MENTORS IN ORTHOPEDICS

ARTHRODESIS WITH RETROGRADE COMPRESSION NAIL IN CHARCOT NEUROARTHROPATHY OF THE HINDFOOT

https://doi.org/10.71165/lgpe-t3cs

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SUMMARY

Background: Charcot neuroarthropathy of the hindfoot frequently progresses to severe deformity and instability, often necessitating amputation when conservative measures fail. While various fixation methods exist, achieving stable arthrodesis remains challenging due to poor bone quality and the high metabolic demands of prosthetic ambulation compared to successful limb salvage.

Objective: This article describes a standardized surgical technique for retrograde tibiotalocalcaneal (TTC) intramedullary compression nailing as a salvage procedure for advanced Charcot neuroarthropathy.

Key Points: The procedure utilizes a lateral transfibular approach, where the distal fibula is longitudinally split to serve as both an autologous bone graft and a lateral stabilization plate. Essential technical steps include meticulous articular surface debridement, subchondral drilling, and precise guidewire placement to dictate nail trajectory. The system employs internal compression mechanisms and interlocking screws to stabilize the ankle and subtalar joints. Clinical data from a 19-patient series demonstrated a 84% limb salvage rate, although complications such as infection, non-union, and stress reactions occurred. Success requires preoperative optimization of glycemic control (HbA1c < 7.5%) and vascular status.

Conclusion: Retrograde TTC compression nailing is an effective salvage intervention for reconstructable Charcot hindfoot deformities. By providing rigid internal fixation and facilitating compression, this technique supports bony union and functional weightbearing, offering a viable alternative to below-knee amputation in complex neuropathic cases.

KEYWORDS

Arthrodesis; Arthropathy, Neurogenic; Bone Nails; Foot Deformities, Acquired; Tibia

INTRODUCTION

The treatment of charcot neuroarthropathy of the hindfoot often leads to amputation after unsuccessful attempts of conservative and surgical treatment.[1,6,7] Despite highly advanced exoprothetics after amputation, when compared to successfully fused hindfoot, looks less functionally efficient in terms of ambulation and energy expenditure, resulting in excessive cardiac strain.[8] Hindfoot fusion using a tibiotalocalcaneal nail can be a valid option before considering amputation. Therefore, the amputation and exoprothetics should exclusively be reserved for the non-reconstructable foot. For charcot arthropathy there are numerous different arthrodesis techniques with screws, plate osteosynthesis and external fixators described in the literature.[1,6] The correction of bony deformity, a stable intraosseous fixation, the locking function as well as the ability of compression are the perquisites for the bony union in hindfoot arthrodesis.[1]

Retrograde tibiotalocalcaneal compression nail often provides a robust hindfoot capable of pain- free full weightbearing avoiding secondary dislocation and implant failure. Hindfoot fusion with a retrograde tibiotalocalcaneal nail is of great value in advanced stage of chracot neuroarthropathy and is therefore an effective operative salvage procedure.[1] In this article we describe the indication, planning and a step-by-step guide of the operative technique for the retrograde compression nail in charcot arthropathy of the hindfoot.

The aim of this procedure is the reconstruction of the hindfoot using a lateral approach. The fibula is split in the distal third. The medial fragment can be used for bony interposition, when needed. The lateral fragment is spared and used as an anatomical plate which will be fixed with 2 screws over the tibiotalar aspect at the end of the operation. Hindfoot arthrodesis is achieved at both joints; ankle and subtalar, through a retrogradely inserted nail traversing the calcaneous and talus to fit in distal tibia intramedullary canal. Bones are captured with interlocking screws. Interfragmentary compression is applied across the fusion sites. Bone grafting can be performed from the medial fibular half that got harvested at the beginning of the procedure.

1. INDICATIONS & CONTRAINDICATIONS

Indications

- Advanced hindfoot/ankle neuropathic arthritis.
- Severe hindfoot arthritis with significant deformity or instability (Figs. 1-A through 1-G).
- Failed hindfoot fusion.
- Failed ankle arthroplasty.

Figs. 1-A through 1-G Multiple clinical photographs and radiographs. Severe hindfoot valgus is demonstrated with and without weightbearing.

Contraindications

- Severe foot ischemia.

- Deep active bone infection.

