6 Revision Surgery for Pilon Fractures

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Introduction

Fractures of the distal tibial plafond are notorious for their poor outcomes even with the most meticulous management. These injuries can occur as a result of lower energy rotational forces or more typically as higher energy mechanisms. There is often substantial articular injury with varying degrees of impaction. Most importantly, this injury pattern represents a significant soft tissue injury, which often dictates the management of pilon fractures. Currently the standard of care is for staged reconstruction, with initial external fixation and definitive surgical stabilization once the soft tissues are healthy [1, 2]. Despite thoughtful consideration when treating these injuries, multiple complications can occur such as nonunion, malunion, infection, avascular necrosis (AVN), and post-traumatic arthritis [3–10].

There are multiple complications that can occur during treatment. Open pilon fractures significantly impact the soft tissue envelope [9]. Proper antibiotic and debridement techniques are needed initially, and then consideration for future planning of fixation is needed. Multiple studies have shown increased risk of infection and nonunion with open pilon fractures [3, 10]. Patient factors also contribute to potential causes of complications. Comorbidities such as diabetes mellitus (DM), peripheral vascular disease (PVD), and chronic steroid use among others may affect the soft tissue and bone healing potential. Careful consideration should be paid not only to the fracture but also to the patient as a whole. Even with ideal management of the fracture in the primary setting, patients still have fair to poor outcomes. The management of complications for pilon fractures is extremely complex and requires significant planning.

Pathoanatomy

The reason for poor outcomes for these injuries relates to the mechanism of injury. Pilon fractures are, by definition, impaction injuries of the distal tibial articular surface. This results in immediate injury to the cartilage which cannot be undone. Even with anatomic realignment of the articular surface and restoration of the anatomic axis, there is still the damage done at the time of impact which permanently affects the cartilage. This can lead to avascular necrosis (AVN) of the tibial plafond, and if collapse occurs early, symptomatic post-traumatic arthritis occurs.

Additional causes for poor outcomes relate to anatomic reasons. The metaphyseal-diaphyseal junction of the distal tibia has a poor blood

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supply which puts it at risk for nonunion [11]. The soft tissue injury creates disruption of that blood supply. In addition, surgical dissection causes further disruption, which is why meticulous dissection and careful incision planning is crucial. Additional patient risk factors such as smoking, peripheral vascular disease, or diabetes mellitus can increase the risk of nonunion.

Pilon fractures often have significant comminution involving the articular surface, metaphyseal region, as well as the fibula. While obtaining an anatomical reduction of the articular surface is paramount, the main goal of treating the tibial metaphyseal region and fibula is to restore alignment and rotation [12]. Without this, malunions will occur, and these are more difficult to deal with in the future, particularly in the setting of traumatic arthritis [5, 7]. Malreduction of the fibula can complicate future reduction of the fibula and may inhibit future incisions. As this is often done at the time of external fixation, current recommendations are to let the surgeon who will treat the fracture definitively address the fibula. With respect to the tibial metaphysis, there is often significant medial comminution. Shortening of the medial column of the tibia can lead to varus malunions affecting the mechanical axis.

All of the above are issues that are difficult to treat during the primary surgery. When considering revising a pilon, correcting deformity becomes even harder. As a result, the common response to revising a pilon is ankle fusion or in the case of poor soft tissue coverage, amputation. Options to preserve the ankle joint are supported by few case reports and case series.

Evaluation of the Patient and Reason for Failure

History and Physical Examination

The first step in performing a successful revision pilon is determining why the original procedure failed. Since patient factors are a major cause of failure in pilon fracture fixation, a thorough patient history is important. Knowing the mechanism of the injury as well as whether the fracture was open or closed can give a good picture of the amount of soft tissue damage that occurred at the time of injury. Details on the treatment course are critical, including timing and number of operations, initial external fixation, and known early complications. All of these factors play a role into what type of options exist for reconstruction.

Patient medical and social history is another important and potentially modifiable factor. A history of diabetes and the patients' Hgb A1C, PVD, and controlling an autoimmune condition are all important for maximizing blood supply and healing potential. If the patient has an elevated Hgb A1C (>7), the patient should be referred to endocrinology for tighter glucose control. In a patient with a history of PVD or poor peripheral pulses, a consult with a vascular surgeon could resolve an upstream blockage. While autoimmune disease cannot be cured, the DMARDs used to treat the patient should be noted and held as needed. The patient's social situation is also an important directing factor in the patients care. Nicotine is well-known to cause small vessel constriction and leads to a high nonunion rate. Drug abuse and uncontrolled psychiatric disorders may be considered a contraindication to revision ORIF due to the increased risk of noncompliance and poor outcomes.

There should also be a thorough physical exam noting prior incisions, ankle function, and clinical deformity. Prior incisions should be used for any revision surgery planned, if appropriate, as additional incisions may destroy any remaining blood supply to the soft tissue envelope. A thorough neurovascular exam is performed, including assessment for neuropathy. Range of motion of the ankle, hindfoot, and transverse tarsal joints should be evaluated. Patients with significantly limited motion at the ankle may not benefit from joint-sparing reconstruction. The overall alignment of the limb should be assessed clinically with the patient standing. Alignment in the coronal and sagittal planes should be inspected as well as any limb length discrepancies. Patients with pilon fractures can sometimes have had ipsilateral proximal injuries which may affect alignment distally and should be factored into planning.

