Case Report

Retrograde calcaneo-talo-tibial nail, subtalar arthrodesis and fibula transposition in the treatment of traumatic bone and articulatory defect of the distal tibia and talocrural joint: A case report

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ARTICLE INFO

Keywords:
- Bone defect
- Articular loss
- Calcaneo-talo-tibial nail
- Fibula transposition

ABSTRACT

High-energy trauma of the lower leg can cause conditions such as bone defects, loss of the articular surface or a complex soft tissue injury. Given the type of the injury, as well as the often poor general status of the patient, the initial treatment usually consists of debridement and external fixation. The role of the retrograde calcaneo-talo-tibial nail is acknowledged in the treatment of post-traumatic arthritis of the talocrural joint, rheumatic arthritis, the neuropathic joint as well as some other conditions. We present a case of a thirty-five-year-old man with a lower leg fracture and significant bone defect associated with the loss of the articular surface of the distal tibia which was treated with a retrograde calcaneo-talo-tibial nail. Due to the lack of an adequate implant on the market, an inversely introduced tibial nail was used. Following the nailing of the fracture and the recovery of the soft tissue, transposition of the ipsilateral fibula was performed. Nowadays, different methods for bone defect reconstruction are available such as distraction osteogenesis, bone transport, and the Masquelet technique. However, the calcaneo-talo-tibial nail and transposition of the fibula is another feasible and effective option, especially for unreconstructable joint surfaces.

Introduction

Due to its subcutaneous localization, the tibia is particularly susceptible to open fractures with bone extrusion and defects. The treatment of the high-energy lower leg and foot injuries requires a different approach compared to the low-energy injuries. However, current recommendations of the AO foundation regarding open reposition and internal fixation for such cases are prone to numerous complications [1]. The poor general condition of the patient and the condition of the soft tissue dictate the pace of the treatment,
therefore stepwise approach using the external fixation is often required. Despite an increasing number of such clinical cases, large comparative studies providing guidelines are still lacking. As a result orthopedic surgeons still rely on recommendations [2]. Patients with bony lower leg and foot defects often present acutely as polytraumatized patients thus the orthopedic surgeon is faced with the dilemma of an early amputation or limb salvage surgery [3]. The most common methods for the management of a critical bone defect of the tibia are immediate shortening of the bone with subsequent lengthening, distraction osteogenesis, the use of vascularized and non-vascularized bone grafts and the induced membrane method according to Masquelet [4].

The bone loss and an unreconstructable articular surface further complicate the limb salvage approach. Since our patient presented with the loss of the articular surface in addition to the bony defect, we opted for the subtalar arthrodesis with a nail and the transfer of the ipsilateral fibula.

Case report

A thirty-five-year-old man presented with a Gustilo-Anderson 3B lower leg injury. The initial X-rays revealed a bony and an articulation defect of the distal tibia and lateral malleolus, along with a non-displaced talar neck fracture (Fig. 1). The patient also obtained an open fracture of the ipsilateral distal femur. On admission, the injured foot was warm, pulses were palpable, capillary reperfusion time was normal and the sensations were preserved. Part of the distal tibia articular surface was hanging on a strip of tissue outside the wound (Fig. 1). The remaining extruded distal lower leg bone was not found. The true extent of the injury was revealed after necrectomy of the soft tissue and avital bone (Figs. 2 and 3). The injured lower leg was stabilized by means of external fixation, and the bone defect was estimated to be at 15 cm with the loss of the articular surface of the tibial plafond. Seven days after the injury the necrectomy was repeated due to the appearance of purulent secretion on the wound and an increase in the inflammatory laboratory parameters. Microbiological analysis of the samples verified the presence of Enteroccocus spp. Five weeks following the injury, the bony defect of the lower leg was bridged with a retrograde calcaneo-talo-tibial nail. In addition, the subtalar arthrodesis was performed (Fig. 4). The implant we utilized was an inversely inserted tibial nail. Soft tissue defects were treated by means of multiple exchanges of the vacuum-assisted closure system. Finally, the medial soft tissue defect was treated with a split-thickness skin graft. Twelve weeks after the initial injury, when the soft tissue status was adequate, transposition of the ipsilateral fibula was performed (Fig. 5). On a regular follow up two and a half years later, the patient was satisfied with the outcome. The X-ray images displayed advanced “tibialization” of the transferred fibula and bone healing of the subtalar joint arthrodesis (Figs. 6 and 7). Local soft tissue status was satisfactory (Fig. 8) while leg length discrepancy of 2.5 cm was present. The patient had a moderate limp and was using an orthopedic...

Fig. 1. X-ray image of the lower leg upon arrival at the hospital. A bony defect of the distal tibia and lateral malleolus can be observed. Part of the articular surface of the tibial plafond is outside the wound and is held onto tissue strips (indicated by an arrow in the picture).
insole. He had a score of 53/80 (66 %) on the Lower Extremity Functional Scale questionnaire.