- Significant bone loss of the hindfoot or distal tibial metaphysis.

- Distal tibia deformity interfering with intramedullary nail fitting.

2. PLANNING

- Preoperative radiograph of the ankle (ap and lat view)

- Salzmann view of the ankle to assess the valgus or varus deformity of the heel

- Full leg radiograph (HKA) to determine limb axis

- Radiographs of the fore foot to determine combined foot deformity.

- In case of active ulcer put the patient in a non-weight baring cast to achieve complete or partial healing prior to surgery.

- In case of infected ulcer preoperative antibiotics are indicated.

- Neurological assessment is mandatory prior to surgery.

- Asses peripheral vascularization of the limb with angiography to identify vascular pathologies prior to surgery.

• In case of diabetic Charcot arthropathy, diabetes should be controlled prior to surgery with the target of HbA1c less than [7,5].

3. OPERATIVE TECHNIQUE

Step 1. Patient positioning

- Place the patient in a vacuum mattress on the lateral decubitus position keeping the operative side up (Figs. 2-A and 2-B).

• Later, position is changed to supine to facilitate proper hindfoot/leg alignment. The vacuum mattress facilitates intraoperative position changing of the patient.

Figs. 2 Intraoperative patient positioning2A. Patient positioned on the vacuum matrass. 2B. Lateral decubitus position facilitates direct lateral approach to the leg and lateral foot.

Step 2. Surgical incision

- Plan the skin incision directly along the distal fibula for transfibular approach to ankle and direct it slightly over the sinus tarsi (Fig. 3).

Fig. 3 Surface anatomy of the lateral ankleIncision line is set directly on the lateral aspect of the distal fibula to the sinus tarsi .

Step 3. Distal fibula preparation

- Expose the distal third of fibula.

- Release the distal fibula circumferentially except for its posterior tissue attachment (Fig. 4-A).

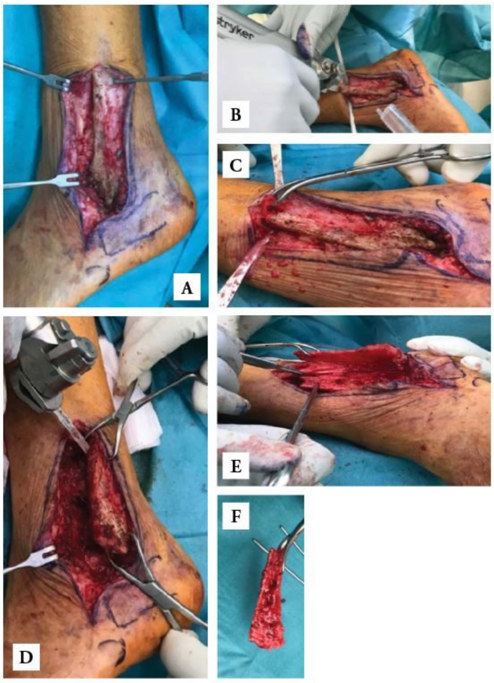
- Divide the distal fibula at the junction of middle and distal thirds (Fig. 4-B).

Remove small wedge of bone to allow for shortening later (Fig. 4-C).

- Reflect the distal fibula and split it longitudinally into medial and lateral halves (Fig. 4-D).

- Keep lateral fragment attached posteriorly (Fig. 4-E).

- Detach the medial fragment and reserve it for bone graft (Fig. 4-F).



Figs. 4 Preparation of the distal fibular third Fig. 4-A Intraoperative image shows the distal fibula exposure. Notice the posterior soft tissue bridge to fibula is preserved. Fig. 4-B The fibula is osteotmized at the junction of middle and distal thirds. Simultaneous saline irrigation helps reduce heat necrosis. Fig. 4-C Small bony wedge is removed at the osteotomy to allow freedom for subsequent shortening. Fig. 4-D The distal fibula is dissected longitudinally into two medial and lateral halves. Fig. 4-E The lateral half remains in continuity with posterior soft tissue sleeve. Fig. 4-F The medial half is completely detached and prepared for consequent bone grafting.

