Foot and Ankle Trauma

Chapter 25
Fractures of the Calcaneus
Todd S. Kim, MD

Introduction

Calcaneal fractures are among the most disabling lower extremity injuries. Early complications, long-term pain, posttraumatic arthritis, and reoperation are common. These injuries are challenging to manage, and the best treatment approach remains controversial. Alternative and minimally invasive surgical approaches have gained popularity in recent years and may have potential for minimizing the risk of complications and improving outcomes.

Pathoanatomy and Epidemiology

Most calcaneal fractures are intra-articular injuries from a high-energy mechanism, the most common of which are a fall from a height and a motor vehicle crash. Although the injury can occur at any age, often it affects a relatively young individual in an industrial setting. The socioeconomic effect is great because of this demographic pattern and the disability associated with the injury. Significant impairment has been reported to last 3 to 5 years after injury. The general health outcomes of patients with calcaneal fracture were found to be worse than those of patients with other orthopaedic injuries or patients who had a serious medical event such as an organ transplant or myocardial infarction. Calcaneal fracture is considered to be a serious, life-changing event.1,2

The typical calcaneal fracture involves an axial load on the lower limb that drives the talus down into the calcaneus. The exact fracture pattern can depend on the position of the foot at the time of impact, the patient’s bone quality, and the amount of energy.3 The heel is shortened, widened, and displaced into varus. Almost always the patient has significant associated soft-tissue swelling and damage. Severe swelling, fracture, blisters, and even compartment syndrome can occur. Associated lumbar spine fracture or another lower extremity fracture is common.

The involvement of the posterior facet of the subtalar joint is one of the major challenging factors in achieving successful treatment and outcomes. Articular cartilage injury at the time of the impact and subsequent displacement of the articular fragments can lead to the development of posttraumatic arthritis. The classification of a fracture classification and the treatment algorithm are largely determined by the extent of involvement of the subtalar joint.

Intra-articular Fractures

Classification and Imaging

The initial radiographic assessment of a calcaneal fracture involves plain radiographs and often CT. Plain radiographs should include lateral and AP views of the foot and a Harris axial heel view. On the lateral view, a decreased Böhler angle, an increased angle of Gissane, and an inferior displacement of the posterior facet can be seen (Figure 1). If only the lateral portion of the joint is displaced, a double density sign (when two portions of the posterior facet articular surface are visible on the lateral radiograph) can be seen at the posterior facet (Figure 2). The AP foot view may show extension of the fracture into the anterior process and calcaneocuboid joint. The axial view may show varus displacement and shortening of the tuberosity. CT is indicated for most intra-articular fractures to evaluate the extent of joint involvement and displacement (Figure 2 B, C, and D, and Figure 3, A and B).4

A displaced intra-articular calcaneal fracture is identified as a joint depression fracture or a tongue-type fracture, based on the Essex-Lopresti classification. With a relatively posterior-directed force, the fracture line extends into the posterior facet to produce a joint depression fracture. If the force is directed more inferiorly, the fracture line extends inferior to the posterior facet and produces a tongue-type fracture pattern.

The classification of Soeur and Remy was expanded by Sanders to define a system based on the number and location of articular fragments at the posterior facet, as

Dr. Kim or an immediate family member serves as a board member, owner, officer, or committee member of the American Orthopaedic Foot and Ankle Society.
seen on semicoronal CT.6,7 (Figure 4). A type I fracture is nondisplaced. A type II fracture is a two-part fracture with a subtype based on the location of the primary fracture line. A type III fracture has three parts, often with a centrally depressed fragment. A type IV fracture has at least four articular fragments and typically is highly comminuted.

