ADITUM
Enrich your Research

International Surgery Case Reports

Review Article

Approach to the Treatment of Tibial Pilon Fractures

Horacio Tabares Sáez[1], Horacio Tabares Neyra[2*]

[1]Transylvania University of Brasov, Medicine PhD School, Orcid: 0000-0002-0204-7414.

[2]Havana Medical University, Orcid: 0000-0001-6599-4948

Article Info

Received: January 15, 2026
Accepted: January 29, 2026
Published: February 09, 2026

***Corresponding author:** Horacio Tabares Neyra, Havana Medical University, Orcid: 0000-0001-6599-4948.

Citation: Horacio T Sáez, Horacio T Neyra. (2026) "Approach to the Treatment of Tibial Pilon Fractures.", International Surgery Case Reports, 8(1); DOI: 10.61148/2836-2845/ISCR/113.

Abstract

Introduction : Pilon fractures, or tibial pilon fractures, are typically injuries caused by axial loading that results in a fracture across the articular surface of the distal tibia. This article aims to provide an overview of the treatment of tibial pilon fractures.

Search strategy: A systematic literature search with terms such as "treatment of pilon fracture," "pplafond fracturetreatment," "distal tibial fracture treatment".

Development: Two factors must be considered for treatment: decreased circulation in the tibia and a thin soft tissue envelope in the distal tibial region. Conservative treatment approaches do not yield good results. Surgical treatment planning requires consideration of several factors: the timing of the surgery, surgical incisions spaced 6-7 cm apart, a four-column classification system, and the general principles recommended by Rüedi with a staged protocol. Two treatments are available: open reduction and internal fixation, and external fixation with joint reconstruction using minimal internal fixation.

Conclusions : Tibial pilon fractures present a significant challenge. Preoperative planning is crucial for successful treatment, requiring a thorough preoperative plan, stable anatomical alignment of the articular surface and metaphyseal/diaphyseal fractures, careful soft tissue management and appropriate management of complications.

Keywords: Tibial pilon fractures, treatment, soft tissue

Introduction:

Tibial fractures are the most common lower extremity trauma fractures, with fractures of the distal tibial plafond, also referred to as the tibial pilon, accounting for approximately 5-7% of those fractures.1 Similar to malleolar fractures in the ankle, the distal tibia has a relatively thin soft tissue sheath prone to injury in high-energy trauma. These injuries are associated with significant swelling of these tissues and, therefore, often require initial external fixation due to collateral damage to these structures.2

They are relatively infrequent traumatic injuries of the lower extremity. They generally occur with high-energy trauma, making them one of the most serious and debilitating injuries in this region of the body.

Pilon fractures present a notable management challenge due to their frequent association with fracture comminution and soft tissue injury, increasing the risk of wound dehiscence, infection, and nonunion.3

The treatment of distal intra-articular fractures of the tibia has evolved in the last century. Previously, due to the scarcity of available implants and poor results with surgical treatment, these fractures were defined as inoperable, and conservative measures were advocated.4 In an effort to improve patient outcomes by reducing immobilization time, Learch decided to use open reduction and internal fixation of the fibula

and conservative treatment of the tibia.[5] Subsequently, Rouff and Zinder advocated open internal fixation of the fibula and minimal internal fixation of the tibial fragments.[6] Some authors, such as Witt, Weber, Cox and Laxon, and Müller, proposed performing tibiotalar arthrodesis as a first step for comminuted fractures, given the poor functional results obtained.[7-10]

In the late 1950s and early 1960s, with the emergence of the AO, general principles for the treatment of intra-articular fractures of the distal tibia were developed.[11] With the application of these treatment principles, success was achieved; therapeutic treatment of tibial pilon fractures, especially in injuries caused by low-energy trauma or in patients with minimal soft tissue involvement.[11-15]

The results, when these same principles were applied to fractures from high-energy trauma in which the soft tissues were severely affected, were not similar.[8,16-19] The high number of complications associated with the surgical treatment of these fractures caused by high-energy mechanisms made the need to develop other therapeutic guidelines obvious in the late 1980s. Another osteosynthesis system, previously advocated, was revived: external fixation with or without limited internal fixation, implanted percutaneously.[9,20] The use of external fixation resulted in a decrease in complications associated with open reduction and internal fixation, and it quickly gained popularity among orthopedic surgeons.[21-24] However, one of the problems with treating tibial pilon fractures with external fixators is the difficulty in achieving excellent reduction of the damaged articular surface, which logically impacts long and medium-term clinical outcomes. Despite advances, tibial pilon fractures continue to present a high risk of complications, making them a challenge for orthopedic surgeons.[25,26]

Currently, the treatment of tibial pilon fractures secondary to high-energy trauma remains a controversial topic. Most authors agree that the surgical treatment of these injuries should be tailored to the degree of soft tissue damage, the fracture pattern (fracture characteristics), and the surgeon's experience, although the condition of the surrounding soft tissues ultimately determines the most appropriate treatment.