Step 4. Ankle and subtalar joints preparation

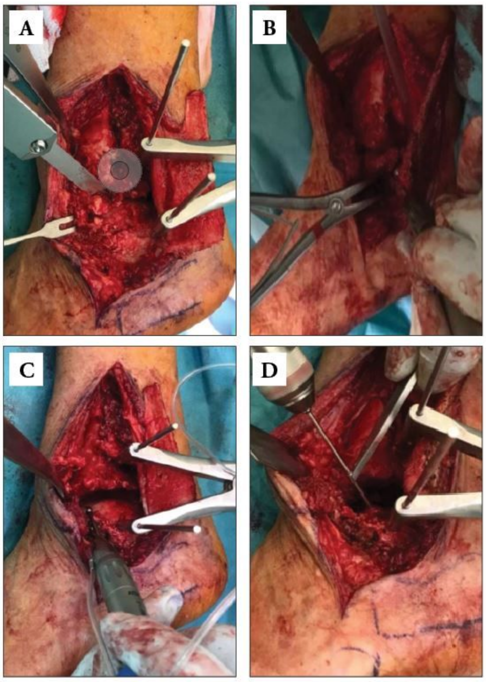
• Take out ankle articular surfaces with a chisel or burr. Hintermann spreader facilitates holding articular surfaces apart. Try to anatomically remove the cartilage. In case of hindfoot malalignment correction asymmetric bone cuts are necessary additionally (Figs. 5-A and 5-B).

• Similarly, take away articular surfaces of the subtalar joint. Lamina spreader provides adequate exposure (Fig. 5-C).

• Remove all osteophytes.

• Refashion the resultant surfaces for optimal matching in the desired hindfoot position in an attempt to recreate the normal anatomy with care to preserve bony volume as much as possible.

• Freshen up subchondral sclerotic areas with a drill 2.0 mm (Fig. 5-D).



Figs. 5 Extirpation of articular surfaces Figs. 5-A and 5-B Articular surfaces of ankle joint are held apart with Hintermann retractor. Removal of articular cartilage and osteophytes is carried out deep to subchondral bone. Burr with continuous irrigation is used to cool the area. Fig. 5-C Similarly, subtalar joint articular surfaces are distracted using lamina spreader and cartilage excised. Fig. 5-D Sclerotic areas are pierced with a 2 mm drill

Step 5. Hindfoot correction

- Flip the patient to supine position.

- Achieve temporary fixation across the prepared surfaces in an appropriate alignment using wires (Figs. 6-A and 6-B).

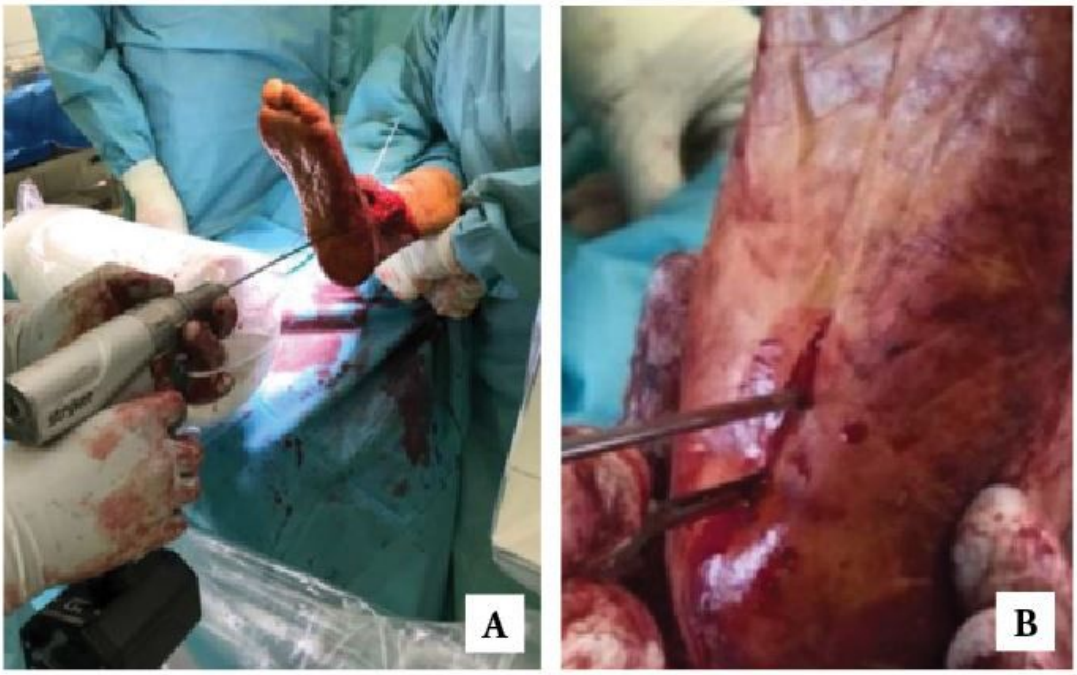
- Confirm optimal hindfoot position clinically and radiologically (Fig. 6-C).

