PILON FRACTURES

The term pilon is from the French language and refers to a pestle and Plafond, meaning ceiling in French.

Ruedi's obtained best results were obtained by open reduction and internal fixation according to the ORIF. However, the patients involve in a lower energy mechanisms of injury. In reality most of these fractures are due higher energy axial-loading motor vehicle collisions. Additionally, the experience with soft tissue handling techniques was potentially not as advanced as those for treating the osseous injury.

In a series of high-energy tibial plafond fractures, Bone colleagues reported their results using combined internal and external fixation techniques. This consisted of open reduction and stabilization of the articular surface with screws or small plate fixation and an ankle-spanning external fixator was used to primarily neutralize the distal metaphyseal fracture until union.

Tornetta described combined open stabilization of the articular injury and neutralization of the metaphyseal fracture with the use of hybrid external fixation without spanning across the ankle joint. Tornetta's favorable results demonstrated a substantial decrease in soft tissue complications, with only one deep infection noted in 26 managed fractures, and 71% of patients with intra-articular fractures followed between 8 and 34 months demonstrating good and excellent results. Other authors using hybrid or fully circular wire and ring external fixation devices supported these results.

1996 textbook, Schatzker and Tile made a distinction between the soft tissue envelope that is adequate for an immediate major surgical procedure and the soft tissue is not suitable for surgery because of the presence of marked swelling or fracture blisters.[-] In this latter group, a 7-to 10-day delay prior to definitive fixation was suggested, allowing for the skin and soft tissues to return to a “reasonable” state. Until resolution of the soft tissue injury, it was recommended that the limb undergo a closed reduction and plaster splint immobilization, or some form of skeletal traction or external fixation.[+]

Hontzsch had also noted the advantages of two-stage treatment in treating 50 tibial pilon fractures, using external fixation as a temporizing device.

Mechanism of injury

Rotation	Axial Load
Slow rate of load application	Rapid rate of load application
Little energy released at failure (yield point)	Large amount of energy released
Predominant translational displacement of the talus	A component of proximal displacement of talus
Little comminution	Comminuted articular surface and metaphysis
Minimal soft tissue injury	Severe soft tissue injury

Most articular fractures of the distal tibial weight-bearing surface are the result of high-energy mechanisms that occur during motor vehicle accidents, falls from heights, motorcycle accidents, and industrial mishaps. The majority of intra-articular fractures of the distal tibial weight-bearing surface are primarily the result of axial loading forces in which the talus is forced proximally into the distal tibia, producing the "explosion" fracture.

A vertical impact while the foot is in dorsiflexion results in cephalad and anterior force, resulting in significant anterior plafond comminution, whereas impact with the foot in the neutral position results in significant central comminution. These injury patterns are much more common than those of the posterior plafond, which are thought to occur during plantarflexion.

Associated Injuries

Present in between 27% and 51% of patients

The incidence of open fracture varies: 3% and 6%

Complete vascular injury and compartmental syndrome is rare [0% to 5%]

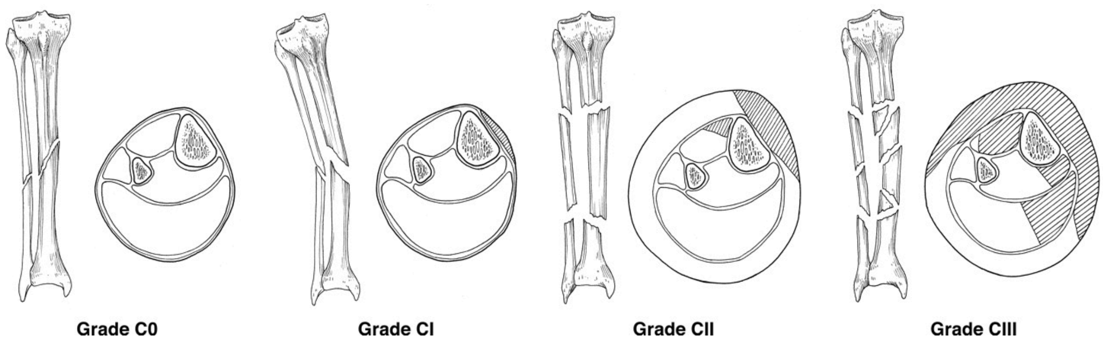
Ipsilateral injuries of the talus and/or the calcaneus are extremely unusual; however, chondral injuries of the talus, particularly gouges, scuffing, and frank chondral fractures are quite common but are likely under reported.

