# Interpretation of ankle and foot radiographs

## Introduction

Lower limb trauma is extremely common, with foot and ankle radiographs frequently simultaneously requested, as clinically it is often difficult to elucidate the exact site of trauma. Careful clinical assessment is imperative to minimize the amount of unnecessary radiographs. Plain radiographs remain the first-line investigation, but interpretation can be difficult because of the variety of possible injuries, and their sometimes subtle appearances. Understanding of normal anatomy is key to avoiding errors in the management of these injuries. This article provides a systematic approach to interpreting ankle and foot radiographs and describes the common conditions requiring these X-rays along with radiological signs.

## Interpretation of ankle and foot radiographs

The routine radiographs of the ankle include a minimum of the anteroposterior (AP) and lateral view. Oblique views are occasionally useful for further assessment of subtle injuries, particularly of the talar mortice. Foot injuries require a minimum of an AP and an oblique view. The lateral view is not usually performed as bones become superimposed, with the exception of possible calcaneal injuries, which may also need a dedicated axial calcaneal view. Weight-bearing foot or ankle views are rarely of use.

## Technical factors

**Anteroposterior ankle film:** The AP ankle radiograph is taken with the foot slightly internally rotated so that the fibula does not overlap the lateral joint space.

**Lateral ankle film:** The lateral radiograph is taken with the X-ray beam centred over the talus. This film should include the calcaneum and base of the fifth metatarsal.

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**Foot films:** The foot radiographs (AP and oblique) are taken with the X-ray beam centred over the midfoot with the foot at least partly dorsiflexed.

## Adult anatomy

The ankle joint consists of three bones and multiple ligaments. The distal fibula and tibia articulate with each other, joined by an interosseous membrane or syndesmosis. Posterior and anterior tibiofibular ligaments strengthen this joint. The talus articulates with both distal fibula and tibia (also termed medial and lateral malleoli). Lateral and medial collateral ligament complexes connect the malleoli to the talus and also the calcaneum. The talus is locked between the malleoli in extreme dorsiflexion, with no movement possible in this position. The posterior aspect of the tibia is also termed the posterior malleolus.

The foot is divided into three areas: the hindfoot, the midfoot and the forefoot. The hindfoot consists of the talus and calcaneum, which articulate at the subtalar joint. The remaining tarsal bones make up the midfoot, with the metatarsals and phalanges comprising the forefoot. Numerous ligaments link the multiple bones, but one of the most clinically important ligaments is Lisfranc's ligament, which extends from the medial cuneiform to the base of the second metatarsal.

## Developmental anatomy

The developing ankle and foot can have numerous accessory ossification centres, although the commonest is the os trigonum which is posterior to the talus. This is present in up to 25% of the population but is commonly mistaken for a fracture. Other ossification centres are less common but typically are regular and well corticated, and should be distinguished from fractures.

## Systematic radiological assessment

The patient's name, date of birth and date on the film should always be checked.

**Film quality:** As stated, optimal positioning is essential. On the AP ankle view, the fibula should not overlap the talus, and the lateral joint space should be visible. On the lateral ankle view, the whole of the calcaneum and the base of the fifth metatarsal should be visualized. The oblique foot view should not be over-angulated such that the bones are superimposed, yet it should have a clear obliquity from the AP view.

**Bone and joint alignment:** On the AP ankle view, the joint space should be uniform and can be followed from the medial side, over the dome of the talus and down the lateral side of the joint (*Figure 1*). On the lateral view, the lateral malleolus extends more inferiorly than on the medial side.

Also on this view there is a normal line that can be drawn from the posterior aspect of the calcaneum to its highest midpoint. This should intersect a second line drawn from this point to the superior point of the calcaneum anteriorly (*Figure 2*). The angle measured between these two lines (termed Bohler's angle) should be between 25 and 40°, and if this is reduced a depressed fracture of the calcaneum is suspected.

On the foot views the calcaneum and talus articulate with the cuboid and navicular respectively. The bases of the first, second and third metatarsals align with the three cuneiform bones. The fourth and fifth metatarsals articulate with the cuboid. Specifically, two normal anatomical lines should always be assessed, one on the AP view and one on the oblique view; these are termed the Lisfranc lines. On the AP view, the medial margins of both the middle cuneiform and the base of the second metatarsal should align (*Figure 3*). On the oblique view the medial margins of both the lateral cuneiform and the base of the third metatarsal should align (*Figure 4*).

