

Concept of Tibiototalcaneal Fusion with a IIIrd Generation Intramedullary Nail

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INTRODUCTION

Many different techniques have been proposed for tibiototalcaneal fusion (TTCF). Fixation may be obtained with screw constructs, plates, external fixators and intramedullary (IM) nails [1,2]. The compression, stable fixation, correct hindfoot alignment, and apposition of well-vascularized bony surfaces resulting in sound bony union and a low complication rate, are considered to be the main principles of TTCF [1,2,3,9,10].

As long ago as 1962, Küntscher [4] described closed retrograde TTCF using unlocked nails. Since then, special IM nails with appropriate locking systems and different compression options have been designed. Mann et al. [5] found a second generation retrograde nail with a posterior-to-anterior interlocking screw passed through the calcaneus in a longitudinal fashion to provide significantly more rotational stiffness as compared with a nail construct using a conventional transverse calcaneal screw. Berson et al. [1] demonstrated fusion-site compression by the same second generation nail with an external compression mechanism. The results of our own biomechanical study clearly show that, for the TTCF, compressed IM nails provide good fusion-site compression and great biomechanical rigidity [6]. In terms of primary stiffness, the compressed IM nails were significantly su-

perior to the cannulated screw construct as well as to the uncompressed IM nails [6]. The question of whether there are major biomechanical differences between nails with an external and nails with an internal compression mechanism could not be answered by the above mentioned study.

However, in a follow-up study we were able to demonstrate that a double compression (tibiotalar internal compression and subtalar external compression) is biomechanically superior to a simple external compression [7]. In addition to biomechanical aspects, the limited compressibility of the sometimes poor bone quality and the complex anatomy in this area must be carefully considered.

RECENT DEVELOPMENT T2 AAN

We have recently taken part in the development of a new so-called third generation nail for TTCF with the following features.

Special considerations - implant features

1. 150, 200 and 300 mm long, type II anodized titanium nail, 12 mm diameter at the base of the nail and 10, 11 or 12 mm at the nail tip. To accommodate the anatomical conditions (hindfoot valgus, longitudinal extorsion of the calcaneus) the nail features a 5° valgus bend in the hindfoot area and a P/A locking screw which is rotated by 10°

from the posteromedial to the anterolateral plane. The bend improves the guidance of the nail base in the calcaneal bone (Fig. 1) and prevents a hindfoot varus position, which is a common problem in retrograde TTCTF intramedullary nailing techniques [8]. Furthermore, the external rotation of the P/A locking screw improves its bony guidance. As the IM nail is customized to the anatomical conditions, it is available in a left and a right version.