Clinical features

Mechanism of injury: High or low velocity

Assessment of soft tissue injury: Swelling
Tcherene classification
Blisters: clear or bloody

Tcherene Classification of soft tissue injury



Grade 0 An indirect fracture with a simple pattern.

Grade 1 soft tissue injuries have superficial contusion of skin; medium-energy fracture pattern

Grade 2 injuries have deep abrasions; medium to severe fracture pattern. May also demonstrate imminent compartmental syndrome.

Grade 3 injuries have extensive contusions or crushing, and significant muscle destruction and subcutaneous tissue degloving. Compartmental syndrome, vascular injuries, and severe fracture comminution and a high-energy mechanism are often identified

Blisters

Histologic evaluation demonstrated that both fracture blister subtypes represented cleavage injuries at the dermal-epidermal junction. The main difference between clear- and blood-filled blister types was the retention of some degree of epidermal cells in the clear filled blisters, which the authors believed contributed to a more rapid re-epithelialization and was indicative of a more superficial injury

Imaging

1. X ray — AP, mortise, and lateral
   Images of the tibia and fibula with joint above and below.
2. CT — Magnitude of talar displacement or talar subluxation
   The presence or absence of a fibular fracture,
   The degree of articular comminution,
   The distal tibiofibular syndesmosis.
   The ability to assess the injury and formulate a preoperative plan

CT scanning should be performed after a provisional reduction is obtained, preferably with a spanning **external fixator**.

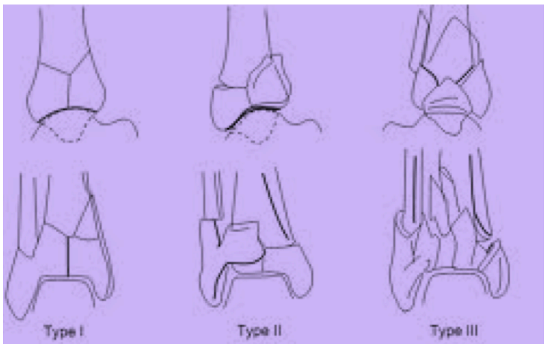
3. Currently there is no described role for routine MRI

Ruedi's Classification

Type 1 Undisplaced

Type II Displaced but not comminuted

Type III Displaced and comminuted



Ruedi & Allgower classification of pilon (tibial plafond) fractures. (Reproduced with permission from Ruedi, T. P. & Allgower, M. The operative treatment of intra-articular fractures of the lower end of the tibia. *Clin. Orthop. Relat. Res.*, **138**, 105–110, 1979.)

