# Pilon fractures: a review of current classifications and management of complex Pilon fractures

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## Abstract

Pilon fractures result mainly from high energy injuries. Owing to this, the implications on the long-term prognosis are significantly affected by the damage inflicted during the event. Improving the prognosis will inevitably involve a multidisciplinary approach, taking into consideration a number of variables. Reducing the overall risk of complications through soft tissue protection whilst implementing appropriate treatment objectives through well timed surgery will aid the clinical outcome. In this article we review Pilon fractures, their aetiology, current classifications, and their management.

**Keywords** classification; management; Pilon fractures

## Introduction

A Pilon fracture is a distal tibial metaphyseal fracture that involves the ankle joint.[1] Etienne Destot, a French Radiologist, first adopted the French word for pestle (Pilon) to describe this fracture in 1911.[2] Fractures that only involve the horizontal weight-bearing surface of the tibia are tibial plafond fractures not Pilon fractures; only if these tibial plafond fractures extend into the supra-malleolar region of the distal tibia are they considered Pilon fractures.[3]

Pilon fractures are mainly the result of high energy mechanisms; the injury to the soft tissue surrounding the bone can present in a number of ways. They are often described as a heterogeneous group of injuries. It is this variation of injury patterns which inevitably means that they cannot all be treated the same. However, the treatment objectives do not change. In summary, these are:

- Re-establish the articular congruency
- Correct any mechanical malalignment
- Reduce the risk of soft tissue complications

Despite our best efforts, it is inevitable that any joint surface damage occurring at the time of the injury has a significant effect on the long-term clinical outcome. Nevertheless, minimizing complications associated with the soft tissue envelope by appropriately timing and choosing surgical interventions may improve the clinical outcome. In this article we review the notable aspects of Pilon injuries and their management.

## Aetiology

Pilon fractures are rare. They represent between 1 and 10% of all lower limb fractures (5–7% of all tibial fractures[4]), and are more common in men than women in their fourth decade by a ratio of 3:1.[5] These fractures are more frequently associated with high energy injuries. Examples of a high energy injury include motor vehicle accidents and falls from significant height.

Previous papers describe two distinct mechanisms of injury for Pilon fractures: torsion injuries and axial compression injuries. The less common mechanism of injury is a torsional force (such as that which may occur in skiing injuries). Torsional fractures result in large bone fragments and minimal joint impaction – essentially they are tibial diaphyseal injuries that extend to the joint. These differ significantly from true Pilon fractures in which high energy axial forces lead to severe joint comminution, impaction and very large zone of injury.[5] It is the axial force that results in the talus being driven into the tibial plafond. These higher energy injuries are frequently associated with extensive soft tissue trauma including widespread fracture blisters and open fractures.[6]

There are a number of complications that are concomitant with high energy Pilon fractures. These include: open injuries, compartment syndrome, non-union, malunion, infection, skin necrosis, de-gloving/crush injuries, and polytrauma.[5–7]

## Classification

The most commonly quoted classification systems for Pilon fractures are the AO/OTA classification (Figure 1). The Rüedi and Allgöwer classification historically has been the most common and simplest system used. It divides Pilon fractures into three main groups based on the size/number of the

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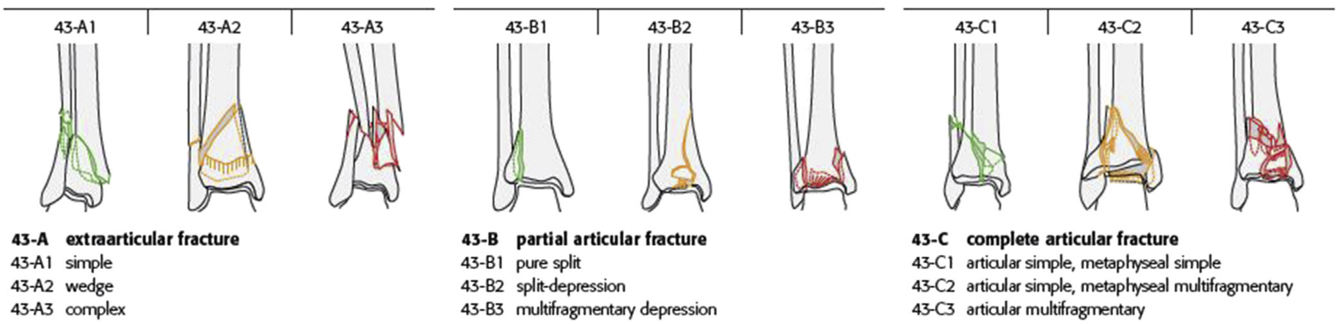


