Surgical Treatment of Tibial Plafond Fractures

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KEYWORDS

• Tibial plafond fractures • Pilon fractures • Internal fixation • External fixation • Surgery • Reconstruction

KEY POINTS

- Rotational distal tibial plafond fractures are usually associated with low-energy injuries.
- High-energy axial load injuries can result in tibial pilon fractures with severe intra-articular impaction, comminution of the metaphysis, and poor soft tissue envelope.
- Understanding the mechanism of injury, fracture pattern, and soft tissue injury is paramount to the patient's overall successful outcome.
- Open pilon fractures are surgically addressed in staged procedures with a thorough understanding of the role of free tissue transfer for major soft tissue defects.

INITIAL CARE PLAN

Ultimate success to the management of tibial plafond fractures stems from a logical systematic approach that is predicated on the overall assessment of the patient, fracture pattern, and associated soft tissue injury. Addressing the associated soft tissue injuries encountered with the tibia plafond fractures is paramount to the overall patient's successful outcome. Crushing injuries, open wounds, fracture blisters, and/or compartment syndrome are typically associated with the high-energy tibial plafond fractures. The surgical plan will need to be formulated early on at the initial presentation to determine whether a single or multiple staged procedures are required to achieve the definitive fracture reduction.

Tibial plafond fractures are often present among polytrauma patients with several body injuries. Although life-threatening trauma is a priority, the lower extremity needs

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to be assessed to determine if early care is required for stabilization in a temporary and expedited fashion. Fractures with severe instability, open fractures, and fractures associated with compartment syndrome may need to be addressed in an expedited manner and if the patient's general condition permits. Open wounds should be meticulously debrided and irrigated to prevent septic complications; fasciotomies should be performed for the compartment syndrome, and unstable fractures may need to be stabilized with spanning external fixators. Closed fractures that are stable may be managed with an early application of well-padded splints and until a definitive surgical treatment plan can be performed. A simple bar to clamp external fixators is most commonly used in these types of injuries because they provide reliable temporary fracture stabilization in an expedited manner until the definitive surgical treatment is performed.

STEPWISE APPROACH

Single-staged procedures are reserved for low-energy rotational tibial plafond fractures without soft tissue compromise and relatively healthy individuals. These fractures are typically associated with little impaction of the articular surface and involve large fracture fragments that make reduction feasible through a limited approach and/or percutaneous plating (**Fig. 1**). Typically, the fibular fractures encountered along with the rotational tibial plafond fractures are fixated first, while the tibia can be fixated by means of a limited open reduction and internal fixation (ORIF), percutaneous plating, or standard ORIF of the tibia.[1] High-energy axial loading tibial plafond fractures are definitively fixated once the soft tissue envelope permits.[2]

Understanding the fracture pattern and forces that led to failure of the tibia are paramount in formulating a surgical approach. The AO/OTA (Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association) classification system simplifies tibial plafond fractures into 3 broad categories with 3 subdivisions. Type A is extra-articular and is further divided into: A1: pure distal tibia metaphyseal fracture; A2: distal tibia metaphyseal wedge; and A3: complex distal tibia metaphyseal complex. Type B fracture is partially articular and is further divided into: B1: pure lateral split; B2: medial split with joint depression; and B3: posterior split with multiple fragmentary joint depression. Last, type C fractures are completely articular and are divided into: C1: articular fracture simple with metaphyseal fracture simple; C2: articular fracture simple with metaphyseal multifragmentary fracture; and C3: articular fracture multifragmentary with metaphyseal multifragmentary fracture.[3]

An associated tibia deformity with a varus or valgus component will alter the surgical approach and/or surgical construct to stabilize the tibia plafond. For example, a varus failure of the tibia is best treated with a medial buttress plate once the articular segment is secured (**Fig. 2**). On the other hand, a valgus failure of the tibia is better treated with an anterior-lateral plate. These basic principles of fixation will aid in neutralizing the major deforming forces that occur at the metaphyseal-diaphyseal junction and may prevent the incidence of hardware failure, malunion, and/or nonunion.

