(ii) The hindfoot: Calcaneal and talar fractures and dislocations—Part II: Fracture and dislocations of the talus

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Summary Talar fractures and dislocations are uncommon but even initially apparently simple fractures may be more complex after adequate investigation. Talar neck fractures and the less common talar body fractures remain a surgical challenge with high complication rates, which have been shown to be reduced by early intervention with anatomical reduction and fixation.

Introduction While fractures and dislocations of the talus are rare they can have devastating effects leading to significant disability due to the unique anatomy and blood supply of the talus. Patients must be informed of this risk from the outset.

Anatomy and blood supply

It is essential to understand the special anatomy and blood supply of the talus (Fig. 1). The talus has three parts, the head, neck and the body. It transmits body weight between the ankle and subtalar joints and articulates with the navicular distally and medially. The trochlea is wider at the front and, therefore, dorsiflexion of the ankle provides a more stable configuration. In addition its unique shape accommodates plantar-flexion and rotation at the ankle, inversion and eversion at the sub-talar joint with rotation and translation at the talo-navicular joint.

About 70\% is covered with articular cartilage and only the extensor digitorum brevis takes origin from...
its surface. The extraosseous blood supply arises from the three main arteries in the distal leg; the posterior and anterior tibial and the peroneal. The artery of the tarsal canal (posterior tibial) delivers most of the blood supply to the talar body and the artery of the tarsal sinus (anterior tibial and peroneal) provides the main contribution to the talar head and neck. These latter two vessels form an arterial ring around the sinus tarsi and talar neck. Additional blood supply to the talar body is derived from the deltoid artery in the deep portion of the deltoid ligament (Fig. 1). It is vulnerable to avascular necrosis as arterial continuity across the talus only occurs in about 60%.

Talar injuries

A variety of injuries may occur to this relatively small bone. They may be described as central or peripheral or in anatomical terms:

- Fractures of the talar head.
- Fractures of the talar neck with or without dislocation.
- Fractures of the talar dome.
- Fractures of the posterior process.
- Fractures of the lateral process.
- Osteochondral fractures affecting the talar dome.
- Minor avulsion fractures usually associated with ligament injuries of the ankle.

Fractures of the talar head

These are rare, only accounting for about 5–10% of talar fractures. There are two main types; a compression fracture (sometimes with an associated navicular injury) and a longitudinal or oblique fracture. These rarely require treatment of themselves but a talar head fracture may be associated with other midfoot injuries including fracture dislocations, which will require separate management.

Fractures of the talar neck with or without dislocation

These constitute about 50% of all talar fractures, 3–4% of fractures affecting the foot and 0.5% of all fractures. Nowadays, they most frequently result from road traffic accidents but they were classically described in pilots as ‘aviators astragalus’. Approximately, one-fifth to one-third will have associated foot or ankle fractures, particularly the medial malleolus, and two-thirds will have other bone or soft tissue injuries. The fractures may be open and part or all of the body may be extruded through the skin.

Mechanism

The fracture is caused by forced dorsi-flexion of the ankle against a fixed distal tibia with the talar neck impacting against its anterior margin. Wilson considered this in some detail, reviewing the literature and suggesting the following:

- A high injury injury is required e.g. RTA or airplane crash.
- The victim is braced for an emergency i.e. has a rigidly extended limb with the joints fixed by muscular action.
- The arch of the foot is poised on a small impact body e.g. The pedal of a car or the rudder bar of an older type of aircraft.

Subsequently, with further force, rotation either occurs into inversion (commonest) with dislocation of the sub-talar, ankle or talo-navicular joints. The talar body may extrude through the skin postero-medially and may damage the local neurovascular bundle. Rarely, rotation occurs into eversion with the foot and talar head subluxating or dislocating laterally.

Classification

Hawkins described three fracture types in 1970 with Canale and Kelly adding a fourth. These are:

- Type I: Undisplaced fracture of the talar neck which only disrupts the blood supply to the dorsolateral neck.
• Type II: Displaced fracture of the talar neck with sub-talar joint subluxation or dislocation. This affects the blood supply to the dorsolateral neck but also from the sinus tarsi and tarsal canal.

• Type III: Displaced fracture of the talar neck with dislocation of the sub-talar and ankle joints. The talar body blood supply is completely disrupted except for the deltoid branches, which may be twisted.

• Type IV: Displaced fracture of the talar neck with dislocation of the sub-talar and ankle joints and subluxation or dislocation of the talo-navicular joint. This additionally affects the blood supply to the talar head.

