6.10.1 Hindfoot: calcaneus and talus

1 Fractures of the calcaneus 899
1.1 Assessment of fractures and soft tissues 899
1.2 Surgical anatomy 901
1.3 Preoperative planning 903
1.4 Surgical treatment 903
1.5 Postoperative treatment 906
1.6 Pitfalls and complications 906
1.6.1 Wound healing
1.6.2 Malunion
1.6.3 Arthritis
1.7 Outcomes 908

2 Fractures of the talus 908
2.1 Assessment of fractures and soft tissues 908
2.2 Surgical anatomy 909
2.3 Preoperative planning 909
2.4 Surgical treatment 910
2.5 Postoperative treatment 913
2.6 Pitfalls and complications 914
2.6.1 Avascular necrosis
2.6.2 Malunion
2.6.3 Arthritis
2.7 Outcomes 915

3 Bibliography 915

4 Acknowledgment 916
6.10.1 Hindfoot: calcaneus and talus

1 Fractures of the calcaneus

1.1 Assessment of fractures and soft tissues

Fractures of the calcaneus are common and account for approximately 60% of tarsal injuries.

The etiology of calcaneal fractures is usually high-energy trauma, such as a fall from height or a motor vehicle crash.

During axial loading the talus is forced caudally into the calcaneus, resulting in frequently observed fracture patterns. The severity, type, and location of the fracture are determined by the position of the foot, the direction and magnitude of the applied force, and the quality of bone. Fractures to the spine and the extremities are frequently associated and require accurate assessment.

The radiographic assessment of the calcaneus begins with three views of the foot (AP, lateral, and oblique) as well as an axial (Harris) view. The basic fracture pattern (tongue type versus joint depression type) is best demonstrated in the lateral view. A decrease in Bohler's angle (measured as the angle between lines connecting the cranial portion of the tuberosity, the posterior articular surface of the talus, and the anterior process of the calcaneus) is determined on the lateral x-ray. The oblique and AP views delineate fracture extension into the calcaneocuboid joint. The axial view shows the primary displacements and angulations of the tuberosity (shortening and varus) as well as any increase in heel width. Broden's views (oblique views of the posterior articular surface of the talocalcaneal joint) are helpful preoperatively and intraoperatively. An x-ray comparison with the uninjured, contralateral extremity can be useful for assessing the injury pattern and planning surgical fixation.

CT scans in the axial and coronal planes are necessary to fully understand the fracture pattern.

The axial images demonstrate any anterior process extensions of the fracture into the calcaneocuboid joint (Fig 6.10.1-1a). The coronal images depict the involvement of the posterior articular calcaneal surface as well as shortening and position of the tuberosity (Fig 6.10.1-1b). Sagittal CT reconstructions can further be used to identify the injury.

Fig 6.10.1-1a–b Axial (a) and coronal (b) CT scans of a calcaneal fracture, identifying the lateral joint fragment (LJF), the sustentacular fragment (SF), and the tuberosity or body fragment (TF). There is lateral dislocation, impaction, and displacement at the articular surface.
**Classification**

Fracture classification assumes an understanding of major fracture displacements and fragments that are commonly observed (Fig 6.10.1-2a–b). Essex-Lopresti differentiated joint depression patterns and tongue-type fractures, depending on the exit point of the secondary fracture line (Fig 6.10.1-2c–d). In tongue-type patterns, a variable portion of the posterior articular surface remains in continuity with the tuberosity fragment. The Sanders CT classification is based on the location and number of fracture lines of the posterior articular surface as demonstrated by the coronal images at the widest part of the calcaneus. The OTA Classification is comprehensive and includes a description of both intraarticular and extraarticular fractures (Fig 6.10.1-3). An AO classification for calcaneal fractures has been developed by the foot expert group and is currently being tested for its practicability.

Significant soft-tissue swelling is common and related to a combination of forces producing the injury and the persisting fracture displacement. In highly displaced tongue-type patterns, the posterior skin may be severely compromised due to pressure from the posterior calcaneal tuberosity, which is pulled proximally by the Achilles tendon. Similarly, in displaced joint depression patterns, the fracture displacements may produce significant medial skin tension resulting in a skin blister (Fig 6.10.1-4). The risk of foot compartment syndrome should be considered in all calcaneal fractures and has been estimated to occur in up to 10% of patients [1].

