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review

Pilon tibial fractures: What they are, classifications and surgical management .

Celia Enguídanos [1], Elena Saez [2], Francisco Torrecillas [2,*], Lucía Cucó [2],

[1] Degree in Medicine. University of Castilla La Mancha. Orthopedic Surgeon Registrar at Hospital Universitario and La Fe Polytechnic, Valencia, Spain;
[2] Degree in Medicine. University of Valencia. Orthopedic Surgeon Registrar at La Fe University and Polytechnic Hospital, Valencia, Spain; * Correspondence:
celiaengui@gmail.com

Abstract: A single Tibial pylon fractures are articular injuries of the distal tibia. They are fractures caused by a high-energy mechanism, and in most cases involve the fibula. The most accepted classification is that of the AO/OTA. There are constant articular fragments that can have different sizes and comminution: anterolateral, posterolateral and medial. They are best visualized by computed tomography (CT), so this study is essential before surgery. Soft tissue involvement, fracture pattern, patient profile and surgeon experience guide treatment. Therefore, understanding the fracture pattern and the forces that have caused the tibial failure is necessary to perform surgical approach.

Keywords: Tibial pylon; classification; ankle approaches

Abstract: Tibial pilon fractures are joint injuries of the distal tibia. They are fractures caused by a high-energy mechanism, which is why in most cases the fibula is involved. The most accepted classification is that of the AO/OTA. There are constant articular fragments that can vary in size and comminution: anterolateral, posterolateral, and medial. The best way to visualize them is by computed tomography (CT), so this imaging study is essential prior to the intervention. The involvement of the soft tissues, the fracture pattern, the patient's profile, and the surgeon's experience guide the treatment.
Therefore, understanding the fracture pattern and the forces that have caused tibial failure is paramount to formulating a surgical approach.

Keywords: Tibial pilon; Classification; Ankle approaches.

1. Introduction

The tibial pilon comprises the distal third of the tibia, including the weight-bearing articular surface at the ankle. Its proximal limit is 8-10 cm from the articular surface, where the shaft of the tibia, which is triangular with the tibial crest, changes to form the metaphysis. This conformational change occurs to increase the articular surface area, reducing the stress placed on the ankle.

However, when we refer to tibial pilon fractures, we are mainly talking about distal tibial fractures with involvement of the articular facet. Fractures of the medial malleolus, lateral malleolus, and trimalleolar fractures in which the fragment of the posterior malleolus involves less than 1/3 of the articular surface are excluded from this definition (1–3).

1.1. production mechanisms

The tibial pilon fracture is usually caused by high-energy trauma, such as a fall from a height (axial compression) or a traffic accident, where the talus impacts the articular surface of the distal tibia, causing the pilon to implode. For this reason, the most affected population are men of working age. It is associated with a large metaphyseal comminution and 85% of cases associate a fibula fracture (2). In addition, massive local inflammation occurs that conditions the survival of the surrounding soft tissues and can lead to the appearance of compartment syndrome. Both in the latter case and in open fractures (20% of cases), they should be treated as soon as possible by means of fasciotomy or debridement, respectively (4–7).

Another type of tibial pilon fractures are those produced by a low-energy torsion mechanism, which causes a spiral fracture of the distal tibia including the articular facet. They occur mainly in elderly women with osteoporosis (2). The bone fragments are larger and the articular surface is less comminuted with minimal displacement. However, by themselves they pose a type of difficult injury because the soft tissue envelope may be intrinsically compromised by comorbidities such as diabetes, vascular disorders, chronic intake of corticosteroids or other medications. It is an osteopenic bone, it is difficult to achieve stable osteosynthesis, the healing process is slower and postoperative rehabilitation is prolonged.