*Figure 1. Normal anteroposterior ankle view. The joint space is uniform and can be followed from the medial side, over the dome of the talus and down the lateral side of the joint.*

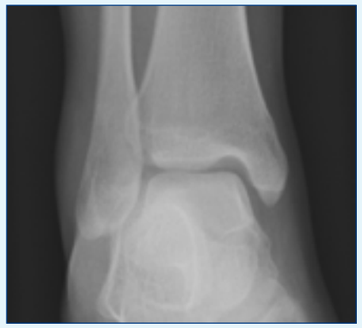

*Figure 2. Normal lateral ankle view. A normal line (line 1) is drawn from the posterior aspect of the calcaneum to its highest midpoint (black arrows). This intersects a second line (line 2) drawn from the highest midpoint to the superior point of the calcaneum anteriorly (white arrow). A normal Bohler's angle is measured between these two lines (white curved line) and is between 25 and 40°, although if this was reduced a depressed fracture of the calcaneum would be suspected.*

**Bony density and margins:** The cortical surfaces of all the visible bones should be systematically examined for irregularities. The internal trabecular pattern should be carefully assessed for subtle radiolucencies

*Figure 3. A normal anteroposterior view of the foot showing the first Lisfranc line. The medial margins of both the middle cuneiform and the base of the second metatarsal are seen to align (line).*

*Figure 4. A normal oblique view of the foot showing the second Lisfranc line. The medial margins of both the lateral cuneiform and the base of the third metatarsal are seen to align (line).*

or bands of sclerosis, which may be the appearance of an impacted fracture. This is particularly common with fractures of the calcaneum. As with any other bone, the cortices should be smooth and regular, and depressions or steps should be considered as at least suspicious for a fracture.

**Soft tissues:** Extensive soft tissue swelling around the ankle joint is a common but non-specific sign of trauma, and is often not associated with a bony injury. Soft tissue swelling, however, often accompanies ligamentous and bony foot injuries.

## Ankle trauma

### Ligamentous trauma

Severe ligamentous trauma can produce normal radiographs, although medial ligament rupture often leads to widening of the joint space on the AP view, and is commonly associated with a fracture. The ankle joint and its supporting ligaments frequently behave like a ring; a fracture or ligament rupture on one side will often be accompanied by a more subtle break (fracture or rupture) elsewhere.

### Fractures around the ankle

Various mechanisms of injury are responsible for different patterns of ankle fracture too numerous for this article, although most are radiographically obvious.

A twisting force will initially produce a spiral fracture of the distal fibula (*Figure 5*), but if more severe this will be accompanied by rupture of the medial ligament or a medial malleolus avulsion (*Figure 6*), and if extreme the posterior malleolus may also be avulsed. Sometimes this fracture will pass through the distal tibiofibular joint, which may become widened. Any distal fibula fracture at this level should be considered as potentially involving this joint even if there is no joint space widening, as it may subsequently displace during the healing period. These injuries therefore require careful conservative management and follow-up radiographs.

An inversion force will initially result in a lateral ligament rupture, then a lateral malleolus avulsion and finally a compression fracture of the medial malleolus. Accessory ossicles are commonly sited near the malleoli, and can sometimes be difficult to distinguish radiographically, although are typically well defined with a sclerotic margin.

Occasionally medial joint damage (fracture or ligamentous rupture) is associated with a midshaft or proximal fibula fracture, so this should always be assessed clinically and if there is doubt, a full lower leg radiograph can be performed

*Figure 5. An anteroposterior view of the ankle showing a spiral fracture of the distal fibula. Soft tissue swelling is present on the medial side of the joint, although no fracture is seen and the medial joint space is not widened to suggest a ligamentous injury. However, these injuries should be treated with suspicion as an occult medial ligament injury is common and the mortice may later displace.*

(Maissoneuve fracture). In a patient with an apparent isolated medial or posterior malleolar injury and a radiographically normal lateral malleolus, this injury should be strongly considered.

In children as with other joints, epiphyseal plate fractures are common.

More severe injuries include complete ankle dislocation.

### Talus fractures

Like the scaphoid bone in the wrist, a fracture of the talus may result in avascular necrosis since the body receives its blood supply from the distal aspect (head). Therefore a fracture of the waist may result in avascular necrosis of the body. Osteochondral fractures of the talar dome can be identified by either a small defect in the upper cortex of the talus, or a bone fragment within the ankle joint (*Figure 7*).

## Foot trauma

### Calcaneal fractures

While calcaneal fractures may occur from a simple twisting injury, a fall from a height is the commonest mechanism of injury, and is often associated with spinal fractures. In the latter situation the fractures are often obvious on a lateral foot view, but a dedicated axial view may be required (*Figure 8*). Some are less obvious and Bohler's angle should then be assessed (*Figure 2*); an angle of less than 25° indicates a depressed fracture which may be impacted and only visible as a thin sclerotic line.

