Pilon Fractures: A structured review and evidence-based note template.

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Objectives: The purpose of this study is to synthesize Level IV or higher evidence related to tibial plafond (pilon) fractures and to translate this evidence into a standardized, evidence-based clinical note template designed to support consistent evaluation, risk stratification, and treatment planning in orthopedic trauma practice.

Design: Structured literature review with development of an accompanying evidence-based clinical note template.

Main Outcome Measurements: Fracture classification, diagnostic evaluation, treatment strategies, complication rates, functional outcomes, and evidence-supported elements of clinical documentation relevant to pilon fractures.

Results: A structured review of the orthopedic literature identified tibial plafond fractures as complex, high-energy injuries frequently associated with articular comminution, soft-tissue compromise, and concomitant musculoskeletal injuries. The AO/OTA classification system remains the most widely utilized framework for fracture characterization. Evidence supports a range of management strategies, including nonoperative treatment, staged open reduction and internal fixation, circular frame fixation, intramedullary nailing with limited internal fixation, primary hindfoot arthrodesis, and, in rare cases, amputation. High rates of complications persist across treatment modalities, including infection, nonunion, post-traumatic arthritis, and long-term functional impairment. These findings informed the development of a comprehensive, structured clinical note template that incorporates key history, physical examination, imaging, risk factors, and management considerations, supported by current evidence.

Conclusions: Tibial plafond fractures remain among the most challenging injuries in orthopedic trauma, with substantial morbidity despite advances in surgical technique. An evidence-based, standardized documentation approach may improve clinical consistency, facilitate multidisciplinary care, and support evidence-informed decision-making. The accompanying note template provides a practical tool for integrating current evidence into daily clinical practice.

Level of Evidence: Level IV; Structured Review of Level IV or Higher Evidence

Key Words: Pilon fracture, tibial plafond, evidence-based documentation, clinical note template, orthopedic trauma, fracture management

INTRODUCTION

Tibial plafond (pilon) fractures are challenging injuries for patients and orthopaedic surgeons because of articular injury, metadiaphyseal comminution, and soft-tissue injury [1]. These fractures, predominantly affecting men aged 30-40 years, often result from high-energy mechanisms and can lead to complications and long-term functional impairment [2]. The complexity of these injuries and their potential for poor outcomes underscores the importance of effective management strategies.

Current literature recognizes the multifaceted nature of pilon fracture treatment. These injuries often require a staged approach, with initial external fixation followed by definitive internal fixation. The fracture pattern, influenced by foot position at the time of injury, guides treatment planning [3, 4]. Additionally, the high incidence of associated injuries (up to 57% of cases) necessitates a multidisciplinary approach to management [5].

This review synthesizes current knowledge of pilon fractures, focusing on their classification, initial evaluation, and surgical and non-surgical treatment options. By comprehensively examining these aspects, we aim to provide orthopedic surgeons with an up-to-date resource for managing these challenging injuries, thereby improving patient outcomes and reducing complication rates.

METHODS

This structured review was conducted using a PRISMA-informed methodology, including a predefined search strategy and dual-reviewer screening. A comprehensive literature search was conducted using the ISI Web of Science database (accessed 21 January 2021) with the search terms "pilon fracture" and "tibial plafond fracture". Our search encompassed all articles published in orthopedic journals from the inception of the database through the date of our search.

Search Strategy and Study Selection

The initial search yielded 1448 articles. The search was then filtered for English, full text, and MEDLINE. The results were sorted in descending order by total citations. Following initial screening, articles were reviewed in order of citation frequency to prioritize highly influential studies relevant to tibial plafond fractures. Two authors independently reviewed the abstracts and full texts of the articles to determine their relevance to tibial plafond fractures.