**Fig 6.10.1-2a–d**  
Primary intraarticular fracture line shown in a superior (a) and lateral (b) view of the calcaneus. It divides the calcaneus into an anteromedial fragment (red) and a posterolateral fragment (blue). This fracture usually crosses the posterior articular surface.

**Fig 6.10.1-2a–d**  
Secondary intraarticular fracture lines (green) shown on a superior (c) and lateral view (d). (Joint depression type.)

LJF  
Lateral joint fragment.

SF  
Sustentacular fragment.

TF  
Tuberosity or body fragment.

ALF  
Anterolateral fragment.

AMF  
Anteromedial fragment.

BF  
Lateral wall blow-out fragment.
1.2 Surgical anatomy

An understanding of the complex calcaneal anatomy begins with a 3-D appreciation of the multiple articulations and bony processes. There are two articulations (with three facets) with the talus and one saddle-shaped articulation with the cuboid. Frequently, the anterior and middle facets are contiguous with one another as they form one articulation, and are separated from the larger posterior articular surface by the floor of the tarsal canal. The sustentaculum tali is the dense bone beneath the middle articular facet, which bears the greatest weight per area. The lateral wall of the calcaneus is thin and has attachments for the calcaneofibular ligament and the osseus reflection of the peroneal tendons. On the medial aspect, the bone is thicker and there is close proximity to the toe flexors and neurovascular structures.

An understanding of the commonly observed fracture displacements is essential for operative treatment. Both the intra-articular and extraarticular fracture displacement must be considered. The extraarticular displacement determines the loss of heel height, the increase in heel width, and the varus position of the heel. The intraarticular displacement may include the calcaneocuboid joint, the posterior articular surface, and/or the anterior and middle articular surfaces. The primary

![Fig 6.10.1-3](image)

*Classification of calcaneal fractures as proposed by the AO/OTA.*

![Fig 6.10.1-4a–b](image)

*a Medial soft-tissue blisters 3 days after fall.  
b Soft-tissue swelling 2 weeks after fall.*
6 Specific fractures
6.10 Foot

Fracture line for intraarticular fractures (Fig 6.10.1-2a–b) typically extends obliquely from the posteromedial to the anterolateral calcaneus (Fig | Animation 6.10.1-5). This fracture line produces a posterolateral segment consisting of the tuberosity, the lateral wall, and a variable portion of the posterior articular surface. The anteromedial segment consists of the anterior process, the medial sustentaculum, and the remaining medial aspect of the posterior articular surface. Secondary fracture lines (Fig 6.10.1-2c–d) are common and can extend into the calcaneocuboid joint (separating the anterior process into anteromedial and anterolateral fragments) or medially (separating the sustentacular fragment from the anteromedial fragment). A lateral fragment of the posterior articular surface characterizes joint depression patterns and is produced by extension of a secondary fracture line to the cranial portion of the tuberosity (Fig | Animation 6.10.1-6).

Because of the strong ligamentous attachments between the talus and the sustentacular fragment, this fragment is “constant”, and usually in a relatively standard position. The location of this fragment and the density of bone in this area are critical for reduction and fixation of calcaneal fractures.

It is essential to understand the vascular supply to the subcutaneous tissues of the lateral hindfoot as wound healing complications may be encountered after open reduction and internal fixation using an extensile lateral approach. The lateral calcaneal artery, the lateral hindfoot artery, and the lateral tarsal artery contribute to the vascularity of the lateral skin and soft tissues of the foot. The lateral calcaneal artery definitely is responsible for the majority of the blood supply to the corner of the flap in the extensile lateral approach [2].
1.3 Preoperative planning

The management of displaced intraarticular calcaneal fractures remains controversial. Closed management may be indicated in patients with minimal articular involvement, adequate maintenance of the heel position, and in patients with contraindications to operative treatment. Closed management consists of early functional treatment. This comprises ankle and subtalar joint exercises that encompass a full range of motion, but only after an appropriate decrease of soft-tissue swelling. Weight bearing should be limited until fracture healing has occurred, which is usually after 6–12 weeks.