Figs. 6 Temporary fixation of hindfoot to distal tibia Figs. 6-A and 6-B Percutaneous insertion of a wire through distal tibia across hindfoot aside to the intended nail tract. Fig. 6-C Fluoroscopic confirmation of the proper wire placement.

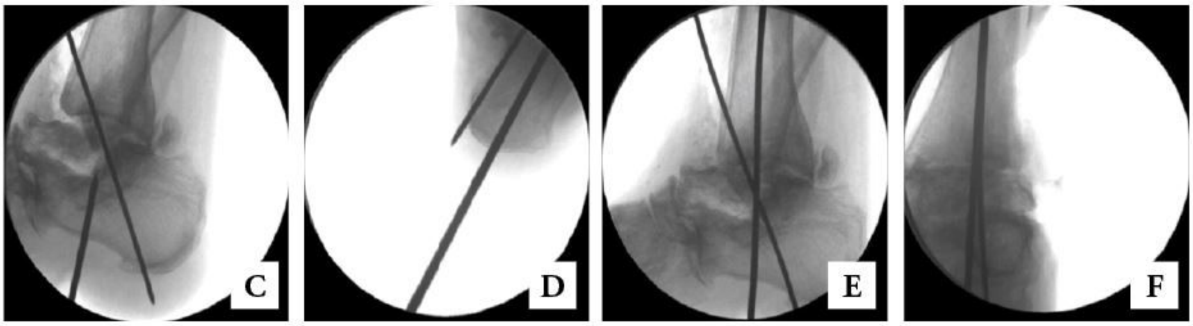
Step 6. Tibiotalocalcaneal nail insertion

(Système de clou pour fusion de la cheville ValorTM, Wright Medical Inc., Memphis, TN)

- Insert the guidewire under fluoroscopic guidance from plantar aspect across calcaneus, talus and distal tibia medullary canal (Figs. 7-A through 7-F).



Figs. 7 Proper placement of the guidewire. This is paramount to pilot the reamer creating a right pathway for the nail. Figs. 7-A and 7-B Intraoperative images show insertion of the guidewire through the heel across the hindfoot toward distal tibia. Figs. 7-C to 7-F Fluoroscopic images illustrate guidewire insertion in the desired position in lateral, axial and anteroposterior projections.