Nonsurgical Treatment
A nondisplaced (Sanders type I) fracture usually is treated nonsurgically. A displaced fracture in a patient with significant perioperative risk factors can be treated nonsurgically. Smoking, poorly controlled diabetes, peripheral neuropathy, and a serious medical comorbidity are relative contraindications to surgical treatment. Chronologic age probably should not be considered a contraindication to surgical treatment; a retrospective study found equivalent outcomes after surgical treatment in patients who were older or younger than 50 years.8

Surgical Versus Nonsurgical Treatment of a Displaced Fracture
The definitive treatment of patients with displaced intra-articular calcaneal fracture remains controversial. Historically, these fractures were treated nonsurgically. The benefit of surgical treatment was difficult to establish, and the rate of perioperative complications was considered too high to justify surgical treatment. In recent decades, however, surgical treatment has become the standard of care for many of these injuries. Improved understanding and management of the associated soft-tissue injury have led to the development of surgical techniques with relatively low complication rates. At the same time, developments in preoperative and intraoperative imaging and newer implants have improved the ability to perform open reduction and internal fixation.

Several studies compared the surgical and nonsurgical treatment of intra-articular calcaneal fractures. Many of these studies were limited by a small patient population, a lack of consistency in fracture classification, and variations in surgical technique. A randomized prospective study of 30 patients with a displaced fracture (Sanders type II or III) found that the patients treated surgically had a statistically significant improvement in outcome at 17-month follow-up over those treated nonsurgically.9

In a large multicenter randomized study comparing surgical and nonsurgical treatment of displaced intra-articular calcaneal fracture, validated outcomes measures revealed no overall difference between patients in the two treatment groups at 2- to 8-year follow-up.10 However, among patients who did not have a workers’ compensation claim, surgical treatment led to better satisfaction scores than nonsurgical treatment. Women, younger patients, and patients with a greatly displaced fracture also had a better outcome after surgical treatment. Patients treated nonsurgically were much more likely than those treated surgically to require subsequent subtalar arthrodesis for posttraumatic arthritis. Despite the large number of enrolled patients and the sound methodology, this study did not clearly establish the optimal treatment of patients with a displaced intra-articular calcaneal fracture.

Open Reduction and Internal Fixation of a Displaced Fracture
Prospective studies are needed to define the patient groups that will benefit from surgical treatment, but open reduction and internal fixation generally is recommended for patients with a Sanders type II or III intra-articular fracture, as long as there is no clear contraindication.3 It is clear that outcomes are poor if these injuries are treated nonsurgically.

Although several surgical approaches have been described, most studies have reported open reduction and internal fixation through an extensile lateral approach.3,11-13 (Figure 5). This approach remains the most common for surgical treatment of displaced intra-articular calcaneal fractures.

One of the key elements in this surgical treatment approach is the management of the associated soft-tissue injury and swelling. The most common and serious early complications of surgical treatment are delayed wound healing and infection.4,14 To minimize wound complications, surgical treatment should not be attempted before resolution of the soft-tissue swelling, as indicated by the absence of pitting edema and by the presence of skin wrinkling at the lateral heel.16,17 (Figure 6). Some surgeons

---

**Figure 1** Lateral radiograph of a displaced intra-articular calcaneal fracture in a 38-year-old man, showing loss of calcaneal height, depressed articular fragments, a decreased Bohler angle, and an increased angle of Gissane.
recommend the use of an aggressive soft-tissue protocol to decrease the delay to surgery and minimize the risk of complications.\textsuperscript{18} Delay of more than 3 weeks after the injury makes fracture reduction extremely difficult because early fracture healing has occurred.

**Surgical Treatment of a Tongue-Type Fracture**

A displaced tongue-type fracture may require urgent surgical treatment. A severely displaced superior tuberosity fragment places the posterior skin under tension and can lead to soft-tissue injury and even skin necrosis within a few hours (Figure 7). A 21% incidence of posterior soft-tissue compromise was found in a study of 139 tongue-type fractures.\textsuperscript{19} Six soft-tissue coverage procedures and one amputation resulted. The patients treated with emergency percutaneous reduction avoided soft-tissue complications.

