TECHNICAL NOTE

Technique and early experience with posterior arthroscopic tibiotalocalcaneal arthrodesis

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Accepted: 1st March 2010

KEYWORDS
Arthroscopy; Posterior approach; Minimally invasive; Retrograde nail; Tibiotalocalcaneal arthrodesis

Summary Tibiotalocalcaneal arthrodesis is indicated for pain relief in patients with combined arthritis of the ankle and subtalar joint. An arthroscopic posterior approach was designed to improve upon traditional methods by using a minimally invasive technique. The technique involves prone positioning of the patient, one anterolateral and two posterolateral portals, and arthroscopic debridement of both the tibiotalar and posterior talocalcaneal joint. Stabilisation is obtained with a retrograde intramedullary nail, with static interlocking. This article presents illustrative cases and discusses some of the technical advantages and disadvantages over conventional open surgery. For surgeons familiar with posterior ankle or subtalar arthroscopy, this minimally invasive debridement and nailing appears to offer superior exposure, high patient satisfaction and lower postoperative morbidity than traditional methods; fusion is encouraged by preserving the medullary reaming material at the site of the fusion.

Introduction

Tibiotalocalcaneal (TTC) arthrodesis is a reasonable treatment option in patients with arthritis involving both the ankle and subtalar joints, when all non-surgical treatments have failed. TTC fusion is now being used for a variety of indications: post-traumatic osteoarthrosis affecting both subtalar and ankle joints; presence of pathologic features in either joint, for example after failed fusions or reduced bone stock with soft tissue problems; talar avascular necrosis; failed total ankle arthroplasty; stage 4 adult acquired flatfoot; several neurological indications; rheumatoid arthritis; poliomyelitis deformities; ankle fragility fractures, etc. [1–11].

The use of cancellous bone screws, staples, blade plates and locking plates, intramedullary fibular grafts, intramedullary rods and external fixators in various configurations has already been described. The ideal technique should be straightforward, provide excellent stability and a high fusion rate, whilst still preserving the soft tissue envelope. Amongst the abovementioned techniques, intramedullary nailing appears to yield reproducible results, and offers the benefit of a load-sharing construct with rigid internal fixation and potentially less soft-tissue damage [12–17]. This is important as the patient’s skin may present...
abnormalities due to systemic diseases or scarring following prior injuries or major operations [18].

When performing posterior ankle arthroscopy for impingement or intra-articular pathology, as well as when performing modified arthroscopy-assisted fusion of the subtalar joint, the proximity of both tibiotalar and subtalar joints is a beneficial feature of the technique. We developed posterior arthroscopic tibiotalocalcaneal (PATTC) fusion to improve on the conventional open methods, through the use of a minimally invasive debridement and fixation technique, which, in theory, maintains an optimal blood supply to the tibial plafond, the talus and the posterior facet of the calcaneus. It is suggested that this factor should also reduce perioperative morbidity and shorten the time to fusion.

We will outline the surgical technique of the PATTC fusion with the patient in prone position, present illustrative cases and discuss some of the major advantages of the technique compared to traditional methods.

**Surgical technique**

The procedure is performed under general anaesthesia with the patient in prone position; a regional nerve block can be combined. In the absence of preexisting infectious episodes, antibioprophylaxy is given. Otherwise, cultures are made before giving the antibiotics. A tourniquet is applied to the upper leg. The technique can also be performed under a regional nerve block without the use of a tourniquet, in patients with a precarious vascular status. A support under the lower leg allows free mobilisation of the ankle. Normal saline is used for irrigation with gravity flow. After standard preparation and draping, surgical landmarks are drawn on the skin. Standard posterolateral and posteromedial portals are used according to Van Dijk [19]. A 4.0 mm, 30° angled arthroscope is inserted through the posterolateral portal. A 5.5 mm full-radius shaver, from the posteromedial portal, frees up the posterior compartment, keeping the flexor hallucis longus tendon as an important medial landmark. An accessory anterolateral portal, placed under arthroscopic control using a 21-gauge needle, permits exposure and debridement of the posterior facets of the subtalar joint, using the blunt trochar for joint distraction. We did not use an additional posterolateral portal due to the risk of damaging the sural nerve or the fibular tendons. Most of the debridement of the subtalar joint is carried out with the arthroscope in the posterolateral portal and the instruments (shaver, chisel, periosteal elevator and chondral pick) in the posteromedial portal, although the portals are used alternatively for viewing and instrumentation [20].

By applying manual distraction with a non-invasive strap around the hindfoot, the posterior compartment of the ankle opens up and the shaver, the curettes and chisels can also be introduced into the tibiotalar joint space. To obtain a good overview, the intermalleolar ligament and the posterior tibiofibular ligament are partially resected. Taking care not to alter the geometry of the tibiotalar and subtalar joints, one to two millimetres of subchondral bone is then removed from the tibial plafond, the talar dome and the posterior talocalcaneal facet until the bleeding cancellous bone is visible (Fig. 1).

