Death of the triple arthrodesis?

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Abstract

Triple arthrodesis has for many years been a gold-standard treatment for a multitude of hindfoot deformities and arthritis since it was first described in 1923 by Edwin W. Ryerson of Chicago (1872–1961). However, in contemporary foot and ankle practice there has been a shift toward joint preserving techniques. In this article we cover the biomechanics of the triple joint and the surgical technique for a standard two-incision approach. The role of this once common procedure in modern foot and ankle practice is assessed by a systematic review of the literature reporting series of triple arthrodesis over the past 10 years. 13 studies met the inclusion criteria and reported the results of 515 operations in 481 patients. The three most common diagnoses were tibialis posterior insufficiency (30%), inflammatory arthropathy (19%) and neuromuscular disorders (18%). Subjective outcome was good in 75%, fair in 18% and poor in 7.9% (n = 354). The complication rate was relatively high, with wound complications and/or infections in approximately 10% and non-union of at least one joint in 6.5%. There have been recent advances in surgical technique. It is possible to perform triple arthrodesis through a single medial incision and a double arthrodesis (subtalar and talonavicular joint) via a medial approach is currently emerging as a good alternative for the plano-valgus foot. External fixation can be useful for gradual correction of severe deformity and surgeons have started using arthroscopic techniques with early success. In conclusion, the triple arthrodesis is still alive and remains a useful operation for the foot and ankle surgeon. However, trainees should be aware of the alternatives and aim to preserve healthy joints where possible.

Keywords arthrodesis; fusion; hindfoot; subtalar; talonavicular; triple

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Introduction

Triple arthrodesis has for many years been a gold-standard treatment for a multitude of hindfoot deformities and arthritis since it was first described in 1923 by Edwin W. Ryerson of Chicago (1872–1961).[1] However, in contemporary foot and ankle practice there has been a shift toward joint preserving techniques, using more limited fusions, osteotomies and soft tissue procedures to realign the foot and balance the soft tissues. In this article we examine the role of a once common procedure in modern foot and ankle practice, and look at alternative options to the triple fusion for hindfoot deformities.

Biomechanics of the triple joint

The complex biomechanics involved can be hard to understand, but are necessary to fully appreciate dysfunction of the triple joint and the technical aspects of triple arthrodesis. The detailed anatomy of the triple joint can easily be read in textbooks and we will go on to mention a few salient points.

The subtalar, talonavicular and calcaneocuboid joints work in concert to form the triple joint. Their movements are significantly co-dependent, to the extent that fusion of one joint will significantly reduce the motion in the remaining two. The subtalar joint and the talonavicular joint are most coupled in this respect, with fusion of one abolishing approximately 70% of the motion of the other. The main role of the triple joint is the conversion of torsional forces in the tibia and fibula to torsion in the foot and vice versa. The key axis for this motion occurs through the subtalar joint, which is orientated at approximately 41 degrees to the horizontal plane (i.e. the floor) and 23 degrees medial to the axis of the foot (i.e. the second ray). Although a sliding joint, the function of the subtalar joint has been compared to a mitred hinge or the differential of a rear-wheel drive car. The near 45-degree axis converts rotational forces in the tibia to supination or pronation of the foot, and vice versa. Hence, in forced supination of the foot, for example slipping off a curb, the forefoot supination force is transmitted through the triple joint causing external rotation of the talus within the ankle mortise, leading to the typical supination external rotation injury described by Lauge-Hansen.

The talonavicular joint is essentially a ball and socket joint, which allows forefoot supination and pronation to be coupled with hindfoot varus and valgus respectively. Additionally, the forefoot can adduct and abduct through the talonavicular joint, with the axis of rotation in the middle of the talar neck. Some dorsiflexion and plantarflexion can also occur through the talonavicular joint. This is very much appreciated in patients with a fused ankle who often retain a surprising amount of sagittal plane movement.

In hindfoot varus and forefoot supination, the axis of the talonavicular joint and the calcaneocuboid joint become divergent, which locks the transverse tarsal joint, stabilizing the midfoot and making it more rigid.[2] In hindfoot valgus and forefoot pronation the opposite happens, and the foot becomes flexible. On heel-strike of the foot in gait, it responds by unwinding through the triple joint with eccentric contraction of the tibialis posterior and peroneus longus tendons. This helps the foot absorb impact and dissipate energy. Through mid-stance the heel starts to swing into varus, and the first ray is plantar flexed

via the concentric contraction of tibialis posterior and peroneus longus respectively. The foot becomes much more rigid as the midtarsal joint locks and thus provides a solid beam for efficient push-off using the gastrocnemius and soleus complex and flexor hallucis longus in toe-off.

Dysfunction of the triple joint and hindfoot deformity severely compromise this vital change in foot shape and function through the gait cycle. A plano-valgus foot will initially tend to be too flexible and unstable medially, fatiguing quickly and often preventing a patient from standing on tip-toe. A cavo-varus foot is too stiff, absorbing impact poorly and transferring energy to the Achilles and peroneal tendons, plantar fascia, lateral ankle ligaments and lesser rays, which may all exhibit signs of overload and failure.

