumatoid patients by providing an un-staged fusion while allowing for moderately early weight-bearing.[30] Kile reported good results when using an IM nail with autogenous bone graft.[11] Several other studies have deemed retrograde intramedullary nailing a useful alternative to other forms of tibiotalocalcaneal fusion.[13,22,31,32] While it has been cited as less appropriate in the neuropathic population,[13] other studies have determined IM nail fusion to be an excellent salvage procedure for patients with severe Charcot deformities.[2,22]

Several methods for IM nail fixation have been investigated.[17,19,20,22,33] Posterior-to-anterior distal screw orientation has become the norm since it provides increased rotational stability compared to a transversely placed lateral-to-medial distal screw (Fig. 42.3).[19,20] The authors have utilized multiple systems. Most current systems provide a lateral-to-medial screw as well as a posterior-to-anterior distal screw and have individual unique properties and modifications. More traditional systems offer a lateral-to-medial calcaneal screw. A number of the current systems have a dual stage compression mechanism with the ability to compress the ankle and subtalar joints independently. These systems normally utilize a special alignment arm to assist with proper positioning of the transfixation screws. A small number of the IM nails in the marketplace have a lateral bend to allow for better anatomical alignment and calcaneal screw purchase. Regardless of materials and configuration of each specific nail, the overall technique is not significantly different.

42.3.1 Technique

The patient is provided prophylactic antibiotic prior to surgery, and prophylactic deep vein thrombosis measures are also utilized. The patients wear support hose on the opposite leg as well as intermittent compression pumps during the course of the surgical procedure. Following the surgery, low weight molecular heparin is prescribed in effort to prevent a deep vein thrombosis.

Following proper identification of the patient and an appropriate time-out, the patient is placed in a lateral decubitus position for a lateral approach. If there is a significant soft tissue compromise to the lateral hind foot and ankle, then the patient is placed into a prone position and a posterior approach is utilized. A midthigh tourniquet is applied for hemostasis, and a typical prep and drape is performed. The prep and draping should be above the knee as this will provide excellent exposure to the entire lower extremity assisting the surgeon with alignment throughout the case.

In the presence of a severe hindfoot and ankle deformity, a gastrocnemius or gastroc-soleus equinus oftentimes will be present. Linked with these pathologies, a significant contracture will be present contributing as a major deforming force. The deformities can be addressed with a complete tenotomy, gastroc recession, or a tendo-Achilles lengthening based on the appropriate indication. This will reduce forefoot and midfoot pressures, aid in the realignment, and allow for restoration of the hindfoot beneath the leg (Fig. 42.4).[34]

The lateral approach permits for outstanding exposure to the fibula, anterior and posterior ankle as well as the subtalar joint. The posterior approach provides an exceptional exposure to the posterior ankle, subtalar joint, syndesmosis as well as the medial and lateral malleoli.

42.3.1.1 Lateral Approach

The lateral incision is made over the distal one third of the fibula and carried out to the calcaneal cuboid joint. The lateral incision is carried deep to the level of the bony structures, avoiding all neurovascular structures.

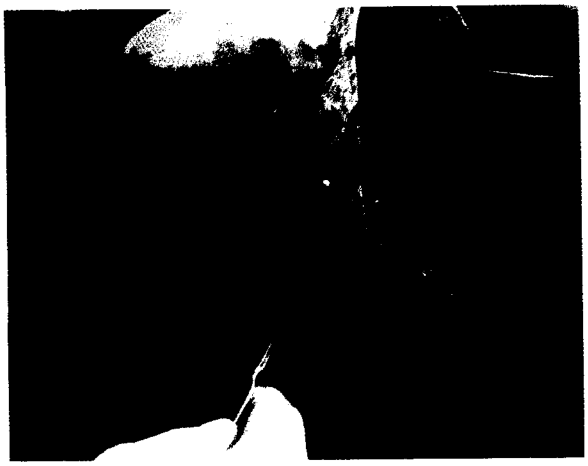


Fig. 42.4 Intraoperative view demonstrating a performance of a percutaneous tendo-Achilles lengthening. This was needed in order to get the calcaneus in alignment with the lower leg

Fig. 42.5 Intraoperative view of a lateral approach of the hindfoot and ankle providing excellent exposure to the fibula; lateral, anterior, and posterior ankle; and subtalar joint

At this time, all soft tissues are retracted to allow for complete visualization of the bony anatomy (Fig. 42.5). An oblique fibular osteotomy is performed and retraction of the fibula from the distal tibia taking down the syndesmosis, in attempt to keep the calcaneal fibular ligaments intact providing excellent exposure to the ankle and subtalar joints.