**Figure 1**  A–C. Drawing of the necessary incisions on the skin. A. The lateral malleolus is marked, as well as the para-Achilles tendon posterolateral incision (PLP) for the hindfoot arthroscopy according to the technique of Van Dijk. The anterolateral portal (ALP) at the sinus tarsi will be used for distraction of the subtalar joint. The other two incisions will be used for the latero-medial screw in the calcaneus as well as in the talus. B. The medial malleolus and the posteromedial portal (PMP) are drawn. More proximally the stub incisions made for the medial to lateral proximal tibial screws can be seen. C. Plantar approach for the nail. D. Lateral fluoroscopy, demonstrating the simultaneous, easy accessibility of both the tibiotalar and subtalar joint. E. *: view of the posterior section of the debrided posterior talocalcaneal facet. **: view of the posterior tibiotalar joint, immediately anterior to the intermalleolar ligament. ***: medial landmark of the working space by the tendon of the flexor hallucis longus.
When both joints have been debrided of cartilage and subchondral bone, the skin is closed, and the ankle and hindfoot are placed in 5° of valgus, neutral dorsiflexion and 5° external rotation. A 1.5 cm longitudinal incision is made on the plantar aspect of the foot under the calcaneus. A guide wire is passed through the calcaneus and talus into the tibia under fluoroscopic control. After reaming, a retrograde intramedullary nail is inserted for fixation. A titanium alloy intramedullary nail of 10 mm × 15 cm or 30 cm (Versanail DePuy® or T2Stryke®) is used statically, with two screws in the calcaneus (one from posterior to anterior and one from lateral to medial), one in the talus (lateral to medial) and two proximally in the tibial shaft (medial to lateral). No additional bone grafts are used.

The skin incisions are closed, and a bulky sterile dressing and a posterior splint are applied. The tourniquet is then released. A lower leg cast is applied for 8 weeks.

Postoperatively, patients are instructed to avoid weight bearing until the radiographs demonstrate union.

Illustrative cases

Case 1

A 61-year-old man with a 26-year history of type 2 insulin-dependent diabetes mellitus, retinopathy and chronic hepatitis B had presented a cerebrovascular stroke in 2006 and had undergone a coronary artery bypass in 2007. He had undergone a right transfemoral amputation for necrosis of the 2nd and 3rd toes in another institution. When he presented at our outpatient clinic, the amputation was complicated by infection and ischaemia of the wound. The patient was admitted and underwent a popliteal-posterior tibial artery bypass, followed by a Chopart amputation and Achilles tendon tenotomy. The Achilles anterior tendon was not reinserted due to the poor anterior skin coverage. Secondary granulation and a split-thickness skin graft allowed skin coverage, with weight bearing in a Sarmiento brace. A persistent equinus deformity had a negative effect on the anterior plantar aspect of the skin whenever full weight bearing was allowed. After 4 months, the decision was therefore made to perform a TTC arthrodesis using this minimally invasive technique, without using a tourniquet owing to the risk of peripheral artery occlusion. Postoperatively, no cast was applied, to prevent skin compression. The patient remained non-weight bearing for two weeks, following which walking was allowed with a Sarmiento brace. Fusion was observed on conventional radiographs at 8 weeks (Fig. 2). The American Orthopaedic Foot and Ankle Society (AOFAS) hindfoot score improved from 26 to 86.

Case 2

This 26-year-old patient presented with a comminuted pilon fracture dislocation and talar dome fracture following an occupational accident. He was initially treated with minimal open reduction-internal fixation (ORIF) combined with external fixation. Rehabilitation was started after removing the fixator; however, additional surgical posterior arthrolysis was required.

Unfortunately, the patient developed a complex regional pain syndrome, which was treated using analgesic pumps, physiotherapy and morphine derivatives. We saw the patient for the first time one and a half year following the trauma; he presented with a painful ankle fixed in 10° of equinus, and a stiff subtalar joint. He also presented with dysaesthesia on the dorsum of the foot. We decided to perform a TTC arthrodesis, as it was potentially less aggressive to the soft tissue. Fusion was observed after 6 weeks at the subtalar joint and at 10 weeks in the tibiotalar joint (Fig. 3). The patient resumed full weight bearing at 8 weeks. The AOFAS hindfoot score improved from 30 to 70.