Management

Type I (Fig. 2)

These are usually treated conservatively with immobilisation in a lightweight below knee cast for 6–12 weeks non-weight bearing. Radiographs should be obtained regularly over the first few weeks. There is some controversy about the position of the cast with some advocating partial or full equinus to reduce the risk of displacement and others proposing ORIF of these fractures to ablate this risk. An equinus cast may lead to an equinus deformity and, therefore, there should be a low threshold for fixation. Clearly if the fracture does displace it automatically becomes a type II.

Type II

This is essentially a displaced unstable fracture with a variable soft tissue injury. The minimum initial treatment should be an immediate closed reduction to relieve soft tissue tension. A cast may be applied, usually in plantar-flexion, but if a perfect anatomical reduction cannot be achieved then surgical intervention should not be delayed. Alternatively if the position is satisfactory a CT scan may be requested prior to surgery. The ideal situation, however, is closed reduction, followed by a CT scan then surgery.

The aims of the operation are the same as in any fracture involving a weight-bearing joint; stable anatomical reduction and internal fixation. Closed percutaneous screw fixation is an occasional option but does not allow for adequate visualisation of the reduction. Most therefore advise open reduction and internal fixation, using anteromedial, anterolateral or posterolateral approaches with or without a medial malleolar osteotomy. Two or more screws are generally used to provide stable fixation (Fig. 3) and are best inserted from posterior to anterior, as this is more biomechanically sound. The position is confirmed using an image intensifier.

Type III (Fig. 4)

These injuries require immediate surgical treatment. Closed reduction is seldom possible and even open reduction may be anything but straightforward. Reduction is aided by maximum muscle relaxation and the use of a calcaneal pin or a reduction device on a frame. Similar approaches
are utilised as with type II fractures but there is a high incidence of associated medial malleolar fracture that may facilitate reduction. The fracture itself is often comminuted especially in the medial neck and care has to be taken with reduction and fixation to prevent varus deformity of the neck. The anterolateral approach allows accurate reduction of the lateral neck and visualisation of the sub-talar joint. Bone graft may be used medially if required.

Type IV

These are similar to type III fractures with supplementary stabilisation of the talonavicular joint, usually with K-wires, which are removed at 6–8 weeks.

Open fractures

Type II, III and IV fractures are frequently associated with significant open wounds, which should be treated in a standard manner with lavage, surgical debridement, fixation to protect the healing tissue, antibiotics and, usually, secondary closure. Minor wounds will usually heal uneventfully but occasionally more major soft tissue loss may require the attention of a plastic surgeon, who should be involved early.

Post-operative care

For grade II, III and IV fractures the post-surgical care is similar. An initial plaster backshell is applied for comfort to allow the soft tissues to heal and the swelling to settle followed by a below knee cast for 8–12 weeks to allow fracture healing, as assessed by serial radiographs. Following plaster removal weight bearing is allowed with physiotherapy to encourage early mobilisation of the affected joints. Follow-up should be for a minimum period of 2–3 years.

Dislocations

Isolated dislocations of the sub-talar joint (Fig. 5) are rare with 80% occurring medially but they may be lateral, anterior or posterior, the latter two being extremely rare. In order to occur there has to be an associated dislocation of the talo-navicular joint. The injury may initially be misdiagnosed but prompt closed reduction is necessary and can usually be achieved. Once reduced the position is often stable with a good range of movement. Occasionally, open reduction is required most

Figure 4 Type III talar fracture.

Figure 5 Subtalar dislocation.
commonly because of interposed anterior soft tissues. Associated fractures are common and may be diagnosed on CT scans. They are treated on their own merits. A below knee cast is applied for 4–6 weeks followed by physiotherapy.

Complications

The frequency and severity of complications is usually proportional to the degree of displacement, in particular (Table 1):

- delayed union,
- malunion,
- avascular necrosis.

Delayed union and non-union occur with increasing frequency with the greater severity of the injury. Non-union is usually defined as no evidence of healing at 6 months. Treatment is difficult but may include revision fixation with bone grafting.

Varus mal-union is common in conservatively treated cases but should be minimised by prompt and adequate surgical intervention. Late treatment is difficult although corrective osteotomies have been suggested.