1.2. Epidemiology

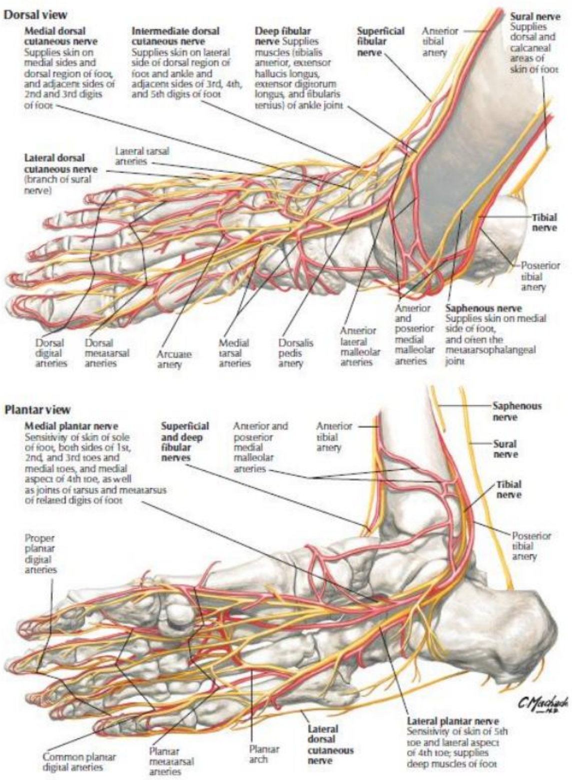
They represent 5-10% of tibial fractures, and less than 1-10% of lower limb fractures (1-3) (, Luo). Fractures in this area can cause a significant decrease in blood flow to the foot and impaired nerve function, hence the importance of thoroughly evaluating the distal neurovascular status. Low-energy pylons are increasing in number, proportional to the aging of the world population and the higher level of activity of the elderly.

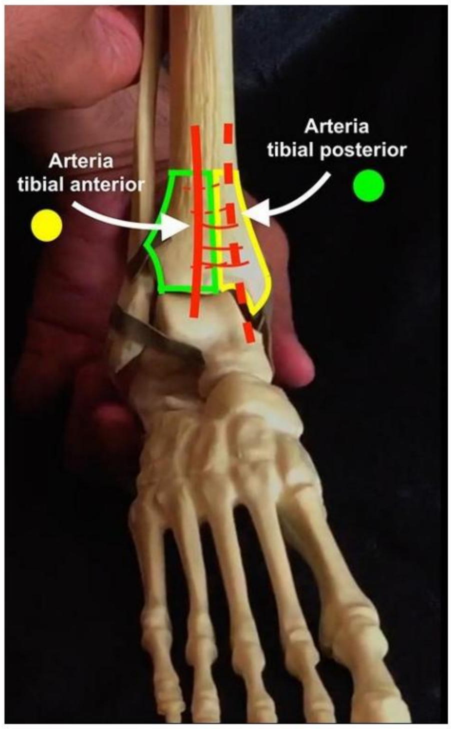
2. Material and methods.

2.1. Physical exploration

Inflammation that occurs in this area can cause a significant decrease in blood flow to the foot and impaired nerve function, hence the importance of thoroughly evaluating the distal neurovascular status.

There is no type of muscular insertion on the pilon and this means that the vascular supply of this region depends on two sources: one third receives nutrition from a network of periosteal vessels that come from the anterior and posterior tibial artery, mainly on the medial surface. ; the other two thirds derive from a feeding artery branch of the posterior tibial, which penetrates through the middle and posterior third of the tibia, anterior to the soleus muscle, emitting ascending and descending branches (6,8), as we can see in Figures 1 and 2.





Figures 1 and 2. Vascular anatomy of the ankle. Left image from the Atlas of Human Anatomy (8); the right image has been taken from the blog aware.doctor (9).

The force required to produce this injury can produce extensive and complex soft tissue injuries, so the soft tissue envelope should be evaluated for swelling, bruising, or blistering, as well as excluding compartment syndrome.

2.2. Supplementary tests

Radiographic evaluation begins with standard radiographs of the ankle and images of the tibia and fibula to determine the proximal extent of the fracture, fracture association of the fibula, and metaphyseal comminution. With the anteroposterior projection we will be able to determine the impaction and shortening of the limb. The lateral projection shows us joint incongruity and helps us locate the posterior articular segment. In selected cases, radiographs of the contralateral ankle help plan subsequent reconstruction.

Obtaining a CT scan for a tibial pilon fracture will provide information regarding the orientation of the fracture fragments and the surgical approach. Axial slices of CT images are essential to define the location of the main fracture line, the fracture pattern, and the number of fragments. This information is crucial for preoperative planning, incision placement, and joint surface reduction. Furthermore, CT has been shown to provide beneficial additional information in most cases, which may lead to a change in the surgical plan (6,7).

23. Classification

There is no unanimously accepted classification of tibial pilon fractures.
The most widely used radiographic classifications for pilon fractures are that of Rüedi and Allgöwer and that of the AO Foundation and the Association of Orthopedic Traumatology (AO/OTA) (1,3).