- Careful patient assessment is critical if operative treatment is considered.

The prognosis is worse if the patient is male, has medium to heavy labor requirements at work, has a worker’s compensation claim, or bilateral injuries [3]. Moreover, patients with open fractures, patients who smoke, and patients with diabetes have been identified as having a higher incidence of wound complications after surgery [4].

- The condition of the soft tissues is the primary determinant for the time of surgery in the treatment of displaced calcaneal fractures.

Patience is required to optimize the local surgical environment and to minimize the incidence of wound complications. The use of a foot pump is reasonably tolerated by patients and has been shown to decrease the foot volume and local edema [5].

- The return of skin wrinkles to the lateral foot at the surgical incision site should be used as a guide for timing surgery, which is usually possible 7–14 days after injury [6].

Longer delays may be associated with increased difficulty in obtaining a reduction and closing the surgical incision.

- If soft-tissue condition does not allow a full surgical approach, then limited percutaneous techniques can be useful and help to reduce the posterior articular surface to a more acceptable position.

The necessary instruments and implants include K-wires, small-fragment screws and plates (one-third tubular plate, reconstruction plate 2.7 or 3.5), and newer calcaneal implants. A 4.0 or 5.0 mm Schanz screw helps to manipulate a tuberosity fragment. Dental picks and small elevators can be useful for the reduction of articular fragments. Bone substitutes may be useful to fill the large bone defect left after the reduction of impacted fragments.

1.4 Surgical treatment

Lateral patient positioning optimizes the approach and the reduction. An extensile lateral approach allows access to the entire lateral calcaneus, the anterior process, and the middle articular surface. In this approach the vertical limb courses parallel to the Achilles tendon, while the horizontal limb is parallel to the plantar aspect of the calcaneus (Fig 6.10.1-7). A full-thickness flap is created by subperiosteal dissection of the lateral calcaneus. The flap includes the sural nerve, the peroneal tendons, and the calcaneofibular ligament. The sural nerve is at risk at the proximal and distal parts of the incision. Distally, the calcaneocuboid joint is exposed. The flap can be retracted manually or with K-wires placed into the talus and/or lateral malleolus as well as the cuboid. Care should be taken to protect the flap throughout the exposure and reduction.

The lateral wall may need to be reflected to expose the lateral posterior articular surface fragment and the calcaneofibular ligament. In rare situations a second medial approach to the sustentaculum may be required.
Specific fractures

6.10 Foot

Reduction of the calcaneus should restore the entire calcaneal morphology as well as the articular surfaces of the subtalar and calcaneocuboid joints.

There are several aspects of the reduction that deserve particular mentioning. The medial sustentacular fragment is usually in a stable position and the remaining osseus segments are reduced in relation to this “constant” fragment. The anterior process is usually separated from the medial sustentacular fragment and lateralized. The frequently observed secondary fracture line that extends into the calcaneocuboid joint requires reduction. The reduction of the posterior articular surface can only be accomplished after the tuberosity segment has been distracted from its impacted position between the fragments of the posterior articular surface (Fig 6.10.1-8).

The sequence of fracture reductions depends on the experience and preference of the surgeon. Each strategy has its proponents and some flexibility may be required in these difficult injuries.

One strategy is to perform the reduction in the following sequence:

- reduction of the anterior process (and, hence, the calcaneocuboid joint);
- reduction of the anterior process to the medial sustentacular fragment;
- reduction of the tuberosity fragment to the medial sustentacular fragment;
- reduction of the lateral articular fragment of the posterior articular surface;
- replacement of the lateral wall.

It is usually desirable to reduce the entire calcaneus and maintain this reduction with K-wires to allow an intraoperative assessment, by both inspection and image intensifier. Intraoperative use of an image intensifier and/or plain x-rays (Broden’s views) in the lateral, axial, and oblique planes can help to assess the reduction of the tuberosity, the posterior articular surface, and height and length of the calcaneus.