Discussion

In the presented case, the orthopedic surgeon was faced with a significant bone defect, loss of the articular surface, and a significant soft tissue injury.

Primary arthrodesis with a retrograde calcaneo-talo-tibial nail is a valuable treatment solution, especially if the joint surface is unreconstructable. Furthermore, the advantages of intramedullary nails in terms of sparing soft tissues are well known. In the literature, we found case reports and case series presenting the treatment of complex injuries of the lower leg and hindfoot using this method [1, 5, 6]. The retrograde calcaneo-talo-tibial nail is a well known method used mainly for ankle arthrodesis in advanced post-traumatic or rheumatic osteoarthritis of the talocrural joint, Marie Tooth Charcot disease and Charcot foot, avascular necrosis of the talus and loosening of the ankle endoprosthesis [7, 8]. Standard implants used for subtalar and talocrural arthrodesis are deficient in managing additional ankle and lower leg pathology as exemplified in the case report [9]. Taking it into account, we used a tibial nail inserted inversely. A long implant as such can later serve as a shaft for bone transport, a bone graft, or as a support for fibular transfer,
as it was done in our example. Furthermore, the length of the nail plays a biomechanical role. Shortcoming of a standard shorter implant for upper and lower ankle arthrodesis is the potential stress concentration and potential fracture at proximal end of a nail. Moreover, subtalar arthrodesis increases the lever force exerted by the implant on the tibia which is amplified in the case of a bone defect [10]. Therefore, it is biomechanically more favourable to use a longer implant anchored in the proximal tibia (Fig. 7). By utilizing such an implant, we can achieve bone defect bridging, axial and rotational stability, and plantigrade foot position in one act.

The use of fibula grafts for the treatment of lower leg bone defects is an old and well known method [11–13], nowadays often replaced with modern techniques. The fibula can be utilized as a vascularized or non-vascularized graft, free on the vascular pedicle or transposed on the pedicle. Although, the free vascularized fibula has numerous advantages, it is a method that requires microsurgical skills [14]. Transposition of the ipsilateral fibula is a simpler procedure with certain advantages, for instance, there is no surgical

Fig. 4. Bridging the bone defect with an inversely inserted tibial nail. Subtalar arthrodesis. Also, it can be seen that vacuum-assisted closure therapy is in progress. A: profile view. B: frontal view.

Fig. 5. Intraoperative picture during ipsilateral fibula transposition.
exposure except for the area of the affected lower leg [15].

While amputation is a difficult decision for both the patient and the surgeon, in terms of quality of life, it can be comparable to limb salvage surgery since it spares the patient from numerous hospitalizations and surgeries [16,17]. Alternative treatment methods include immediate bone shortening with subsequent lengthening, distraction osteogenesis, non-vascularized bone grafts, Masquelet technique, vascularized grafts and the use of RIA [2,4]. Novel recently developed techniques that can also be used are all-inside distraction osteogenesis using the PRECISE 2 IM Limb Lengthening System (Nuvasive) and three-dimensional bioprinting [4]. Each of these has its limitations and complications. Acute shortening is limited to smaller defects (3 cm–7 cm) due to the potential vascular complications and is better tolerated on the upper extremity [4]. Distraction osteogenesis with an external fixator according to Ilizarov or other devices offers a wide range of correction possibilities. However, it is burdened by the long length of the treatment, the bulky device and the possibility of pin tract infection [2,4,18]. RIA (Reamer Irrigation Aspiration) enables the harvest of autologous bone graft in a relatively simple and safe manner with less donor site morbidity compared to the iliac crest [19]. The Masquelet technique in two acts, enables the bridging of a large bone defect, up to 25 cm long [20]. The membrane induced around the polymethyl methacrylate cement spacer protects the autologous graft from resorption and soft tissue ingrowth. Also, the membrane is thought to release

Fig. 6. X-ray image after two and a half years. A successful arthrodesis of the subtalar joint can be seen. The progress of “tibialization” of the transferred fibula can be monitored. A: frontal view, B: profile view.

Fig. 7. After two and a half years. A: long leg view, frontal image. Correct axial alignment is visible. A healed fracture of the distal femur can also be seen. B: profile image of the lower leg. Progression of the tibialization of the transferred fibula is seen. The length of the implant and the location of the proximal anchorage can be seen on the A and B view.
growth factors that promote bone formation. The method can be used with external and internal stabilization with an intramedullary nail [21].

Conclusion

Retrograde calcaneo-talo-tibial nailing and transposition of the fibula are not among the common techniques of bone defect management. However, in the case of a massive bone loss, especially if it is associated with the loss of the ankle articular surface, they can provide a satisfactory method of limb salvage surgery.

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