42.3.1.2 Posterior Approach

In patients who have experienced soft tissue compromise laterally, a posterior approach should be considered. The posterior incision is made directly over the Achilles tendon onto the calcaneus. The Achilles can be completely excised and/or be retracted via a tenotomy. Next a breakdown of the remaining syndesmosis is performed allowing for separation of the distal fibula from the distal tibia and providing excellent exposure to the ankle and subtalar joint as well as the medial and lateral borders of the tibiotalocalcaneal joint. The medial aspect of the viable remaining fibula and the lateral aspect of the distal tibia are prepared for fusion via a rongeur, osteotome/mallet, and curettes. It is important that this site is prepared for a syndesmotic arthrodesis.

Following exposure either through a lateral or posterior approach, based on the degree of pathology present, a wide aggressive resection of all diseased bone, cartilage, fibrous tissue as well as any other unhealthy structures is obligatory. The involved joints need to be debrided to healthy viable bone. It is extremely important that the surgeon identifies the extent of bony disease involved. This is crucial as the surgeon must determine the amount of bone removal/resection necessary in order to obtain good anatomic alignment and to understand what bone is salvageable and nonsalvageable. Wide excision of the unhealthy bone is mandatory. It has been the author's understanding to leave as much healthy bone intact while being extremely aggressive in resecting the pathological-appearing bone. For example, when the nonpathological portion of the fibula can be salvaged, it is highly recommended that the fibula be used as an onlay graft or put into a bone mill to be utilized for autogenous bone graft. Another example is when a talectomy is being performed; it has been the authors' practice to leave the head and neck of the talus intact when there is no pathological process involved with the head and neck. This typically provides for a more stable construct which in turn has allowed for more favorable outcomes. In particular, with cases of osteomyelitis and Charcot joint resection, there will be areas of large resections that occur. It also has been the author's experience to leave the remaining viable bone intact as the resected areas can be backfilled with bone graft and the remaining viable bone areas provide a solid foundation for an arthrodesis (Fig. 42.6).

Following adequate joint preparation and certainty that all articular surfaces and nonviable bones are removed, clinical and radiographic assessment of anatomical alignment and temporary fixation is performed. Please note that in normal anatomy, the calcaneus falls lateral to the midline of the long axis of the tibia (Fig. 42.7). Based on the amount of bony destruction and involvement, the surgeon may be able to "medialize" the calcaneus directly under the long axis of the tibia.[6] In cases where the calcaneus cannot be "medialized," the surgeon may want to consider using an IM nail with a valgus design.

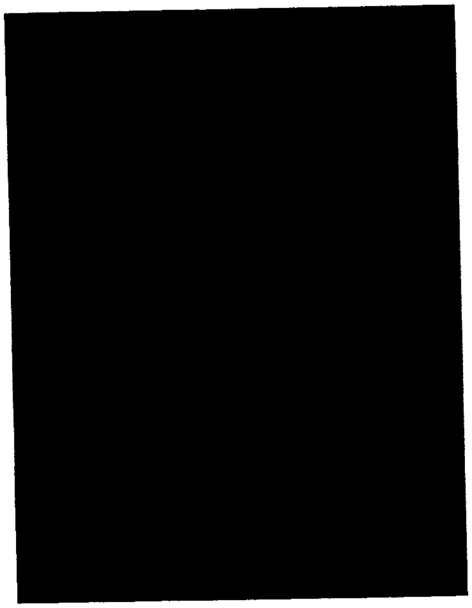


Fig. 42.6 Postoperative anterior-posterior view demonstrating the fibula used as an onlay graft

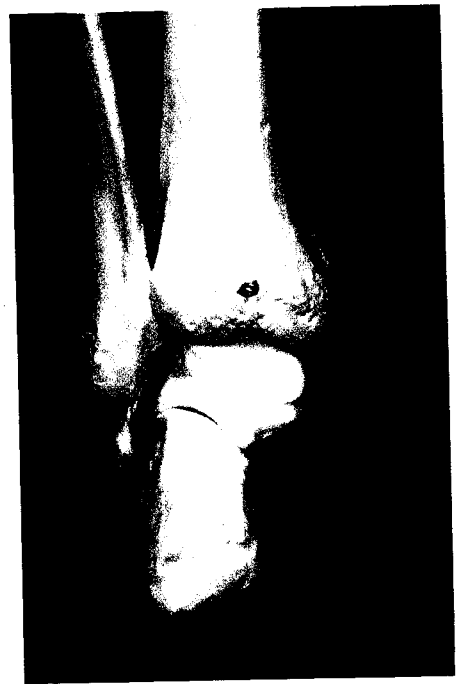


Fig. 42.7 The midline of the calcaneus is lateral to the midline of the tibia in nonpathological anatomy

Following adequate joint preparation, good anatomic alignment temporary fixation is inserted with large Steinman pins. Attention is directed to the plantar aspect of the calcaneus where a skin incision is made along the axial alignment of the distal tibia. This incision can be horizontal with the resting skin lines or it can be longitudinal.[2,6] Blunt dissection is carried down to the bone and care is taken to avoid neurovascular structures particularly the lateral plantar vessels.