Preoperative planning is an essential part of the treatment of tibial plafond fractures. Careful evaluation of the preoperative radiographs will need to be compared and correlated with computed tomographic (CT) images to identify the individual fracture fragments that are amenable to reduction and those that need to be manipulated to gain access to areas of comminution. In many cases of high-energy and/or open tibia plafond fractures, the application of a spanning external fixator may need to be

Fig. 1. Anteroposterior (*A*) and lateral (*B*) radiographs of a low-energy rotational tibia and fibula pilon fracture. Postoperative anteroposterior (*C*) and lateral (*D*) radiographs demonstrate reduction of the associated fractures. The fibula was fixated using a posterior lateral incision, while the tibia was fixated through a limited open reduction and percutaneous plate fixation in a single stage reconstruction.

Fig. 2. Anteroposterior (*A*) and lateral (*B*) radiographs of a displaced tibia and fibula pilon fracture with varus deformity. Anteroposterior (*C*) and lateral (*D*) radiographs demonstrate an ORIF of the tibia pilon fracture with a medial buttress plate to neutralize the varus deformity. Definitive fixation of the tibia was performed 7 days after the initial ORIF of the fibula with a spanning external fixator.

performed in an expedited manner and before the CT imaging of the lower extremity. In those cases, CT imaging after the application of an external fixator provides a clinical benefit in regard to assessment of the fracture pattern and surgical approach to achieve definitive reduction. Obtaining CT scans for a grossly displaced tibia plafond fracture before the initial reduction will many times offer little information in regard to orientation of the fracture fragments and surgical approach.

FRACTURE PATTERN AND REDUCTION TECHNIQUES

OTA type A fractures require reduction of the tibial diaphysis to the articular segments. Emphasis is placed on applying internal plate fixation that counteracts with the deforming force of the tibia. Concomitant comminuted metaphyseal segments are associated with higher nonunion rates. Bone defects can be managed with simultaneous autogenous bone grafting versus placement of antibiotic cemented spacers and delayed autogenous bone grafting. In addition, plate osteosynthesis for these fractures should provide adequate stability and compression. OTA type B and C fractures often display significant impaction of the articular osteochondral surface. Understanding the common fracture fragments that are present on the articular surface is important in achieving a congruency of the articular joint.

The most common fracture fragments encountered are the posterior-lateral, anterior-lateral, medial, and central impaction (**Fig. 3**). The posterior-lateral fracture fragment is the essential fracture fragment to reduce first as the remainder of the articular reduction is fixated to the posterior-lateral fracture fragment. Larger posterior-lateral fragments are more amenable to plate fixation across the tibial metaphyseal-diaphyseal junction. Difficulty arises among smaller and significantly displaced posterior-lateral fracture fragments. Often, the ligamentous structures of the ankle remain intact after tibial plafond fractures and reduction of the posterior-lateral fracture fragment can be achieved through anatomic reduction of the fibula. Reduction can be carried out either through a posterior-lateral approach or by reflection of the anterior-lateral fragment and reduction by placement of a large pin fixation or curved periosteal elevator. Once the posterior-lateral fragment is reduced, the medial fragment is reduced and stabilized to the posterior-lateral fragment. The central impaction can then be addressed and stabilized followed by reduction of the anterior-lateral segment. Initially, reduction is performed with the placement of multiple Kirschner wires. Once the articular surface is congruent, Kirschner wires can be exchanged for screw fixation. Once reduction of the articular segment is achieved, plate osteosynthesis can be applied to secure the articular segment to the diaphysis. Additional reduction of the metaphysis and diaphysis can be performed with lag screws as necessary.

In certain cases, multiplane circular external fixators can be useful to achieve axial alignment and osseous union by avoiding fixation constructs that would interfere with eventual ankle arthrodesis (**Fig. 4**). Other options consist of a primary ankle arthrodesis with bone grafting using a blade plate or intramedullary nail. A circular external fixator can be used or combined with a blade plate and/or intramedullary nail if a primary ankle arthrodesis is performed.[4]

Open pilon fractures with extensive soft tissue loss require staged osteosynthesis with planned free tissue transfer. In addition, delayed autogenous bone grafting is often required to achieve union. In some cases, a proximal leg amputation may be indicated among these devastating injuries especially if neurovascular injury is evident in the presence of significant comminution, bone loss, and extensive soft tissue injury.