In general, simple or extra-articular tongue-type fractures (Sanders type IIC) are treated with percutaneous fixation (Figure 8). Guidewires are placed percutaneously on either side of the Achilles tendon and into the displaced tuberosity.\textsuperscript{20} The guidewires are used to reduce the fracture and subsequently are advanced toward the anterior process. Definitive fixation can be achieved with
large cannulated screws placed over the guidewires. Alternatively, multiple small fragment screws can be placed percutaneously to maintain the reduction. Early mobilization is generally encouraged to minimize stiffness.

Complex intra-articular fractures with a tongue-type component (Sanders types IIA, IIB, and III) may not be amenable to reduction using the percutaneous Essex-Lopresti technique. Sagittal fracture lines and comminution at the articular surface cannot be appropriately reduced. These fractures should be treated with open reduction and internal fixation through an extensile lateral approach or with a minimally invasive technique.

**Primary Arthrodesis for a Type IV Fracture**

Because of multiple joint fragments and comminution, Sanders type IV fractures generally are not amenable to anatomic reduction and stable fixation. Even if anatomic reduction is possible, the articular cartilage damage from the time of impact is significant, and progression to posttraumatic arthritis is inevitable. For these reasons, primary arthrodesis is the surgical treatment of choice. Multiple researchers have reported on open reduction and internal fixation of the calcaneus combined with primary arthrodesis of the subtalar joint, using the extensile lateral approach. In this technique, the extra-articular calcaneal anatomy is restored with open reduction and internal fixation, and iliac crest bone graft is used at the arthrodesis site. High union rates, more rapid return to work, and generally good clinical outcomes have been reported when this method was used to treat these severe injuries.

Primary subtalar arthrodesis may be a good treatment option for a type IV fracture even without formal fracture reduction. Good results were obtained in a series of seven fractures treated with primary arthrodesis but not with formal open reduction and internal fixation.

**Minimally Invasive Techniques for a Displaced Fracture**

In recent years, interest has increased in surgical approaches less invasive than the extensile lateral approach. These alternate approaches may carry less risk of wound complications. In addition, some researchers have suggested that the extensive soft-tissue stripping required for the extensile approach may compromise calcaneal vascularization and may lead to scarring and stiffness of the subtalar joint. It is possible that a minimally invasive technique can lead to better outcomes and an improved subtalar range of motion than surgery through the extensile lateral approach. The described procedures...
have included limited open reduction, closed and percutaneous reduction, percutaneous internal fixation, and external fixation. Regardless of technique, the goals of the minimally invasive approach are similar to those of open reduction and internal fixation through an extensile lateral approach: anatomic reduction of the articular surface, restoration of the height and valgus position of the tuberosity, and stable fixation to allow early mobilization. With minimally invasive incisions, it is safe to proceed with surgery before the complete resolution of swelling. Because percutaneous and indirect reduction techniques are used, surgery must take place before early consolidation of the fracture. The general recommendation is that surgery be undertaken within 5 days of the injury.

**Percutaneous Reduction and Fixation**

Of 54 consecutive displaced calcaneal fractures treated with percutaneous reduction and external fixation, 49 (90.7%) had an excellent or good clinical and radiographic result. There were no deep infections and only three superficial pin site infections. These results were comparable to those of conventional open reduction and internal fixation except for the absence of serious wound infections.

In 37 displaced calcaneal fractures treated with closed reduction and percutaneous screw fixation, the patients were positioned prone and the initial closed reduction was done with a temporary external fixator spanning the distal tibia to the calcaneal tuberosity. The joint surface was reduced percutaneously, and internal fixation was obtained with multiple cannulated screws placed percutaneously. Five wound infections occurred. At a mean 66-month follow-up, 2 patients had required subtalar arthrosis, and 17 (46%) had undergone removal of painful screws. Patient-reported scores revealed good overall results: the mean American Orthopaedic Foot and Ankle Society score was 84 of a possible 100 points, the Medical Outcomes Study Short Form–36 score was 76 points, and the patient satisfaction score was 7.9 of a
possible 10 points. The study showed that this treatment is viable and relatively safe.