AO classification

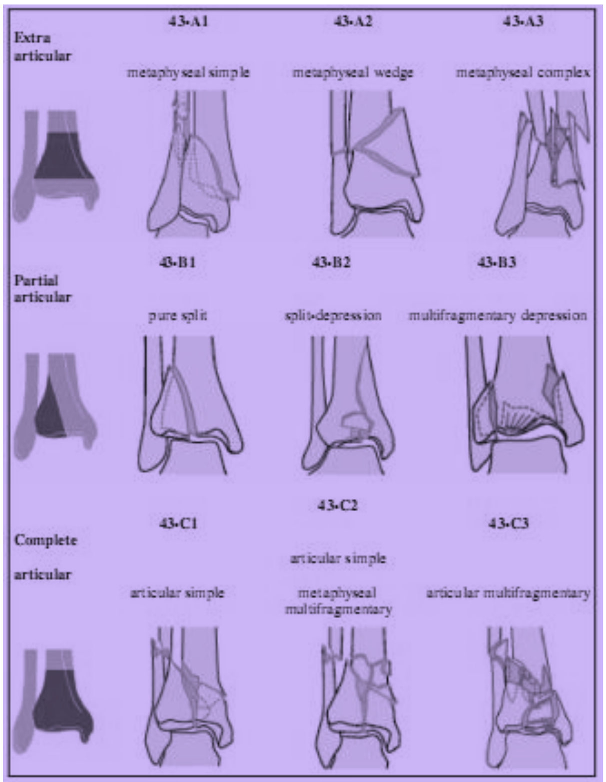


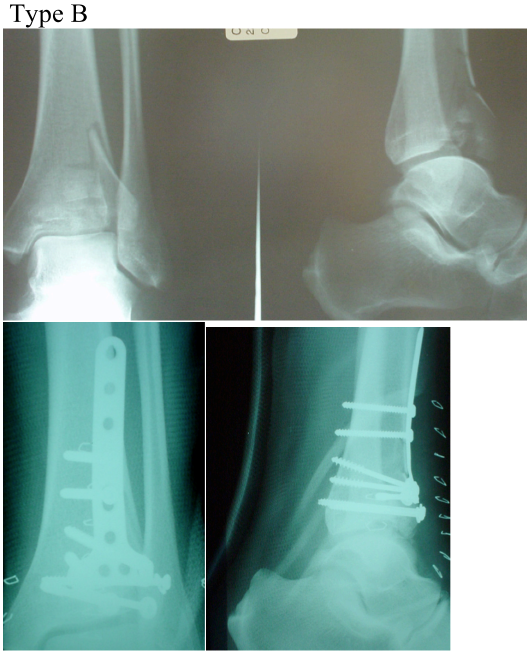
Figure 1. AO classification system, type 43 – distal tibial fractures.

A Exta-articular

B Partial intra-articular

C Complete Intra-articular

Type B



Relevant Anatomy

The distal ends of the tibia and fibula together form a mortise into which articulates with dome of the talus [Condyloid joint]

The postero-lateral aspect of the distal tibia, the distal tibio-fibular syndesmosis.

Maximum compressive strength of the tibial plafond occurs within approximately 3 cm from the articular surface.

The strongest cancellous bone in the region of the distal tibia is located near the subchondral bone plate and may provide an optimal area for fixation devices.

The mid-diaphyseal line of the tibia passes through the lateral process of the talus (center of rotation of the ankle joint) when the foot is at 90 degrees to the tibia.[+] Understanding these relationships is particularly important during the application of **external** fixation devices and the use of indirect fracture reduction techniques.

The flat and triangular-shaped anterior tibiofibular ligament travels from the anterolateral aspect of the distal tibia, usually referred to as the tubercle of Chaput, laterally and distally to insert on the anterior aspect of the distal fibula.

The deep portion of the deltoid ligament [arising from posterior colliculus of the lateral malleolus] is the principal stabilizer of the talus in the ankle mortise.

Although the array of fracture patterns involving the tibial plafond are nearly limitless, general fracture characteristics have been observed. Frequently, the important ligaments of the ankle often remain largely intact after a tibial plafond fracture and are associated with the three commonly observed major fracture segments. These three fracture fragments are the medial malleolar fragment, the anterolateral (Chaput) fragment, and the posterolateral (Volkmann)[15] fragment.

In complete articular injuries (AO/OTA C-type fractures) these fracture segments typically retain connections with portions of the deltoid(medial malleolar segment), posterior tibiofibular ligament (posterior malleolar segment), and anterior tibiofibular ligament (anterolateral tibial segment).

One of the most important factors in choosing the appropriate surgical approach for a given injury is the location of the fracture lines and associated comminution. The most frequently used approaches for articular injuries are the anterolateral and anteromedial.

