(iv) Hindfoot arthritis

Paul Hodgson
Kartik Hariharan

Abstract

Ankle and subtalar arthritis are commonly encountered by foot and ankle surgeons, but their prevalence is not as common as arthritis of the hip or knee.

Trauma is the most common aetiology for both, but primary osteoarthritis and inflammatory arthropathies are also encountered.

Clinical and radiological assessments are vital for correct diagnosis and for formulating an appropriate management plan. The recognition of abnormal alignment is particularly important as failure to do so will result in poor clinical outcomes of treatment.

Both conditions can be managed using non-operative and operative treatment. Ankle arthritis in particular has generated much controversy with regards to the definitive treatments of arthrodesis and arthroplasty.

Keywords ankle joint; arthritis; arthrodesis; arthroplasty; subtalar joint

Ankle arthritis

Prevalence

The prevalence of osteoarthritis (OA) of the ankle is thought to be 1% worldwide.1

Primary OA of the ankle is relatively rare, with approximately nine times more patients presenting with primary osteoarthritis of the hip or knee. In one study, the clinical incidence of OA was reported as 41% in the knee but only 4.4% in the ankle.2 An inspection of 50 cadavers for the presence of degenerative morphological changes classified 66% of knees compared to only 21% of ankles with severe degeneration.3 In terms of patient numbers, total knee replacement is performed more than 20 times more frequently than ankle arthrodesis and replacement combined.4

Aetiology

Epidemiological studies indicate that trauma is the most common cause of ankle OA, but ankle OA may be associated with several associated risk factors including ageing, obesity, joint mal-alignment and genetic predisposition.5 In a study of 406 ankles with end-stage OA, post-traumatic OA accounted for 78%, 13% was secondary arthritis and primary OA accounted for only 9% of the cases. Of the 78% of post-traumatic OA cases, 62% was attributed to fracture events and 16% to ligamentous post-traumatic OA1 [Figure 1].

Ankle and subtalar arthritis are commonly encountered by foot and ankle surgeons, but their prevalence is not as common as arthritis of the hip or knee.

Other causes of ankle arthritis include inflammatory arthritis, avascular necrosis of the talus, congenital deformity, sepsis, haemophilia, pigmented villonodular synovitis and as a result of previous ankle surgery.

Rheumatoid arthritis (RA) is the most common inflammatory arthropathy causing ankle arthritis. Fifty per cent of RA patients can be found to have ankle hindfoot involvement.6 However, most patients will also have involvement of the hindfoot, midfoot and forefoot in addition, and coupled with bone destruction and deformity, immunosuppression and polyarticular arthropathy poses significant challenges to the treatment of these patients.

Other inflammatory arthritides that commonly affect the ankle are sarcoidosis and psoriatic arthritis.

Sepsis can lead to ankle arthritis, with common infective organisms being Staphylococcus, Streptococcus, gonococcus and meningococcus.7

Patients with a bleeding disorder such as haemophilia may suffer repeated episodes of intra-articular bleeding, which can in turn lead to arthritis. Surgical management of these patients often requires a multidisciplinary approach and is best undertaken in centres where the relevant skill base is available.

Anatomy and pathomechanics

The low incidence of primary OA of the ankle is surprising, given that the ankle joint experiences a greater force per unit area than either the hip or the knee. This can be explained by several factors in which the ankle differs from these joints.

First, the thickness of the articular cartilage of the ankle is less, and more uniform than that of the knee.6 Thinner articular cartilage has a higher compressive modulus i.e. stiffer cartilage (there is an inversely proportional relationship between cartilage thickness and compressive modulus), and thinner cartilage tends to allow for increased joint congruency.