Avascular necrosis (osteonecrosis) of the talar body occurs more frequently with increasing severity of the injury. Symptoms arising from this are variable and not always disabling, in fact, 25% do well with no treatment. The main problem arises when the talus revascularises and becomes quite soft, the whole process taking 2–3 years. Hawkins described a sign that may be an early indicator of adequate blood supply to the talar body. It is usually present by 6–8 weeks and appears as a subchondral linear radiolucency of the talar dome on AP radiographs of the ankle, usually on the medial side. However, absence of this sign does not necessarily indicate that avascular necrosis will not develop. Conservative treatment with partial or non-weight bearing, or with a patellar tendon bearing brace, for 2 years is poorly tolerated. In symptomatic cases a trans-calcaneal-talar-tibial arthrodesis may be appropriate, usually supplemented with bone graft and with care to maintain a plantigrade foot. In selected cases with minimal collapse a combined sub-talar fusion with an ankle replacement may be appropriate.

Ankle and sub-talar osteoarthritis tend to increase with the Hawkins grading and should be treated on their own merits. They usually develop within 2 years of the injury but it may be difficult to isolate the exact site of the patient’s discomfort clinically. CT scans and diagnostic injections may be useful.

Fractures of the talar dome

These injuries are less common than talar neck fractures but tend to have a poorer prognosis with avascular necrosis occurring more frequently the more posterior the injury. The fracture usually exits the talus posteriorly and frequently involves the ankle and sub-talar joints (Fig. 6). Unfortunately, this frequently leads to secondary osteoarthritis. While undisplaced fractures confirmed on CT scan can be treated conservatively there should be a low threshold for open reduction and internal fixation, which should be undertaken for all displaced fractures. The fracture(s) may be approached via a medial malleolar or fibular osteotomy, or both, with anatomical reduction and rigid internal fixation. Occasionally a posterior fracture may be held with closed percutaneous screw fixation (Fig. 7). Post-operative treatment is the same as with other talar fractures.

Fractures of the posterior process

These fractures usually involve the lateral posterior process (Stieda), and less frequently the medial posterior process. They are frequently confused with a large os trigonum. The diagnosis may be made more accurately with a CT scan. Small undisplaced fractures can be treated conservatively, but larger displaced fractures should be treated by open reduction and internal fixation using a posterolateral or posteromedial approach as required. Occasionally, these fractures affect the

<table>
<thead>
<tr>
<th>Hawkins type</th>
<th>Type I (%)</th>
<th>Type II (%)</th>
<th>Type III (%)</th>
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</thead>
<tbody>
<tr>
<td>Delayed/nonunion</td>
<td>1.5</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>AVN</td>
<td>3</td>
<td>31</td>
<td>77</td>
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<tr>
<td>AnkleOA</td>
<td>15</td>
<td>36</td>
<td>69</td>
</tr>
<tr>
<td>Sub-talar OA</td>
<td>24</td>
<td>66</td>
<td>63</td>
</tr>
<tr>
<td>Good results</td>
<td>72</td>
<td>37.5</td>
<td>24</td>
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</tbody>
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NB: there are no reliable figures for type IV fractures in the literature.
Small undisplaced fractures may be treated conservatively but larger displaced fractures require open reduction and internal fixation to reduce the risk to the ankle and sub-talar joints. However, these fractures tend to do badly even when the fixation is adequate.

**Osteochondral fractures affecting the talar dome**

These are mainly associated with trauma but occasionally are idiopathic. They frequently occur with acute ankle sprains but are commoner in chronic lateral ligament instability. They are usually medial or lateral and may present with pain, instability, locking and a history of injury. Plain radiographs may make the diagnosis but CT and MRI scans often will reveal unrecognised

**Fractures of the lateral process**

These injuries account for about 25% of all talar fractures and occur with axial compression with dorsiflexion and external rotation. They frequently occur in snowboarders. A high index of suspicion is required to diagnose as they are frequently missed on plain X-rays, necessitating CT scan (Fig. 8). They may extend into the talo-fibular articulation and the posterior facet of the sub-talar joint.
associated lesions. There are various classifications depending on the severity of the lesion. An arthroscopic assessment aids diagnosis and treatment that may include debridement, drilling, micro-fracture or autologous chondrocyte implantation usually harvested from the knee, but more recently from the ankle.

**Practice points and research directions**

- Fractures and dislocations of the talus are rare but can cause significant problems.
- Certain injuries, in particular posterior and lateral process fractures or osteochondral defects, may be difficult to accurately diagnose with potential significant implications. However, minor avulsion fractures do occur which may be treated simply.
- Talar neck fractures are the commonest injuries and are classified according to Hawkins as grades I–III and Canale and Kelly grade IV. This grading correlates well with the potential for complications, in particular, avascular necrosis and osteoarthritis.
- Talar body fractures tend to have a poorer prognosis.
- Patients should be warned from the outset about the potential risks including those associated with treatment.
- Further studies to determine the exact mechanism of injury and to clarify the short and long term effects of surgical intervention are required.

**References**