After a satisfactory clinical and radiographic exam, a large guide wire is inserted through the plantar aspect of the heel up into the talus and into the tibial medullary canal. It is critical that the guide wire be placed into the central medial aspect of the calcaneus and centered in the medullary canal of the tibia. The body of the calcaneus is lateral relative to the alignment of the tibia in a nonpathological anatomy. In cases with significant pathology, it is usually necessary to medialize the calcaneus in order to get the calcaneus under the central portion of the tibia. Guide wire placement is evaluated using intraoperative fluoroscopy. It is very important at this time to evaluate the entire lower extremity for placement of the foot at 90° to the lower leg maintaining the heel in a neutral position with 10–15° of external rotation and/or maintain alignment that is consistent with the contralateral limb. With regards to the transverse plane, the second metatarsal should be aligned with the tibial tuberosity. It is critical that at this point – prior to insertion of the intramedullary nail – the most favorable alignment is obtained. Next a large drill is used to drill through the calcaneus and into the distal one third of the tibial canal. It is important to continuously check the alignment in all planes with fluoroscopy throughout the procedure in order to detect any shifting or malalignment that may occur. Next a flexible reamer is used to help determine the optimal diameter of the nail to be used. During the reaming process, the surgeon should experience "chatter." Chatter occurs when maximal diameter has been obtained and the reamer fits "tight" within the cortical walls. It is very important to reach this point in order to avoid the "wiper blade affect." The wiper blade affect occurs when too small of a diameter nail is inserted into the distal tibia allowing for toggle to occur with eventual loosening; therefore, it is desirable to obtain the largest diameter nail that will fit within the medullary canal for most favorable results. It is also important for the surgeon to be aware of "fatty emboli" which can occur during the reaming process. Once the nail size is determined, it is attached to the alignment jig and placed into the canal. The nail is driven into the tibia until the most inferior portion of the nail is slightly recessed into the plantar calcaneus. If a dynamic nail is desired, there are three techniques in order to obtain dynamic compression. One is by only using distal calcaneal transfixation and not utilizing proximal tibia transfixation. With this technique, the surgeon may