The ankle moves mainly as a rolling joint as oppose to the rolling, sliding and rotational movement seen in the knee. Therefore the ankle maintains congruency throughout movement and at high loads, again protecting against degeneration.9

The histological appearance of ankle articular cartilage differs from that of the hip and knee; the superficial layer makes up a higher proportion of the overall cartilage thickness in the ankle, and as the superficial regions are more responsible for compressive deformation this may play an important role in resistance to development of OA.9

Several studies have demonstrated that there are significant differences between the biochemical and biomechanical properties of ankle versus knee cartilage, ankle cartilage having a lower water content and a higher sulphated-glycosaminoglycan (sGAG) and collagen content, with a higher equilibrium modulus and dynamic stiffness.9 Interestingly, chondrocytes derived from ankle cartilage are less susceptible to the effects of soluble pro-inflammatory mediators and cytokines, including interleukin 1 (IL-1) and fibronectin fragments.10 In addition to this they do not express mRNA from key degradatory enzymes, including matrix metalloproteinase-8 (MMP-8), which play important roles in the development and progression of OA.11 These findings suggest that the ankle cartilage may possess intrinsic properties that protect it from developing primary OA.

Disruption of normal joint loading mechanics predisposes cartilage to degenerative changes. This is clinically evident in the
Post-traumatic ankle, either due to mal-union of fractures or chronic ligamentous instability.

Congruency of the ankle joint plays an important role in preventing primary OA, therefore any mal-union seen after a fracture can alter the contact area and stresses. This has been demonstrated in cadaveric studies, showing that 1 mm lateral talar shift reduces the contact area between 15% and 42%. This may also depend on the integrity of the medial ligaments.

In addition to this, fractures that lead to angular deformity at the ankle (such as tibial shaft fractures) also significantly increase the risk of subsequent ankle OA. It is unlikely that a single soft tissue injury will lead to ongoing problems, but recurrent instability might do. Patients presenting with ankle OA frequently give a history of recurrent giving way and instability, and arthroscopic studies of ankles with chronic instability have confirmed evidence of chondral damage.

Clinical evaluation

Patients usually present with pain, which is felt both anteriorly and in the medial and lateral gutters. Rest or night pain is uncommon, and the pain is usually exacerbated by standing and walking. Stiffness is a common complaint, limiting patient mobility. Alternatively, some patients report instability, which may indicate this being the cause of OA, but more often the ankle giving way is precipitated by pain and is indicative of a functional instability.

Examination findings are important and guide decisions on the most appropriate treatment. It is important to establish the hindfoot alignment in the coronal plane, and whether such deformity is correctable. The range of ankle movement is an important finding, including the presence of any equinus deformity. This should be examined eliminating movements in the subtalar and midfoot joints. Dorsi-flexion is usually more reduced than plantar flexion because of large anterior osteophytes. The use of walking aids should be documented, and footwear examined to assess patterns of wear. It is also important to palpate and move the subtalar and midfoot joints to assess if there are any signs of degenerative disease in these joints, as this may have a significant bearing on treatment options. A full neurovascular examination of the extremity is mandatory, again because any abnormality may influence treatment. An indication of this should have been gained from a thorough patient history, which may reveal co-morbidities such as diabetes and vascular disease. This will also reveal previous trauma and surgery to the foot or ankle.

Radiographic evaluation

Plain radiographs (AP and lateral) should be obtained of the ankle and foot with the patient weightbearing. This will reveal the extent of ankle OA and alignment, but will also show evidence of degenerative disease in the subtalar and midfoot joints. A grade (0–3) of ankle OA can be given on the basis of the X-ray findings using the classification system described by Pell, Myerson and Schon.

If there is concern about the presence of degeneration in the subtalar and/or midfoot joints then further imaging can be useful (e.g. Broden subtalar view, CT, MRI). At times it can be difficult to establish the joint responsible for the patient’s pain, and in these circumstances selective joint injections under image guidance can be very helpful for aiding formulation of a management plan.

Treatment

The treatment options for ankle arthritis can be either non-operative or operative. The clinician’s decision is based on the level of symptoms, clinical and radiological findings, and the general condition of the patient. It is important to equate the level of symptoms with the need for surgical intervention, which is not without risk.

Non-operative treatment: simple measures, including lifestyle modification and weight loss, can sometimes be sufficient. Lifestyle changes may range from stopping certain sporting activities to an alteration in working patterns. Weight loss decreases the joint reactive forces in an exponential manner and can therefore be very effective.

Medical therapy can include simple analgesia, opioid analgesia or non-steroidal anti-inflammatory drugs. Care must be taken to minimize side effects such as gastrointestinal sequelae.