Case 3

This 36-year-old non-compliant male patient, a smoker and drug addict, was involved in a motor vehicle accident in 2005, with, amongst multiple upper and lower limb injuries, a distal fracture of the tibia and fibula. After external fixation, ORIF was performed with a plate on the fibula and an anterograde intramedullary nail in the tibia. He consulted 6 months after the trauma, presenting with established osteomyelitis and non-union of the distal tibia fracture. A two-stage procedure was performed: we initially performed a resection of 4 cm of the distal quarter of the tibia, with interposition of a polymethylmethacrylate cement spacer. The pathogen encountered was a multi-S "Coagulase-negative" staphylococcus. He received clindamycin and ciprofloxacin for 3 months. The second stage, involving anterograde tibia...
osteonecrosis and severe ankle and subtalar arthritis. Ankle arthrodesis, failed total ankle replacements, talar hindfoot deformities, disabling fixed deformities, failed surgical procedures, progression of degenerative disease, failed antibiotic coverage at 6 weeks.

Discussion

Arthroscopic fusion of the tibiotalar and subtalar joints has gained in popularity due to the reduced invasiveness of the procedure [11,21]; for this reason we believed it would be worthwhile to perform a minimally invasive procedure in cases of combined tibiotalar and subtalar fusion.

TTC arthrodesis provides an alternative to amputation in a variety of conditions: non-braceable neuropathic hindfoot deformities, disabling fixed deformities, failed ankle arthrodesis, failed total ankle replacements, talar osteonecrosis and severe ankle and subtalar arthritis [2,6,8,10].

The same basic principles applicable to tibiotalocalcaneal arthrodesis must also be applied to this technique. As an appropriate alignment of the ankle and hindfoot will considerably influence the clinical outcome, we believe that, whilst repositioning the hindfoot underneath the ankle joint, a slight external rotation and a slight posterior displacement of the talus under the tibia is required. A medial translation with medial malleolus resection was not considered necessary. Moreover, preserving both malleoli protects against malrotation during the fixation. A worthwhile benefit of the posterior shifting of the hindfoot in relation to the talus could be a reduction of forces exerted on the tibiotalocalcaneal fusion in the sagittal plane, thereby achieving a higher primary stability, better heel-to-toe walking and lower stress on the neighbouring joints. This minimally invasive technique seems to ease the posterior shifting of the talus, as can be seen, for example, in the case of preexisting anterior subluxation of the talus [15,22].

A solid, functional and pain-free fusion is difficult to achieve, as reflected by the reported non-union rate of 15% or higher [10]. Predisposing factors for delayed union or non-union are patient age, medical comorbidities (especially diabetes, immunosuppression, systemic diseases, etc.), prior surgery, poor tissue and bone quality, non-compliance, presence of neuropathy, alcohol use, smoking and illicit drug use, which may be difficult to alter [2,5]. All three patients had several risk factors. The first patient had a lengthy history of diabetes mellitus, had previously been operated under septic conditions with healing difficulties due to macro- and micro-angiopathy; the second patient was a heavy smoker, still receiving worker’s compensation and having suffered a severe regional pain syndrome; the third patient had recently been hospitalised for a psychiatric disorder, had a record of poor compliance, and was a smoker as well as drug abuser.

Previous authors have identified four essential factors required for bony union: bony coaptation, compression, secure fixation and, last but not least, living bone [2,15].

By arthroscopically de visu controlling resection down to subchondral bleeding bone and taking care not to alter the geometry of both joints, a maximum amount of bone mass is preserved and an optimal coaptation of the bony surfaces obtained, which could be advantageous in avoiding leg length discrepancy [3,11].

Biomechanical studies have demonstrated a greater stability with intramedullary fixation compared to screw fixation for ankles and subtalar arthrodesis constructs [7,14,23]. Other authors suggest that the use of blade plates and/or locking plates provides a stronger fixation than intramedullary nailing; however, these are non-load-sharing static devices, requiring extensile approaches and involving a higher risk of bone vascular compromise [12,22,24]. A recent study has shown that the stability of an intramedullary nail is higher than that of an external fixator, but this latter is inherently capable of applying and sustaining greater amounts of compression [25]. Nevertheless, because of the prone position, a nail was preferred over an external fixator. With regards to the intramedullary nails, distal calcaneal posterior to anterior screws allow for much larger amounts of bone to secure the screws. They offer greater stability due to a higher resistance during dorsiflexion, which is the predominant loading stress encountered clinically as