**Figure 1** The AO classification of distal tibial fractures (Müller AO Classification of Fractures – Long Bones, Copyright by AO Foundation, Switzerland).

articular fragment(s) and the displacement. In summary, these are:

- Type 1 are intra-articular fractures that are not displaced
- Type 2 are intra-articular fractures with displacement but no comminution
- Type 3 are intra-articular fractures with displacement, comminution and impaction of the distal tibia

Whilst type 1 fractures tend to be associated with torsional forces being applied around the ankle, types 2 and 3 are more often associated with high energy mechanisms.[8–10] The Rüedi and Allgöwer classification has historical significance but has now been superseded by the AO/OTA system.

The AO/OTA is an alphanumeric classification tool. The first number indicates the bone, the second number describes which part of the bone, and the letter denotes whether it is extra-articular, partial intra-articular, or completely articular. The AO/OTA system groups Pilon fractures into two main groups: B and C. Group B (43-B) fractures are described as partial articular fractures. Group C (43-C) are complete articular fractures generally resulting from higher energy injuries. The AO/OTA system is further sub-grouped numerically from grade 1 to 3 depending on the degree of comminution.[8]

In 2005, Topliss et al. provided a CT-based classification system for Pilon fractures. The CT-based classification was based on the analysis of a case series of 126 consecutive Pilon fractures. They suggested ten types of Pilon fractures that belong to two distinct families: the sagittal and coronal, based on the primary fracture line seen on the axial view at the level of the tibial plafond. The main factors that influence which family the injury belongs to are:

- the degree of energy transfer at the time of injury
- the direction of force
- the age of the patient

The sagittal fracture family of fractures are associated with a high energy mechanism, varus angulation, and tend to be seen in younger patients. The coronal fracture family of fractures are associated with low energy mechanisms, valgus angulation, and older patients.[11]

## The principles of management

Due to their high energy nature, soft tissue management for both open and closed Pilon fractures cannot be over-emphasized. Embarking on definitive management with fragile soft tissue increases the risk of infection, wound dehiscence and a poor overall clinical outcome. Protecting the soft tissue can be achieved initially with a spanning external fixator (delta frame).[12] An equinus contracture may be prevented by extending the delta frame construct to include the first metatarsal or first and fifth metatarsals. By bringing the leg out to length and providing skeletal stability the environment for soft tissue recovery may be optimized.

The principles of managing any intra-articular fracture are the same. This is to achieve anatomical reduction of the articular surface and maintain absolute stability.[13,14] The reconstructed metaphysis is then attached to the diaphysis with attention to rotation, mechanical axis and length. The metaphysis can be attached to the diaphysis with either anatomical reduction (for a simple fracture pattern) or with relative stability (for a multi-fragmentary fracture pattern[5]). Finally, rehabilitation through early mobilization is also a key principle in achieving a better clinical outcome.

### Key stages in initial management

In the vast majority of cases, since Pilon fractures are high energy injuries,[6,15] it is essential to evaluate and manage the patient based on the principles of Advanced Trauma Life Support® (ATLS) protocols. This involves a systematic evaluation and management of life threatening injuries before focussing on the limb itself. The concept of early appropriate care should be applied to the management of the patient. This is ultimately judged on a number of physiological markers such as lactate[5,8] and on the soft tissue envelope.