A retrospective study compared 83 fractures treated with percutaneous reduction and fixation with 42 fractures treated with traditional open reduction and internal fixation. The outcomes were similar in terms of the Böhler angle, maintenance of reduction, and rates of late fusion. The incidence of wound complications was significantly decreased in the patients treated percutaneously. No deep infections occurred in the patients treated percutaneously, but six deep infections occurred in those treated with open surgery.

**Limited Open Reduction Using the Sinus Tarsi Approach**

The sinus tarsi approach to the subtalar joint is commonly used in elective procedures such as subtalar arthrodesis. The use of the sinus tarsi approach for displaced calcaneal fracture allows open reduction and fixation of the articular fragments through a relatively small and safe incision.

**Research Findings**

A prospective study of displaced fractures treated using a mini-open sinus tarsi approach and percutaneous fixation found a good to excellent clinical result in 16 of 19 patients available for follow-up. Reduction of the posterior facet was graded as good to excellent on CT in 14 of 22 fractures. Three of 21 patients (14%) had a superficial wound complication that resolved within 2 weeks with appropriate treatment.

The limited open approach was used in 24 patients and compared with the extensile lateral approach used in 26 patients. Patients treated using the limited open approach had a shorter surgical time and no wound complications (compared with four wound complications in...
those treated using the extensile lateral approach). The functional results were similar, but a minor secondary procedure for screw removal was more common in the patients treated with the limited open approach.

In the largest study to compare the minimally invasive sinus tarsi approach with the extensile lateral approach, no statistically significant differences in patient satisfaction or patient-reported outcomes (using the Medical Outcomes Study Short Form–36, Foot Function Index, and visual analog pain scale) were found between the 33 fractures treated with a minimally invasive approach and the 79 fractures treated with an extensile lateral approach. There was a significant difference in rates of wound complications. Twenty-nine percent of those treated using the extensile lateral approach had a wound complication, compared with only 6% of patients treated using the minimally invasive approach. Despite the inherent limitations of a retrospective study, these results appear to corroborate the finding that effective reduction of a displaced fracture can be achieved through a minimally invasive approach and that the incidence of wound complications is decreased when a minimally invasive technique is used.

The gold standard for surgical treatment of a displaced calcaneal fracture remains the extensile lateral approach. Alternative approaches, especially early in a surgeon’s learning curve, should be reserved for relatively simple fracture patterns. Some complex and difficult fractures require the use of the extensile lateral approach for optimal reduction and fixation.

Surgical Technique
The lateral decubitus patient position is used with the sinus tarsi approach. The pelvis is rotated slightly back to allow access to the medial aspect of the foot when the hip is externally rotated and to facilitate positioning of the foot for the axial fluoroscopic view. An external fixator can be used as an intraoperative reduction tool. External fixator pins are placed in the medial distal tibia and the calcaneal tuberosity. Placement of the fixator on the medial side allows reduction of the varus angulation of the tuberosity and the restoration of calcaneal height (Figure 3, C and Figure 9, A).

A longitudinal incision is made from the distal tip of the fibula toward the base of the fourth metatarsal for a standard sinus tarsi approach to the subtalar joint. Specialized distractors using Kirschner wires inserted into the talus and the distal calcaneus can be helpful for visualization and reduction of the articular fragments (Figure 3, D and Figure 9, B). The medial fixator sometimes must be loosened temporarily to allow reduction and fixation of the posterior facet from the lateral side. The ability to reduce the tuberosity in relation to the sustentaculum tali at the medial cortex should be confirmed fluoroscopically before final fixation of the posterior facet. Indirect reduction of the tuberosity with the distracting fixator sometimes is not sufficient. Direct reduction maneuvers through the fracture from the lateral side are necessary but are not possible after reduction and fixation of the posterior facet is completed.

Once adequate exposure of the posterior facet of the subtalar joint is established, direct and indirect reduction maneuvers can be employed to achieve reduction of the articular surface (Figure 9, D). Initial fixation of the articular reduction typically is done with a 2.7-mm cortical screw placed from the lateral articular fragment toward the sustentaculum tali (Figure 10, A and B). Additional fixation can be achieved with screws or with a...

