Radiology of acute foot injuries

Introduction

Many traumatic foot injuries can be adequately managed clinically without the use of imaging, even in the presence of metatarsal or phalangeal fractures. However, plain radiographs remain the first-line investigation for traumatic injury to the foot.

Injuries to the foot can be classified into three sections: hindfoot, midfoot and forefoot. The hindfoot consists of the calcaneus and the talus. The midfoot comprises the navicular, cuboid and cuneiforms. The forefoot includes the metatarsals and the phalanges.

The majority of tarsal fractures occur in the calcaneus, 75% of these being intra-articular. These often occur following a fall from height, or occasionally from a twisting injury, and are usually in the region of the tuberosity. Compression fractures are often bilateral, and may be associated with compression fractures of the lumbar spine.

Fractures of the midfoot and forefoot are often caused by direct trauma to the foot. Forced inversion or eversion of the forefoot with a fixed hindfoot can result in fracture-dislocation of the midfoot. An inversion injury of the ankle is usually the aetiology of a fracture of the base of the fifth metatarsal.

Radiographs

The films required are an anteroposterior radiograph of the forefoot and midfoot, and an oblique radiograph of the forefoot and midfoot.

Anatomy

Hindfoot

The subtalar joint is a synovial joint between the talus and calcaneus, allowing inversion and eversion. Owing to its tenuous blood supply, fractures that pass through the neck of the talus are prone to non-union and avascular necrosis, in a similar manner to scaphoid fractures. Although rare, these are therefore very important to identify. Osteochondral defects in the talar dome may be visible as a small bone fragment within the ankle joint. The hindfoot and the midfoot are connected by the Chopart joint, a joint between the calcaneus and the cuboid, and between the talus and the navicular.

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Midfoot

The midfoot consists of five irregular shaped tarsal bones: the navicular bone medially, the cuboid bone laterally, and the medial, intermediate and lateral cuneiforms. These form the foot arch. The midfoot is connected to the forefoot by the Lisfranc joint, a joint between the cuneiforms and the metatarsals. The Lisfranc ligaments connect the base of the medial cuneiform to the base of the second metatarsal, which are disrupted in a Lisfranc injury (tarso-metatarsal dislocation).

Forefoot

The metatarsals and phalanges are similar to the metacarpals and phalanges in the hands. The only unique issue to be aware of in the forefoot is that the normal apophysis of the base of the fifth metatarsal runs in long axis (*Figure 1*), parallel to the metatarsal, and should not be mistaken for a fracture line. A fracture is commonly seen perpendicular to the metatarsal.

Multiple accessory ossicles can be seen in the foot. These rarely prove to be of diagnostic concern, and are too numerous for this article but are readily found in Keats and Anderson (2006) (*Figure 2*).

Radiological assessment and classical signs

The ABCS system of radiological assessment is followed for systematic evaluation.

Adequacy

Hindfoot

Standard calcaneal views include the more useful lateral view, and an axial view. The lateral view can be used to assess Bohler's angle, where a line is drawn from the supero-posterior aspect of the calcaneus to its highest midpoint, and from this point to its highest point anteriorly. This should normally measure between 30° and 40° (*Figure 3*).

Midfoot

Dorsi-palmar and oblique views should be obtained. With the occasional radiographs that appear relatively normal in the presence of severe pain and swelling, a Lisfranc injury should be suspected and stress radiographs obtained.

Alignment

Hindfoot

A calcaneal fracture may only be evident if there is a decrease in Bohler's angle to below 30°. However, a normal Bohler's angle does not exclude a fracture.

Midfoot

The dorsi-palmar projection shows the medial margin of the second metatarsal

Figure 1. Normal anatomy of the foot, showing the normal apophysis of the base of the fifth metatarsal (arrow). Note it runs in long axis.

Figure 2. A fracture of the fifth metatarsal (white arrow) with incidental os naviculare (grey arrow) and os perineum (dashed arrow), which are accessory ossicles.

align with the medial margin of the middle cuneiform (*Figure 4*).

The oblique projection shows the medial margin of the third metatarsal align with the medial margin of the lateral cuneiform.

Occasionally, when assessing the radiograph for a Lisfranc injury, there may be malalignment of only the medial edges of the third metatarsal and lateral cuneiform on the oblique projection. The medial edges of the second metatarsal and middle cuneiform on the dorsi-palmar projection remain aligned. In this situation, the second metatarsal has fractured distal to the base, with the base held in place by the intact Lisfranc ligaments. However, the distal portion of the second metatarsal and the third, fourth and fifth metatarsals have dislocated laterally, best seen on the oblique view.