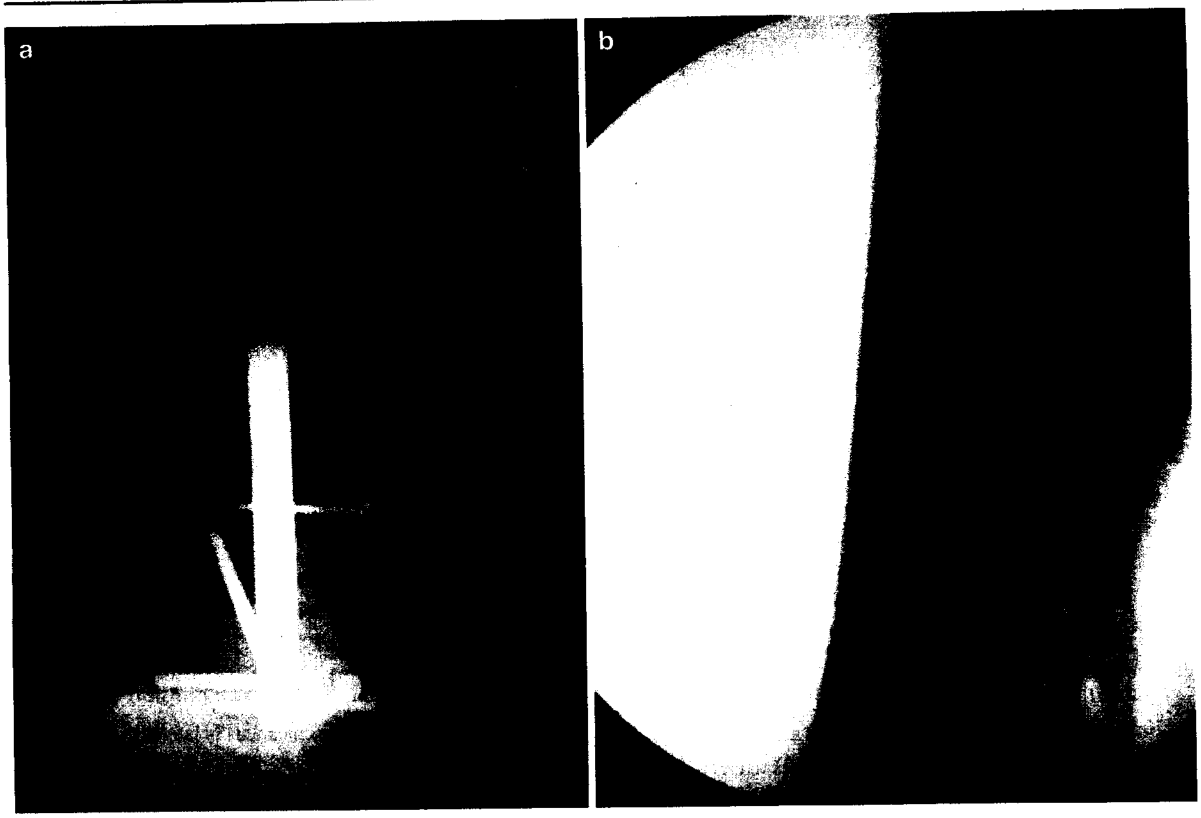


Fig. 42.8 (**a**) This radiograph demonstrates proximal and distal screw establishing a static nail. (**b**) This radiograph demonstrates how a dynamic compression construct can work. Note, once the patient is full weight-bearing and the proximal tibial transfixation screws are not utilized, this will create dynamic compression

apply a multi level external fixator and allow immediate weight-bearing. In this scenario, once a bony biological response is identified at the arthrodesis site, the external fixator may be loosened or "de-tensioned." The biology of healing with an external fixator is straightforward. Stiffness of the "construct" should be adjusted to match the biologic state of the bone. Some situations necessitate a very stiff construct while others require a flexible construct. In general, early phases of treatment start with stiff constructs, followed by progressive load transfer as the bone demonstrates a biologic response to healing (callus). Once a biologic response has been radiographically confirmed, the fixator can be adjusted to begin transferring load to the newly formed callus. This gradual load transfer is monitored closely by the surgeon and done by slowly "de-stiffening" of the fixator. This can be completed in many ways: removing bars, increasing the distance of bars from the load bearing axis (bone), removing fixation points (wires or pins), or using "dynamic" components that allow a predetermined spring stiffness. Once an appropriate amount of healing has taken place, the fixator can be completely "dynamized" by removing all connecting elements. The second technique is very similar to the external fixation described above with the difference being in utilizing a below-the-knee cast instead of an external fixator. Once the surgeon identifies an adequate biological response during the non-weight-bearing immobilization period, the patient is then transferred to a full weight-bearing walking boot. This will provide weight-bearing dynamization. The third technique is utilization of the more advanced systems. This technique involves the proximal screws being inserted first into the tibia. These systems have the ability to internally compress at the tibial–talar joint and/or the talar–calcaneal joint. Following the desired compression, the distal screws are inserted into the calcaneus to maintain compression. If a static nail is employed, an attempt to align the distal portion of the nail with the plantar calcaneus is made and the distal most transfixation screw (posterior to anterior or lateral to medial) is placed first. At this time, manual compression is applied from distal to proximal and the proximal tibial transfixation screws are inserted from

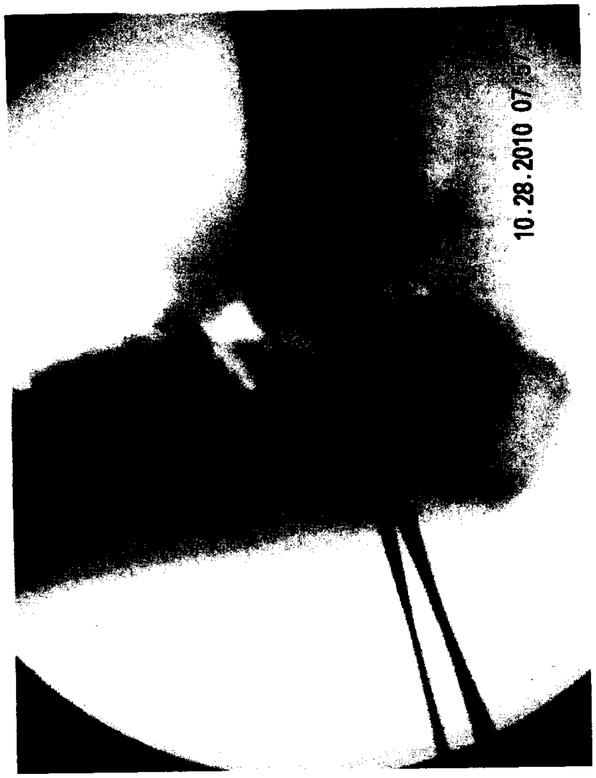


Fig. 42.9 This intraoperative radiograph demonstrates the use of two temporary Steinman pin fixation while inserting the guide wire in the medullary canal of the tibia