Fig. 3. Anteroposterior (*A*) and lateral (*B*) radiographs of a severely comminuted tibia pilon fracture. Note the common fracture fragments encountered consist of the anterolateral, posterolateral, medial fragment, and central comminution. This fracture pattern was also associated with a comminuted fracture involving the tibial metaphysis. Anteroposterior (*C*) postoperative radiograph demonstrates an ORIF of the fibula with spanning external fixation of the tibia. Postoperative long-term anteroposterior (*D*) and lateral (*E*) radiographs demonstrate successful union with posttraumatic arthritis of the ankle.

Fig. 3. (*continued*)

SURGICAL INCISIONAL APPROACHES

Anteromedial

The most common exposure to the tibial plafond fractures is an anteromedial approach. The traditional anteromedial approach allows for excellent exposure and visualization of the anterior and medial aspects of the plafond with limited lateral exposure unless the incision is slightly modified. Typically, the traditional incision is started 1 to 1.5 cm lateral to the anterior crest of the tibia and over the anterior compartment and fashioned distally to travel just medial to the tibialis anterior tendon. A full-thickness skin and subcutaneous tissue flap is elevated until the anterior tibial tendon is encountered. The extensor retinaculum and periosteum just medial to the anterior tibial tendon is then incised. A full-thickness flap that includes the skin, subcutaneous, and periosteal tissue is then elevated from the distal tibial metaphyseal region. Elevation of the anterior compartment allows for better access to the lateral aspect of the tibia. A longitudinal arthrotomy is performed at the interval of the main fracture split of the anterior tibial plafond and is extended to the level of the talar head. If an external