Restoration of fibular length, alignment, and rotation has a substantial impact on the indirect realignment of the anterolateral and posterolateral tibial plafond from their attachments to the anterior and posterior tibiofibular syndesmotic ligaments. Any change in either the length or the rotation of the distal fibula will be reflected in the anterolateral and posterolateral segments of the distal tibia. The fibular malalignment or residual shortening can therefore have a substantial negative impact on: (i) the ability to reduce the articular surface of the distal tibia, (ii) restoration of distal tibial alignment, and (iii) final position of the talus beneath the tibia.

Fibula

Historically a 7-cm skin bridge was routinely recommended,
Recently demonstrated minimal soft tissue complications with skin incision bridges between 5 cm.
Incision should be relative posterolateral location.

Tibia

Anterolateral or Anteromedial approach

Anteromedial approach:

a. The skin incision for the modified anteromedial approach begins proximally approximately 1 to 2 cm lateral to the anterior crest of the tibia.

b. At the level of the tibiotalar joint at which point the incision curves medially to create an angle between the vertical and the horizontal limbs of approximately 105 to 110 degrees.

c. The horizontal incision extends to a point approximately 1 cm distal to the medial malleolus

d. The medial edge of the tibialis anterior tendon is identified and protected as the extensor retinaculum and periosteum immediately medial to the tibialis tendon sheath is incised sharply.

e. A full-thickness skin, subcutaneous, and periosteal tissue flap is then elevated from the distal tibial metaphyseal region. Elevation of the anterior compartment with lateral retraction allows improved access to the lateral aspect of the distal tibia.

Anterolateral Approach to the Tibia

Although visualization of medial plafond comminution is more difficult than with either of the anteromedial approaches, the anterolateral approach otherwise allows excellent access to the vast majority of the tibial plafond, particularly the lateral, posterior, and central aspects.

The exposure exploits the fracture involving the anterolateral (Chaput) fragment, which, after the exposure is performed, is manipulated and typically externally rotated on the anterior tibiofibular ligament to allow access to the posterior and central aspects of the plafond.

The skin incision is oriented longitudinally and in line with the fourth ray and travels over the anterolateral aspect of the distal tibia.

Care is taken when inserting retractors below the anterior compartment as the anterior neurovascular bundle (anterior tibial artery and vein, and deep peroneal nerve) may be entrapped within anterior fracture fragments or, after 1 to 2 weeks from the time of injury, adherent to this region. A longitudinal capsulotomy is performed at the medial extent of the Chaput fragment, thereby exposing the tibiotalar articulation. Transversely oriented capsular vessels are often encountered and require ligation or cauterization.

Decision Making

1. Respect blood supply of the soft tissue:

   Staged fixation: I: Fix fibula and Bridging EF

   II: Joint reduction + graft + Plate

2. Articular anatomic reduction
3. Minimal invasive fixation of tibia
4. Cancellous bone graft metaphysis
5. Timing: Within 6 hours: Fix fibula and Unilateral joint spanning external fixation.

   After 10 days: Wrinkle sign

   Minimal invasive fixation of tibia

Closed fracture with severe soft-tissue injury, joint-bridging external fixator

Skin wrinkling after 7 days

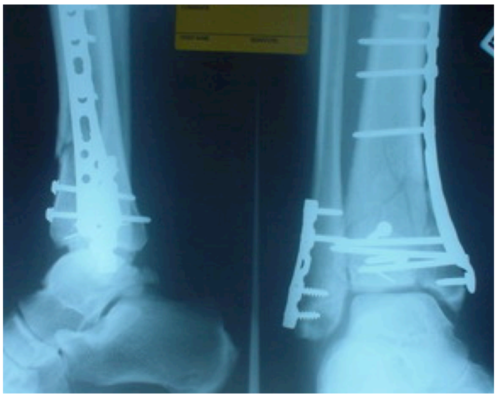
First stage: Closed reduction, fibular reduction and stabilization, and joint bridging external fixation.

Accurate reduction and stabilization of the fibula re-establishes its proper length, alignment and rotation.