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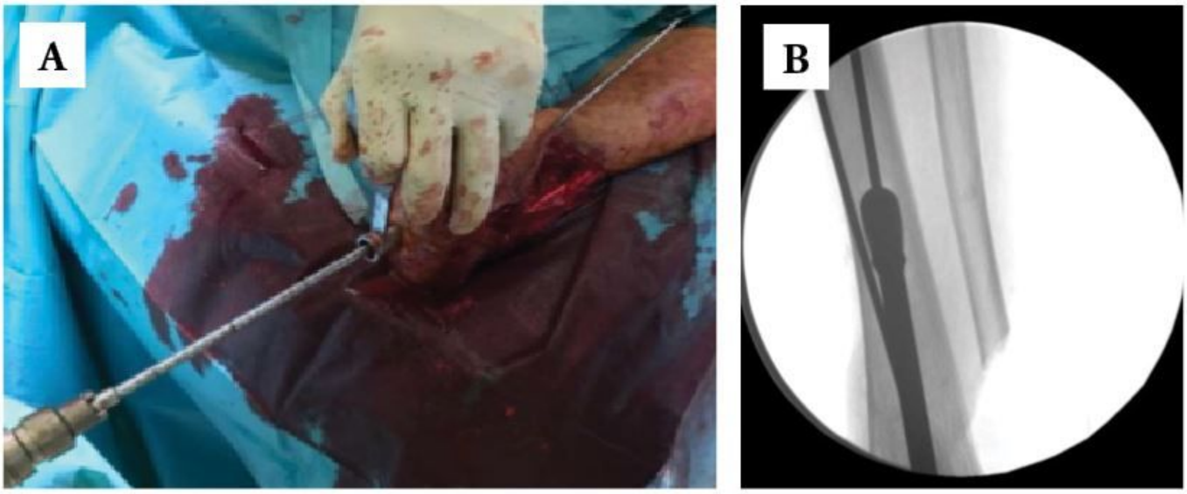
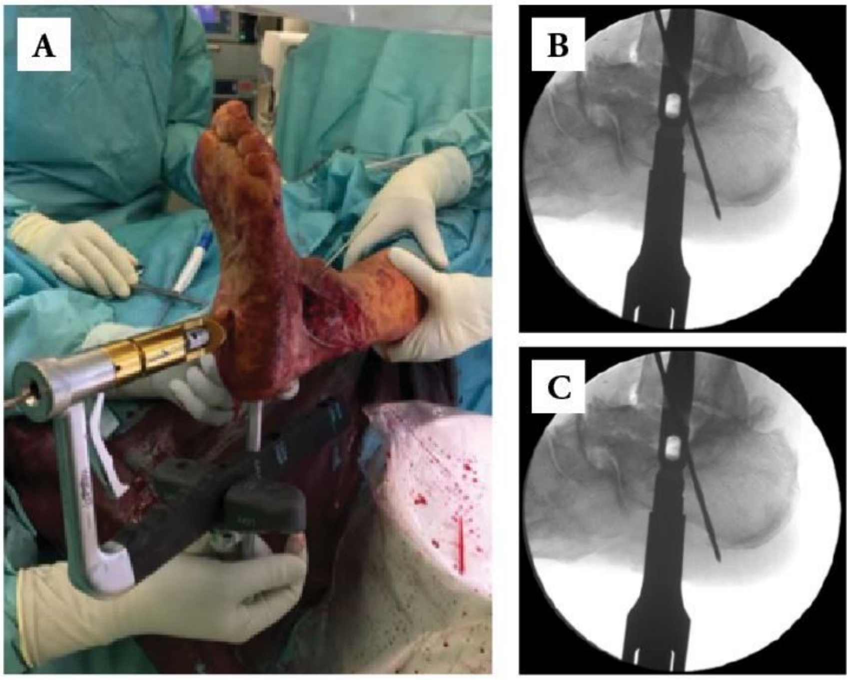
- Ream over the guidewire up to one millimeter greater than the proper nail size (Figs. 8-A and 8-B).

- Assemble the nail and test screw aiming guide precision.



Figs. 8 Reaming over the guidewireReamer followes the guidewire all the way to fit in the distal tibia medullary canal. Fig. 8-A Intraoperative photo demonstrates the guided reaming. A protective sleeve is held forcibly against the calcaneous to safeguard adjacents structures. Fig. 8-B Fluoroscopic image shows reamer inside the medullary canal of the distal tibia. Reaming is continued up to one millimeter greater than the proper nail size.