Intraoperative photographs showing a minimally invasive technique for treating a displaced calcaneal fracture. A, A distracting external fixator placed on the medial side from the distal tibia to the calcaneal tuberosity. B, The sinus tarsi exposure of the subtal joint, showing articular reduction, and the use of a lateral Kirschner-wire distractor for joint visualization. C, Placement of a lateral periarticular plate through the sinus tarsi exposure, after reduction of the articular fragments.
periarticular plate, depending on the fracture pattern and the surgeon's preference (Figure 3, E and F and Figure 8, C). The approach can be safely extended to allow reduction of additional fracture fragments and percutaneous plate placement.31 As long as dissection is not carried into the deep portion of the superficial peroneal retinaculum, the blood supply to the lateral skin flap through the lateral calcaneal artery is preserved.

Reduction of the tuberosity and the anterior process is confirmed fluoroscopically. Multiple percutaneous screws can be placed from the tuberosity and from the anterior process, depending on the fracture pattern, to complete fixation (Figure 3, E and F and Figure 10, C and D). The distracting fixator usually is removed when percutaneous fixation of the tuberosity is complete. In an extremely unstable or comminuted fracture, the external fixator can be left in place until early fracture consolidation occurs. To minimize stiffness, patients are kept non-weight bearing until fracture healing at 8 to 12 weeks, but early mobilization is encouraged when the wounds have healed.

Extra-articular Fractures

One third of calcaneal fractures are considered extra-articular because they do not extend into or involve the posterior facet of the subtalar joint. The mechanism of injury is similar to that of an intra-articular fracture, but generally there is less force at impact. An extra-articular fracture is most common in children. The predominance

Figure 10

A minimally invasive sinus tarsi approach was used for limited open reduction and internal fixation. A, Broden view intraoperative fluoroscopic image showing articular reduction. B, Lateral view fluoroscopic image showing placement of the external fixator. Lateral (C) and axial (D) radiographs showing the healed fracture 6 months after surgery.
of boys and men among the patients is less pronounced than with intra-articular fractures. Most of these injuries can be effectively treated nonsurgically, especially if the displacement is minimal.32

Calcaneal body fractures (Sanders type I) most commonly are treated nonsurgically. Surgery is indicated to prevent a problematic malunion with severe shortening, which could affect the gastrocnemius-soleus complex, or with widening, which could affect the peroneal tendons. Most authors recommend surgical treatment of displaced body fractures with more than 30° of angulation or more than 1 cm of translation.1

Tuberous fractures result from forced dorsiflexion and can involve a portion of the Achilles tendon insertion. Like a displaced tongue-type fractures, a displaced tuberosity avulsion fracture can place the posterior skin at risk. Without immediate treatment, skin necrosis and wound complications can occur.31 Urgent surgical treatment with open reduction and internal fixation is indicated. A recent review of calcaneal tuberosity avulsion fractures led to a modified classification scheme.34 Simple extra-articular avulsion fracture (type I) was found to be the most common type. This fracture generally occurred with a low-energy mechanism in older patients. A true nondisplaced fracture can be treated nonsurgically with immobilization in plantar flexion. Because of the inherent risk to the strength of the gastrocnemius-soleus complex, a displaced fracture should be treated with open reduction and internal fixation. Depending on the size of the fracture fragment and the bone quality, fixation can be achieved with lag screws or a tension-band construct.