Focussing on the lower limb injury, it is important to appreciate soft tissue injury and the neurovascular status of the affected limb. A useful classification system for closed injuries is the Oestern and Tscherne classification.[16] The Grades are progressive from Grade 0 to Grade 3. In summary, these are:

- Grade 0 being minimal soft tissue injury with a simple fracture pattern
- Grade 1 involves superficial abrasions or contusions
- Grade 2 deep abrasions and muscle contusions associated with a high energy fracture pattern
- Grade 3 is described as a crush injury or extensive contusions that can be associated with deep muscle injury and compartment syndrome and a high energy fracture pattern[16,17]

Once adequate analgesia has been administered and appropriate radiographs (anteroposterior and lateral of the ankle, tibial shaft and knee) are completed, the leg should be splinted. It is essential to perform a neurovascular assessment of the affected

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limb before and after application of a splint. Radiographs of post-splint limb should also be taken.

### The evolution of Pilon treatment

The treatment of Pilon fractures has significantly changed over the past few decades. In the late 50s and early 60s, it was believed that Pilon fractures should be managed non-operatively, or with a calcaneus pin with traction applied, followed by early range of motion. The thinking behind this was based on ligamentotaxis; the concept being that the soft tissue attachment to the bone will reduce the fracture. However, there were significant flaws to this method of management. In high energy injuries that were associated with multi-fragmentary fracture patterns, there was no soft tissue attachment to help reduce the fracture.[2]

It was only following the publication by Rüedi and Allgöwer and research by the AO group that open reductions and internal fixations of Pilon fractures became more accepted. Rüedi and Allgöwer demonstrated with their case series of 82 patients, with a follow up period of 50 months, that 74% of their patients were pain free. They developed a reproducible technique and stated four key operative principles[9,10] (Figure 2):

- Restoration of length and axis of the fibula (60%) or of the tibia (40%) as a first step
- Reconstruction of the articular surface of the distal end of the tibia
- Filling in of the defect resulting from impaction, using cancellous autografts
- Support of the medial side of the tibia by plating to prevent a late varus deformity

However, over the subsequent decades, other surgeons were unable to reproduce these results. McFerran in the 1980s found that 40% of his patients had complications.[18] The main complications were being wound breakdown, deep infection, non-union and malunion. McFerran concluded that the key to a successful outcome included a better appreciation of soft tissue management. Unlike Rüedi and Allgöwer, McFerran believed that ORIFs for Pilon fractures were associated with a higher level of complications.[18]

It was the disconnect in clinical outcomes between what Rüedi and Allgöwer and the surgeons whom followed, in addition to the appreciation of the mechanism of injury towards soft tissue viability, that led Watson in 2000 to suggest alterations in the operative protocol. Since it takes approximately 10–14 days for skin and underlying soft tissues to heal, Watson suggested applying a temporary external fixator to hold the limb out to length. This, he believed, would allow sufficient time for the soft tissue to recover.[17]

A more recent paper by Duckworth et al. in 2016 reports on the outcome of a study following primary fixation compared against a staged protocol for type C fractures of the tibial plafond. It was a study based on all complex intra-articular fractures (AO type C) over an 11-year period. The paper reviewed 102 type C fractures in 99 patients with a mean age of 42 years. 71.6% of patients underwent primary fixation (open reduction internal fixation), while 19.6% underwent primary external fixation with delayed open reduction internal fixation. The paper demonstrated that a satisfactory outcome, with respect to post operation complications, could be achieved using primary open reduction internal fixation techniques for the appropriate patients.[19] Ultimately, the paper by Duckworth emphasizes the need for appropriate trauma surgeons working in a multidisciplinary environment (with adequate resources) managing these complex fracture patterns in a well-established time frame to achieve the best clinical outcome.