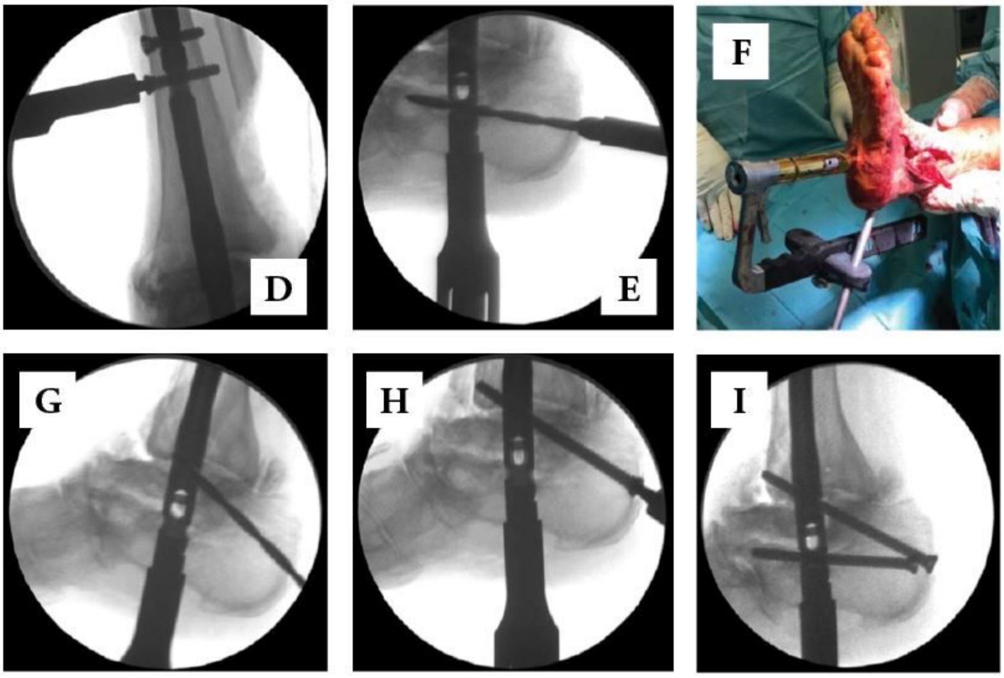
• Insert the nail gently in a retrograde manner over the guidewire until fully seated in (Figs. 9-A, 9-B and 9-C).



Figs. 9 Assembled nail insertion device over the guidewireFig. 9-A Intraoperative image capturing insertion of the nail and adjustment of the nail rotation. Figs. 9-B and 9-C Fluoroscopic monitor confirms proper nail placement in lateral and anteroposerior views.

• Having rotation optimized, remove the guidewire, then transfix the nail with interlocking screws (Figs. 10-A to 10-I). The leg is held-up by the assisting surgeon in order to avoid conflicts of the nail holding sleeve with the operation table which could lead to undesirable rotational changes of the nail.

Figs. 10 Nail transfixation with interlocking screwsFigs. 10-A and 10-B Intraoperative and radiographic images illustrate placement of static and dynamic proximal locking screws. Fig. 10- C Intraoperative photo demonstrates inability to place the transverse calcaneal locking screw as it aims at an unfavorable location through the subtalar joint. Figs. 10-D through 10-G Intraoperative and fluoroscopic images illustrate drilling of calcaneal and subtalar screw channel, respectively. Figs. 10-H and 10-I Fluoroscopic pictures show definitive subtalar and calcaneal locking screw placements.



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• Proximal screw is placed by the screw aiming guide from medial to lateral

• Proximal calcaneal screw is placed from lateral-to-medial.

• Remove the temporary fixation wires

• Achieve compression by advancing an intramedullary pre-loaded internal compression mechanism that translates the lateral-to-medial Calcaneal Screw to the top of the Compression Slot, thereby achieving compression of both the subtalar and ankle joints, as well as locking the Compression Screw into position.

• Radiographs are taken to confirm translation and compression

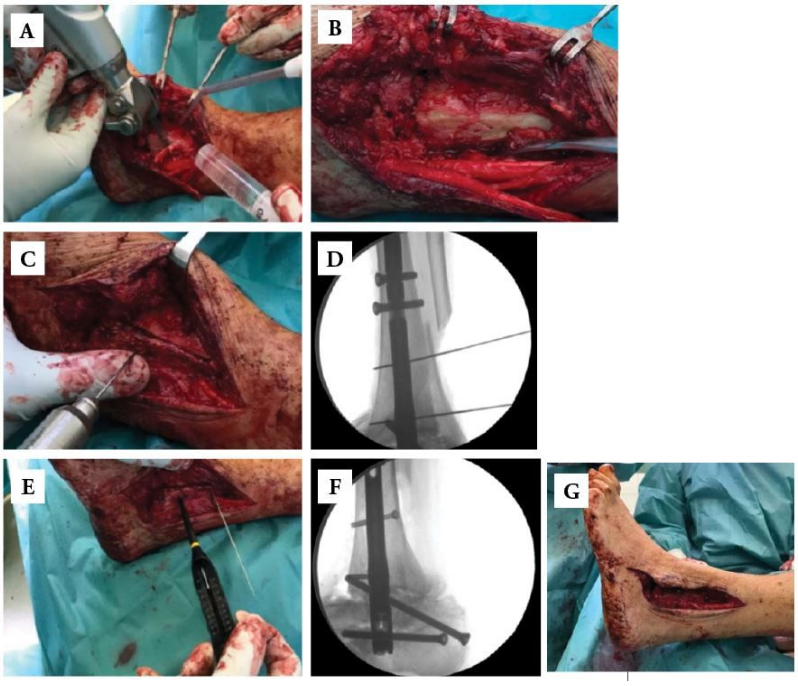
• Dorsoventral screw is inserted with the screw aiming guide at the calcaneus, which allows additional stability