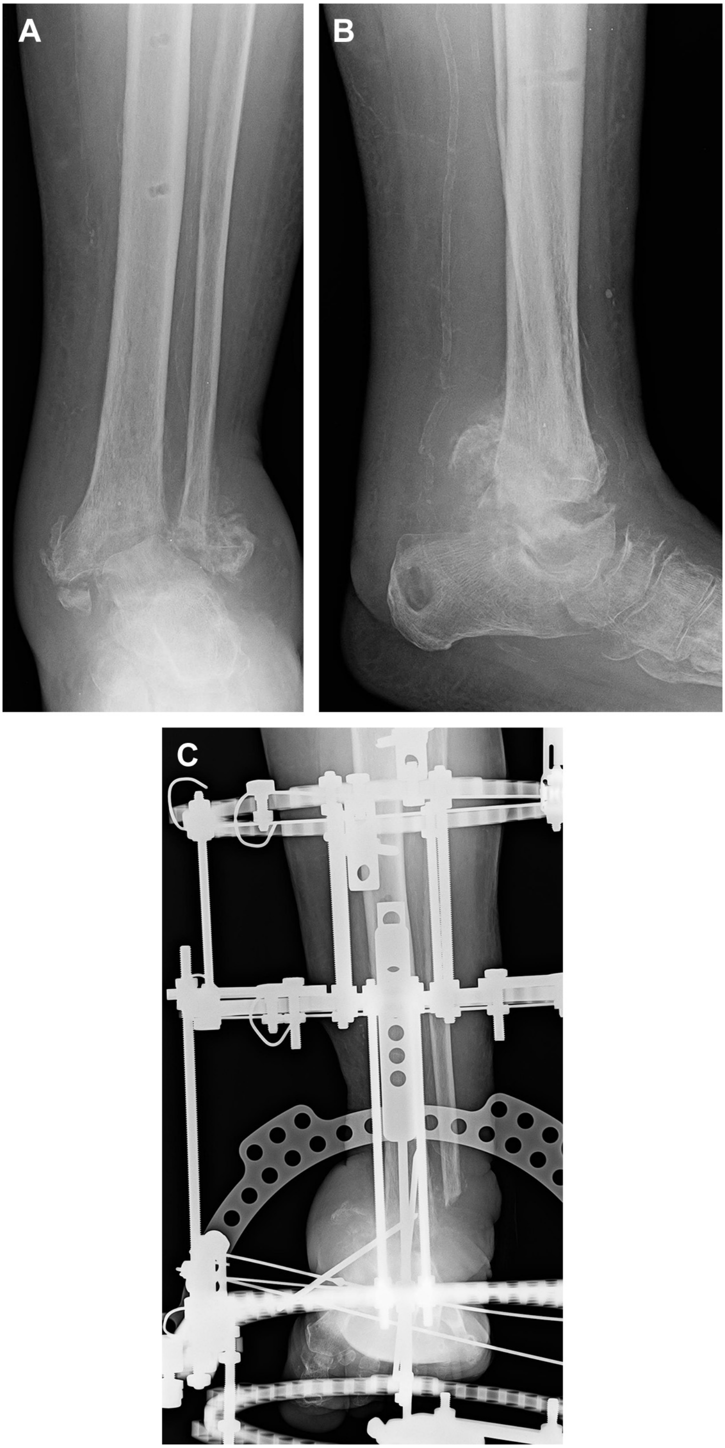

Fig. 4. Anteroposterior (*A*) and lateral (*B*) radiographs of a closed tibial plafond fracture in a patient with diabetic neuropathy with uncontrolled diabetes with peripheral arterial disease and multiple medical comorbidities. Primary tibiotalocalcaneal arthrodesis was performed with a multiplane circular external fixator (*C*, *D*). Postoperative long-term anteroposterior (*E*) and lateral (*F*) radiographs demonstrate successful fusion.

Fig. 4. (*continued*)

fixator was initially used to span the ankle joint, it can be reassembled to maintain distraction across the ankle to facilitate fracture reduction. Often, if a spanning external fixator was applied to initially stabilize the tibial plafond, the bars are disassembled before preparing the lower extremity, but the transcalcaneal and proximal half pins are not removed to allow reassembly of the spanning bars to serve as a distractor intraoperatively. If an external fixator was not initially used for a temporary fixation, a femoral/universal distractor can then be applied by placing a 4-mm Schantz pin into the medial aspect of the talar neck under direct visualization. An additional Schantz pin is then placed into the medial aspect of the proximal tibia diaphysis to allow for necessary distraction.

Anterolateral

The anterolateral approach is performed through an incision over the anterior lateral aspect of the ankle joint in alignment with the fourth metatarsal. After the skin incision is performed, the superficial peroneal nerve is identified and retracted medially. The extensor retinaculum and the fascia to the anterior compartment are then incised and the anterior compartment is raised and retracted medially. A longitudinal arthrotomy is made along the medial edge of the anterior-lateral (Chaput) fracture fragment (**Fig. 5**). This surgical exposure is advantageous to address any valgus angulation, significantly displaced Chaput fracture fragments, displaced posterior-lateral (Volkmann) and centrally impacted tibial plafond fracture fragments.[5] Limitations of the anterolateral approach are poor visualization of the medial tibial plafond and placement of internal fixation of the medial aspect of the distal tibia. Often, percutaneous plates can be placed medially if required. The anterolateral approach should be avoided for varus angulation and impaction of the medial tibial plafond. In addition, the skin bridge of an anterolateral approach if the fibula was fixated needs to be considered to avoid skin necrosis. Often, the fibula is fixated first through a posterior lateral incision followed by delayed fixation through an anterolateral incision that can be performed at a later stage and when the soft tissue envelope permits.