Rüedi and Allgöwer classified pilon fractures into three groups, as we can see in Figure 3: Type I: non-displaced fractures; Type II: displaced fractures with loss of joint congruence; Type III: Displaced and severely comminuted fractures with impaction.

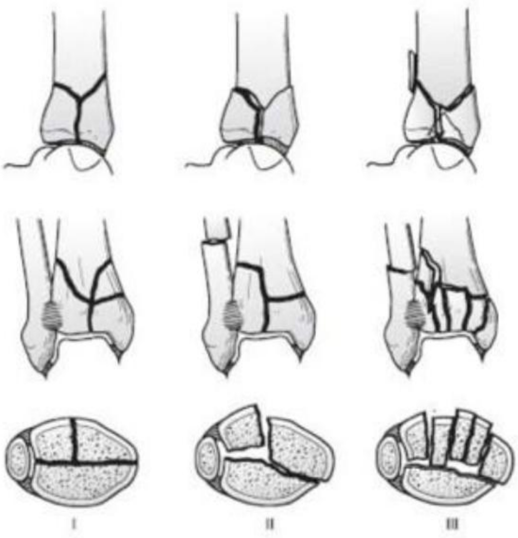


Figure 3. Rüedi and Allgöwer classification.

Image obtained from Google Images.

Ovadia and Beals extended this classification to IV and V: metaphyseal extension and gross comminution, respectively. The Rüedi and Allgöwer classification has been used widely over the years, but has low inter-rater reliability, especially between types II and III.

The AO/OTA classification divides pilon fractures into three main groups (Figure 4): 43-A: extra-articular fractures; 43-B: partial articular fractures; 43-C: complete articular fractures.

- Type A is extra-articular and is in turn divided into A1: pure metaphyseal fracture of the distal tibia; A2: metaphyseal cuneiform of the distal tibia; and A3: metaphyseal complex of the distal tibia. They are not typical tibial pilon fractures.

- The type B fracture is partially articular and is divided into: B1: pure lateral fracture; B2: medial fracture with articular depression; and B3: posterior fracture with multiple fragmentary joint depression. Only type B3 would fall within the tibial pilon fractures.

- Finally, type C fractures are completely articular and are divided into: C1: simple articular fracture with simple metaphyseal fracture; C2: simple articular fracture with multifragmentary metaphyseal fracture; and C3: multifragmentary articular fracture with multifragmentary metaphyseal fracture. All of them are considered tibial pilon fractures.

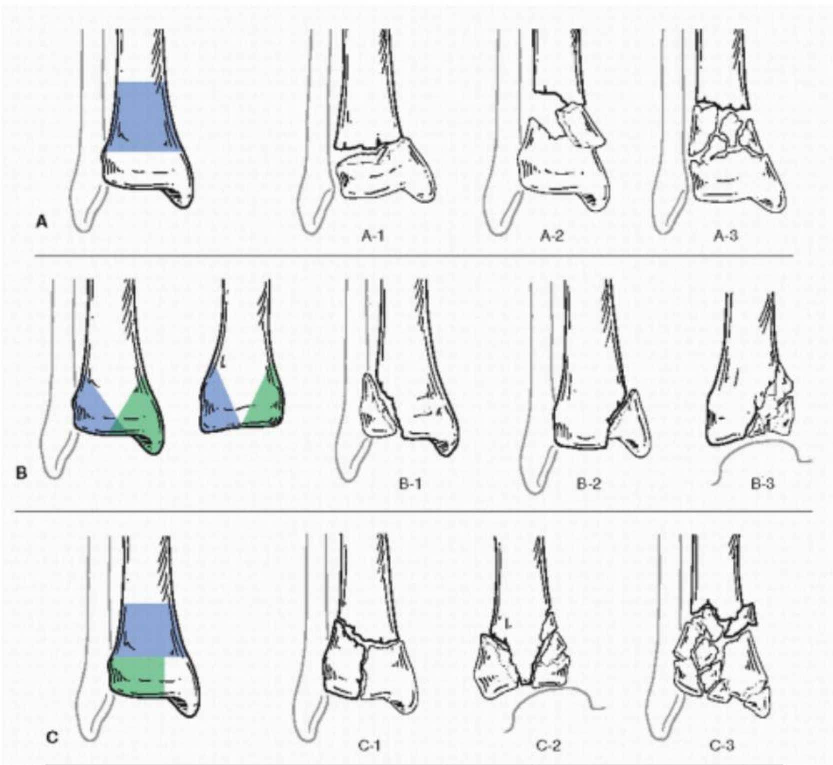


Figure 4. AO/OTA classification. Image obtained from Google Images.