Treatments such as chondroitin sulphate and glucosamine have no strong evidence to support their use, but some patients may benefit from taking them.
Other than oral medications, intra-articular injections of corticosteroids can improve pain by reducing inflammation. In the majority of patients the effects tend to be only temporary, and most clinicians are concerned about the potential for joint sepsis with repeated use. Hyaluronic acid injection preparations (e.g. Synvisc) have no clinical evidence to support their use.

Orthoses can be useful in improving pain, gait and stability. This can be in the form of modified footwear or an ankle support/brace. Gait pattern can be improved by using a rocker bottom sole or a solid ankle cushioned heel (SACH) shoe. A period of time of ankle immobilization in a walking plaster or boot can reduce pain felt with acute inflammation, or give the patient and surgeon an indication of what an ankle arthrodesis might provide.

Operative treatment: operative treatment can broadly be divided into joint sparing and joint sacrificing procedures.

Joint preservation

Ankle debridement — debridement can be performed using an open or arthroscopic technique, with the latter nowadays being favoured by most surgeons. It can address impinging osteophytes, inflamed synovium, impingement lesions, loose bodies and chondral defects.

In rheumatoid patient synovectomy may be a suitable option if there are minimal erosions.

Debridement is not suitable in end-stage OA or when there is marked deformity.

Articular distraction — the use of a spanning external fixator, such as an Ilizarov frame, has been shown to provide improvement in symptoms in patients with post-traumatic OA.

The procedure involves open or arthroscopic joint debridement followed by application of the fixator. The joint is then gradually distracted by 5 mm, in 1 mm increments per day. The patient is allowed to weight bear, and hinges can be incorporated after approximately 6 weeks to allow some ankle movement. The frame is usually removed between 12 and 15 weeks.

It is postulated that with distraction, the joint surfaces are not in contact (even with loading) and this increases the hydrostatic pressure within the joint, which increases proteoglycan synthesis.

Results using this technique have been varied in the few studies that have been carried out, with the good results of Marijnissen et al not being repeated by others. There is no Level 1 evidence currently available to suggest the validity of this operation in the setting of ankle arthritis but anecdotal evidence suggests that it may have a role in the treatment of the early stages of the disease.

Lateral ligament reconstruction ± calcaneal osteotomy — patients with chronic lateral ligament deficiency may present with an isolated medial wear pattern and varus mal-alignment. Such patients should be assessed arthroscopically for the pattern of wear, and to check joint congruency when the joint is reduced.

The lateral ligament complex can be reconstructed to provide joint stability and congruence. This may be augmented with the use of a laterolising calcaneal osteotomy which serves to lateralize the ground reaction force and thereby spare the medial side.

Supramalleolar osteotomy — corrective osteotomies to improve joint alignment and change loading patterns are more commonly performed for the hip and knee, but are occasionally used in the treatment of ankle arthritis in its earlier stages.

There is insufficient literature to draw conclusions on the success of this technique, but it can be used for patients with mal-alignment (such as after fracture mal-union) and partial articular involvement.

Joint sacrificing surgery

Ankle arthrodesis — ankle arthrodesis has been considered the gold standard treatment for end-stage ankle OA, and in particular post-traumatic OA. It still remains the treatment of choice in the young and active patient, in whom an ankle replacement may wear or loosen prematurely because of high demands and physical load. Other indications include OA secondary to previous sepsis, inflammatory arthritis, large osteochondral defects and talar avascular necrosis. It can also be used as a salvage procedure for failed ankle arthroplasty.

There is a wide variety of methods/techniques that can be used, but it is generally accepted that the optimum position for fusion is neutral dorsi-flexion, 5° of hindfoot valgus and external rotation equal to that of the contra-lateral leg (or 5°–10° if the other side is abnormal). The talus should be positioned in the axis of the tibia, as an anterior position causes an increased extension force on the knee during gait. Fusion in equinus leads to a vaulting gait as there is a premature heel rise during the stance phase.

Ankle arthrodesis does carry a risk of non-union in the presence of risk factors e.g. smoking or the use of non-steroidal anti-inflammatory drugs (NSAIDs). The overall surface area of fusion is relatively small and the foot creates a large lever arm across the ankle, causing large stresses across the fusion site. Occasionally there may be a paucity of blood supply on the talar side of the fusion, with avascular necrosis.

Smoking is a significant risk factor with a relative risk of non-union four times greater than in non-smokers.