Direct Lateral Approach

The direct lateral approach to both the distal tibial plafond and the fibula is performed through a single incision fashioned over the fibula and extended distally in a curvilinear fashion at the tip of the fibula to the anterior process of the calcaneus. Dissection is carried down between the interval of the lateral and anterior compartments. Identification of the superficial peroneal nerve in the subcutaneous tissue is required and usually raised with the anterior compartment. The anterior compartment is raised with an intact soft tissue envelope of the tibia with blunt dissection preserving the angiosome of the anterior tibial artery. The ankle joint is exposed through a lateral longitudinal arthrotomy that is extended to the talar neck. This surgical incisional approach offers many advantages because a single incision is used, can provide access to concomitant comminuted fibula fractures associated with displaced lateral tibial plafond fractures, allows for direct visualization and reduction of valgus deformities of the tibial plafond with anterolateral plating, and, last, its exposure over the anterior compartment provides excellent soft tissue coverage over the bone and hardware.[6] Some limitations of this incision include its minimal exposure of the medial aspect of the tibial plafond. Medial malleolar fractures can be visualized and percutaneous screws can be placed, but difficulty would arise with more comminuted or impacted medial tibial plafond fractures such as those with an associated varus deformity. This direct lateral approach is usually advantageous for staged reconstruction of open pilon fractures that are associated with a medial wound and valgus deformity of the tibia.