The AO/OTA classification has shown to have a greater concordance between evaluators and its use has been gaining followers, being increasingly used and accepted.

Despite all of the above, it is difficult to classify these injuries since the fracture pattern will be different depending on the position of the foot and the direction of the force of the impact. If the foot is dorsiflexed, the anterior part of the pilon will be more comminuted, whereas if the foot is neutral or plantarflexed, the central and posterior part will be more affected, respectively. There are normally three constant articular fragments that can vary in size and comminution: anterolateral, posterolateral and medial (6,7), visible in Figure 5. From a surgical point of view, it is useful to recognize and take them into account.

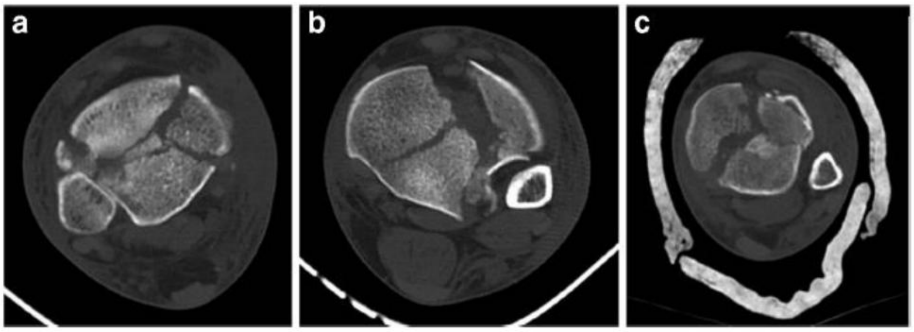


Figure 5. CT of the ankle: presentation of the different fragments. Image obtained from the article by Zelle et al. (7)

3. Results: therapeutic scheme and approaches

The ideal goals of treatment are good soft tissue management, reconstruction of the articular surface and posterior column, restoration of limb alignment and length, with a stable construction that allows early ankle movement and ambulation.

3.1 Conservative treatment

It consists of a transcalcaneal traction or cast for 6 weeks (4). After this time, a splint is placed to perform exercises in the range of motion of the joint.

It is practically out of use since it could only be used in non-displaced fractures and when the alignment of the limb can be maintained with a cast, two cases that are not frequent in this type of injury. If there is joint displacement, it offers little chance of success, with frequent loss of reduction. Another drawback of conservative cast management is the impossibility of monitoring the condition and edema of the soft tissues.

3.2 Fixation with plates VS External fixation

Although they are the two most commonly used options, there is still no consensus about which option obtains better results depending on the type of fracture (1,4–7,10).

No treatment method has shown a clear superiority in terms of rates of pseudoarthrosis, delayed union, deep and superficial infection, symptoms of arthritis or chronic osteomyelitis, so they conclude that one or the other technique should be performed depending on what is needed. comfortable that the surgeon feels with these.

Recent reviews of the literature and treatment guidelines from the National Institute of Health and Care Excellence (NICE) have identified the need for robust randomized controlled trials to assess whether internal or external fixation is better for the treatment of pilon fractures. (eleven). A multicenter, randomized, parallel-group study is currently underway to evaluate the clinical and cost-effective outcomes of external fixation versus open reduction and internal fixation for treating tibial pilon fractures (12) .

In general, if it is a low-energy rotational injury without soft tissue involvement, it is usually safe to immobilize the limb in a cast and plan for open early primary reduction and internal fixation (ORIF). On the other hand, early primary ORIF of high-energy pilon fractures is often associated with soft tissue complications and, in the case of an open fracture, the incidence of deep wound infection or dehiscence requiring surgical debridement (10). For this reason, staged treatment is generally accepted for high-energy fractures with soft tissue involvement.

3.2.1. Open Reduction and Internal Fixation (ORIF):

Internal fixation is a valid treatment option for AO/OTA types A and B because they tend to have less soft tissue involvement. There are currently improvements to avoid failure rates: avoiding anterointernal incisions, the use of locked plates or percutaneous insertion techniques have achieved complications in series from 0 to 6%, low compared to older ones that range from 33-50% (2.5).

Fibula

First, fixation of the fibula should be performed if it is affected to obtain the correct tibial length and to facilitate three-dimensional orientation and reduction of the fracture (2). There is indirect reduction by ligamentotaxis of the anterolateral fragment of Chaput and the posterolateral fragments of Volkman that remain in continuity with the lateral malleolus. Fibular reduction is also beneficial to counter significant valgus angulation and/or lateral translation of the tibia (5).