After assessment of the reduction, definitive fixation can be accomplished. Ideally, a lateral plate should span between the tuberosity fragment and the anterior process, while simultaneously allowing screw fixation through the plate and into the medial sustentacular fragment. Smaller, low profile implants have been shown to have biomechanical properties similar to larger, bulkier implants [7]. Special locking plates allow fixation of all commonly observed fractures but are not mechanically stronger than traditional nonlocking plate fixation [8]. Lag screw fixation across the reduced posterior articular surface can be placed either through the plate or independently, prior to application of the plate (Fig 6.10.1-9).
6.10.1 Hindfoot: calcaneus and talus

Fig 6.10.1-8a–d Reduction of calcaneal fractures.

a The sustentacular fragment (SF) is nondisplaced because of its soft-tissue attachments. The tuberosity fragment (TF) is impacted and in varus position. The lateral articular fragment (LAF) is depressed and impacted. The lateral wall fragment (LWF) is displaced laterally, causing fibula impingement.

b Reduction of the tuberosity segment frequently requires placement of a Schanz screw. The primary reduction maneuvers restore the length, eliminate varus angulation, and medialize the tuberosity.

c A periosteal elevator inserted through the fracture can be used to disimpact and reduce the tuberosity fragment relative to the sustentacular fragment. This frequently requires rotating the lateral joint and lateral wall fragments away to allow access to the primary fracture line.

d The lateral articular fragment (LAF) is then reduced to allow anatomical reduction of the posterior articular surface. This is held with a temporary K-wire and then fixed with a 3.5 mm cortex lag screw which should pass into the sustentaculum.

Fig 6.10.1-9a–c

a Complex calcaneal fracture with impaction of the posterior joint facet.

b Fixation with a lag screw for the reconstruction of the articular surface, a cancellous autograft to support it, and a lateral one-third tubular plate as a buttress.

c 8-month follow-up.
The large bone defect left below the posterior articular surface of the calcaneus after reconstruction poses a dilemma. Some surgeons do not fill the defect, while others use autograft, allograft, or bone substitutes to fill the defect. With the new locking calcaneal plate (Fig 6.10.1-10) this may not be necessary. Minimally invasive techniques are also helpful if indicated by the patient’s general condition and the soft-tissue condition. Limited incisions under image intensifier may allow for indirect or direct reduction of joint surfaces. Limited internal fixation or percutaneous fixation may maintain these reductions in patients unable to undergo a major surgical procedure. The surgical incision should be closed in layers. The deep closure consists of multiple, interrupted sutures that incorporate the periosteum and are usually tied from peripheral to central. Care should be taken to ensure that this portion of the closure adequately reapproximates the deep tissues. The skin can then be closed without tension using interrupted, modified Allgöwer-Donati sutures (chapter 3.1.2).

1.5 Postoperative treatment

Initially, the patient’s leg is kept in a well padded posterior splint that maintains the foot in a neutral position. Surgical drains are removed at the earliest 2 days after surgery. Because of concerns regarding wound healing, the leg should be slightly elevated above heart level for several days. The ankle and subtalar joint are put through range of motion exercises that can begin as soon as the incision allows, usually at 2–5 days. Weight bearing is delayed for 8–12 weeks, depending on the degree of comminution and the adequacy of the fixation. Activity can progress depending on symptoms; however, impact activities should be avoided for 6 months from the time of injury. Radiographic evaluations including lateral and axial views are obtained at 6 weeks, 12 weeks, 6 months, and 1 year.

1.6 Pitfalls and complications

1.6.1 Wound healing

Wound healing remains a common complication after operative fixation of calcaneal fractures. Wound edge necrosis occurs commonly at the tip of the extensile lateral approach. Deep wound infection, while seen less frequently, can lead to disastrous results. Open fractures, smoking, and diabetes have been identified as risk factors for the development of wound complications [4]. Other risk factors include a single layered closure, a high body mass index, and an extended interval between injury and surgery [9].

Careful patient assessment is critical if operative treatment is considered. Attention to operative details, careful wound closure, and appropriate timing of surgery can all contribute to reducing the rate of wound healing complications (2–10%) [10, 11].