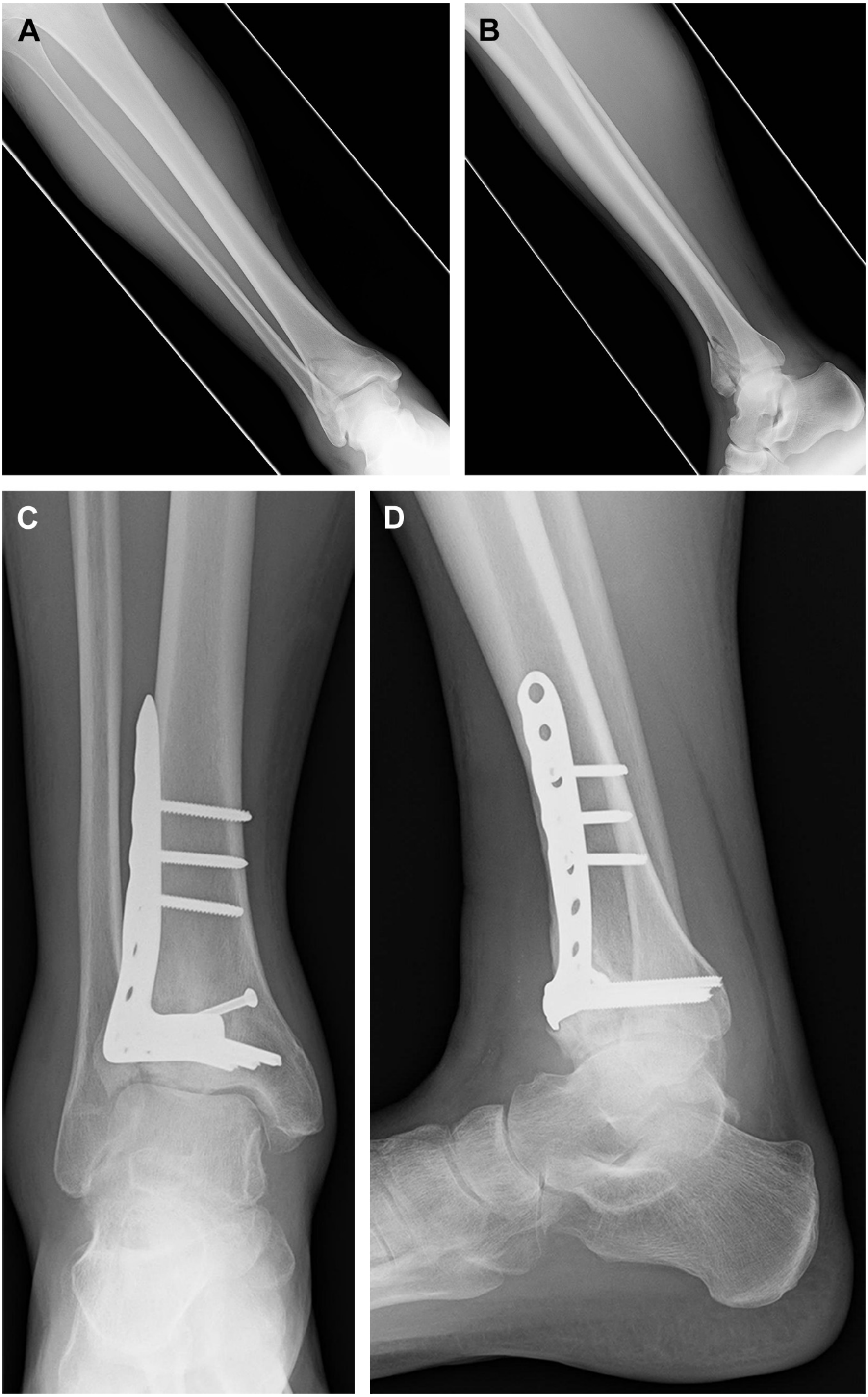

Fig. 5. Anteroposterior (*A*) and lateral (*B*) radiographs demonstrate a displaced tibial anterolateral "Chaput" fracture fragment with central impaction. Postoperative anteroposterior (*C*) and lateral (*D*) radiographs demonstrate an ORIF of the distal tibia through an anterolateral surgical exposure.

Fig. 6. Anteroposterior (*A*) and lateral (*B*) radiographs of a displaced tibia and fibula pilon fracture. C-arm fluoroscopy anteroposterior (*C*) and lateral (*D*) views after osteosynthesis of the fibula. Note the near anatomic reduction of the tibia secondary to ligamentotaxis. Postoperative long-term anteroposterior (*E*) and lateral (*F*) radiographs of the same injury after definitive ORIF of the tibia.

OSTEOSYNTHESIS OF THE FIBULA

A common surgical approach to staging tibial plafond fractures is to perform an ORIF of the fibula at the time the spanning external fixator is applied. The decision to address the fibula during the initial stage along with the application of a spanning

Fig. 6. (*continued*)

external fixator should be considered on the fracture pattern of the tibia, whether the fibula fracture is simple or complex, and the staged incisional placement that will be required to achieve definitive reduction of the tibial plafond. Fixation of the fibula is an important part of the initial reduction of tibia plafond fractures. Fibula fractures along with tibia plafond fractures differ in their fracture pattern when compared with low-energy rotational ankle fractures. If the fibula is fractured along with the tibia plafond fracture, they typically present in a comminuted, transverse, or oblique fracture pattern. Bone loss and mal-rotation are commonly encountered. For this reason, reduction needs to focus on providing stable constructs that allow restoration of fibula length, axial alignment, and rotation. Small fragment reconstruction plates, stacked one-third tubular plates, and/or dynamic compression plates for complex fibula shaft fractures are rigid and provide more stability versus one-third tubular plates that are commonly used for low-energy rotational lateral malleolar ankle fractures. Fixation