Other risk factors for non-union are infection, patient non-compliance, neuropathy and vascular compromise (including avascular necrosis of the talus). Surgical factors include mal-alignment and excessive stripping of the soft tissues. NSAIDs have been shown to contribute to fracture non-union, but there is no evidence to show reduced union in surgical arthrodesis. However, due to NSAIDs’ inhibitory effects on angiogenesis seen in fracture healing, some surgeons would avoid their use in the post-operative period after arthrodesis.

Operative technique — the operative technique utilized is largely dependant on whether or not any deformity exists. Whatever the method used, adequate joint preparation, meticulous care of the soft tissues and adequate and optimal positioning of the arthrodesis are all of paramount importance in achieving optimal results.

In those with deformity, an open technique is favoured. This can be performed using an anterior, anterior-lateral, lateral or a posterior approach. The lateral malleolus and sometimes the medial malleolus may require resection if there is significant angular deformity. The lateral approach requires excision of the distal fibula for joint access and it is common practice to then use this for cancellous bone graft, if healthy.

When there is little or no deformity present the surgery can be performed using a mini-arthrotomy (one or two incision techniques) or arthroscopically. The latter has become more popular in recent years. It does require a surgeon with adequate experience in ankle arthroscopy, and the ability to convert to an open technique if required. Although the overall rate of fusion between the
open and arthroscopic techniques is comparable, the latter is thought to have a faster time to union, less blood loss, less morbidity associated with wounds and soft tissues, shorter hospital stay and quicker mobilization.\(^\text{26}\)

Surgeons with greater experience of arthroscopic arthrodesis have reported using this technique for patients with up to 15\(^\text{25}\)/C14 of deformity, providing some of the hindfoot deformity can be corrected with a calcaneal osteotomy.\(^\text{26}\)

The methods of fixation also vary. No evidence exists to suggest one method is superior, but options available can be broadly classified into external and internal fixation. Simple cast immobilization has also been described.

External fixation was popularized by Charnley in the 1950s using a compression clamp device. Pins are placed transversely through the tibia and talus and are connected medially and laterally by compression clamps. The main disadvantage of this technique is that it provides very little rotational stability, and in view of this the technique was modified by Calandruccio to give a triangular configuration.

Modern external fixators tend to incorporate fine wires (e.g. Ilizarov, TSF), and this technique can allow good compression in osteoporotic bone. This is also a useful technique in patients with a past history of infection and in those who have multiple scars or skin issues in the surgical field. Repositioning of the arthrodesis site and additional compression can be made relatively easily in an outpatient setting in addition to being able to keep the patient mobile. It is also useful in the presence of limb length discrepancy, when lengthening procedures can be incorporated into the process.\(^\text{27}\)

The preferred option in most ankle fusions is internal fixation, which includes screws, plate fixation and on-lay grafts and intramedullary nails. Internal fixation is favoured because of the lower rate of non-union compared to external fixation, and it is much better tolerated by patients. The higher rate of union may be due to the fact that internal fixation provides greater rotational and sagittal stability than external fixation devices.\(^\text{28}\) Screw fixation has been shown to be superior to plates,\(^\text{21}\) with a higher rate of union. This is because greater compression can be achieved with screws. Plate fixation requires greater exposure and soft tissue stripping, which can adversely affect local bone vascularity.

The orientation of screw placement varies significantly between surgeons, but it is widely accepted that at least two screws are required. Biomechanical studies have shown that crossed screws (Figure 2) provide a more rigid construct than two parallel screws,\(^\text{29}\) and the addition of a third screw adds to rotational stability.\(^\text{21}\)

Most surgeons using an internal fixation technique adopt a post-operative regime of 6–8 weeks of non-weightbearing, protected by a plaster cast, followed by a further 6–8 weeks of partial or protected weightbearing. There is anecdotal evidence to suggest that the use of arthroscopic fusion techniques may allow earlier mobilization.\(^\text{26}\)

**Outcomes** — the rate of union in recent studies using internal fixation methods has generally been greater than 90%. The investigation of choice to identify a non-union is CT (Figure 3).

Treatment of a non-union depends on whether the patient is symptomatic. Some fibrous non-unions may be asymptomatic and may necessitate no further treatment.