The purpose of this article is to provide an overview of the treatment of tibial pilon fractures.

Search strategy and selection criteria

A systematic literature search was performed across PubMed, Scopus, Google Scholar, Elsevier and Web of Science. The search was restricted to studies published between 2013-2025. Articles accessible freely or through the Clinical key and Hinari services were also reviewed.

Keywords and medical subject headings related to pilon fractures, including terms such as "pilon fracture," "plafond fracture," "distal tibial fracture". A number of articles were selected that make the necessary requirements to support this review. Articles were added that are more than ten years old, but that are key to the topic. We excluded papers because they were duplicates or the source data was insufficient. Power Point presentations were discarded.

Development

Most tibial pilon fractures result from high-energy trauma, making them highly complex injuries. They are frequently associated with soft tissue injuries such as wounds, abrasions, or friction burns, leading to significant controversy in treatment decisions and the challenge of determining the correct surgical approach.[2] The axial mechanism in pilon fractures is often combined with shear, rotation, and flexion forces, depending on the foot's position at the time of impact. This results in a wide variety of fracture patterns, with variable fibular involvement. In addition to these complex forces, the different energy levels applied to the bone can cause significant damage to the ankle articular surface.[27]

To determine the treatment for tibial pilon fractures, it is important to understand two fundamental factors present in the distal third of the leg: the marked decrease in tibial circulation at this level and the thin soft tissue sheath surrounding this distal tibial region. Both factors determine the optimal timing for open surgery, as well as the surgical approach to be employed.[28]

For a long time, due to the characteristics of these fractures already described, a conservative treatment approach was proposed, using closed reduction, sometimes accompanied by percutaneous fixation of some fragments and prolonged immobilization of three or four months. The success of tibial pilon fracture treatment following these recommendations was achieved primarily in injuries caused by low-energy trauma or in patients with minimal soft tissue involvement.[11-16] Unfortunately, identical results were not obtained when these same principles were applied to fractures caused by high-energy trauma, in which the soft tissues were severely affected.[16-21]

With this treatment approach, the results obtained were not good, due to the inability to anatomically reconstruct the articular surface and the resulting ankle stiffness due to prolonged immobilization; This was frequently associated with soft tissue damage, also related to immobilization. Poor outcomes were also linked to high rates of infection and other surgical site complications.[17-19] Furthermore, loss of reduction is quite common with this method.

Conservative treatment of tibial pilon fractures should be reserved for nondisplaced fractures and for patients with comorbidities who therefore have a poor surgical prognosis. Fracture distraction using calcaneal skeletal traction can achieve satisfactory alignment if the central portion of the articular surface is not impacted. This technique allows direct access to the soft tissues, reduces inflammation by elevating the limb, and can be combined with joint rehabilitation. Managing the fracture with calcaneal traction alone requires the patient to remain in bed until bone healing, typically a minimum of 6 weeks.[29]

Similarly, skeletal traction via the calcaneus can be used as initial damage control in fractures requiring surgical intervention, but where surgery must be postponed due to the condition of the soft tissues. The ligamentotaxis effect of traction can achieve provisional reduction, maintaining leg length and treating soft tissue injuries until surgery can be safely performed.[27]

For surgical treatment planning, it is essential to consider several factors that are crucial for achieving good results:[30]

- The condition of soft tissue coverage, which determines the timing of surgery and the possible location of the approach(s) to be used.

Most authors recommend that the timing of surgery be determined by the reduction of inflammation, with palpable bony prominences, the presence of skin folds (wrinkle sign), and, above all, the absence of hemorrhagic blisters. Simple fractures with minimal soft tissue involvement can be definitively stabilized within the first 6-8 hours. For other closed fractures, this intervention is preferably deferred until the soft tissues allow it (7 to 10 days), and another treatment should be implemented (external fixator,

calcaneal traction). In fractures with significant soft tissue involvement, the surgical approach may be limited; in these cases, external fixation is considered an appropriate temporary treatment until re-epithelialization occurs.

When several surgical incisions are required, they should be made 6-7 cm apart.