In cases of severe comminution of the fibula it may be difficult to obtain a perfect anatomical reduction in terms of length and rotation. In that situation, it may be more useful to begin the surgical sequence by reducing the tibia.

In cases where an anterolateral approach to the tibia is planned, the addition of a close incision for the fibula may contribute to wound complications and is not recommended. If these approaches are combined, it is necessary to take into account the need to leave a skin bridge of at least 6 cm between them, to avoid said complications, and in these cases, an incision is made more posterior to the fibula. Small fragment or dynamic compression plates are usually used, since they offer greater stability than third-cane plates.

Tibia

In the approach to the tibia, the proposal by Ruedi and Allgower must be followed: leave no more than 2mm of incongruity on the articular surface. The trend is to design the approach closer to the main fracture line in axial CT slices, to minimize soft tissue damage.

Restoration of the articular surface usually begins by opening the most anterior articular fragments to visualize the central and posterior fragments. The articular fragments are then reduced from posterior to anterior, using the posterolateral articular fragment as a template, which is sometimes reduced by prior fixation of the fibula or when the fibula is intact.

After the posterolateral fragment is reduced, the medial fragment is reduced and the posterolateral fragment is stabilized. The central impaction is then addressed and stabilized, followed by reduction of the anterolateral segment.

In complete articular fractures, the Tillaux-Chaput tubercle is the only useful marker for correct anatomic reduction of the fracture. This remains attached to the fibula through the syndesmosis.

Initially the reduction is performed with the placement of multiple Kirschner wires. Once the articular surface is congruent, the Kirschner wires can be exchanged for screw fixation.

In Figure 6 we can see different possibilities of ankle approaches.

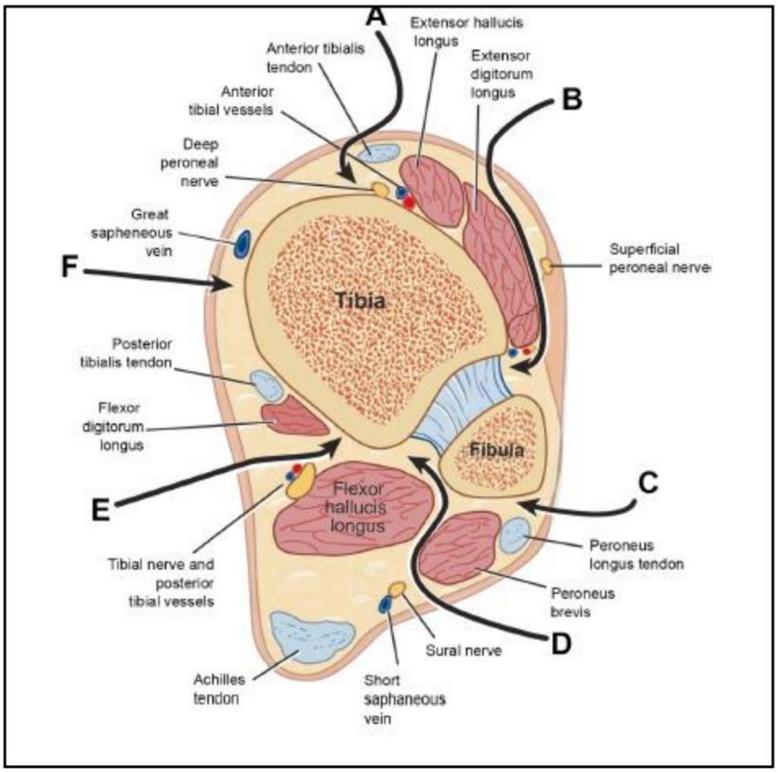
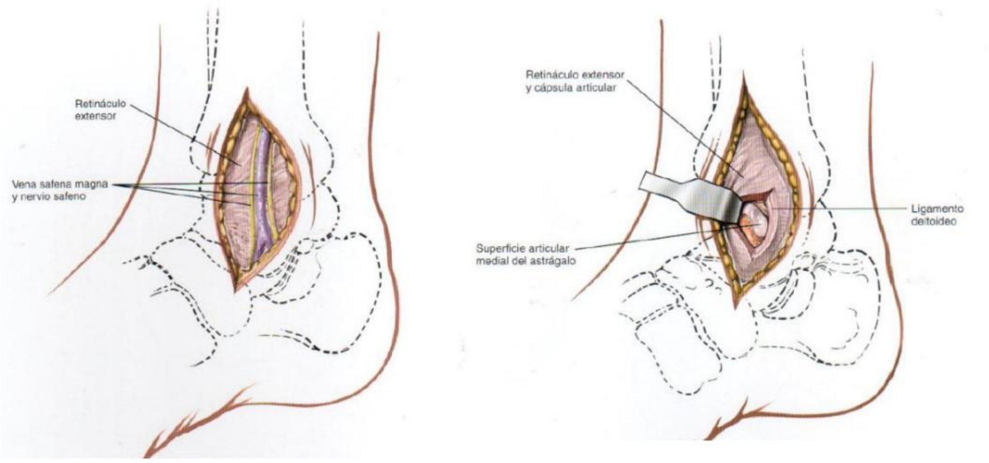