In symptomatic cases, the cause should be identified if possible, and measures taken to correct it. Revision fusion with bone graft harvested from the iliac crest is the standard technique although other forms of treatment including the use of synthetic bone substitutes and bone morphogenic proteins have also been used.\(^\text{30}\)

Non-invasive low intensity pulsed ultrasound treatments have been used to promote union but there is no evidence to support this for arthrodesis.

Other complications include infection, mal-alignment, neuro-vascular injury and thromboembolism. Late complications include prominent metalwork (necesitating removal) and tibial stress fractures. Long-term outcome studies have found that the majority of patients with a successful isolated ankle arthrodesis will develop substantial and accelerated arthritis in the ipsilateral foot (subtalar, talonavicular, naviculocuneiform, calcaneocuboid and tarsometatarsal joints) but not the knee, and that these changes correlate with reduced function and pain.\(^\text{31}\) However, others have reported that degenerative changes in these joint are radiologically evident prior to surgery, hence such changes may not be an actual consequence of ankle arthrodesis.\(^\text{32}\)

**Figure 2** Open ankle arthrodesis with excision of distal fibula and crossed compression screws.

**Figure 3** Sagittal CT image demonstrating non-union of an ankle arthrodesis.
Gait pattern is altered due to loss of ankle motion.33 Patients often report difficulty walking on uneven surfaces, and gait velocity as well as stride length are reduced resulting in poorer gait efficiency. This can be improved by the use of an orthosis with a rocker bottom sole. Arthrodesis may lead to limb length loss and require a shoe augment.

Ankle arthroplasty — the use of total ankle replacement (TAR) is becoming an increasingly popular alternative to arthrodesis in patients with end-stage ankle arthritis (Figure 4). TAR was first introduced in the 1970s and over 20 different types of prosthesis have been developed. Early designs tended to yield poor results, with an unacceptably high complication rate, and most failed in the short and intermediate term.34 The increasing success and evolution of hip and knee arthroplasty provided the motivation for development of TAR with increased longevity and improved function.

Indications — TAR is the main alternative to arthrodesis. It has been used in patients with rheumatoid arthritis. In primary and post-traumatic OA some surgeons would reserve the use of TAR to older or less physically active patients, with its use in higher demand patients being avoided because of the perceived risk of earlier failure. In these patients arthrodesis may be favoured.

In patients with radiological evidence of ipsilateral midfoot and hindfoot OA, TAR may be a more favourable option than arthrodesis even in the younger patient, because of the risk of increasing symptoms in these joints with a fused ankle.31

Contra-indications to TAR are mal-alignment (valgus/varus), active or recent infection, vascular insufficiency, poor bone stock, neurological impairment (including neuropathy e.g. Charcot), avascular necrosis of the talus and severe ankle joint laxity.35

A previous ankle arthrodesis can be converted to TAR but this is a challenging procedure and requires preservation of both malleoli.22

Subtalar deformity must also be assessed pre-operatively. Severe deformity may preclude the use of TAR, but in mild or moderate cases the arthroplasty may be coupled with a corrective calcaneal osteotomy or subtalar arthrodesis36 (Figure 5). Similarly, midfoot disease such as talonavicular arthritis can also be treated concomitantly. Prior to surgery, close attention should also be paid to identifying any longitudinal mal-alignment, for example from previous tibial fractures.

Surgical approach — most surgeons and modern prosthetic designs favour implantation via an anterior approach, developing a plane between tibialis anterior and extensor hallucis longus so that the neurovascular bundle is protected by EHL during retraction, to gain adequate exposure.35

A sandbag can be placed under the ipsilateral buttock so that the ankle lies in neutral rotation, and a tourniquet is used.

Following implantation of the prosthesis (according to the manufacturer’s guidelines), the capsule and extensor retinaculum should be closed, and most surgeons will use a single drain.35

At the time of surgery it is important to ensure that there is sufficient ankle dorsi-flexion. Failure to achieve dorsi-flexion beyond neutral will result in early failure. If this is the case then an Achilles tendon lengthening is advisable.