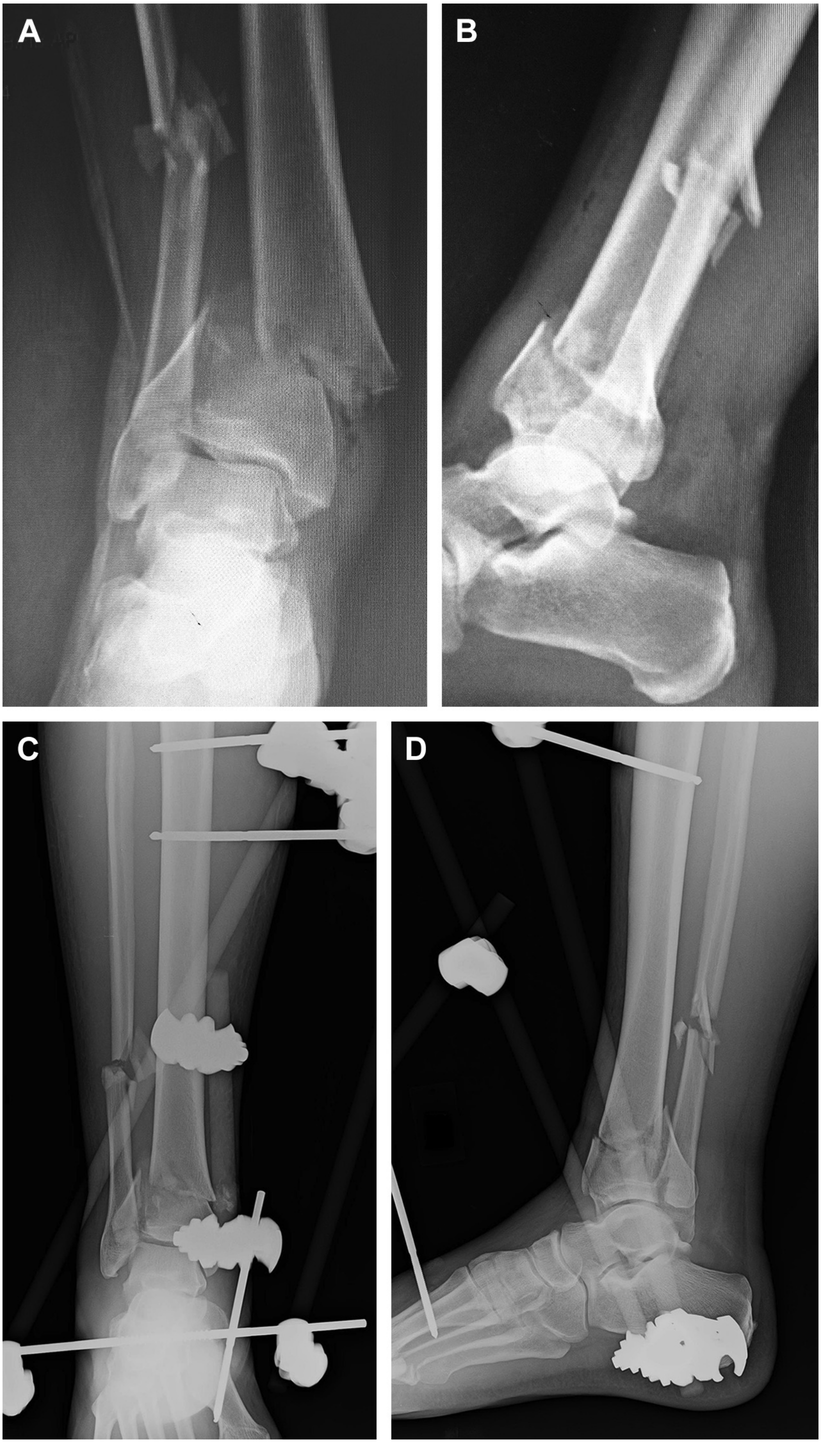

Fig. 7. Anteroposterior (*A*) and lateral (*B*) radiographs of an open tibia and fibula pilon fracture. Anteroposterior (*C*) and lateral (*D*) radiographs after surgical debridement of the open fracture and spanning external fixation. Postoperative anteroposterior (*E*) and lateral (*F*) radiographs of the fibula shaft and tibial plafond fracture fixated through a direct lateral approach. The tibia was fixated first given the degree of fracture comminution and bone loss noted to the fibula.