Joint spanning external fixation should be remote from the fracture. External fixation pins should avoid the planned future surgical approaches including the neck of the talus.

Second Stage

1. **AM or AL incision**
2. use distractor thro' neck of talus
3. Realign central portion to the posterolateral process
4. Reduce Medial malleolus
5. Multiple screws/wires
6. Neutralised contoured plate



Alternative treatment

1. Bestian: 2 stage for type III

I stage: Fix fibula;

MIF articular surface with wires or screws

Ex Fix bridging ankle [Ex fix: 2 pins for tibia; One through calcaneum and the I Metatarsal and triangular configuration: Triangular configuration]

Watch for any subluxation of talus.

II stage: MIF with medial plate

2. Hybrid frame
3. Primary arthrodesis

Current Options

1. Nonoperative management should be reserved for those fractures that are truly nondisplaced or for those patients who have a significant or absolute contraindication to surgical management.
Rouff noted that closed reduction and cast immobilization often did not prevent the talus from its natural tendency to displace anteriorly and superiorly.

2. The majority of displaced distal tibial fractures are managed operatively; particularly those with displaced intra-articular fracture fragments. Nevertheless, the ideal treatment has yet to be determined. Unstable, displaced extra-articular distal tibial fractures can be treated with numerous techniques including **external** fixation, open or percutaneous reduction and plate fixation, medullary nailing and combinations.
The fracture pattern and conditions of the local soft tissue envelope are the major determinants for the surgical technique chosen.

Transarticular Spanning External Fixation

A transarticular spanning pin **fixator** is an excellent method to temporarily stabilize the ankle, particularly in the setting of a high-energy tibial plafond fracture and is typically applied soon after the injury.
A planned second operation after a delay of days or even weeks.

Advantages of transarticular spanning **f**ixation

1. Is technically the easiest to apply.
2. The zone of injury is not typically violated during its application
3. It indirectly maintains limb length, alignment, and rotation, which facilitates soft tissue recovery

The application of temporary transarticular spanning **external** fixation of the tibial plafond is usually performed after fibular stabilization.

1. **External** fixation effectively stabilizes the tibial component of the injury, maintains neutral talar tilt, and resists the tendency of the talus to displace anteriorly out of the tibial plafond.
2. Effective stabilization of the reduced tibia and fibula provides soft tissue recovery.
3. Uses ligamentotaxis.
4. a. A 5-mm Schanz pin is placed from anteromedial through the proximal tibial diaphysis.
   b. A second 5-mm pin is placed into the posterior aspect of the calcaneal tuberosity
   c. A 4-mm Schanz pin is then placed from medial to lateral across the three cuneiforms

Talar neck pins are specifically avoided, as these frequently compromise anteromedial exposures of the distal tibia.
Manipulation of the calcaneal Schanz pin typically performs the vast majority of the reduction.

Complications

1. Superficial Wound Complications: Superficial wound necrosis, or partial-thickness skin slough, is the most common wound complication after open reduction and internal stabilization of tibial plafond fractures. With formal open exposures, skin necrosis rates have ranged from 5% to 17%.

2. Deep Wound Complications: Often a small dehiscence can undergo primary suture repair, but most often skin retraction prevents closure. In these cases, the remaining wound is covered with a vacuum-assisted closure device (VAC) to seal the open wound from the hospital environment, eliminate the formation of wound seromas or hematomas, and facilitate granulation and wound contraction.
Larger wounds, however, or those with exposed tibialis anterior tendon or metal, require formal soft tissue coverage, and a surgeon trained in microvascular techniques should be consulted.