- Accurate determination of the articular and non-articular fragments requiring reduction as anatomically as possible; for this, radiographic studies and computed tomography are essential. This includes the type of osteosynthesis to be used to achieve this reduction (Key fragments? Screws-plates-position?).
- The need to provide bone grafts; to guarantee proper biomechanical stability and thus consolidation.

A system based on the anatomical characteristics of the ankle joint has been proposed. This system uses a four-column classification, dividing the segments along the intermalleolar line:[31]

-Lateral column: distal fibula

-Medial column: medial third of the tibial plateau with the distal tibial diaphysis

-Anterior column: portion anterior to the intermalleolar line

-Posterior column: posterior segment of the intermalleolar line with the distal tibial diaphysis

This classification not only allows for the identification of anatomical zones and articular columns to plan approaches more precisely, but is also important for protecting soft tissues and guiding the treatment of fractures with extensive comminution.

The open reduction and internal fixation technique follows the general principles recommended by Rüedi.[11-15]

1. Anatomical reconstruction of the fibula. This first step restores the length of the lateral column of the ankle, providing a guide for the subsequent reconstruction of the tibial surface. It also reduces or brings other fracture fragments, such as the Tilleaux-Chaput tubercle, into position.
2. Reconstruction of the tibial articular surface. The articular fragments are reduced from lateral to medial and from posterior to anterior. Temporary fixation using Kirschner wires may be employed, which are replaced with screws if possible.
3. Autologous bone grafting. In cases with a defect in the metaphyseal area, the use of cancellous or corticocancellous bone is recommended to achieve proper biomechanical stability.
4. Tibial osteosynthesis. This can be performed with a plate and screws placed medially, or with two separate plates (medial and lateral to the tibia). It is often necessary to place screws, independent of the plate, cannulated or not, to achieve additional fixation of the articular surface.

Currently, a staged approach is the primary method for open reduction and internal fixation (ROF) of tibial pilon fractures. The main goals are anatomical reconstruction of the articular surface and restoration of proper rotational alignment to achieve optimal functional outcomes.[26] The chosen approach should allow direct visualization of the main fracture site and the joint block, while preserving soft tissue as much as possible.[32]

The articular surface must be anatomically reduced, which may require a specific sequence. Generally, reduction begins laterally, where fibular osteosynthesis contributes, progressing medially and from posterior to anterior. The posterior (Volkmann) fragment is usually reduced first and used as a stabilizer so that the rest of the joint block can be reduced around it. The reduction can be temporarily maintained with Kirschner wires until the entire joint block is congruent. Final reduction is possible using traction screws, minifragment screws, and anatomically locked or non-locked low-profile compression plates to preserve as much soft tissue as possible.[33]

In general, fractures with valgus deformity usually require an anterolateral reinforcing plate, while varus deformities require medial reinforcement. The posterior plate to address the posterior tibial column and prevent tibial shortening should be achieved via posteromedial or posterolateral approaches.[33]

Primary arthrodesis generally serves only as a salvage procedure in a highly selected subgroup of patients.[26]

Due to the poor results obtained with open reduction and internal fixation in high-energy tibial pilon fractures, numerous authors revived the principles described by Scheck in 1965, which advocated the use of external fixation and joint reconstruction with minimal internal fixation through small surgical approaches. The external fixator functions as a medial support plate and is based on the principle of ligamentotaxis. The distraction produced by the fixator causes bone fragments with retained capsuloligamentous attachments to automatically reduce.[27] Once length is restored and large fragments are reduced with the external fixator, any remaining displaced articular fragments can be reduced by open manipulation (incisions < 2 cm) or percutaneous manipulation.[27]

When the external fixator is combined with minimal internal fixation (Kirschner wires, conventional screws, or cannulated screws), the principles described by Rüedi and Allgöwer are met: restoration of length, reconstruction of the articular surface, the possibility of treating metaphyseal defects with autologous bone graft, and the provision of internal support by the external fixator.[27]

When proper joint reduction is achieved, the external fixator can be the definitive treatment method. In fractures with severe soft tissue injuries or joint comminution, unilateral fixators provide stability to facilitate bone grafting and soft tissue healing (flaps in open fractures).[27] The obvious drawback of a non-articulated fixator is that it does not allow early ankle mobilization. Articulated external fixators allow early, albeit somewhat restricted, mobilization.