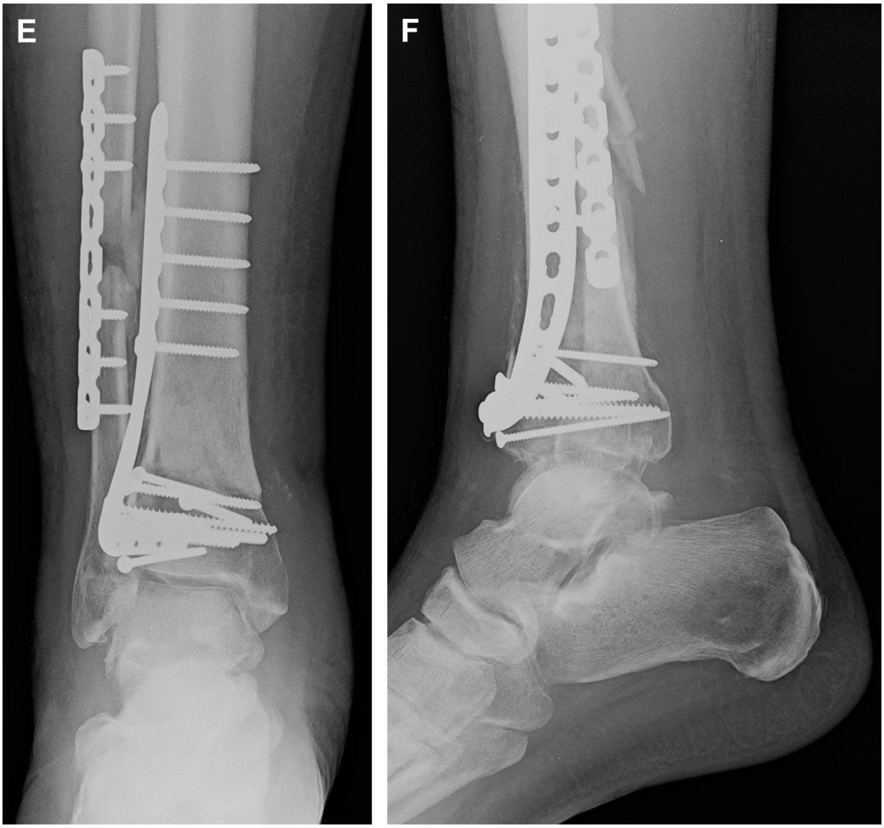

Fig. 7. (*continued*)

of simple fracture patterns of the fibula will provide reduction of most of the tibia plafond deformity secondary to the remaining ligamentous attachments (**Fig. 6**).

Fibular reduction is also beneficial to counteract significant valgus angulation and/or lateral translation of the tibia. However, in certain tibia plafond fractures that display significant valgus angulation with a concomitant comminuted fibula shaft fracture, a single direct lateral approach to address both the tibia and the fibula in one surgical setting may be at times advantageous. In open fractures with the aforementioned pattern, initial debridement of the open fracture and spanning external fixation is applied, while the tibia and fibula can be fixated through a single extensile lateral incision in staged fashion. In addition, complex fibula fractures are preferably addressed after reconstruction of the tibia (**Fig. 7**). The syndesmosis ligamentous structures are usually intact, and therefore, realignment of the fibula occurs with reduction of the tibia, especially of the anterior-lateral and posterior-lateral fracture fragments of the tibia. Although reduction and stabilization of the fibula are important parts in the management of tibia plafond fractures, careful consideration is given to the staged surgical approach for definitive fixation and before proceeding with fixation of the fibula during the initial surgical stage.

Fig. 8. Anteroposterior (*A*) and lateral (*B*) radiographs of an open tibial plafond fracture with significant comminution of the tibial metaphyseal-diaphyseal region. Postoperative long-term radiographs (*C*, *D*) show the nonunion of the metaphyseal-diaphyseal segment of the tibia, which was also confirmed with CT. Final anteroposterior (*E*) and lateral (*F*) radiographs demonstrate successful union with autogenous bone grafting to repair the tibia nonunion.

Fig. 8. (*continued*)

POSTOPERATIVE COMPLICATIONS

Although tibial plafond fractures are associated with many potential complications, those that require further surgery are the most challenging. Subsequent surgery may be required for wound-healing complications, infection, malunion, nonunion, and posttraumatic arthritis.[2,7] Prompt attention to infected wounds and/or osteomyelitis with meticulous debridement is paramount to promote healing. Wounds with exposed bone and/or hardware may require hardware removal and excision of all infected nonviable bone and soft tissue to provide a wound bed amenable to plastic surgery reconstruction. Bone transport, autogenous bone grafting, realignment osteotomies, and/or ankle arthrodesis may be necessary for the postoperative management of tibial plafond complications (Fig. 8).

SUMMARY

The treatment necessary for tibial plafond fractures is best determined on an individual basis. Tibial plafond fractures and associated soft tissue injuries can be quite challenging to the surgeon, and careful attention is paid to the initial injury as well as the entire thought process of staged reconstruction when necessary. Treating these injuries in an efficient and expedited manner can prevent frequent complications encountered in this patient population.

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