Triple arthrodesis has been used over the years to treat either of these two broad categories of hindfoot deformity, as well as arthritis without significant deformity. Understanding the biomechanics, it can readily be appreciated that mal-union of a triple arthrodesis in either too much valgus or worse still varus, will have significant knock-on effects for the patient, causing both forefoot problems and potentially varus or valgus failure of the ankle. Triple arthrodesis is a technically challenging operation, the aim of which is to restore slight valgus of the hindfoot, correct forefoot adduction/abduction plus supination/pronation, and a normal medial arch with restoration of Meary's angle. It is therefore a complex multi-planar correction.

Anatomical considerations

The subtalar joint is split into anterior and posterior compartments by an often substantial interosseous ligament within the sinus tarsi, which contains the artery of the sinus tarsi, which supplies the neck and head of the talus. The posterior tibial artery medially gives the main blood supply to the body of the talus via deltoid branches and also the artery of the tarsal canal, which anastomoses with the artery of the sinus tarsi. The anterior tibial artery gives capsular branches supplying the head and neck. Exposure of the subtalar and talonavicular joint inevitably compromises the talus blood supply and care must be taken to avoid overzealous medial dissection to preserve the main blood supply if performing a standard two-incision approach.

The talonavicular joint is located surprisingly proximal, close to the ankle and also extends a fair way laterally. Due to its curvature in two planes it is technically a difficult joint to access and prepare, and curved osteotomes and a high-speed burr are helpful tools.

The spring ligament extends from the sustentaculum tali to the navicular and acts as a hammock, supporting the head of the talus. In a severe plano-valgus deformity the spring ligament is often torn or severely attenuated, allowing the talus to flex and the forefoot to abduct off the talar head, leaving it uncovered. It is important to appreciate this feature on weight-bearing radiographs. Due to the chronically flexed talus, the gastrocnemius and soleus become contracted and once the talonavicular joint is reduced and fixed, the foot may often remain in equinus, necessitating gastrocnemius release or Achilles tendon lengthening.

Surgical technique

The patient is positioned supine with a thigh tourniquet and a sandbag under the ipsilateral buttock to ensure that the foot is vertical. Intravenous antibiotics are administered before the limb is exsanguinated and the tourniquet inflated. The standard technique involves two incisions. The lateral incision runs between the tip of the fibula and the base of the 4th metatarsal. Structures at risk here include the sural nerve, especially distally, and the peroneal tendons. Before making an incision we often use a small hypodermic needle to probe and locate the sinus tarsi. The second incision is on the medial side. Traditionally it is between tibialis anterior and tibialis posterior, from the tip of the medial malleolus to the navicular cuneiform joint. However an alternative is to go just lateral to tibialis anterior. This improves joint visualization, facilitates preparation of the lateral part of the joint and also leaves a scar that can be extended distally if a Cotton osteotomy is needed to correct forefoot supination, and it can also be incorporated into an anterior approach to the ankle if, for example, ankle arthroplasty is needed later. A dorsal staple can be used easily through this approach to augment screw fixation. The down-side to this more midline approach is that a stab incision is needed medially for a lag screw through the navicular tuberosity.

Joints are prepared with sharp chisels, small sharp curettes, bone nibblers and a drill. A high-speed burr can be useful to dimple the bone surfaces but it can catch soft tissues and must be used with care. Laminar spreaders and Hinterman spreaders are used to improve access. Once all three joints have been exposed, released and prepared, the hindfoot is generally quite mobile and can be properly positioned. Temporary fixation is achieved with stout K-wires from a cannulated screw set. Generally, the talonavicular joint is reduced and fixed first, then the subtalar joint through a stab incision in the heel. Finally, the calcaneocuboid joint is fixed from proximal to distal with an oblique wire. The image intensifier is used to carefully check the reduction and wire placement. Cannulated screws are then placed over all three wires to compress the joints. It is vital to properly screen the ankle and ensure that it is not penetrated with hardware. Additional stabilization of the talonavicular and calcaneocuboid joint is often advisable using a staple or small plate. An example of fixation construct is shown in Figure 1.

Bone graft is not routinely used, and is not necessary in the majority of cases.[3] However, if significant bony defects are encountered we have achieved good results with dried cancellous bone allograft chips. Alternatively, iliac crest autograft can be used.

Closure is with simple interrupted 3–0 non-absorbable sutures. Care must be taken not to catch the sural or superficial peroneal nerves in the closure. A backslab is applied and the patient is risk assessed for venous thrombosis and treated with prophylactic low-molecular weight heparin according to local guidelines. Follow-up is a wound review at 2 weeks and full cast. If X-rays are satisfactory at 6 weeks we may convert to a boot and allow partial weight-bearing with crutches for the next 6 weeks, plus ankle range of motion exercises out of the boot. If there are risk factors for slow union such as diabetes or steroid use, the patient is asked to remain in plaster, non-weight bearing for the full 12 weeks.