Figure 3 A and B. Preoperative standing AP and lateral radiographs of a 26-year-old patient, with previous ORIF and external fixation for a comminuted pilon and talar dome fracture. He presented after a complex regional pain syndrome, with a painful ankle, still in equinus after a posterior arthrotomy, and a stiff and very sensitive subtalar joint. C and D. Postoperative standing AP and lateral radiographs after posterior arthroscopic tibiotalocalcaneal arthrodesis. Fusion was observed after 6 weeks at the subtalar joint and at 10 weeks at the tibiotalar joint.
Figure 4  A and B. Preoperative AP and lateral radiographs of the left ankle of a 36-year-old male patient, who received a two-stage allograft reconstruction over an anterograde intramedullary nail for a distal tibial osteomyelitis after a closed tibiofibular fracture. To be noted: absence of fusion at the allograft-native bone transition, which led to macro-mobility, rupture of the distal locking screw and subsequent progressive distal migration of the nail, destroying the ankle joint. C and D. Due to the poor skin conditions and requiring sufficient bone stock for fixation, we performed a PATTCA. Fusion was obtained at 8 weeks on the subtalar joint and at 12 weeks on the ankle joint. We presume that this “delayed union”, in comparison to the other two patients, could be due to less available osteo-inductive reaming material due to the presence of the anterograde tibial nail. During the follow-up after 6 months, we also observed callus formation at both the native tibia and allograft transitions.
the patient moves from heel to toe in gait [26,27]. On the other hand, intramedullary nails with compression used for TTC fusion produce good contact surfaces and primary stability [17,28]. In this respect, they reportedly are significantly superior to uncompressed nails and the screw construct, which can translate into improved union rates [16]; however, the nails used in our study were fixed statically without compression. The high non-union rate reported with the use of Marchetti nails has shown that biomechanical resistance to shear and torsional stresses is not provided by all intramedullary nails [29].

Many studies emphasise that maximum rigidity and correct positioning are critical to successful outcome and bony union; however, it is also believed that less disruption to the soft tissue and vascularisation supplying living medullary cells locally also plays a major role. With the technique presented here, the vascularisation of the talus is fully preserved due to the absence of disruption of the interosseous ligament in the subtalar joint. It has been observed that the largest vessels entering the body originate from the tarsal canal posterior to the neck and from the sinus tarsi through the interosseous talocalcaneal ligament. The posterior tubercle branches are consistently small and relatively insignificant in comparison to the other arteries [30]. Furthermore, no devascularisation was observed at the medial side of the talus, as the deltoid ligament and the medial malleolus are left intact. Preservation of the soft tissue, surrounding the tibiotalar and subtalar joint, results in the maintenance of a good blood supply to the healing arthrodesis [28].

Sekiya has previously described a minimally invasive tibiotalocalcaneal fusion using an anterior approach; however, we consider this technique presents a higher risk for the talus blood supply, as the debridement of the posterior talocalcaneal facet is achieved through the sinus tarsi, with a higher risk of damaging the nutrient arteries which enter the talus through the interosseous ligament and the tarsal canal [11].

Bone grafts are used to enhance healing in arthrodesis and fracture non-union. Although autogenous cancellous and cortical bone grafts are most frequently used, other common grafts include allogeneic frozen, freeze-dried, or processed allogeneic cortical, corticocancellous and cancellous grafts and demineralised bone matrix. To varying degrees these grafts stimulate active bone formation, induce bone formation and serve as a substrate for bone formation. Thanks to minimally invasive surgery and reaming, our technique leaves the medullary graft bone at the union site, where it is contained by the intact anterior tibiotalar capsule (Fig. 5). Moreover, neither additional graft costs nor donor site pain are involved [10,13,14].

The PATTCA technique could be used on patients with avascular necrosis of the tibial plafond or talar dome by supplying living medullary cancellous bone during reaming. Furthermore, post-traumatic avascular necrosis may remain undiagnosed in patients who have undergone multiple previous surgical procedures, with a higher risk for slower consolidation [8]. Special considerations in patients who have undergone previous surgery should include noting the location of fixation devices, prior use of bone cement, the quality of the soft-tissue envelope and previous incision placement [8]. This technique is the best option when absence of any severe deformity allows an in situ arthrodesis. In cases presenting with a marked deformity in the sagittal or coronal plane, open surgery could offer a more convenient repositioning through larger bone debridement, reshaping of the joint contours and some bone grafting [18].

This extremely convenient technique is recommended in cases where a combined total ankle arthroplasty and subtalar fusion is not an option due to previous infection, poor bone quality, previous regional pain syndrome, and virtual ankylosis of both joints.

Two features probably inherent to arthroscopic arthrodesis are the low incidence of postoperative swelling and pain. It was noted that all three patients reported virtually no postoperative pain at any stage; however, this observation is not based on any scientific evidence.

Conclusion

For surgeons familiar with posterior ankle or subtalar arthroscopy, this minimally invasive debridement and nailing offers superior exposure, high patient satisfaction and lower postoperative morbidity than traditional tibiotalocalcaneal arthrodesis methods; fusion is encouraged by presence of the medullary reaming material at the site of the fusion. If significant deformity is present, an open fusion technique should however be preferred.

Conflict of interest

None.

References

Posterior arthroscopic tibiotalocalcaneal arthrodesis