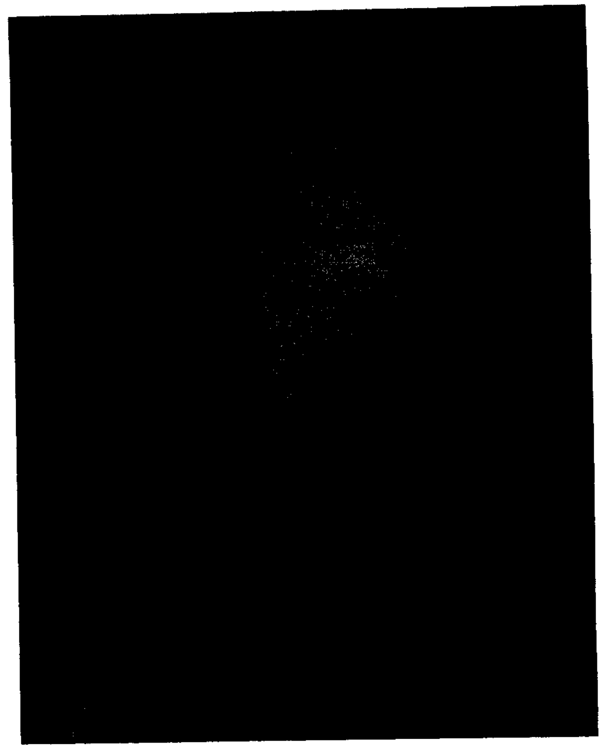


Fig. 42.10 (**a**) A view of the plantar incision following insertion of the IM nail. (**b**) A calcaneal axial view postoperatively demonstrating the nail is in good position within the calcaneus

medial to lateral in order to avoid the musculature lateral to the tibia (Fig. 42.8).

Regarding the calcaneal screw placement, the posterior-to-anterior screw offers more bone purchase. If a posterior-to-anterior calcaneal screw cannot be obtained, then a distal calcaneal transfixation lateral-to-medial screw is used, offering the least risk to the vital structures. Regarding the insertion of the proximal tibial screws, the screws should be inserted from medial to lateral, again avoiding vital structures. After evaluating the placement of the nail and fixation to the surgeon's satisfaction, the alignment jig is dismantled and an optional end-cap can be inserted at the most distal end of the nail to prevent fibrous ingrowth. This will offer an advantage should the nail need to be removed in the future (Figs. 42.9–42.11).

As stated earlier, it is the authors' recommendation to use tangential (peripheral) screws for additional stabilization. The authors have found that this provides a much more solid construct with the additional points of fixation (Fig. 42.12).

Following stabilization of the hindfoot and ankle, any osseous defects should be packed with some form of bone graft. The distal fibula is decorticated medially and the distal tibia and ankle are decorticated laterally allowing the fibula to be used as an onlay graft for added stability. The authors' experience has now recommended

Fig. 42.11 An intraoperative view inserting the end-cap following insertion of the IM nail. Next, backfilling of bone graft is completed to allow for a solid bony union

Fig. 42.12 (**a**) Lateral intraoperative view following complete insertion of the IM nail. (**b**) After the bone grafting is completed, the tangential screws are inserted providing additional stability. (**c**) Postoperative lateral radiograph demonstrating solid bony union with a stable hindfoot and ankle

the use of additional fixation outside of the nail. The authors believe this obtains a more solid construct to have individual screw fixation inserted from plantar posterior calcaneus into the anterior distal tibia and or screw fixation inserted from the inferior midfoot into the posterior distal tibia. The surgical site is then flushed with irrigation solution. Care is taken not to wash away any bone graft. The tourniquet is deflated and hemostasis is obtained; typical deep tissue and skin closure is performed with the insertion of a closed suction drain.