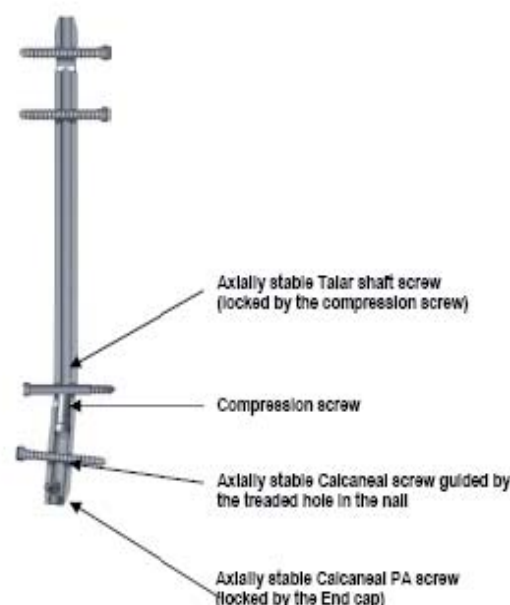
Fig. 1



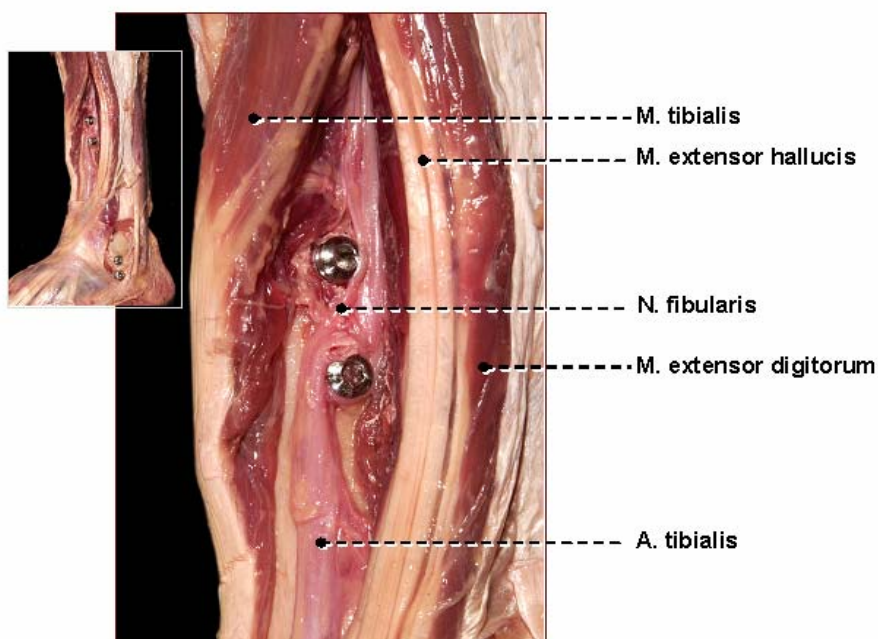
2. When locking the AAN, compression of the bony surfaces can be achieved internally by a tibiotalar compression screw. In addition, an external handle helps to achieve subtalar compression. The compression option may be chosen in the presence of good bone quality to improve the fusion and the biomechanical strength of the bone/implant interface. This ensures a stable bony fusion and allows the early functional postoperative treatment of adjacent joints. If the application of compression is not possible due to poor bone quality (i.e. if the locking screw did not purchase sufficiently into the talus and if the external compression sleeve were not supported enough by the distal cortex of the calcaneus), the AAN can still be locked in a stable angle pattern in the hindfoot area (Fig. 2), which improves the biomechanical rigidity and prevents the

locking screws from migrating under load bearing. It is advantageous in this context that the cannulated compression screw is assembled onto the nail *ex situ* at the beginning of the procedure and that the preloaded nail can then be inserted over a smooth tipped guide wire. Compression or blocking of the locking screw in the talus can be achieved by a specially designed screwdriver which does not require the dismounting of the targeting arm.

Fig. 2



3. The targeting device was developed for complete locking of the right and left versions of the 150 mm and 200 mm nails. For this purpose, the targeting device must be rotated between the various locking steps from lateral to medial, back to lateral, and finally to posterior. This additional effort is well justified in minimizing the risk of compromising relevant anatomical structures. We conducted anatomical studies in which we were able to clearly demonstrate that the locking at the nail tip in the distal portion of the tibial shaft from medial to lateral is associated with significantly less damage to arteries (anterior tibial artery), peroneal nerves and muscles (extensor digitorum longus, extensor hallucis longus) than the locking option from lateral (Fig. 3) [8].

Fig. 3

However, when locking the nail from medial to lateral, one obstacle remains: the drill hits the sloping medial surface of the tibia and might lead to misdrilling if it slips off (Fig. 4).

Fig. 4

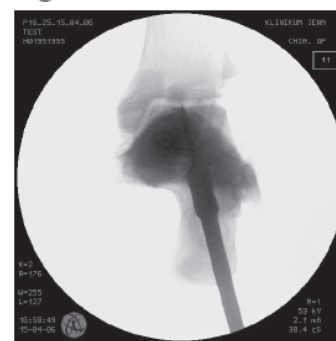
4. The surgeon must therefore pay particular attention to this risk, which can be reduced by adequate spreading of soft tissues so that the guide sleeve is in direct contact with the surface of the tibia without deviation through transverse forces. Moreover, a

shorter dedicated drill should be used for opening the first cortex. If in doubt about the deviation of the drill, this step should be performed under fluoroscopic control.