Figure 4 Radiographs showing a modern design total ankle replacement.
Post-operative regimens may vary depending on the prosthetic design. For example, the Mobility (Depuy) design requires an anterior tibial bone block to be resected for implantation of the tibial component, which is then replaced. The recommendation is for a period of 4–6 weeks, plaster immobilization to allow consolidation. Other designs may not require this length of immobilization.

Evolution of TAR – the first generation of TARs was introduced in the 1970s, with most designs comprising of two components. There were constrained and unconstrained designs, with almost all using cement fixation. The results for these prostheses were generally poor, with an unacceptably high complication rate, and most failed in the short and intermediate term.

The increasing success in both design and outcomes of hip and knee arthroplasty, coupled with poor results from the first generation of TAR, led to the evolution of the second generation TAR.

The medium-term outcomes of the newer generation of TAR appear to be encouraging, with 5-year survival greater than 90% and 20-year survival of almost 75%.

Complications of TAR – some complications will be similar to those encountered with arthrodesis, and will often depend on patient factors. These include infection, wound problems and thromboembolism. If such surgery is performed in patients with co-morbidities, such as inflammatory arthritis, then they should be followed up regularly in the post-operative period to ensure that problems are identified early and treated. Other early complications are related to surgical technique and include neurovascular injury and fractures of malleoli (intra-operatively and post-operatively, when they may be stress fractures).

Loosening is the most common late complication, with no identifiable cause in the majority, although this will be accelerated in cases with mal-alignment or component mal-position.

Failure of a TAR represents a significant challenge irrespective of the cause. If the cause is infection then this will necessitate removal of the prosthesis and eradication of the infection. The treatment options then are arthrodesis (usually requiring bone graft) or in the worst cases below knee amputation.

Even without infection, failure is usually associated with loss of bone stock, which will mean that revision arthroplasty is not feasible. Therefore, bone graft interposition arthrodesis is required to best maintain leg length equality. In cases where there is insufficient talar bone stock remaining (most commonly seen in rheumatoid patients), then tibio-talo-calcaneal fusion using an intramedullary device may be required.

Arthrodesis or arthroplasty? – a recent systematic review evaluating the intermediate and long-term outcomes of both these options has found similar results in terms of scoring (using AOFOS scores), and revision rate; 9% and 7% for arthroplasty and arthrodesis respectively.

The incidence of below knee amputation was 1% in the arthroplasty group and 5% in the arthrodesis group. The study concluded a lack of data to make a confident assessment of superiority and suggested that further comparative studies are required.

Subtalar disease

Disease of the subtalar joint usually presents with pain and instability when walking on uneven ground. Similarly to the ankle, primary OA of the subtalar joint is rare, and again the most common aetiology is trauma i.e. talus or calcaneal fractures, with the latter being more common.

An acquired flatfoot deformity as a result of rupture or disruption of the tibialis posterior tendon results in subtalar joint deformity and disease, but this topic deserves a mini-symposium of its own and will therefore not be discussed here.

Other subtalar joint pathologies include instability (which can be linked with ankle instability) and sinus tarsi syndrome.

Subtalar OA

Aetiology and prevalence: primary subtalar OA is rare and degeneration usually occurs as a consequence of trauma or instability. Other causes are inflammatory arthritides (in which case other surrounding joints are also usually affected) and tarsal coalition.

The most common cause is a mal-united calcaneal fracture. Calcaneal fractures are the most common tarsal fractures (65%) and account for up to 2% of all fractures, usually as a result of a fall from height with men being affected more than twice as often as women.

The long-term outcome of calcaneal fractures will depend on the severity of the injury and the treatment received. Studies have shown improved results with operative intervention of...
calcaneal fractures but even if a good reduction is achieved patients can still go on to develop symptomatic OA. However, it has been demonstrated that in patients requiring a subtalar fusion following a calcaneal fracture, those who were initially treated with operative fixation have better functional outcomes and fewer wound complications.

**Anatomy and pathomechanics:** The subtalar joint comprises of the inferior surface of the talus and the three articulating surfaces on the superior surface of the calcaneum; the anterior, middle and posterior facets. Its unique shape makes its movement complex, but in general terms it allows mobilization on uneven ground. It is closely coupled with the talonavicular and calcaneocuboid joints in allowing hindfoot motion and function.