Isolated fracture of the sustentaculum tali is rare. CT usually is necessary because the fracture characteristics can be difficult to appreciate on plain radiographs. Fractures that involve the posterior facet or are displaced more than 2 mm require surgical treatment.33 A study of 15 patients who underwent open reduction and internal fixation through a medial approach to the sustentaculum tali found that all fractures healed with maintained reduction, and there were no complications related to the surgical approach.36

Most anterior process fractures can be treated nonsurgically with cast or boot immobilization. Surgical treatment is reserved for fracture fragments that involve more than 25% of the calcaneocuboid joint.3 If the fracture fragments are too small or comminuted to allow open reduction and internal fixation, primary excision may be necessary. Delayed excision sometimes is necessary to treat painful nonunion of small fragments. Successful endoscopic excision of a symptomatic nonunion recently was reported.37

Complications

Wound Complications

The most common and serious early complication of surgical treatment of calcaneal fracture is delayed wound healing and infection, which was reported to occur in as many as 25% of patients after open reduction and internal fixation using a lateral extensile approach.13-15,17 Despite awareness of soft-tissue swelling, attention to intraoperative handling of the flap, and meticulous two-layer closure, delayed healing and necrosis at the apex of the flap can occur. Treatment using local wound care, antibiotics, and occasionally surgical débridement generally is effective. Fewer than 5% of closed fractures progress to deep infection and osteomyelitis.

A recent study of 490 calcaneal fractures treated with open reduction and internal fixation found a wound complication rate of 17.8%.13 Patient-related risk factors were identified as tobacco smoking, diabetes, and a Sanders type fracture. Surgery-related risk factors were the presence of residents or fellows in the operating room, duration of surgery, estimated blood loss, and a total of 10 or more people in the operating room at any time during the surgery. Use of a tourniquet was associated with a lower risk of wound complications. An earlier study identified high body mass index, increased time from injury to surgery, and a single-layer closure as risk factors for wound complications.37

Open calcaneal fractures have a much higher complication rate than closed calcaneal fractures. A recent study of 115 surgically treated open fractures found superficial wound infection in 9.6%, deep infection in 12.2%, and culture-positive osteomyelitis in 5.2%.38 Six patients (5.2%) required amputation. The overall complication rate of 23.5% was lower than expected for open fracture. A study of 12 fractures with a plantar medial wound found that this subtype of open fracture was associated with a very high rate of complications.39 Infection developed in five patients, and three required a soft-tissue coverage procedure. Nonunion developed in three patients, and one patient required a below-knee amputation.

Posttraumatic Arthritis

Posttraumatic arthritis of the subtalar joint is a common complication of calcaneal fracture, whether the fracture was treated surgically or nonsurgically. Displaced intra-articular calcaneal fractures result from a high-energy mechanism; the energy on impact often causes direct and irreversible articular cartilage injury that can be seen at the time of surgery. The mechanisms of chondrocyte injury and death with impact loading have been well described.40-43 Further joint destruction will occur...
in a displaced fracture if the articular surface is not anatomically reduced. Fractures treated nonsurgically and fractures treated surgically with a suboptimal articular reduction will progress rapidly to subtalar arthrosis. An analysis of the risk factors reported a 10% rate of late subtalar fusion.44 The strongest factor for predicting the risk of long-term sequelae was the severity of the initial injury, based on the Böhler angle and Sanders classification. Nonsurgical treatment and the existence of a workers’ compensation claim also predicted a poor outcome and the need for late subtalar fusion.

A patient with pain and disability from posttraumatic arthritis often requires surgical treatment with subtalar fusion. Removal of the internal fixation and in situ arthrodesis are recommended.45 A large study of patients who underwent subtalar fusion to treat a late complication of calcaneal fracture found that the patients who had undergone initial surgical treatment had fewer wound complications and better functional outcomes than those who initially had been treated nonsurgically.46 The researchers concluded that long-term outcomes were improved because the initial open reduction and internal fixation restored the calcaneal shape, alignment, and height, even if subtalar fusion later was required.

Calcaneal Malunion
Nonsurgical treatment of a displaced calcaneal fracture often leads to a problematic malunion. Loss of calcaneal height results in shortening of the gastrocnemious-soleus complex and can affect ankle dorsiflexion. Varus malalignment of the tuberosity can negatively affect gait and ankle stability. Widening of the calcaneus can lead to subfibular impingement and peroneal tendon dysfunction.