3. **Osteomyelitis:** The surgical goals after union has occurred are the removal of all potentially contaminated material, including stabilizing implants and devitalized soft tissue and bone, deep tissue cultures, and secure closure of the soft tissue envelope if needed. Often patients may need soft tissue coverage to eliminate a densely scarred area, or a previous sinus tract that is not amenable to primary closure. Chronic osteomyelitis associated with nonunion of the distal tibia is an extremely challenging management problem.
Formal débridement, with implant removal, medullary débridement, and cortical débridement of nonviable bone must be performed. Bone defects are filled with nonbiodegradable drug delivery systems, such as antibiotic-impregnated beads or cylinders. Soft tissue defects are covered with local, or more commonly distant, tissue transfer, and the skeleton is stabilized with **external** fixation. Culture-specific antibiotics are administered according to an infectious disease specialist, with the duration of treatment typically between 6 and 12 weeks.
Once the soft tissue healing has stabilized, with complete epithelialization of muscle flaps reconstruction is directed at achieving union with bone grafting, consideration of definitive treatment.

An important factor to consider is whether the articular surface of the distal tibia is involved or not, and whether ankle joint function is expected to be satisfactory. If the articular surface is involved may require tibiotalar arthrodesis. In recalcitrant situations, a well-timed below-knee amputation remains an option.

4. Nonunion[20%]: Usually at metadiaphyseal junction. Rates of nonunion range from 0% to 16%.
Intra-articular nonunions are extremely rare.
Distal tibial metaphyseal nonunion can be managed with medullary nails, plates, or **external** fixation, depending in part on the location of the nonunion.

A typical scenario is the varus, extended, malaligned nonunion. Restoration of appropriate alignment often requires the use a medially based universal distractor or **external fixator**, followed by plate or nail stabilization.

5. Posttraumatic Arthritis[50%]: Radiographic changes indicative of posttraumatic arthritis are common after fractures of the tibial plafond, but exact incidences remain unknown.
Marsh reported an arthrodesis rate of 13% in 40 ankles after a minimum follow-up of 5 years. Historically, reported arthrodesis rates with operative management of tibial plafond fractures have ranged from 5% to 26%, with most of this data being obtained in patients followed for less than 5 years.

Total ankle replacement is a relatively new alternative to arthrodesis for posttraumatic ankle arthrosis. Despite the intuitive reconstruction of joint mechanics, total ankle replacement remains unproved in this patient population, and may be associated with substantially higher rates of complications and revision procedures.

OUTCOMES

Despite optimal treatment of AO/OTA C-type tibial plafond fractures with anatomic articular reconstruction, restoration of distal tibial alignment, and avoidance of surgical complications, the outcome is not always favorable. The irreversible injury that occurs to the chondral surface and other supporting structures continues to be delineated.

On the other hand, others have contended that if an anatomic reduction of the articular surface is achieved, then a good outcome can be expected.

The severity of injury and accuracy of articular reduction as assessed on preoperative and postoperative radiographs strongly correlated with the radiographic presence of arthrosis, but that the presence of arthrosis had no correlation with the clinical ankle score.

Posttraumatic arthrosis was a progressive disease, with increasing incidence evident on plain radiographs, but still demonstrated that rather few of these patients required later arthrodesis. Generally 15% arthrodesis and 50% changed their job.

Recent article in JBJS 2007 on long term of 56 Pilon fracture with contemporary two stage fixation at 5 years: Arthrodesis = 5/40 [15%]; The average Iowa Ankle Score was 78 points; the majority of patients had some limitation; 50% changed jobs because of the ankle injury. Suggesting that Pilon fractures have an intermediate-term negative effect on ankle function.

CONTROVERSIES AND FUTURE DIRECTIONS

1. Most challenging and controversial injuries
2. The controversy resides in treatment techniques and balancing the benefits
3. Restoration of anatomy versus the potential risk of further soft tissue injury
4. Iatrogenic complication.
5. An appreciation of surgical timing,

The development of staged open reduction and internal fixation has recognized the important role of the soft tissue envelope, and the problems that are faced with performing extensive surgical dissections during the time of maximal soft tissue swelling.

Reference:

1. Rockwood and Green. Adult fractures, Chapter 56
2. Szyszkowitz. Current Orthop: 13: 42-52
3. Long term JBJS 85A Feb