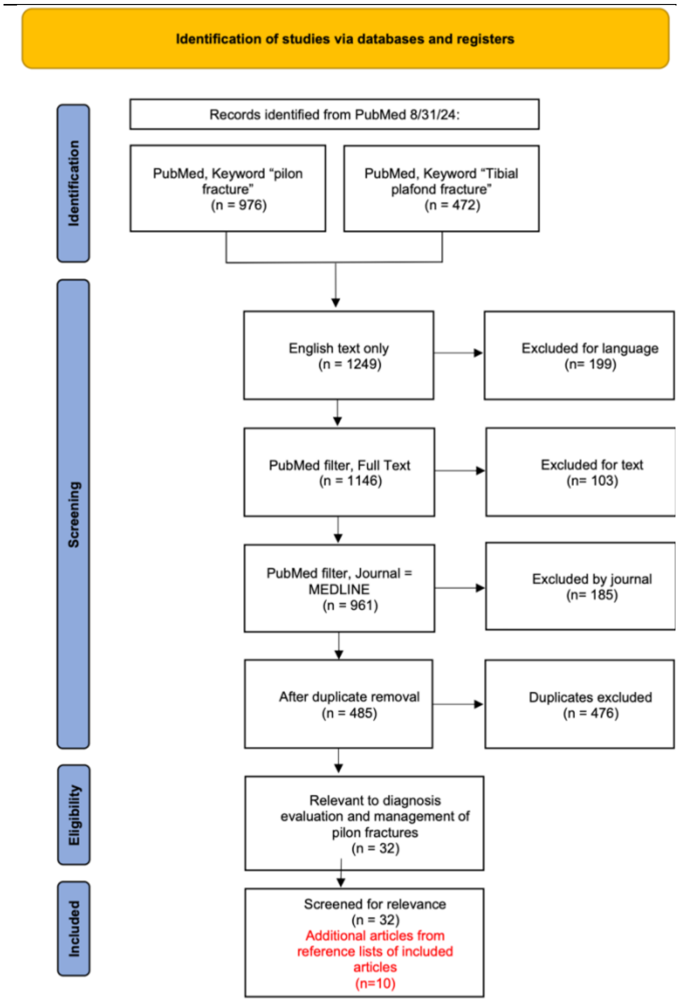
Eligibility Criteria

Studies were included if they focused on the diagnosis, evaluation, and management of pilon fractures. Articles were excluded if they primarily discussed other types of fractures, were not in English, or did not address the diagnosis, evaluation, or management of pilon fractures. Only studies providing Level IV or higher evidence were included.

Data Extraction and Analysis

Two reviewers independently conducted the selection process. Any discrepancies were resolved through discussion and consensus, with reference to the established inclusion/exclusion criteria. Additionally, the reference lists of all included studies were manually searched to identify any relevant articles that may have been missed in the initial database search.

Figure 1: Prisma informed methodology.



RESULTS

Initial Evaluation and Management

Patients are generally non-ambulatory on presentation, with variable gross deformity of the involved distal leg. Initial evaluation should include AP, lateral, and mortise radiographs of the ankle, along with orthogonal radiographs of the tibia and knee. CT with reconstruction of the tibial plafond is indicated to evaluate the fracture pattern and articular surface, and for preoperative planning after splinting or external fixation [2]. Approximately 26.9% of pilon fractures have an additional fracture on the ipsilateral extremity, and 51% have other orthopedic injuries, most commonly calcaneus, tibial diaphysis, or talus fractures [6, 7]. Patients should also be evaluated for other factors that can increase the risk of complications, including malnutrition, alcoholism, diabetes mellitus, peripheral vascular disease, tobacco use, and osteoporosis [1]. A literature review of ankle fractures identified the most significant risk factors for fracture healing as the Gustilo-Anderson classification (OR 3.47), local tissue damage (OR 3.05), diabetes mellitus (OR 2.3), and ASA 3 or greater (OR 2.23) [8].

Classification systems

Several classifications of tibial plafond fractures have been described. In their 1969 article, Rüedi and Allgöwer proposed a classification based on radiographic severity of comminution and displacement of the articular surface. Type I is a nondisplaced cleavage fracture of the ankle joint without loss of articular congruency. Type II is a displaced fracture with minimal impaction or comminution. Type III is a displaced fracture with significant articular comminution and metaphyseal impaction [4, 9]. Although the Rüedi and Allgöwer system is simple, the most widely used classification is the AO/OTA system, published by Müller in 1987. This classification divides pilon fractures into three groups (extra-articular, partial articular, and total articular, similar to other articular fractures) and further subdivides them based on fracture pattern and the degree of comminution [4, 10]. More recently, Leonetti presented a CT-based classification system that divides fractures into four main groups and subgroups, ranging from nondisplaced (type 1) to highly comminuted with at least four fragments (type 4) [11].