1.6.2 Malunion

Malunion of the calcaneus (chapter 5.1:4.7) results from either a failure to accurately reduce the fracture, or a failure to maintain the reduction. An articular malreduction may be associated with the development of subtalar arthritis and should be avoided. An accurate reconstruction of the alignment of the entire calcaneal morphology is important for maximizing heel height and position. A varus malreduction of the tuberosity alters the area of contact between the sole of the foot and the floor, which in turn affects normal loading of the foot and ankle joints. Recent models of implants including locking plates may be helpful in maintaining the reduction of comminuted calcaneal fractures [8].
6.10.1 Hindfoot: calcaneus and talus

Fig 6.10.1-10a–i  Case of a young female mountain climber who sustained complex bilateral calcaneal fractures after a fall. Lateral x-ray (a) and CT scans (b–c) of the left foot. Surgical exposure of the subtalar joint with partial reconstruction (d) and after application of a locking calcaneal plate (e). Postoperative x-rays, lateral (f) and Broden’s view (g). 7-month follow-up x-ray (h) and clinical picture of function (i). The patient is back to mountain climbing.

(With permission by Christoph Sommer.)
1.6.3 Arthritis
Subtalar joint arthritis may occur even after an accurate reduction of the superior articular surfaces of the calcaneus. This is likely due to the injury itself but may occur secondary to an articular malreduction. Increasing comminution has been shown to be associated with an increasing incidence of end-stage subtalar joint arthritis. In patients with persistent symptoms, a subtalar arthrodesis may be required. Non-operative treatment has been shown to have a 6-fold increase in the need for subtalar fusion compared to operative treatment of calcaneal fractures [12]. Similarly, an initial Bohler’s angle of < 0 and increasing comminution of the posterior articular surface have been shown to result in subtalar fusions more frequently [13].

1.7 Outcomes
Fractures of the calcaneus often result in some subtalar joint stiffness. Optimal results appear to be associated with an accurate restoration of both the extraarticular and intraarticular anatomy.

- Several studies have shown good results after selective, operative fixation of displaced, intraarticular, calcaneal fractures in younger patients, female patients, and with anatomical reduction [10, 14–16].

Factors associated with poorer results include increasing comminution [14], articular incongruity [17], and a flattened Bohler’s angle [13].

In a metaanalysis of calcaneal fractures, patients treated without surgery were found to have a higher risk of experiencing severe foot pain [18]. Workman’s compensation was shown to be highly predictive of a poorer result in both treatment groups [15].

- The avoidance of complications in the surgical management has been suggested as a major factor leading to a favorable result in the operative treatment of calcaneal fractures.

2 Fractures of the talus

2.1 Assessment of fractures and soft tissues
Fractures of the talus are rare. Typically, they are the result of high-energy mechanisms, and are frequently associated with disabling complications. Because of its unique anatomy, the tenuous blood supply, and the multiple complex articulations in the hindfoot, these injuries are associated with arthritis, hindfoot deformity, and avascular necrosis. The radiographic evaluation includes an ankle series (AP, lateral, and mortise) and a foot series (AP, lateral, and oblique). The Canale view should be obtained to further evaluate the talar neck and is accomplished by angulating the radiographic beam 15° cranially and medially. Computed tomography with reformations should be obtained as a part of the routine evaluation. These images help to further define the major fractures, show intra-articular debris in the subtalar joint, and amplify underestimated displacements. Fractures of the lateral talar process are best defined on the ankle mortise and lateral ankle views.

Fractures of the talar body are differentiated from fractures of the talar neck by the inferior location of the fracture relative to the lateral process [19]. Talar neck fractures are classified (Tab 6.10.1-1) based on the amount of displacement and the associated subluxations as defined by Hawkins [20] and modified by Canale [21]. The classification is important as avascular necrosis is associated with increasing displacement. Fractures of the lateral process occur as the result of forced dorsiflexion on combined with eversion, and are commonly seen in
snowboarders. Associated soft-tissue trauma and swelling commonly occur in combination with fractures of the talar neck and body. As these injuries are frequently the result of high-energy accidents, associated dislocations of the posterior talar body, fracture of the medial malleolus, and other ipsilateral foot and ankle fractures may be found. With postero-medial dislocation of the talar body, skin necrosis and neurovascular compromise are likely, until the posterior talus is reduced back into the ankle mortise. Because of the significant swelling observed in these injuries, the surgical approach and timing may be altered. A new AO classification is under evaluation.