42.4 Complications

General complications include infection, soft tissue complications, nerve injury, vascular injury, deep vein thrombosis, pulmonary emboli, fatty emboli, delayed union, nonunion, and malunion. A delay union and non union may result from inadequate resection of bone or hardware failure. Painful internal hardware may necessitate removal in rare instances. If a nonunion occurs with no gross evidence of hardware failure, the result may be uneventful as long as clinical stability and alignment is maintained. Nonunions, especially in patients who suffer from peripheral neuropathy, are generally not painful. Malunion (malposition), on the other hand, can be very difficult to manage and may require revisional surgery.

Fatigue fractures of the tibia have been observed at the proximal end of the nails with standard length (15 cm) following a successful tibio-calcaneal arthrodesis. Noonan et al. suggest the use of a long retrograde locked intramedullary nails for tibiotalocalcaneal arthrodesis in patients with systemic or localized osteopenia.[35]

Other complications include wound dehiscence, tibial or calcaneal fracture, and hardware failure. It is important to address any complication, such as ulceration, infection, or hardware failure, with extreme urgency and aggressive treatment since failure to do so may result in below-the-knee amputation (Figs. 42.13 and 42.14).

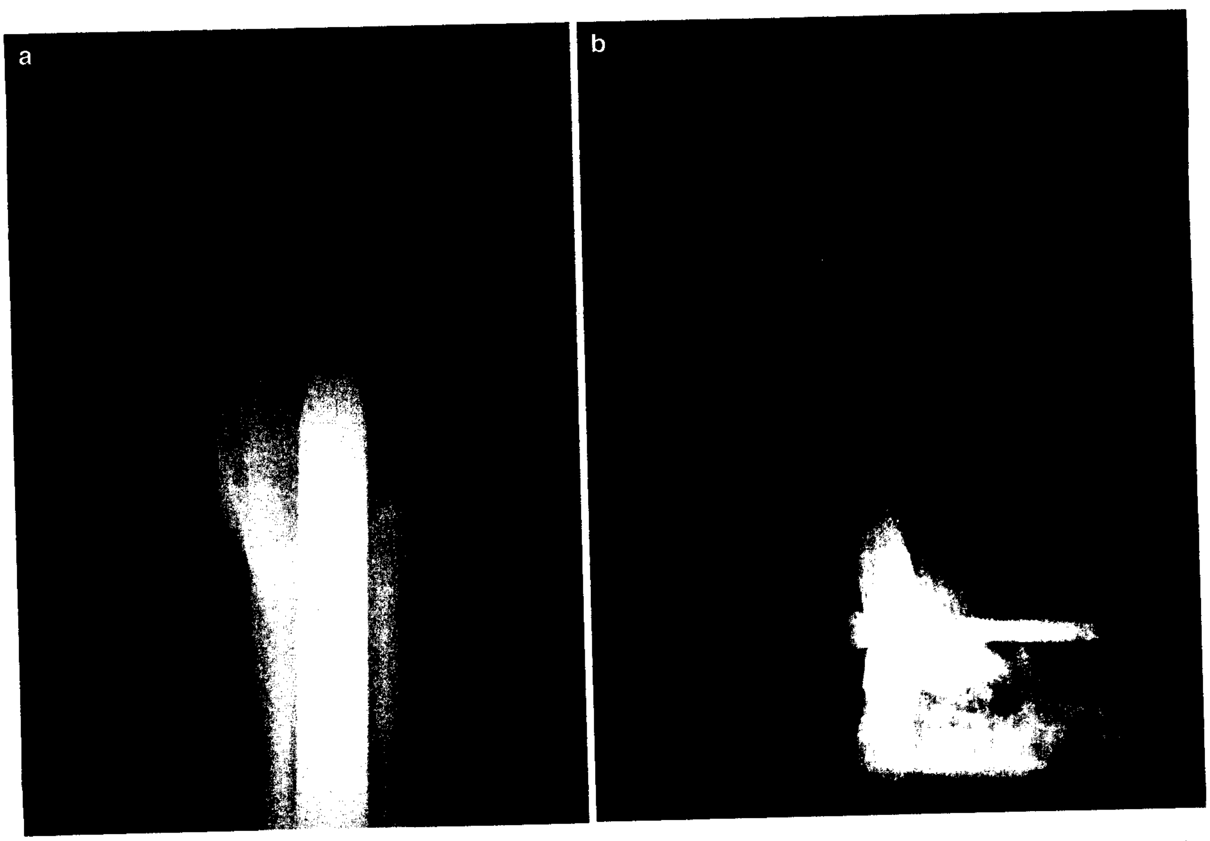


Fig. 42.13 (**a**) This view demonstrates a patient who had experienced a tibial fracture while inserting the nail. (**b**) This view demonstrates a nonunion and a fracture of the intramedullary nail. (**c**) This view demonstrates a fracture of the calcaneus with subsequent hardware failure, collapse of the calcaneus, and loosening with distal projection of the nail