The classification of calcaneal malunion is based on the presence of a lateral wall exostosis, subtalar joint arthrosis, and varus malunion.47 If subtalar joint arthrosis is present, fusion with an attempt to restore calcaneal height is recommended. A 93% union rate was reported in a study of 40 subtalar arthrodesis procedures to correct malunion.48 The functional results were good, but there was difficulty in restoring calcaneal height. The researchers recommended initial surgical treatment to prevent calcaneal malunion.

A recent study of 20 patients with calcaneal malunion who underwent corrective osteotomy with preservation of the subtalar joint found a significant improvement in patient functional scores as well as improvement in radiographic parameters.49 At average 34-month follow-up, only one conversion to a subtalar fusion had been required. Corrective osteotomy with preservation of the subtalar joint may be an alternative to subtalar arthrodesis in some patients with calcaneal malunion.

Summary
Calcaneal fracture can be a devastating injury. Regardless of the initial treatment, chronic pain and disability often ensue. Surgical treatment is technically challenging, even for an experienced surgeon, and serious complications are common. Alternative minimally invasive approaches have shown early promise and carry a decreased risk of wound complications. Future study is needed to determine whether the use of newer techniques improves long-term patient outcomes.

Annotated References


At a mean 12.8-year follow-up, 81 surgically treated calcaneal fractures were retrospectively reviewed with patient-reported functional scores. Level of evidence: III.


A retrospective review of 175 patients with patient-reported scores and other clinical outcomes found no significant difference based on age group. Level of evidence: III.


A systematic review of published studies found high union rates and good outcomes after primary arthrodesis for severely comminuted intra-articular calcaneal fractures. Level of evidence: II.


The short-term and midterm results of seven patients with primary subtalar arthrodesis for a Sanders type IV fracture were reported. Level of evidence: IV.


Good to excellent functional and radiographic outcomes were found in 16 of 19 patients (19 fractures). Level of evidence: IV.


A retrospective review of 37 patients found fairly good functional outcomes, although 46% of patients required removal of painful hardware. Level of evidence: IV.


In a retrospective review, patients treated with percutaneous reduction had a lower incidence of deep infection than those treated with open reduction and internal fixation. Level of evidence: III.

In a retrospective review, 24 patients treated with limited open reduction and internal fixation of a displaced intra-articular fracture of the calcaneum were compared with 26 patients treated with the extensile lateral approach. Level of evidence: III.


A lower rate of wound complications (6% versus 29%) was found in patients treated using a minimally invasive technique rather than an extensile lateral approach. Level of evidence: III.


Thirteen patients were treated using the sinus tarsi approach and followed for complications. A cadaver study defined the relevant vascular anatomy. Level of evidence: IV.


Demographic factors in intra-articular and extra-articular calcaneal fractures were compared. Level of evidence: III.


Skin necrosis occurred after three calcaneal avulsion fractures because of a delay in treatment. Level of evidence: IV.


Calcaneal avulsion fractures in 20 patients were retrospectively reviewed, and a classification system was developed. Level of evidence: III.


A review of 19 surgically treated fractures of the sustentaculum tali found that open reduction and internal fixation through a medial approach was reliable and safe. Level of evidence: IV.


This is a case report of symptomatic nonunion of an anterior process fracture treated with arthroscopic and endoscopic techniques.


A review of 127 open calcaneal fractures found an overall complication rate of 23.5%, which was lower than rates previously reported for open fractures. Level of evidence: III.


Twelve open calcaneal fractures with a plantar medial wound were reviewed for complications and healing. Level of evidence: IV.


A basic science study found that a single-impact load could lead to posttraumatic arthritis in rabbits by disrupting the extracellular matrix and causing a decrease in chondrocyte metabolism.


A study of patients undergoing subtalar fusion found that patients initially treated with open reduction and internal fixation had better functional outcomes and fewer wound complications than those initially treated nonsurgically. Level of evidence: III.


A review of 26 calcaneal malunions treated with osteotomy and preservation of the subtalar joint found that functional and radiographic outcomes were satisfactory, with a relatively low complication rate. Level of evidence: IV.