Hindfoot fusion: Additive triple fusion
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Abstract
Introduction
Painful hindfoot deformity can lead to significant morbidity. It is often difficult to manage these patients and various non-operative and operative treatments have been described, in particular hindfoot arthrodesis. The techniques performed and published outcomes for these procedures have evolved over the past century. Initially debridement and cast immobilisation was standard treatment, now rigid fixation is favoured often with more minimal surgical approaches, mostly a combined medial and lateral (two-incision) approach. In this review we will discuss the management options for painful rigid hindfoot deformity.

Conclusion
We present an illustrated novel surgical technique for additive triple arthrodesis using allograft augmentation with a single lateral incision.

Introduction
Triple arthrodesis involves fusion of the subtalar, talonavicular and calcaneocuboid joints of the hindfoot. The first descriptions of triple hindfoot arthrodesis were primarily for the treatment of paralytic foot malformations such as those associated with poliomyelitis and cerebral palsy. In 1923 Ryerson described the fusion of all three joints emphasising the roles played by each in the alignment and stability of the hindfoot and hence the need for triple arthrodesis for optimal outcomes¹.

The range of indications has now expanded and includes common conditions such as degenerative and post-traumatic arthritis, inflammatory arthropathies, clubfoot and rigid flat foot deformities secondary to posterior tibial tendon dysfunction.

Non-operative treatment options should always be attempted first, including optimising analgesia, intra-articular injections, activity modification and walking aids.

Footwear modification and orthoses should have been tried. Only when these measures have failed should surgery be discussed. It is also important that patients with inflammatory arthropathies or other systemic diseases have their medical condition optimised prior to any surgical intervention.

Limited arthrodesis of one or two joints of the hindfoot may be suitable for some patients, although this may lead to abnormal forces through surrounding joints and subsequent arthrosis. Furthermore the deformity within the foot must be taken into account when planning any arthrodesis surgery. Both clinical and radiological assessment of each of the hindfoot joints should be made, although it can be difficult to make a clear clinical assessment of an individual joint around the hindfoot and many different examination and provocation tests are advocated by different surgeons, including selected diagnostic joint injection. Plain radiographs may not clearly demonstrate degeneration in the hindfoot joints and CT scanning may be helpful. There are no validated radiographic criteria to select patients for a triple fusion.

Different surgical approaches have been recommended to perform a triple arthrodesis, including a single lateral approach², a single medial approach³ or a combined medial and lateral approach⁴. The medial approach is presumed to allow better exposure of the articular surface especially of the talonavicular joint and a cadaveric study of the lateral

Figure 1: Lateral ‘lazy-S’ incision centred over the sinus tarsi.
Figure 2: Preparation of the calcaneocuboid joint with a sharp osteotome.
Figure 3: Exposure of the talonavicular joint and preparation with a sharp osteotome.
Figure 4: High-speed burr being used to prepare the subtalar joint.

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approach\(^5\) reported the difficulty in denuding the articular surface of the talus. The lateral approach has also been implicated in increased post-operative wound complications\(^6\) due to the increased lateral skin tension resulting from correction of the deformity.

We advocate the use of the lateral incision and have found that by using specialised retractors an excellent view of the talonavicular joint is feasible allowing optimal preparation of the joint surfaces. Crucially the lateral incision allows bone grafting of the calcaneocuboid joint which allows adequate correction of the deformity, lengthening of the lateral column and thus powerful correction of the deformity. With meticulous tissue handling and careful placement of retractors we have not found skin healing to be a problem with a single lateral approach.

**Illustrated surgical technique**

Additive triple fusion with bone grafting

After induction of either spinal or general anaesthesia, the patient receives a single dose of prophylactic antibiotics. A single lateral ‘lazy-S’ incision is made, centered over the sinus tarsi (Figure 1). The calcaneocuboid joint is exposed by elevating the origin of extensor digitorum brevis with a sliver of bone using an osteotome. The subtalar and calcaneocuboid joints are denuded of articular cartilage with sharp osteotomes (Figure 2). Hindfoot retractors and laminar spreaders are used to gain access to the posterior facet of the subtalar joint and also the talonavicular joint (Figure 3). A high-speed burr is used to expose bleeding cancellous bone at all fusion sites (Figures 4 and Figure 5). A donated femoral head allograft is prepared to produce small bone chips/flakes, larger croutons and several small blocks. All allograft bone is thoroughly pulse lavaged and impregnated with Vancomycin powder. Small flakes are placed in the posterior subtalar joint (Figure 6) prior to deformity correction, which is effected by manual reduction (Figure 7). The key to triplanar deformity correction is reduction of the talonavicular joint (i.e. the acetabulum pedis) which is transfixed with 2mm Kirschner wires inserted percutaneously into the medial column of the foot (Figure 8).

The lateral column length is restored by using a 8-10mm block allograft in the calcaneo-cuboid joint (Figure 9), which is captured and transfixed by the 2 additional 2mm lateral column K-wires (Figure 10). An additional staple is used if necessary. The subtalar joint...
is typically secured by a staple (Figure 11), prior to firm packing of bone morselised graft (chips, croutons) into the sinus tarsi and the other fusion sites (Figure 12). Satisfactory correction of the deformity and position of the metalwork is confirmed using intraoperative fluoroscopy (Figure 13). After fixation of all 3 fusion sites further bone chips or blocks are tightly packed into the sinus tarsi to ensure intrinsic primary stability. After wound closure a below knee plaster back slab is applied. Patients are reviewed at 2 weeks for removal of sutures and change of cast, at 8 weeks for removal of Kirschner wires and change of cast in the outpatient department, and at 3 months for cast removal.

Discussion

The severe deformity being addressed during triple arthrodesis is almost always a pes planovalgus (abductus-pronation) deformity. In order to correct these deformities the correction must be based around the talonavicular joint and should involve correction of the lateral column with bone grafting to restore length. We use carefully prepared femoral head allograft. This prevents donor site morbidity of large iliac crest bone grafting.

Patients are required to be strictly non-weightbearing for 6 weeks and partial weightbearing for a further 6 weeks. An orthopaedic leg trolley is provided to aid ambulation. After cast removal patients are provided with a moonboot walker until confidence is restored to wear conventional shoes.

There are few absolute contraindications to triple fusion. Patients with poor skin coverage or a very poor blood supply to the foot are not suitable for fusion surgery. Active ongoing infection contraindicates immediate surgery. After adequate treatment for infection it may be safe to proceed to fusion although the complication rate is likely to be increased.

Patients who smoke or have neuropathic changes or ulcers are considered high risk for triple fusion surgery and must be appropriately managed and counselled on these risks.

There is a long recovery phase after triple fusion surgery as previously reported and the potential gains must be considered relative to this period of difficulty. Patients should be advised that some early benefit may be experienced by 6 months, but there is likely to be substantial further improvement up to 1 year after surgery.

The patient’s employment and socioeconomic situation, potential gain in quality of life and health in general should each be carefully evaluated by the treating surgeon. Treatment of advanced hindfoot deformity is technically challenging. Each procedure varies somewhat depending on the specific pattern of deformity in each patient.

Conclusion

The technique we have described here allows the experienced foot and ankle surgeon to access all three joints of the hindfoot through a single lateral incision, to adequately prepare the bony surfaces, to fully correct the deformity and rigidly hold the correction.

Further clinical studies are required to confirm the long term results.
Critical review

Competing interests: None declared.

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References