Figure 6. Ankle approaches. Image obtained from the article by Zelle et al. (7)

Among the most used approaches are (5):

- Anteromedial:

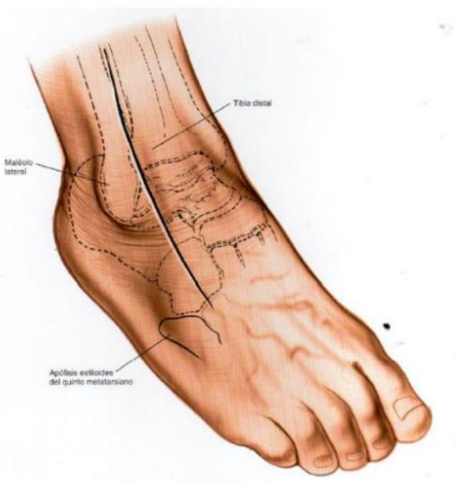
Incision: 1 to 1.5 cm lateral to the anterior crest of the tibia and over the anterior compartment, just medial to the anterior tibial tendon. Skin and subcutaneous tissue are elevated to meet the anterior tibial tendon. The anterior tibial tendon is then incised just medial through the extensor retinaculum and periosteum. Elevation of the anterior compartment allows better access to the lateral aspect of the tibia (Figures 7 and 8).

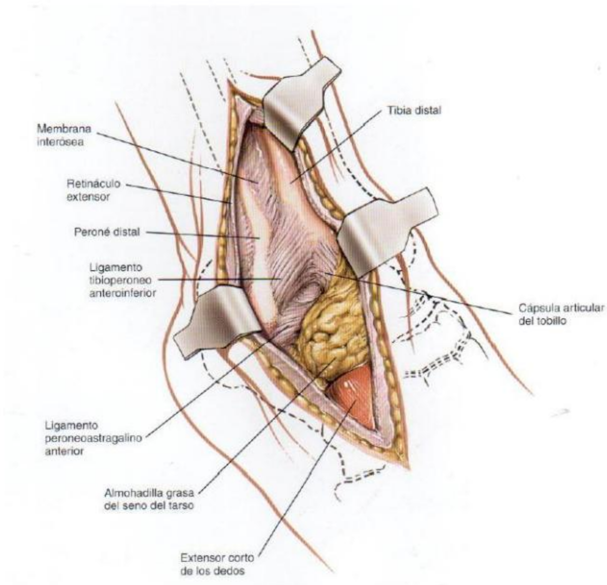


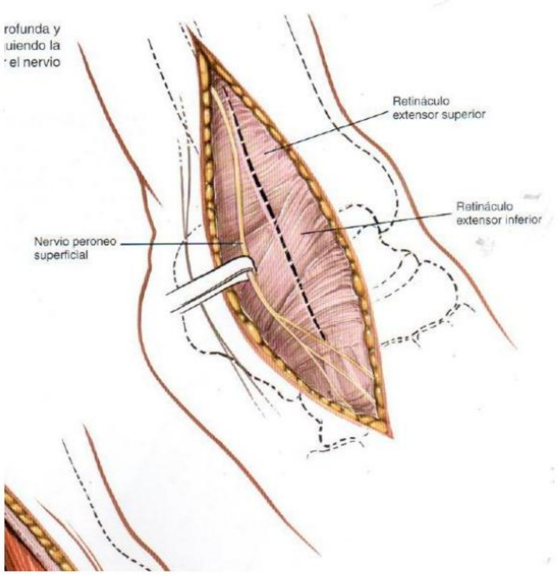
Figures 7 and 8. Images obtained from the book by Hoppenfeld and DeBoer (13).