Anatomical Considerations

Osteology and ligamentous anatomy are important considerations in surgical planning. Initially, three tibial columns or pillars were described by Assal et al [12]. This anatomic framework has expanded to include a fourth column, the distal fibula. Comminution generally occurs in the anterolateral and central tibia, where the central point of the talus coincides with the tibia. This pattern of fragmentation has been described as a "base Y shape at the level of the fibular notch", separating four distinct fragments: a lateral column (distal fibula), a posterior column (Volkmann, posterior inferior tibiofibular ligament (PITFL) origin), an anterolateral column (Chaput, anterior tibiofibular ligament (AITFL) origin), and a medial column (deltoid ligament origin), each consisting of its respective articular fragment and the distal one-third of the tibia [4, 13].

Treatment Options

Non-Operative Management: Nondisplaced pilon fractures or fractures in extremely high-risk patients may be treated nonoperatively with long-leg immobilization for 6 weeks, followed by a fracture brace and range-of-motion (ROM) exercises [2].

Staged Open Reduction, Internal Fixation (ORIF): Pilon fractures are generally treated surgically in a staged fashion. Temporizing external fixation of the tibial plafond across the ankle joint is indicated for length-unstable fractures, open fractures, and for soft-tissue monitoring prior to definitive fixation. Traditionally, immediate ORIF was discouraged because of an increased risk of skin necrosis and wound dehiscence. Clinical series from the mid-1980s to the early 2000s reported complication rates of up to 100% [1]. Recent research has challenged this conventional wisdom, demonstrating that immediate ORIF can be safely performed in select cases, taking into account the condition of the soft-tissue envelope and individual patient risk factors [14-16]. Therefore, clinical judgment remains necessary in determining whether to proceed with immediate or delayed closure.

Circular Frame Fixation (CFF): The most common definitive external fixation method for pilon fractures is circular frame fixation (CFF), such as the Ilizarov external fixation [17]. Patients had a statistically lower rate of skin disorders or complications. With internal fixation, 33.3% of patients (5 of 15) developed dermal complications, whereas none with CFF (0 of 15) did [18]. Despite its potential benefits, CFF has been shown to result in higher rates of post-traumatic arthritis. A recent meta-analysis of two studies including 121 fractures found that the risk ratio for post-traumatic osteoarthritis was 0.48, with a confidence interval of 0.30 to 0.78, favoring ORIF [17].

Intramedullary Nailing (IMN) with Limited Open Internal Fixation: Intramedullary nailing (IMN) with limited open internal fixation is indicated as primary fixation for extra-articular and simple intra-articular pilon fractures (AO/OTA-43A1 and 43C1/C2)[5, 18, 19]. In a retrospective analysis of IMN for AO/OTA-43C1 fractures, patients had an average ankle score of 90.8 on the Olerud-Molander Ankle Score. In a separate retrospective study of IMN for AO/OTA-43C1 fractures, patients experienced a complication rate of 26% and a subsequent reoperation rate of 21%. Complications included nonunion, superficial wound drainage, deep infection, symptomatic hardware, and deep vein thrombosis [20,21].

Primary Hindfoot Arthrodesis: Hindfoot arthrodesis has gained attention as a primary method of fixation, often for high-energy AO/OTA 43 C2 and C3 fractures [22]. Hindfoot arthrodesis may involve fusion at the tibiotalar joint, subtalar joint, or both [23,24]. Tibiotalocalcaneal (TTC) arthrodesis, a common approach for hindfoot arthrodesis, has been proposed as an alternative to ORIF, especially in high-risk elderly patients with comorbidities such as diabetes or peripheral vascular disease [25, 26]. In a case series of 20 patients, using a retrograde calcaneal nail and autogenous fibular bone graft for highly comminuted tibial pilon fractures (Rüedi and Allgöwer Type III) resulted in a fusion rate of 100% and a varus malunion rate of 10%. Fracture union in these patients occurred at a mean of 16 weeks postoperatively. The average time from trauma to arthrodesis was 16 days [3].

Amputation: Amputation is rarely used in the acute treatment of pilon fractures. An analysis of the military orthopedic trauma registry found that of 45 late amputations after pilon fractures, 33% were for severe infection, 13% for infected nonunion, 13% for loss of function, 11% for pain, and 9% for nonunion [26]. Traditional limb salvage scoring systems demonstrate poor reliability in guiding amputation decisions for high-energy lower extremity trauma, and current guidelines favor a comprehensive assessment of injury patterns, physiological status, and psychosocial factors [28].