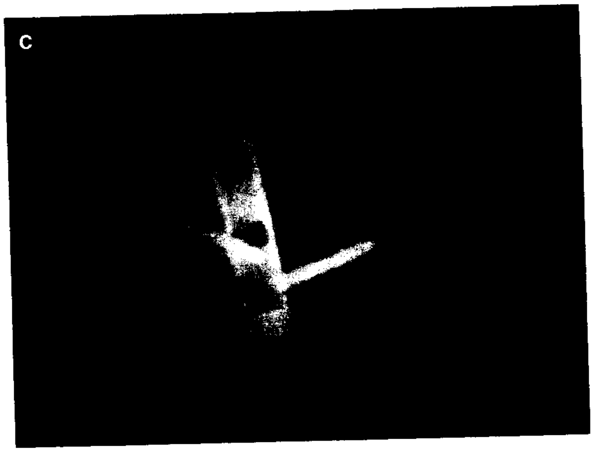
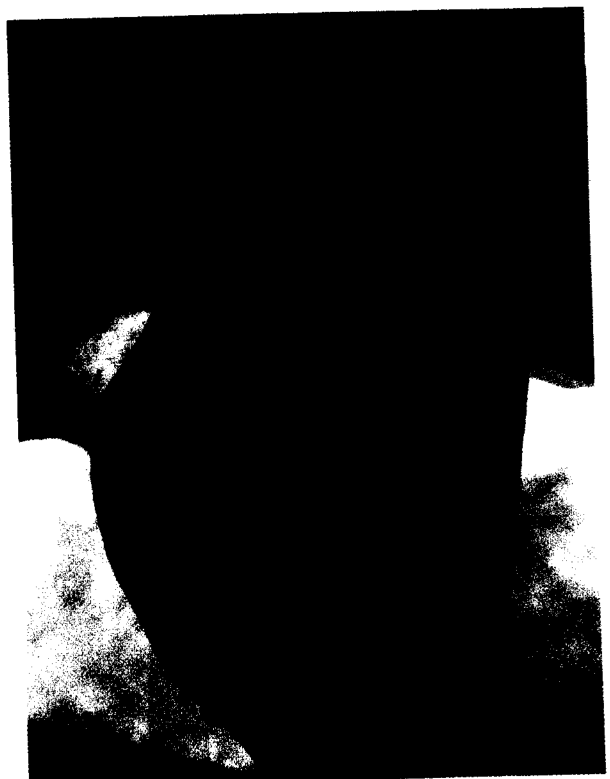


Fig. 42.13 (continued)



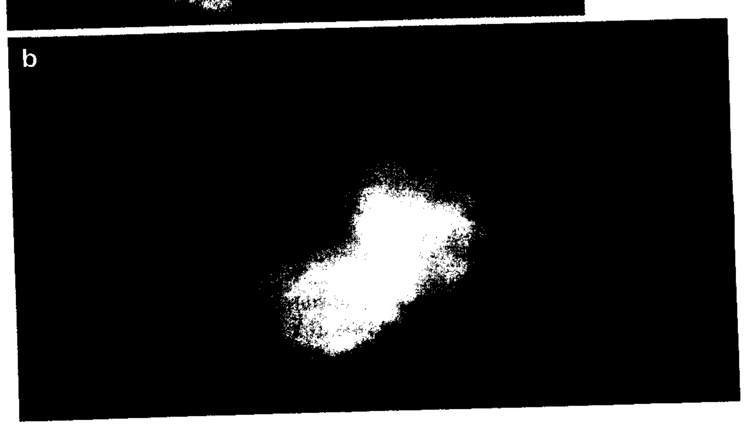


Fig. 42.14 (**a**) A non weight bearing view of a neuropathic patient with exposed bone secondary to an unstable charcot neuropathic deformity. (**b**) A lateral radiograph demonstrating malalignment of the midfoot, hindfoot, and ankle secondary to Charcot arthropathy. (**c**) A anterior-posterior radiograph demonstrating midfoot pathology and osteomyelitis secondary to the ulceration and Charcot arthropathy. (**d**) A lateral radiograph following insertion of an IM Nail. Not the hindfoot and ankle alignment and the use of the tangential screw from the posterior inferior calcaneus into the distal anterior tibia. (**e**) Anterior-posterior ankle view following the insertion of an IM Nail. Note the use of the fibula as an onlay bone graft. (**f**) Reconstruction utilizing a medial column fusion via a locking plate. (**g**) A post operative lateral radiographic view demonstrating a well healed and well aligned reconstructed mid foot, hindfoot and ankle