The emphasis on a staged protocol driven approach to Pilon fractures eventually made CT scans a mandatory part of the assessment tool for planning definitive surgery (Figure 3). Tornetta et al. reported on 22 Pilon fractures where a CT scan was obtained after temporary external fixation and found that this affected operative strategy in 64% of the cases. Performing a CT scan after the application of a spanning external fixator is advantageous as it illustrates the distal tibia once there is restoration of overall alignment. A CT scan will help identify the main fracture lines which will ultimately decide the surgical approach.[20]

There are a number of surgical approaches to the distal tibia that may be used alone or in combination depending on the fracture pattern. These are:

- The Anterolateral approach: the incision is centred at the ankle joint, parallel to the tibia proximally and fourth

**Figure 2** Lag screws and K-wires can aid in attaching the joint surface to the metaphysis before fitting a locking plate.

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**Figure 3** CT scans are essential in determining surgical approach and strategy in Pilon fractures. All three planes must be carefully reviewed. Notice the central die punch fragment.

metatarsal distally. The anterolateral approach may be used for complete articular (43-C) Pilon fractures and anterior/anterolateral partial articular Pilon fractures (43-B). The anterolateral approach allows the tibial articular surface to be visualized.

- The Anteromedial approach: the incision for the anteromedial approach is a straight line that starts 5–8 cm lateral to the tibial crest just proximal to the ankle joint that ends near the base of the navicular bone. This approach is often used for type 43-B and 43C fractures, especially when visualization of the medial and central articular surface is required.
- The Posterolateral approach: the skin incision is made along the posteromedial border of the fibula. This approach is useful for posterior tibial fractures.
- The Posteromedial approach: the incision is centred over the ankle joint. It lies between the posteromedial border of the distal tibia and the Achilles tendon. This is a useful approach for posterior and medial fragment reductions.
- The Medial approach: a direct medial approach is usually used for vertical medial split fractures with associated articular impaction (43-B2 fractures).

### Definitive fixation

Pilon fractures can be fixed either internally or externally. In 1999, Sirkin et al. published their data on a staged approach to the management of Pilon fractures. The study looked at two groups: Closed and Open. The protocol consisted of immediate (within 24 hours) ORIF of the fibula when fractured and the application of a spanning external fixator. An ORIF of the articular surface was performed once the soft tissue swelling had decreased. The study included 29 patients with closed Pilon fractures and 17 patients with open Pilon fractures. Of the closed injuries, five patients had partial thickness skin necrosis that healed uneventfully, and one had a late complication with a sinus associated with osteomyelitis. Of the open fractures, there were two complications which were deep infections of which one of the patients required a below knee amputation. Sirkin et al.,

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based on their findings, believed that previous studies that demonstrated a high level of infection following ORIF procedures for Pilon fractures were caused by operating when the soft tissue encasing the bone was still swollen and the underlying soft tissue was still compromized.[21]

Outcomes for ORIF procedures can be variable. To combine the benefits of ORIFs while reducing further soft tissue injury studies were performed using techniques such as minimally invasive percutaneous plate osteosynthesis (MIPPO). A case series by Khoury et al. that reviewed 24 patients found there were no incidences of deep infection using this technique. There were, however, two cases of malunion.[22]

External fixators can also be used to manage Pilon fractures. The options available include: simple bridging frames, hybrids or circular frames. There is significant debate in the literature as to whether C2 and C3 Pilon fractures are best definitively managed using internal or external fixation techniques.[23,24]

A retrospective study by Pugh et al. compared spanning external fixators, hybrid fixators and ORIF procedures. On the whole, soft tissue complications were associated with ORIFs whilst malunions were associated with external fixators.[25] However, a meta-analysis, by Wang et al., of complications associated with ORIFs compared to external fixation with limited internal fixation for Pilon fractures concluded that there was no significant difference in bone healing, non-union, malunion or infections between the two groups.