Complications

Several complications may arise from tibial plafond fractures, even when reduction is achieved. Two common complications, seen regardless of treatment method, include nonunion and deep infection, with reported incidences of 25% and 20-30%, respectively [29]. Patients generally average less than 10 degrees of dorsiflexion and less than 30 degrees of plantar flexion after recovery [2]. Other complications include infection, residual pain, and loss of function.

Postoperative Management

After a tibial plafond fracture operation, patients should be placed in a splint in neutral dorsiflexion and closely monitored for soft tissue injury. Generally accepted recommendations include non-weight bearing for 10-16 weeks, followed by progression to full weight bearing once radiographic evidence of union is present [2, 3].

DISCUSSION

Until the 1990s, immediate ORIF was the standard treatment for tibial plafond fractures. Poor outcomes and high complication rates prompted a change in management. Following three influential reports in the late 1990s, the trend shifted toward a two-stage ORIF protocol with delayed definitive fixation [1, 27, 30-31]. However, recent literature has begun to challenge this paradigm, with some studies suggesting that early definitive fixation may be appropriate in select cases with favorable soft tissue conditions [14-16]. Despite this evolving debate, the importance of careful soft tissue evaluation and monitoring, as well as the benefit of ongoing physical therapy, remains universally recognized.

While the prognosis for tibial plafond fractures has improved somewhat, these injuries remain debilitating, with increased rates of mortality and post-traumatic arthritis [32]. A prospective cohort study of 102 patients revealed a complex recovery trajectory: physical function significantly declined between baseline and 6 months, improved between 6 months and 1 year, and continued to improve slowly up to 5 years post-injury. Notably, only 64% of patients returned to baseline Short Form 36 (SF-36) scores at 5 years – a commonly used measure of quality of life, SF-36 PCS at 5 years [33]. The main predictors of quality of life are fracture type, reduction quality, and the occurrence of arthrosis [34], with social, demographic, and treatment variables also contributing to outcomes that remain generally poor even three years after injury[35].

Interestingly, patient satisfaction and functional outcomes in pilon fractures do not always correlate with radiographic findings [36]. Following union in ORIF patients, a complex pattern of altered joint mechanics emerges: decreased range of motion between the hindfoot and tibia in the sagittal and transverse planes, but increased range in the frontal plane during push-off as a compensatory mechanism [37]. Moreover, most patients show lower SF-36 scores than the general population two years post-treatment [33].

Complications remain a substantial concern, with an expected rate of 50-55% [38-40]. These can be further subdivided into major and minor complications. Among major complications, post-traumatic arthritis (21.3%) and nonunion (15.6%) were most frequent, while superficial infection (32.6%) and neuropathies (13.5%) were the predominant minor complications [40]. Risk factors for complications include open fractures, smoking history, and increased Charlson comorbidity index [39, 41]. A study by Shafiq et al. found that the number of approaches, type of approach, use of bone graft, and staging were not associated with infection outcomes. However, each additional 10 minutes of operative time over 120 minutes correlated with an increased rate of implant removal [41].

To mitigate infection risk, antibiotics are administered both pre- and postoperatively. A prospective study by O'Toole et al. found that intrawound vancomycin powder at the time of fixation was associated with a reduced risk of gram-positive infection, with a risk difference of -3.7% [42]. These findings underscore the importance of meticulous surgical technique and the appropriate use of prophylactic measures in managing these complex fractures.

Even under the most ideal circumstances, pilon fractures are associated with high complication rates and often result in suboptimal outcomes. This underscores the need for ongoing research to improve our understanding of these fractures and to develop more effective treatment and management strategies. Future studies should focus on long-term outcomes, more precise comparisons of treatment options, and strategies to prevent and manage complications.

This review has several limitations. Given the broad scope of this review, covering classification, evaluation, and various treatment methods, we had to exclude some details that might be relevant to specific aspects of pilon fracture management. Future reviews might benefit from a more focused approach to specific aspects of pilon fracture treatment.

CONCLUSION

Pilon fractures are complex injuries typically caused by high-energy impacts and require a multistage, multidisciplinary approach for optimal outcomes. The operative surgeon may consider a variety of treatment options, each with unique advantages and disadvantages. Regardless of the chosen treatment method, careful consideration of soft-tissue management is crucial.

Given the complexity of these injuries, we strongly recommend a multidisciplinary approach to management. This should involve close collaboration among orthopedic surgeons, plastic surgeons, physical therapists, and other relevant specialists. Treatment should be tailored to each patient's fracture pattern, soft-tissue condition, and overall health status.