### 2.2 Surgical anatomy

The uniqueness of talar anatomy and blood supply contributes to difficulties with fixation and the development of postinjury complications. Over 60% of the talus is covered in cartilage and reflects the complex articulations with the tibia, the fibula, the calcaneus, and the navicular. As a result, most talar fractures involve at least one critical articulation. Moreover, any deformity of the talus will have an effect on hindfoot mechanics and joint function. The blood supply to the talus comes from the peroneal, anterior tibial, and posterior tibial arteries, forming a complex anastomosis [22, 23]. The frequently identified major vessels include the artery to the sinus tarsi from the peroneal and anterior tibial arteries, the deltoid branch from the posterior tibial artery, and the artery of the tarsal canal from the posterior tibial artery. The major blood supply to the talar body has been demonstrated to be the artery of the tarsal canal. The location of these vessels and the impact of an adjacent fracture should be considered when planning surgical approaches and deep dissection [22, 23].

### 2.3 Preoperative planning

An understanding of the fracture pattern precedes the planning of a surgical approach and fixation. Talar neck and talar body fractures frequently occur as combined injuries. Talar body fractures are best defined as those located posterior to the lateral process of the talus and involve both the tibiotalar and subtalar articulations. While the entire talar neck is easily viewed through anterior approaches, talar body fractures are frequently hidden within the ankle joint and require adjunctive osteotomies for inspection. Posteromedial talus fractures are frequently comminuted and are poorly accessible through

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>I</td>
<td>Nondisplaced fracture of the talar neck</td>
</tr>
<tr>
<td>II</td>
<td>Displaced fracture of the talar neck with subluxation or dislocation of the subtalar joint</td>
</tr>
<tr>
<td>III</td>
<td>Displaced fracture of the talar neck with dislocation or subluxation of the talar body from both the tibiotalar and subtalar joints</td>
</tr>
<tr>
<td>IV</td>
<td>Displaced fracture of the talar neck with dislocation or subluxation of the talonavicular, tibiotalar, and subtalar joints</td>
</tr>
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</table>

Tab 6.10.1-1 Hawkins classification of talar neck fractures.
Specific fractures

6.10 Foot

Fractures of the lateral process involve the posterior talocalcaneal articulation as well as the fibulotalar articulation. As a result, simultaneous reduction of both of these articulations must be planned in cases where open reduction is indicated.

Closed reduction should be attempted on talar neck fractures that have an associated dislocation of the subtalar joint. This can usually be accomplished by first flexing the knee to relax the gastrocnemius muscle, followed by plantarflexing and distracting the foot. The foot, the calcaneus, and the talar head are distracted and plantarflexed relative to the talar body component in an attempt to unlock the subtalar articulation and reduce the talar body back onto the posterior articular surface of the calcaneus. In cases where the talar body is completely dislocated from the ankle joint, a closed reduction is typically unsuccessful. We recommend to apply the femoral distractor between tibia and calcaneus, which then allows to gently push back the talus into its correct place. An open reduction may be required. In posteromedial dislocations, posterior tibial neurovascular compromise due to direct pressure of the dislocated body fragment may occur. An emergency open reduction is required in these instances.

Displaced talar neck and body fractures require accurate reduction and stable fixation to allow early motion of the ankle and subtalar joints. The timing of surgical treatment of talar neck fractures remains controversial. Early surgical stabilization has been suggested to decrease the incidence of avascular necrosis; however, recent reports have failed to demonstrate the effects of surgical timing on outcomes [24–27]. Prompt surgical intervention is still required in cases of dislocation of the talar body, neurovascular compromise, open fracture, and excessive soft-tissue pressure.

Temporary spanning external fixation of the ankle joint may be indicated in some talar neck and body fractures where definitive surgical treatment is being delayed. This allows for further evaluation with computed tomography and resolution of soft-tissue swelling. External fixator pins should be placed outside the zone of injury and the zone of future surgery.