*Figure 6. An anteroposterior view of the ankle showing a spiral fracture of the distal fibula (black arrow) accompanied by rupture of the medial ligament as shown by widening of the medial joint space (white arrow). This injury is unstable and surgical correction is usually required.*

### Midfoot injuries

With the exception of avulsion fractures of the navicular (*Figure 9*), tarsal fractures are uncommon frequently resulting from severe trauma. They are frequently associated with severe ligamentous damage, and are difficult to assess clinically and on plain radiographs. Familiarity with the normal tarsal and metatarsal alignment is important, although computed tomography is frequently required. Fractures of the bases of the medial four metatarsals should raise suspicion for a midfoot dislocation, particularly if the normal anatomical Lisfranc lines are disrupted. A homolateral type Lisfranc injury involves a fracture of the base of the second metatarsal with dislocation of the second to fifth metatarsals laterally, resulting in malalignment of the normal metatarsal and cuneiform bones (*Figure 10*). This can also occur with fractures at the base of the third metatarsal with similar associated metatarsal dislocations. Occasionally the first metatarsal may dislocate medially while the second to fifth metatarsals move laterally; this is termed a divergent type Lisfranc fracture dislocation, and is more common in patients with diabetic neuropathy. This type may also be associated with fracture and/or dislocation of the medial cuneiform and navicular.

*Figure 7. An anteroposterior view of the ankle showing an osteochondral fracture of the talar dome which is identified as a small defect in the upper cortex of the talus (arrow).*

*Figure 8. A lateral view of the foot showing a calcaneal fracture (arrows). The calcaneum is clearly flattened and Bohler's angle is much less than 25° (see Figure 2).*

*Figure 9. A lateral view of the foot showing an avulsion fracture of the navicular (arrow). Isolated tarsal fractures such as this are uncommon.*

*Figure 10. Anteroposterior view of the foot showing a fracture of the base of the second metatarsal (arrow) and malalignment of the normal anatomical first Lisfranc line (line), indicating an associated ligamentous rupture. This injury may appear slight, but a homolateral type Lisfranc fracture dislocation of the midfoot is a severe injury and computed tomography may be required for full assessment.*





### Forefoot injuries

An avulsion fracture of the base of the fifth metatarsal usually results from an ankle inversion injury (*Figure 11*). This should be distinguished from a normal unfused apophysis (*Figure 12*). This fracture is often visualized on the standard ankle views, although clinical examination will allow more appropriate foot views to be taken.

Fractures of the shafts of the metatarsals are commonly 'stress' fractures and are caused by repetitive minor trauma (classically marching in young soldiers; this is also termed a march fracture). A thick periosteal reaction surrounding the second metatarsal is a common appearance, although these radiographic appearances may take weeks to develop (*Figure 13*). An isotope bone scan may be diagnostic within 2 days.

## Common errors

The ankle joint frequently behaves like a ring; a fracture or ligament rupture on one side will often be accompanied by a more subtle break (fracture or rupture) elsewhere.

*Figure 11. An anteroposterior view of the foot showing a fracture of the base of the fifth metatarsal (arrow). This most commonly results from an inversion injury, and is usually an avulsion fracture at the insertion of the peroneus brevis tendon.*

Medial joint damage (fracture or ligamentous rupture) can be associated with a midshaft or proximal fibula fracture, so this should always be assessed clinically.

A thin sclerotic line may be the only sign of an impacted calcaneal fracture, and so Bohler's angle should always be assessed. However, a normal Bohler's angle does not exclude a calcaneal fracture.

A fracture of the base of the second or third metatarsal should raise clinical suspicion of a midfoot dislocation (Lisfranc injury). Lisfranc's lines should be carefully assessed.

An avulsion fracture of the base of the fifth metatarsal should be distinguished from a normal unfused apophysis.

Beware of black bands of soft tissue margins which may simulate fractures. If a black line crosses a bone and extends beyond the bone it is probably a soft tissue edge or an artefact. BJHM

*Conflict of interest: none.*

*Figure 12. An oblique view of the foot showing a normal unfused apophysis at the base of the fifth metatarsal (arrow). This is a common finding especially in young patients and should be distinguished from a fracture. The apophysis lies parallel to the long axis of the metatarsal, as opposed to a fracture, which is usually transverse (see Figure 11).*

*Figure 13. An oblique view of the foot showing a thick periosteal reaction surrounding the third metatarsal, consistent with a stress fracture caused by repetitive minor trauma. Although this is a common appearance, these radiographic appearances may take weeks to develop.*

**Further reading**

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Raby N, Berman L, de Lacey G (2005) *Accident and Emergency Radiology. A Survival Guide.* 2nd edn. Bailliere Tindall, London

Ryan S, McNicholas M (2000) *Anatomy for Diagnostic Imaging.* WB Saunders, London

## KEY POINTS

- Always check the name, age and date.
- Assess film quality.
- Assess the bony cortices of the talar dome, calcaneum and the base of the fifth metatarsal for subtle fractures on the ankle radiograph.
- Assess the alignment of the medial margins of the second and third metatarsals with the medial margins of the middle and lateral cuneiforms respectively.
- Consider a metatarsal stress fracture even if the radiograph is normal.