- Anterolateral:

Incision on the anterior lateral aspect of the ankle joint in alignment with the fourth metatarsal. The superficial peroneal nerve is identified and retracted medially. The extensor retinaculum and anterior compartment fascia are then incised and raised and retracted medially (Figures 9, 10 and 11).







Figures 9, 10 and 11. Images obtained from the book by Hoppenfeld and DeBoer (13).

This surgical exposure is advantageous for treating any valgus angulation, significantly displaced Chaput fracture fragments, displaced posterior-lateral (Volkmann) fracture fragments, and centrally impacted tibial pilon fracture fragments.

Limitations of the anterolateral approach are poor medial visualization and internal fixation placement of the medial aspect of the distal tibia. The anterolateral approach should be avoided for varus angulation and impaction of the medial tibial pilon.
Another risk associated with this approach is injury to the superficial peroneal nerve. It can be made somewhat anterior, next to the tendon of the tibialis anterior, to prevent it from falling just above the subcutaneous edge of the tibia.

- Posterolateral

As discussed above, in most pilon fracture cases the posterior fragments can be addressed directly or indirectly from anterior approaches, but there are some situations in which the posterior aspect of the fracture is best addressed directly from a posterolateral approach. , in the interval between the peroneal tendons and the flexor hallucis longus, such as pilon fractures with extensive comminution of the metaphyseal-shaft aspect of the posterior column with shortening and malalignment, or cases in which there are incarcerated fragments in the lower part posterior that are not accessible from the anterior part. In such cases, the posterior column should be reduced and then fixed with an anatomical plate to act as a brace.

Once posterior reduction is achieved, the posterior column acts as a template to reduce the anterior pylon. An advantage of the posterolateral approach is that the fibula it can be approached if necessary from the same incision by mobilizing the peroneal tendons medially (Figure 12).

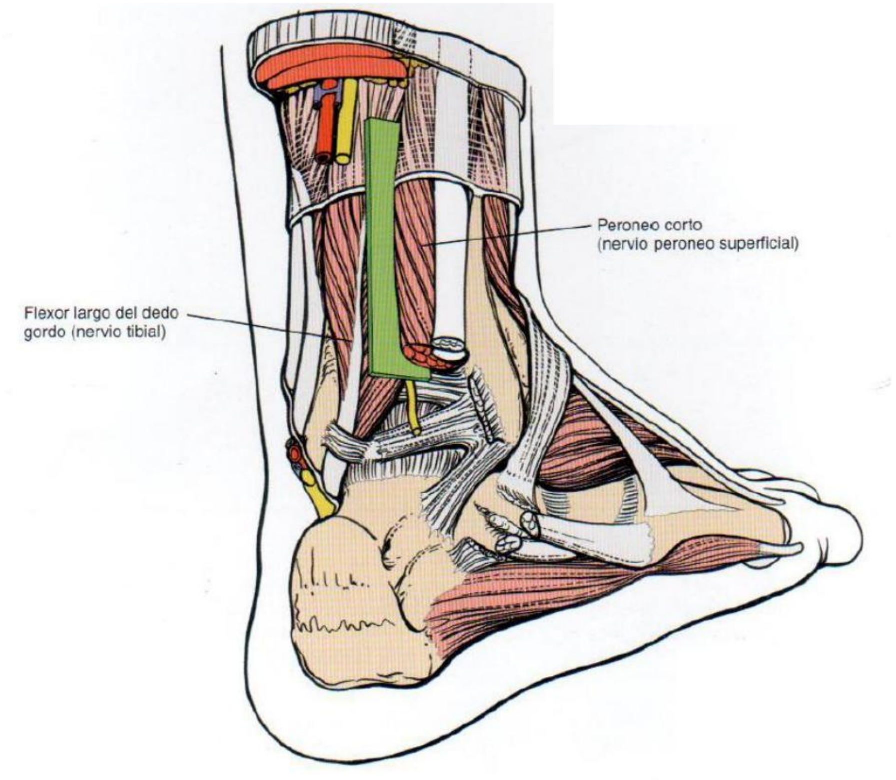


Figure 12. Image obtained from the book by Hoppenfeld and DeBoer (13).