Special considerations - operative technique

1. Beside the thorough preparation of the articulating surfaces for arthrodesis, the retrograde opening and the correct positioning of the nail in respect of its insertion depth and rotation are particularly important. For a correct alignment of the hind-foot, temporary fixation can be achieved by using K-wires (K-wires must be positioned carefully to allow later reaming of the medullary canal and insertion of the nail).

2. The correct entry point for the arthrodesis by a retrograde IM nailing technique must be determined with the image intensifier in two planes. An additional axial heel or Broden view may be helpful. For opening the cortex the valgus bend of the nail must be considered, otherwise a partial gap may occur at the arthrodesis site. In a first step, a K-wire is inserted retrograde in a slight val-

Figure 5a**Figure 5a'****Figure 5b****Figure 5c****Figure 5c'****Figure 5c''**

gus angle and advanced just up to the prepared tibiotalar joint surfaces (Fig. 5a). If positioned correctly, this K-wire can guide a cannulated drill (12 mm) up to this point (Fig. 5b). After that, a guide-wire is inserted through the 12 mm canal in the calcaneus and talus and advanced centrally into the tibial shaft and aligned with the tibial shaft under image intensifier evaluation in both planes (Fig. 5c). Flexible reamers are used for reaming the medullary canal over the guide-wire. For easier insertion of the nail the medullary canal should be reamed 1 - 2 mm more than the selected nail diameter and the canal in talus and calcaneus should be drilled at least 13 mm wide.

3. The nail, pre-loaded with the compression screw, is assembled onto the targeting device and inserted over a smooth tip guide-wire without impacting. Particular attention must be paid to the ideal insertion depth and rotational alignment of the nail. After verifying the alignment and insertion depth of the nail with the image intensifier (Fig. 5d), it is recommendable to adjust the insertion depth by means of the drill sleeve. The most proximal locking hole of the nail's driving end should be positioned in the center of the talar body (Fig. 6) and the central locking hole of the driving end in the calcaneus (Fig. 6').

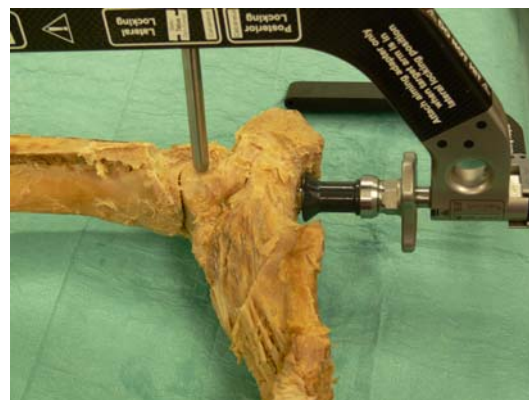
Fig. 5d**Fig. 6**

Fig. 6`

4. It should be considered that a later application of compression may reduce the joint cavity. After the correct insertion depth has been determined, the rotational alignment of the nail is facilitated by the aiming adapter for P/A calcaneal locking. The K-wire which is inserted through the aiming adapter should hit the center of the dorsal aspect of the heel bone (Fig. 7). For easier orientation the medial and lateral calcaneal limits can be palpated. When proper alignment of the nail has been achieved, the K-wire should be advanced into the calcaneus for temporary fixation.

Fig. 7

5. It is highly recommended to place cancellous bone graft onto the resected joint surfaces. Depending on the bone stock, this can be done before compression or after locking of the IM nail. Finally, after removal of the targeting device, the calcaneal P/A locking screw can be secured with the

end cap to obtain an axially stable construct. Additional end caps may be used to extend the bony guidance in the calcaneus and for easier detection when the implants are removed. For postoperative treatment we recommend an orthosis for 8 weeks. Weight bearing can commence 6 weeks postoperatively. Until then, only partial weight bearing is allowed in order to protect the osteosynthesis, the bone graft and the bony fusion. The patient's shoes should be equipped with a roller midfoot and a cushioned heel. Depending on the individual case, orthopaedic custom made shoes may be necessary.

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