Often, studies state pin site infections are common with the use of external fixators. Although this is a recognized complication, most deep infection rates are associated with open injuries. These injuries have a higher proportion definitively managed by external fixation techniques. Vidyadhara et al. conducted a study looking into the management of 21 Pilon fractures (13 of which were classified as C3) using minimally invasive techniques for joint reduction in conjunction with a circular ring fixator. All the fractures united by week 27, seven patients had developed pin site infections that resolved with local care, one patient had the pins removed due to persistent infection, and there were no cases with deep infections.[26] McDonald et al. retrospectively reviewed 13 Pilon fractures which were managed with non-bridging three ring circular frames with a minimally invasive approach to articular reduction. He found that 11 of the fractures had healed by 16 weeks, one delayed union required bone grafting, and one non-union was managed with an arthrodesis. No deep infections were reported.[27]

These studies demonstrate that high energy Pilon fractures can be managed effectively with external fixation techniques with a low incidence of serious complications.

## Special considerations: open fractures and bone defects

Open Pilon fractures should be managed with early wound debridement and skeletal stabilization in an orthoplastic unit as suggested in the NICE NG37 guidelines.[28] The most commonly used classification system for assessing open injuries is the Gustilo-Anderson system. This is used following the initial debridement and is based on three groups:

- Type 1 the wound is <1 cm
- Type 2 the wound is 1−10 cm
- Type 3 are associated with high energy injuries that are subgrouped into A (high energy >10 cm wound), B (extensive periosteal stripping) and C (vascular injury requiring repair)

It is imperative that open lower limb fractures are treated in line with the British Orthopaedic Association Standards for Trauma (BOAST 4) guidelines. There is still ongoing debate on early or delayed definitive management. Conroy et al. (2003) reviewed Type 3B open Pilon fractures that were treated by radical debridement and immediate skeletal stabilization and early soft tissue cover. This protocol resulted in good functional outcome (SF-36 questionnaire: physical component score compared significantly better than amputees) with low infection and amputation rates. There were no long term complications and none of the patients required an arthrodesis. However, two stage management with initial spanning external fixation to allow soft tissue resuscitation prior to definitive management has gained acceptance by many surgeons.[12,21]

Bone defects associated with Pilon fractures are also a special consideration. In summary, these can be treated using:

- Bone grafts
- Vascularized fibular grafts
- Bone transport or acute shortening followed by lengthening

Bone grafts can either be autografts or allografts. Autografts are more commonly used for smaller defects. Their main limitations relate to how much can be harvested from the donor site. Allografts have been used with bone morphogenetic protein (BMP) in some cases of non-union as described by Johnsen et al.[29]

Pelissier et al. described a two-stage technique to correct bone defects.[30] Following bone resection, a cement spacer is placed in the defect to provide stability, which eventually leads to the formation of a membrane around the cement spacer. Once the membrane is formed, the spacer is removed and the membrane is packed with bone graft.

For larger defects, the principles of distraction osteogenesis may be applied, for example, the use of a circular frame for bone transport to bridge a defect. An alternative to this is bone shortening followed by staged reconstruction. In principle, the circular frame (which is applied across but not inside the zone of injury) can be used to lengthen the bone from a separate osteotomy and achieve bony union at the metaphyseal area simultaneously.

## Conclusion

Pilon fractures are best treated in centres that have a capability for both Orthopaedic and Plastic surgery. The treatment objectives are always the same. These are to restore the articular congruency, mechanical alignment, and to encourage early functional rehabilitation. Soft tissue care plays a pivotal role in the management of these injuries; This can be achieved by spanning the fracture and bringing it out to length, obtaining a CT scan and allowing the soft tissues time to heal.

There is no consensus on the optimum management time for tibial Pilon fractures. When soft tissues allow, in the case of Type C1 fractures, open reduction and internal fixation with minimally invasive techniques is desirable. In Type 3C fractures, a two staged approach of initial articular surface restoration and


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spanning external fixator followed by definitive fixation at a later stage appears to yield a better clinical outcome. ◆

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