Evidence-based note template (EPIC format)

Chief Complaint: {left/right/bilateral} pilon fracture, {associated injuries}

Date of Injury: **

Mechanism of Injury: {fall from height/motor vehicle accident, motorcycle accident, auto vs. pedestrian/**}

History of Present Illness: ** year-old {male/female} sustained a @mechanism of injury@ on @date of injury@ and presented on @TODAY@ for evaluation and treatment. Endorses pain in {left/right/bilateral} {lower extremity/**}. Unable to bear weight after injury. There was {no delay/delay of XX days prior to presentation due to**}. Endorses {left/right/bilateral} upper extremity pain following injury.

Prior ambulation status:
{No limitations}
Home: {wheelchair/walker/cane/without assistive devices/**}
Community: {wheelchair/walker/cane/without assistive devices/**}

Prior activity level:
{Sedentary/low demand/recreational} with activities including **

Past Medical History:
@PMH@

Past Surgical History:
@PSH@

Medications:
@MEDS@

Allergies:
@ALG@

Social History:
Tobacco:
Alcohol:
Illicit Drugs:
Lives {alone/with family/in supervised home/**}
Medical power of attorney: ** and phone number **

Family History:
@FAMHXNH@

Review of Systems:
CONSTITUTIONAL: Normal except as in HPI
EYES: Normal except as in HPI
HEENT: Normal except as in HPI
RESPIRATORY: Normal except as in HPI
CARDIOVASCULAR: Normal except as in HPI
GASTROINTESTINAL: Normal except as in HPI
GENITOURINARY: Normal except as in HPI
SKIN: Normal except as in HPI
HEMATOLOGIC/LYMPHATIC: Normal except as in HPI
ALLERGIC/IMMUNOLOGIC: Normal except as in HPI
ENDOCRINE: Normal except as in HPI
MUSCULOSKELETAL: Positive per HPI
NEUROLOGICAL: Normal except as in HPI
BEHAVIOR/PSYCH: Normal except as in HPI

Physical Exam:
Vitals:
@VS@
General:
No acute distress
Cardiovascular:
Regular rate and rhythm, warm and well perfused extremities
Pulmonary:
Non-labored breathing

{RIGHT/LEFT} Upper Extremity:
No lacerations, abrasions, or ecchymoses***
Tender to palpation ***
Compartments soft, compressible***
Range of motion: ***
No pain with passive motion of the fingers***
Able to abduct shoulder, flex and extend elbow, wrist, fingers, and thumb, finger abduction and adduction.
SILT axillary, musculocutaneous, median, radial, and ulnar nerve distributions
2+ radial pulse, brisk cap refill <2s

{RIGHT/LEFT} Lower Extremity:
No lacerations, abrasions, ecchymoses, blisters, open wounds, chronic skin or vascular changes***
Tender to palpation ***

Compartments soft, compressible ***
No pain with passive motion of the toes
Range of motion: {limited/deferred/**}
SILT superficial peroneal, deep peroneal, sural, saphenous, and tibial nerve distributions
2+ dorsalis pedis and posterior tibial pulses, brisk cap refill <2s

Laboratory:
@BRIEFLAB(HGB,WBC,MONOPERCENT,PLT,CA,BUN,CREAT,GLU,HGBA1C,ALB,CK,INR,APTT,ESR,CRP)@

Imaging:
X-ray:
{foot/heel/ankle AP, mortise, lateral/leg/knee}
{femur/hip/pelvis/lumbar spine as indicated}

CT with 3D reconstruction: (usually deferred until after ankle-spanning external fixation for fracture characterization with ligamentotaxis)

Consider ABIs and CT angiography if clinically warranted

Assessment:
@NAME@ is a @AGE@ @SEX@ who presents with ***

Plan:
- Admit to ***.
- Plan for OR (date***) for {external fixation application/arthrodesis} of {left/right} distal tibia
- Informed consent obtained by {patient/medical power of attorney}; risks, benefits, and alternatives discussed
- Additional work-up:
  - CBC, BMP, type and screen, PT/INR/PTT
  - EKG, CXR (as indicated)
- Activity: bedrest***; NWB*** in splint
- Foley ***
- VTE prophylaxis
- NPO for above
- Anesthesia consult for preoperative risk stratification.

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