• An additional subtalar screw might be inserted from lateral calcanear to medial talar which allows additional rotational stability in bad bone quality

• A proximal interlocking screw is inserted to allow dynamization for possible delayed bone healing

Step 7. Bone graft

- Use lateral half of the distal fibula as a lateral buttress along distal tibia, ankle and subtalar joints (Figs. 11-A through 11-H).



Figs. 11 Bone autografting around fusion sitesFigs. 11-A and 11-B The lateral cortex of the distal tibia metaphysis is peeled off exposing its spongy bone to pair up with the preserved lateral half of the distal fibular graft. Figs. 11-C through 11-G Technical steps of fixation of the lateral fibula half to the the distal tibia are demonstrated.

• Utilize the harvested medial half of the distal fibula for bone grafting around the fusion area and complementary procedures if necessary (Figs. 12-A through 12-F).

Figs. 12 Harvested medial half of the distal fibula might be used for bone graftingIn this case, residual forefoot supination and elevated first metatarsal have been addressed with Cotton osteotomy using a bone graft originated from medial fibular half. See Figs. 12-A through 12-F

Step 8. Closure

- Ensure carful hemostasis.

- Layered closure of surgical site.

4. POSTOPERATIVE MANAGEMENT

- Non weight bearing cast for 4 weeks, followed by a weight bearing cast for 8 weeks.

- Standard radiographs 4 weeks and 12 weeks postoperatively.

- In Case of delayed radiographical union the cast might be prolonged for further 4 weeks.

- By suspiscion of nonunion after 16 weeks CT scan should be performed.

- For nonunion the nail is dynamised and a non weight bearing cast for further 8 weeks is subscribed. In case of radiological nonunion after 6 month decision is made for either revision surgery or further conservative therapy depending on patients symptoms

- After cast removal physiotherapy can be started

- After decline of the swelling patients received orthopedic shoes to enable better roll off of the operated foot.

5. PITFALLS & CHALLENGES

- Proximal calcaneal screw might correspond to the level of subtatar joint in case of severe bone loss. In this case do not use it but this will not allow sufficient compression

• Optimization of rotation, hindfoot alignment and plantigrade foot position should be achieved before reaming and nail insertion.

• Temporary wire fixation must be set in a secure place off the nail pathway.

• Acheivement of perfect entry point and and guidewire orientation is the key technical step which dictates the subsequent nail insertion.

• The tip of the guidewire should have enough distance to the tibia crest to avoid stress fractures

• Reshaping of fusion surfaces to match each other in the correct position provides greater surface area for contact and facilitates even distribution of compression forces

• Before locking screws are placed control of perfect foot rotation should be performed

• Placement of interlockig screw through the joint space is ineffective and must be avoided (Fig. 10-C). Alternatively, relying on other interlocking screws can be sufficient

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6. RESULTS

In a recently published case series[1] we were able to save 16 out of 19 limbs with advanced stage neuropathic Charcot pathology using the described technique. The remainder 3 had to undergo below-knee amputation due to persistent infection followed by osteomyelitis resistant to repeated debridement and antibiotic therapy. All of them were initially poor hosts with low general health, poor immune status and infected sole ulceration. Risk of amputation cannot be eliminated irrespective to the method of fixation especially with existing recalcitrant superimposing infection.[1,6,7]

Several further complications occurred including superficial wound infections treated with 3 oral antibiotical therapy, 2 screw removal for skin irritation, 1 final non-union, 1 re-arthrodesis of TN joint, 1 tibial stress reaction treated with immobilitzation and 1 chopart osteotomy to correct bad hindfoot position. Nevertheless, postoperative functional scores showed significant improvement compared to the preoperative situation. The patient with final non-union remained asymptomatic and did not need revision surgery.

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