Mal-united intra-articular fractures often lead to deformity with patients having difficulty with proper fitting footwear. This is due to the heel profile being shortened and widened as a result of the fracture, with the heel widening also causing problems with lateral subtalar impingement, which may encroach on the peroneal tendons or the sural nerve. The intra-articular mal-union, as with any other joint, invariably will lead to degeneration and subsequently pain.

With a joint depression type injury, the talus subsides somewhat and adopts a more dorsi-flexed position, which can in turn result in anterior ankle impingement and pain. The ankle joint may also be affected by varus (or less commonly valgus) mal-union of the heel, which will inevitably alter the loading pattern of the ankle joint (leading to eccentric wear).

**Clinical and radiographic evaluation:** Careful clinical evaluation is essential to address the site of pain, alignment, tendon dysfunction (peronei) and sensory loss (sural and posterior tibial nerves).

Pain is usually felt laterally, inferior to the fibula. Movement of the subtalar joint should be isolated and assessed for pain and reproduction of symptoms. As with assessment of the ankle, a careful neurovascular examination is mandatory, and indications of abnormalities will be alluded to in the patient’s history.

Radiological assessment should include anteroposterior and lateral weightbearing views, axial calcaneal views and Broden’s view (foot in neutral flexion, leg internally rotated 30–40°) (Figure 6). The X-ray is centred over lateral malleolus and four radiographs are taken, with the tube angled 40, 30, 20, and 10° towards the head of the patient to assess the subtalar posterior facet, although a more comprehensive assessment can be made using computerized tomography.

Stephen and Sanders (1996) have described a CT classification graded into three types, depending on the presence of a large lateral exostosis, calcaneal body alignment and degree of subtalar joint OA.

MRI may also be of benefit, showing more subtle changes of oedema isolated to the subtalar joint. Often, a diagnostic intra-articular injection is helpful to clarify that the symptoms are arising from the subtalar joint, and this may be useful in assessing the possible success of any potential subsequent subtalar fusion.

**Treatment:**

*Non-operative treatment* — appropriate management will depend on the level of symptoms, previous treatment and on patient factors dictating suitability for surgery.

Non-operative treatment includes simple analgesia, steroid/local anaesthetic injections and footwear modification or orthoses. Orthoses are designed to limit joint motion and loading and may range from an insole (UCBL type) to a custom made ankle-foot orthosis.

*Operative treatment* — operative management needs to take into account the cause of the arthritis and hindfoot alignment. In some patients following a calcaneal fracture, the joint itself may be spared and pain can be due to impingement from a lateral exostosis. In this case joint preservation is possible and an exostectomy may be all that is required.

Similarly, when the joint is relatively spared but heel malalignment is the main concern then a corrective osteotomy may be possible, which might avoid the need for fusion.

With joint degeneration the operative treatment of choice is a subtalar arthrodesis.

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**Figure 6** Broden’s view radiographs showing the posterior subtalar joint; normal (a) and with degenerative change following a calcaneal fracture (b).
Although joint preparation can be performed arthroscopically, the majority favour an open approach via a lateral utility incision i.e. from just below the tip of the fibula towards the base of the fourth metatarsal. Preparation of the posterior subtalar joint alone is usually sufficient. The need for bone graft will be determined by the degree of residual deformity, and the graft can usually be harvested from the ipsilateral iliac crest.

Multiple methods of stabilization are available including staples, dowels and compression screws. Screws are the most popular method and most surgeons will introduce these via the calcaneus, although entry from the talus is also described. The number of screws used depends on surgeon preference, but using a single large calibre (6.5 mm or greater) compression screw does not yield inferior results to multiple screws.

In cases with a calcaneal fracture mal-union and talar dorsiflexion causing anterior ankle impingement, it is important to restore the effective height of the calcaneum to relieve the anterior impingement. This can be achieved by performing a distraction fusion using an iliac crest tri-cortical bone graft.

Post-operative regimens can vary between surgeons, but a commonly used regime is 6 weeks in a below knee plaster, non-weightbearing, followed by 6 weeks protected weightbearing in an orthotic boot.

Outcomes — most studies report high success rates with primary subtalar fusion, regardless of the technique used, with union rates ranging between 86% and 100%. However, these figures may be falsely high given that clinical and radiological assessment methods may not identify all cases of non-union. The best method to assess union is using CT (Figure 7), and although this would be ideal in all cases it represents a large radiation dose and has resource and cost implications.