Osteosynthesis:

After reducing the joint segment, a plated osteosynthesis can be applied to fix the joint segment to the tibial shaft. Generally, fracture patterns that end in valgus failure and lateral compression are best supported with anterolateral plating. On the other hand, varus angulated fracture patterns of the tibia are best supported with medial buttress plates. These basic fixation principles will help neutralize the major deformation forces that occur at the metaphyseal-shaft junction and may prevent the incidence of screw failure and/or nonunion. The plates used must be locking and at least one of the distal holes must have a fixed angle screw.

On the other hand, early open reduction (less than 1 week) obtains better results with fewer complications compared to those performed after 10-15 days or more.

Minimally Invasive Plate Osteosynthesis (MIPO) (2)

The biggest problem with ORIF is the poor vascularization of this area and the difficulty in treating the most comminuted fractures (AO/OTA type C). Tears of the periosteum should be avoided, limited to the edges of the fracture to appreciate how the reduction is without compromising the blood supply. Another appropriate option is the use of MIPO of which we highlight the following:

- Maintains the blood flow provided by the extraperiosteal vessels (2/3 of the total).
- When there is extensive soft tissue injury on the medial side of the tibia or an open wound, it is quite difficult to process a MIPO.
- Two types of incision methods: between the extensor hallux tendon and the tibialis anterior tendon, and between the extensor hallux tendon and the extensor digitorum tendon.

Postoperative

Postoperative protocol after ORIF generally includes a posterior splint for 2 weeks to prevent equinus of the ankle and allow soft tissue healing, followed by a nonweight-bearing orthosis for 10 to 12 weeks. Once the skin has healed, free motion ankle exercises are allowed. At ten or twelve weeks postoperatively, progressive weight lifting is allowed, depending on the results of the X-rays.

3.2.2. External fixation

Used primarily for comminuted fractures (AO/OTA type C).

Fractures with metaphyseal comminution and large articular fragments reducible by ligamentotaxis, open fractures with soft tissue injuries that compromise standard approaches, and severely contaminated open fractures or patients with comorbidities are scenarios in which treatment with external fixation with or without posterior ORIF may be a good option.

A minimally invasive open reduction is performed. Once the joint segment is stabilized, the fixative is applied to the bone. The incision site, number and configuration of the screws will depend on the configuration of the fracture and will be left to the surgeon's choice. Proximally, the pins are placed at the medial subcutaneous edge of the tibia. Distally, they are placed on the calcaneus.

If it is temporary, we must move away from the fracture site so as not to interfere with the definitive fixation. An extension of the fixator on the first metatarsal is useful to avoid an equinus contracture in cases where external fixation is expected to be necessary for a long period due to the initial state of the soft tissues.

If it is definitive, when the fixator is placed, the articular surface is temporarily reduced by means of ligamentotaxis. Percutaneous forceps can be placed to reduce the fracture and approximate displaced fragments. Articular fragments can be fixed with fixation screws. The major drawback of this therapeutic option is that it does not provide sufficient joint congruence.

3.3. Two-stage surgery

This therapeutic option is indicated mainly in open fractures or with extensive soft tissue injury.

In the first stage, the external fixator is placed with transskeletal traction to maintain length, alignment, and prevent rotation of the fragments. If ORIF of the fibula is possible, it is appropriate to do it in the first stage. The use of a VAC device stimulates soft tissue recovery, reduces the incidence rate of associated complications and the possibility of requiring flap surgery.

The second stage consists of removing the fixator and ORIF with a plate of the distal tibia, using the technique described above.

3.4. Arthrodesis:

Currently, it is only contemplated in cases of significant joint comminution that cannot be repaired in any other way, that is, selected cases in which the fragmentation and deformation are extensive. In young patients, the use of an allograft could be considered in these cases.

3.5. Amputation

In cases where soft tissues are severely damaged, bone stock is low, and multiple associated comorbidities coexist, below-knee amputation may be the only available procedure that provides a good functional option.

4. Conclusion

Tibial pilon fractures, despite being rare, can have devastating consequences for the quality of life of patients who suffer from them if they are not treated properly. We usually refer to these as those that affect the articular surface of the ankle. The most accepted classification is that of the AO/OTA, however a CT study prior to surgery is necessary for preoperative planning, since it defines the articular fragments that will indicate the approach route. In fractures classified as OTA type A and B without extensive soft tissue injury, an initial ORIF can be performed if it is carried out early. In all other cases, two-step treatment with external fixation and ORIF will be preferable when the soft tissues allow it. The most widely used ORIF in the literature consists of primary reduction of the fibula if it is affected and an anatomical reduction is possible; later, the reduction of the articular fragments from posterior to anterior, and finally the osteosynthesis of the tibia.

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