2.4 Surgical treatment

The two commonly used surgical approaches for the fixation of most talar neck fractures are the anteromedial approach and the anterolateral approach [28] (Fig 6.10.1-11) (Video 6.10.1-1). Both incisions are frequently necessary to allow accurate reduction and stable fixation. As an alternative, the Ollier approach can be recommended. The primary sites of comminution are dorsal and medial. The anterolateral approach provides access to the subtalar joint as well as to the lateral talar neck and the lateral process. The subtalar joint should be thoroughly inspected and all debris removed to minimize the incidence of posttraumatic subtalar joint arthritis.

Implants—preferably made of titanium to allow for later MRI studies—can be placed both laterally and medially (Fig 6.10.1-12). The order of fixation, the size of implants, and the location of an implant are determined by the location of the fracture and the zones of comminution. The talar neck usually fractures under tension on the plantar and lateral aspects, with compressive failure occurring dorsally and medially. This makes the plantar and lateral talar neck easier to reduce accurately and an appropriate location to initiate fracture reduction. Small plates (a talar locking plate is under development) can also be placed dorsomedially, spanning the comminution in this location [29]. However, the extraarticular talar neck is much more limited medially than laterally. Screw fixations can be placed from distal to proximal. The usual direction is from the talar head to the talar body. These implants can be placed from either the medial or lateral aspects of the talar head and require countersinking to avoid impingement at the talonavicular joint. Abduction of the foot
6.10.1 Hindfoot: calcaneus and talus

Fig 6.10.1-11a–b  Anterolateral (a) and anteromedial (b) approach to the talar neck. The anterior tibialis tendon, dorsalis pedis artery, and posterior tibial artery must be protected.

Video 6.10.1  Anteromedial and anterolateral approaches to the talar neck.
6 Specific fractures
6.10 Foot

Fig 6.10.1-12a–d

a–b The typical location of a talar neck fracture is anterior to the lateral process of the talus. Lag screws can be placed from anterior to posterior after countersinking beneath the talar head cartilage surface.

c–d A talar body fracture is typically located posterior to the lateral process of the talus. After reduction, screws can also be placed from anterior to posterior at the lateral process, where good purchase can be obtained. Alternatively, screw insertion can be done in a posterior to anterior direction [30].
6.10.1 Hindfoot: calcaneus and talus

combined with the occasional removal of a small portion of the extraarticular medial navicular allow for uncovering of the medial talar head articular surface. In general, if good osseous apposition is obtained, lag screw fixation can be used to maximize stability and healing (Fig 6.10.1-13). For fixation across a zone of comminution, a position screw should be used.

- Osteotomy of the medial malleolus or the fibula is often necessary for inspection and fixation of talar body fractures.

Because talar body fractures are frequently confined to the articular portions of the talus, it is frequently necessary to place multiple countersunk screws directly through the talar body articular surface. Again, smaller implants with smaller screw heads will minimize the iatrogenic removal of articular cartilage.

Additional approaches such as the posteromedial and posterolateral exposures may be necessary in some talar fractures. The posteromedial approach is frequently required for posteromedial fractures of the talar body.

2.5 Postoperative treatment

A well padded posterior splint with the foot in a neutral position is applied after surgery. Early and unrestricted active ankle and subtalar joint range of motion exercises can be initiated as soon as wound healing allows. Weight bearing on the affected extremity should be restricted for at least 6–12 weeks to allow for fracture healing. X-rays at 6 and 12 weeks are evaluated for healing and radiographic evidence of revascularization.

![Fig 6.10.1-13a–d](image)

Fig 6.10.1-13a–d

a–b  An open fracture dislocation of the talus is a surgical emergency.

c–d  Two incisions are used to accurately restore the talar anatomy.
Subchondral lucency of the talar dome demonstrated on the mortise x-ray indicates that the bone is vascular and suggests aseptic necrosis to be less likely. This is termed Hawkins sign and is a good prognostic sign.