Sinus tarsi syndrome
There is debate as to whether this is a real clinical entity or simply a reflection of other pathology. It was first described by O’Connor in 1958.

The sinus tarsi is the cavity between the inferior aspect of the talar neck and the superior surface of the calcaneum, containing ligaments, nerves and vessels. It is postulated that injury to the nerves may cause hindfoot instability due to a loss of proprioception.

Aetiologies include trauma (70%), inflammatory/crystal arthritides, pes cavus and planus, and chronic hindfoot instability. Histological assessment of the soft tissue has demonstrated synovial hypertrophy, haemosiderin deposition and scar tissue.

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The syndrome presents with chronic lateral ankle pain and symptoms of instability, especially when walking on uneven surfaces.

Pain is usually related to activity and resolves at rest. Symptoms may be reproduced on clinical examination by inverting and everting the hindfoot. Symptoms are usually eliminated for several hours with an injection of local anaesthetic into the cavity.47 Plain radiographs including stress views are usually normal. Arthrogram examination may reveal a complete absence of the micro recesses along the interosseous ligament that are seen in a normal example.47 MRI may demonstrate oedema localized to the sinus tarsi (Figure 8).

Electromyography (EMG) shows abnormal reduction or complete loss of electrical activity in the peroneus brevis and longus during gait, with a reversal of these abnormalities after local anaesthetic injection into the sinus.47 Non-operative treatment entails repeated hydrocortisone injections, immobilization and orthoses to correct any hindfoot mal-alignment that may be present. The success of these measures is approximately 60%.47,48

In cases that do not respond, surgical intervention may be required. This can range from sinus tarsi debridement (ensuring that the interosseous ligament is preserved) to subtalar fusion in recalcitrant cases.47,48

### Combined disease

In some patients, degenerative change in both the ankle and subtalar joints may co-exist. This is more commonly seen in inflammatory conditions such as rheumatoid arthritis.

The management of such patients can be challenging, and conservative measures such as orthoses should be considered. Key concerns that must be taken into account are alignment, site/source of pain, mobility of joints involved, condition of midfoot/forefoot joints and patient factors such as vascularity and body habitus.

If no significant mal-alignment is present and the ankle joint retains a reasonable range of movement, then combining a total ankle replacement and a subtalar fusion can give good results.36 This option is especially useful if pre-operative radiographs demonstrate evidence of midfoot degenerative change, as this is likely to become increasingly symptomatic if both joints are fused.47,31 If mal-alignment is present then TAR is contra-indicated because of the risk of early failure.36 In this situation fusion of both subtalar and ankle joints is the best option.

This can be performed by individually fusing each joint, but a better option to provide more stability and rotational stiffness is the use of a tibio-talar-calcaneal intramedullary retrograde nail49,50 (Figure 9). With modern designs, compression can be applied to each joint, increasing the chance of union.

### Conclusion

Hindfoot arthritis involving the ankle, subtalar joint or both is less common than that of the hip and knee. The most common cause for degenerative change in both joints is trauma.

It is important to make a full clinical and radiological assessment of each patient in order to make appropriate management plans. Important factors to assess are:

- Medical co-morbidities that may increase the risk of post-operative complications
- Neurovascular status of the limb
- Joint movement (and associated pain) and alignment
- Site of pain/symptoms; diagnostic local anaesthetic injections are often helpful
- Patient expectations
- Radiological examination; weightbearing X-rays, CT, MRI.

There is a wide range of treatment options, and each case must be assessed individually to provide the patient with appropriate treatment. Options include:

- Non-operative treatments; lifestyle changes, analgesia, orthoses, therapeutic injections
- Joint sparing surgery
- Joint sacrificing surgery; TAR, arthrodesis.
Complications are not infrequent and patients must be counselled and consented appropriately prior to embarking on surgery. Patients should be encouraged to titrate their level of symptoms against the need for surgery and potential risks. Potential complications include:

- Infection, which may lead to limb loss in severe cases
- Non-union in arthrodesis
- Loosening and component subsidence in TAR
- Thromboembolism
- Potential accelerated degenerative changes in surrounding joints with arthrodesis.

REFERENCES