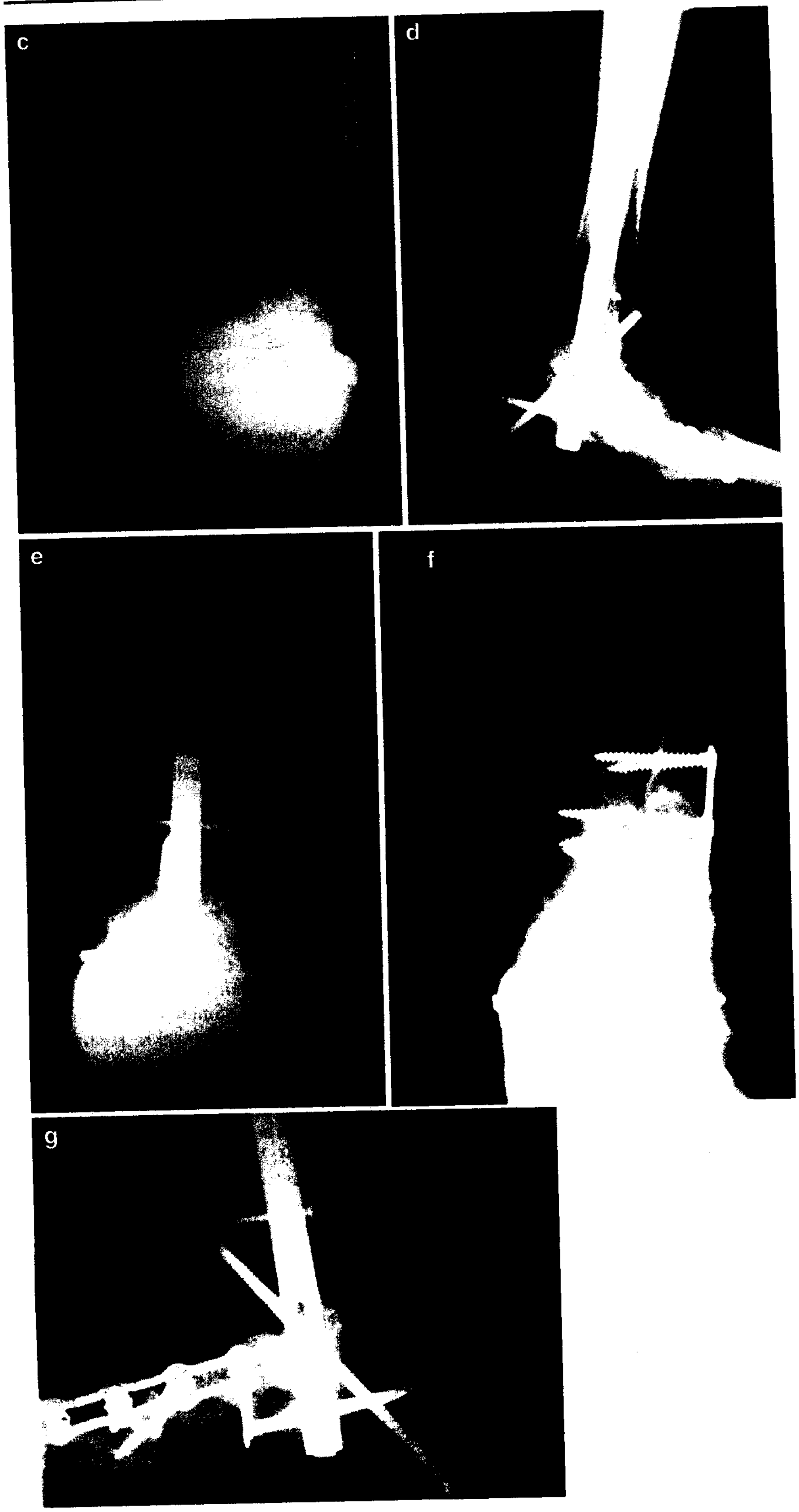


Fig. 42.14 (continued)

42.5 Conclusion

Intramedullary nails for tibiotalocalcaneal arthrodesis are used to treat severe arthrosis, deformity, and malalignment of the hindfoot and ankle. Often the severity of the deformity affects not only the ankle but may also affect the subtalar joint, thereby warranting fusion of both joints. The goal is to create a solid arthrodesis that corrects the deformity, maintains anatomic alignment, and provides a plantigrade foot that allows the patient to function independently while relieving pain. The objective is to have the patient be shoeable or braceable, thus maintaining the ability to ambulate unassisted.

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