Bones

The foot can be analysed specifically in terms of the hindfoot, midfoot and forefoot. Specific injuries demonstrate certain appearances which are described below.

Congruity

Bony fragments should be analysed to determine whether there is a sclerotic margin, implying it being an accessory ossicle, or whether one margin is lucent with a reciprocal lucent margin on the adjacent bone, representing a fracture fragment.

Figure 3. Bohler's angle is normally 30–40°. An angle less than 30° suggests a calcaneal fracture.

Soft tissue

As with any fracture, the bony abnormality might be subtle. However, close inspection of the foot should be prompted by the presence of marked soft tissue swelling.

Figure 4. a. Anteroposterior radiograph of the normal foot, showing alignment of the medial margin of the second metatarsal with the medial margin of the middle cuneiform. b. Oblique radiograph of the foot, showing alignment of the medial margin of the third metatarsal with the medial margin of the lateral

Injuries

Hindfoot injuries

The calcaneus normally has a well-defined trabecular pattern. Subtle fractures can distort this pattern (*Figure 5*). A small sclerotic line may be the only feature of a calcaneal fracture. Additionally, a reduced Bohler's angle can be the only finding to suggest a fracture (*Figure 6*).

Midfoot injuries

If a bony fragment is detached from the base of one of the four medial metatarsals, a Lisfranc injury should be suspected (*Figure 7*). This injury may, however, be clearly visible as a result of a lateral shift of the metatarsals on the cuneiforms.

Forefoot injuries

Fractures of any of the bones may be easily identified, as with any other bone. A fracture of a metatarsal (*Figures 8* and *9*) will commonly demonstrate periosteal reaction resulting from osteogenesis. If this is not evident, but suspicion remains, a repeat radiograph after a few days, isotope bone scan or magnetic resonance imaging can be more forthcoming, and should be considered if the finding will affect patient management.

Pitfalls

1. The calcaneus normally has a well-defined trabecular pattern. Distortion of this pattern, or subtle sclerotic lines, can represent fractures
2. Lisfranc injuries can be subtle, and careful scrutiny of the alignment of metatarsals and cuneiforms should be performed in the presence of fractures

Figure 5. a. A normal calcaneus. b. A calcaneal fracture with cortical irregularity and loss of the regular trabecular pattern.

Figure 6. a. A calcaneal fracture with Bohler's angle of less than 30°. This is highly suggestive of a calcaneal fracture. The calcaneal cortex is also irregular. Note the fixed Lisfranc injury (arrow). b. Note not all calcaneal fractures demonstrate a decreased Bohler's angle. The fracture is clearly identified (arrow).

Figure 7. Lisfranc injury. a. The anteroposterior view best shows the malalignment, indicating ligamentous injury. The fracture of the base of the second metatarsal is seen in both views, and the associated fracture of the calcaneum on the oblique view (b).

***Figure 8. A fracture of the base of the fifth metatarsal base is seen on the lateral and anteroposterior radiographs. Compare with the normal apophysis in* Figure 1.**

of the base of the second or third metatarsals
3. The apophysis of the base of the fifth metatarsal should not be mistaken for a fracture
4. Even in the absence of significant trauma, metatarsal stress fractures should be considered
5. Accessory ossicles should be correctly interpreted and not mistaken as fracture fragments. **BJHM**

Figure 9. A stress fracture of the second metatarsal with periosteal reaction and callous formation.

Conflict of interest: none.

Keats TE, Anderson MW (2006) *Atlas of normal roentgen variants that may simulate disease.* 8th edn. Mosby, St Louis

Further reading

Raby N, Berman L, De Lacey G (2000) *Accident & Emergency Radiology, a Survival Guide.* Saunders, London

KEY POINTS

- The majority of tarsal fractures occur in the calcaneus.
- Decreased Bohler's angle or trabecular disruption is indicative of calcaneal fracture.
- Owing to a tenuous vascular supply, talar fractures can result in non-union or avascular necrosis.
- The talar dome should be carefully scrutinized for fractures.
- Base of second and third metatarsal fractures should raise the suspicion of a Lisfranc injury.
- Metatarsal-cuneiform alignment should be scrutinized to exclude Lisfranc injury.
- Metatarsal fractures usually demonstrate periosteal reaction.