An extended period of restricted weight bearing in patients failing to demonstrate x-ray evidence of revascularization has not been shown to improve results or talar blood flow. Impact activities should be limited for at least 6 months. Radiographic evaluations should continue for 2 years in 6 month intervals to confirm continued talar viability.

2.6 Pitfalls and complications

Talar neck and body fractures are associated with several commonly observed late complications which may be related to the injury, the surgery, or a combination of both. Early complications include wound related issues which can be avoided with careful attention to the placement of surgical incisions and the timing of surgical treatment. In cases where there is dislocation of the talar body, early surgical management is necessary to avoid skin necrosis secondary to pressure from the displaced segment. The use of two approaches has not been associated with wound complications [24, 26–28]. Nonunion is uncommon but late complications include avascular necrosis, post-traumatic arthritis of the ankle and subtalar joints, and malunion.

2.6.1 Avascular necrosis

Avascular necrosis commonly occurs following fractures of the talar neck and has been reported in 10–50% of cases. There is an increased incidence of avascular necrosis with increasing fracture displacement as predicted by the Hawkins classification. While the majority of patients will have some evidence of increased density on x-ray evaluations following a neck fracture, this finding does not predict talar collapse or a poor result. A significant percentage of these cases will undergo revascularization with resolution of the sclerosis, while others will have persistence of sclerosis without collapse. Avascular necrosis with talar body collapse is a very serious complication that results in pain and associated ankle and subtalar joint arthritis. Complex secondary reconstructive procedures are needed. Open traumatic wounds have been shown to be associated with an increased rate of avascular necrosis in both talar body and talar neck injuries, with reported incidences ranging from 69% to 86% [24, 26, 27].

2.6.2 Malunion

Malunion of the talar neck is due to either malreduction at the time of surgery or loss of reduction prior to healing of a previously reduced fracture. The common deformity patterns include talar neck shortening, varus, and dorsiflexion. These late deformities mimic the injury displacement patterns and the patterns of commonly observed comminution. Varus talar neck malunion is directly associated with a loss of subtalar motion and a loss of foot eversion [31]. This complication is best avoided by accurately reducing the fracture on the tension side (typically plantar and lateral), combined with stable fixation spanning the comminuted zones (typically dorsal and medial). Plate fixation placed on the side with the most comminution may assist in minimizing late deformity [26, 29]. Acute bone grafting at the time of fixation is frequently necessary if a void exists dorsally and medially after the proper length of the talar neck has been reestablished.

2.6.3 Arthritis

Peritalar stiffness and arthritis commonly occur after both talar neck and talar body fractures. Subtalar joint arthritis occurs more frequently after talar neck fractures, with an incidence of 60–100%. Talar body fractures have increased rates of arthritis at the tibiotalar joint. Despite x-ray evidence of joint space narrowing in many patients, there is usually little need for secondary reconstructive procedures [24, 27, 32].
2.7 Outcomes

Outcomes are frequently determined by the common complications that occur after treatment of talar neck and body fractures. Open fractures have been shown to be associated with an increased rate of complications, particularly avascular necrosis and posttraumatic arthritis [24, 26, 27]. Outcomes with multiple functional measures showed that lateral process fractures had the best results, followed by neck, and finally body fractures [32]. Posttraumatic stiffness, arthritis, and chronic pain were common outcomes even after anatomical reduction and stable fixation, especially in open fractures [24]. The need for secondary reconstructive procedures increased with time from injury, was correlated with development of a complication, and was necessary in 37% of patients [25]. In a review of 102 talar neck fractures treated with open reduction and internal fixation, Vallier et al found significant functional limitations, frequent complications, and poor outcomes despite an accurate reduction in most patients.

Outcomes after fractures of the talar body have also been studied. In a review of 57 talar body fractures, Vallier et al found high rates of both osteonecrosis and posttraumatic arthritis. Open fractures and talar neck involvement had worse functional results, particularly due to osteonecrosis and arthritis. Tibiotalar joint arthritis was observed more frequently and osteonecrosis less commonly in talar body fractures when compared to talar neck fractures. Overall, significant functional limitations and frequent complications were observed after operative fixation of talar body fractures [21, 27].

3 Bibliography

6 Specific fractures
6.10 Foot


4 Acknowledgment

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