External fixation techniques have reduced the percentage of serious complications seen in the treatment of high-energy tibial pilon fractures with open reduction and internal fixation, and the results obtained are comparable to studies using internal fixation techniques.[27]

Possible complications with external fixation methods include nail tract infection, which is a common complication; delayed union; and loss of proper alignment. The difficulty in anatomically reducing fragments of the articular surface leads some authors to link the treatment of tibial pilon fractures with the relatively early onset of post-traumatic osteoarthritis.[27,34]

Negative pressure wound therapy has become popular. This system is applied to the wound after surgical closure instead of the usual dressing and provides a sealed space that decreases tension on the skin, increases blood flow to the surgical site, and reduces edema. Multiple studies have shown promising results with a significant reduction in superficial and deep skin infections and a lower incidence of wound dehiscence in high-risk injuries.[33,35]

Perioperative intravenous administration of antibiotics It is the standard of care in the surgical treatment of tibial pilon fractures; the benefit of local antibiotics is yet to be determined.[33,35]

Conclusions

Tibial pilon fractures present a significant challenge for orthopedic surgeons. Proper preoperative planning is key to successful treatment. This includes a thorough preoperative plan, stable anatomical alignment of the articular surface and metaphyseal/diaphyseal fractures, careful soft tissue management, and appropriate management of complications. Particular care must be taken when handling the fragile soft tissue sheath surrounding tibial pilon fractures.

Choosing the appropriate approach for each fracture type is important to obtain the best possible visualization and, therefore, to anatomically reduce the articular surface of the tibial pilon. Furthermore, the implementation of staged protocols has proven beneficial in reducing complication rates. The use and combination of different surgical approaches and techniques have been employed to minimize damage to underlying structures, which often influence the outcome and prognosis.

With modern surgical techniques and equipment, the results of treatment for tibial pilon fractures have improved, but are still moderate, with a high overall complication rate.

References:

1. Malige A, Yeazell S, Nwachuku C. Surgical fixation of pilon injuries: a comparison of the anterolateral and posterolateral approach. Arch Orthop Trauma Surg. 2019; 139(9):1179-85. doi:10.1007/s00402-019-03145-3
2. Mair O, Pflüger P, Hoffeld K, Braun KF, Kirchhoff C, Biberthaler P, et al. Management of Pilon Fractures-Current Concepts. Frontiers in Surgery. 2021; 8:764232. Disponible en: https://doi.org/10.3389/fsurg.2021.764232
3. van der Vliet QMJ, Ochen Y, McTague MF, Weaver MJ, Hietbrink F, Houwert RM, et al. Long-term outcomes after operative treatment for tibial pilon fractures. OTA Int. 2019; 2(4):e043. doi:10.1097/oi9.0000000000000043
4. Badavath RR, Akkala P, Aluka SKR, Patnala C. Evaluation of Functional Outcome in Surgically Managed Tibial Pilon Fractures. Cureus. 2024; 16(6):e63242. doi:10.7759/cureus.63242
5. Learch IRE. A means of stabilizing comminuted distal tibial fractures. J Trauma 1964; 4:722-30. https://doi.org/10.1097/00005373-196409000-00018
6. Rouff AC III, Snider RK. Explosion fractures of the distal tibia with major articular involvement. J Trauma 1971; 11:866-71. https://doi.org/10.1097/00005373-197110000-00008
7. Witt AN. Supramalleolare fracturen kombiniert mit luxationfractures des OSG, ihre gefahren für die zirkulation und ihre behandlung. Wiederherstchir Traumat 1960; 5:15-21. DOI:10.1007/978-3-662-45571-5_12
8. Weber BG. Behandlung der Sprunggelenks-Stauchungsbrüche nach biomechanischen gesichtpunkten. Hft Unfall-heilk 1965; 81:176-83.
9. Cox FJ, Laxon WW. Fractures about the ankle joint. Am J Surg 1952; 83:674-9. DOI: 10.1016/0002-9610(52)90301-2
10. 10. Müller ME. Les fractures du pilon tibial. Rev Chir Orthop 1964; 50:557-62.
11. Rüedi TP, Allgöwer M. Fractures of the lower end of the tibia into the ankle joint. Injury 1969; 1:92-9.
12. Bourne RB, Rorabeck CH, Macnab J. Intra-articular fractures of the distal tibia: the pilon fractures. J Trauma 1983; 23:591-6. doi:10.1097/00005373-198307000-00008
13. Mast JW, Siegel PG, Pappas JN. Fractures of the tibial pilon. Clin Orthop 1988; 230:68-82.
14. Ovadia DN, Beals RK. Fractures of the tibial plafond. J Bone Joint Surg Am 1986; 68A:543-51.
15. Rüedi TP, Allgöwer M. The operative treatment of intraarticular fractures of the lower end of the tibia. Clin Orthop 1979; 138:105-10.
16. Bourne RB. Pilon fractures of the distal tibia. Clin Orthop 1989; 240:42-6.
17. Helfet DL, Koval K, Pappas J, Sanders RW, DiPasquale T. Intraarticular «pilon» fractures of the tibia. Clin Orthop 1994; 298:221-8. https://doi.org/10.1097/00003086-199401000-00029
18. McFerran MA, Smith S, Boulas HJ, Schwartz HS. Complications encountered in the treatment of pilon fractures. J Orthop Trauma 1992; 6:195-200. https:// doi. org/ 10. 1097/ 00005131- 19920 6000- 00011
19. Teeny SM, Wiss DA. Open reduction and internal fixation of tibial plafond fractures. Variables contributing to poor results and complications. Clin Orthop 1993; 292:108-17. doi:10.1097/00003086-199307000-00013
20. Sheck M. Treatment of comminuted distal tibia fractures by combined dual pin fixation and limited open reduction. J Bone Joint Surg Am 1965; 47A:1537-53.
21. Barbieri R, Shenk R, Koval K, Aurori K, Aurori B. Hybrid external fixation in the treatment of tibial plafond fractures. Clin Orthop 1996; 332:16-22. doi:10.1097/00003086-199611000-00004
22. Bonar SK, Marsh JL. Unilateral external fixation for severe pilon fractures. Foot Ankle 1993; 14: 57-64.
23. Bone L, Stegemann P, McNamara K, Seibel R. External fixation of severely comminuted and open tibial pilon fractures. Clin Orthop 1993; 292:101-7. doi:10.1097/00003086-199307000-00012
24. Tornetta P III, Weiner L, Bergman M, Watnik N, Stever J, Kelley MH, et al. Pilon fractures: treatment with combined internal and external fixation. J Orthop Trauma 1993; 7:489-96. http://dx.doi.org/10.1097/00005131-199312000-00001
25. Faber RM, Parry JA, Haidukewych GH, Koval KJ, Langford JL. Complications after fibula intramedullary nail fixation of pilon versus ankle fractures. Journal of Clinical Orthopaedics and Trauma. 2020; 75:9. Disponible en: https://doi.org/10.1016/j.jcot.2020.12.025
26. Zelle, B.A., Dang, K.H. & Ornell, S.S. Highenergy tibial pilon fractures: an instructional review. International Orthopaedics (SICOT). 2019; 43:1939-50. Disponible en: https://doi.org/10.1007/s00264-019-04344-8
27. Wallace SJ, Beaman D. Management of Tibia Pilon Fractures With Ring External Fixation. J Orthop Trauma 2025; 39(12):S19-S24. DOI: 10.1097/BOT.0000000000003067
28. Horacio Tabares Sáez H, Tabares Neyra H. Tibial Pilon fractures. A challenge for Orthopedics surgeons. Global Journal of Orthopedics Research. 2025; 4:5. DOI:10.33552/GJOR.2025.04.000600
29. Gerssler WB, Tsao AK, Hughes JE. Fractures and injuries of the ankle. In: Rockwood CA, Green DP, Bucholz RW, Heckman JD, editors. Fractures in adults. Philadelphia-New York: Ed. Lippincott-Raven, 1996.

30. López-Prats F, Sirera J, Suso S. Fracturas del pilón tibial. Rev Ortop Traumatol 2004; 48:470-83.
31. Gutiérrez Fernández F, López Angulo D, Ramírez Perera Sh. Fracturas de pilón tibial, clasificación y tratamiento. Revista Médica Sinergia 2023; 8(6):e1070. https://doi.org/10.31434/rms.v8i6.1070
32. Krettek C, Bachmann S. Pilon fractures. Part 2: Repositioning and stabilization technique and complication management. Chirurg. 2015; 86:187-201. doi: 10.1007/s00104-014-2917-5
33. Mair O, Pflüger P, Hoffeld K, Braun KF, Kirchhoff Ch, Biberthaler P, Crönlein M. Management of Pilon Fractures—Current Concepts. Front. Surg; 8:764232. doi: 10.3389/fsurg.2021.764232
34. Tabares Sáez H, Tabares Neyra H. External Fixation in Tibial Pilon Fractures. Global Journal of Orthopedics Research. 2025; 5:1. DOI: 10.33552/GJOR.2025.05.000604
35. Tabares Sáez H, Tabares Neyra H. Tibial Pilon Fractures. OPROJ. 2025; 11(5). Doi: 31031/OPROJ.2025.11.000772.