Imaging

Weight-bearing ankle and foot radiographs are used to evaluate the overall alignment of the limb and ankle joint as well as the amount of joint space narrowing and arthrosis. If needed, full length tibia and fibula imaging should be ordered to evaluate deformity proximal to the fracture. The mortise should be inspected to evaluate for asymmetry, articular collapse, or sclerosis. Fibular length and reduction can be seen on plain radiography. Residual hardware should be inspected for articular penetration, and if further surgery is considered, removal of the hardware, in particular broken hardware, may present a challenge and will need preoperative planning.

Computed tomography (CT) scan is an extremely useful tool in preoperative planning for revision pilon surgery. It offers a detailed picture of the bony architecture [13]. Alignment can be seen in a three-dimensional orientation. The accuracy of the articular reduction or extent of existing arthrosis can be seen. Mal- or unreduced fragments can be evaluated. Also sclerosis indicative of AVN may be seen in different areas of the plafond. For patients with deformity but a well-preserved articular surface, joint-sparing procedures can be considered. For patients with extensive arthrosis or articular collapse, arthrodesis or ankle replacement may be a better option. Additional information that can be seen on the CT scan includes articular reduction or instability of the syndesmosis. For patients with suspected osteomyelitis, areas of resorption or sequestrum may be identified.

If possible reviewing the initial imaging studies including radiographs and CT imaging is important. This information can provide important bony detail of the initial injury and the quality of the initial reduction. Comparing these to current radiographs can offer information on varus (or valgus) malunion versus collapse and also if there has been collapse or malreduction of the articular surface.

Diagnostic Studies

Aside from imaging, additional diagnostic studies should be performed. As with any revision surgical procedure, a workup of infection should be performed. This includes obtaining a white blood cell count (WBC) with differential, C-reactive protein (CRP), and an erythrocyte sedimentation rate (ESR). Elevated values of any of those laboratory values should be concerning for infection, and this may alter the proposed procedure. Even with normal laboratory values, there can be a subclinical infection. The rate of this can be as high as 20% [14]. Because of this, a bone sample should be sent during the reconstructive procedure. Patient should be counseled about the possibility of encountering infection during the procedure, which may alter the postoperative course.

Surgical Planning/Considerations

A variety of factors should be considered with as part of the preoperative plan. Prior incisions, retained hardware, and residual deformity must be considered when preparing for reconstruction. All of these factors play a role in determining positioning, surgical exposure/incisions, and equipment needs.

Retained Hardware

The presence of retained hardware is an important consideration. The surgeon should determine if all or just some of the hardware needs to be removed. Ideally only the hardware that will be in the way of new hardware or any needed osteotomy should be removed. It is beneficial to know the type of hardware that was used. This can be accomplished through prior operative records or electronic medical records. Obtaining outside records is also important if the procedure was done at another facility. It is important to have the proper screwdriver trays and nail extraction devices. In addition to this, broken screw removal sets and osteotomies are beneficial for difficult to remove hardware.

Patient Positioning

Patient positioning is dependent on what surgical approach(s) will be utilized. Most commonly patients will be placed in a supine position. However, if posterior or posterolateral approaches had been used before with indwelling hardware, a prone position may be useful. However, visualizing the articular surface is difficult in the prone position, and reconstructive procedures/osteotomies may be difficult to complete with the patient in the prone position. At times a prone and then supine positioning is needed. This may require additional time and planning. As an alternative to doing front/back procedures, lateral positioning can be used which allow the surgeon to access the posterolateral and anterior aspect of the lower leg.

Surgical Approaches

During preoperative planning, an approach to correcting the deformity must also be formulated. Due to the nature of the soft tissues in this area, prior trauma to the soft tissue envelope must be considered. If the original injury was an open fracture or a flap needed to be placed, these areas should be avoided. Ideally, the reconstructive procedure should be done through prior approaches whenever possible. However, the surgeon should not compromise exposure by using prior incisions. If a long incision with significant soft tissue stripping was used previously, another extensile incision should be avoided to limit additional soft tissue disruption. Percutaneous techniques may also be beneficial in this scenario, if appropriate.

Use of the anteromedial and anterolateral approaches would be appropriate if these approaches had been used previously [5, 15, 16]. A posterolateral approach is very useful for addressing both the posterior tibia and the fibula through one incision and can be used in combination with another anterior approach.

The author's preferred approach is the anterior approach as it provides the best visualization for the distal tibial metaphysis and articular surface. This approach has typically been described as the plane between EDL and EHL, but in practice the interval between EHL and TA is typically used. By using the latter plane, the neurovascular bundle can be protected under the EHL and retracted laterally. On exposure of the articular surface, the joint can be examined. If the joint is well preserved, this approach allows for osteotomies to be performed in order to restore alignment. If joint salvage is not an option, this approach gives excellent joint visualization for cartilage debridement for fusion and is also a common approach for TAA.

Case Examples

Case 6.1 Infection Case

History

A 29-year-old male sustained a closed, comminuted pilon after falling 7 feet from a ladder. He underwent external fixation for temporary stabilization of the fracture, while the soft tissues healed (Fig. 6.1a). At his initial office visit, he had fracture blisters primarily anterolaterally necessitating delayed fixation. One week after injury, he had initial fixation using a posterolateral approach for initial fixation of the fibula and posterior fixation of the tibia. Ten days after posterior fixation, the patient underwent an anterolateral approach for anterior fixation of the tibia. The medial malleolus was also reduced percutaneously through a small medial incision (Fig. 6.1b). For the next 3 weeks, the patient had continued drainage from his anterior incision and continued pain. Four weeks following stabilization, he was taken to the operating room for serial irrigation and debridement procedures and ultimate hardware removal. Cultures taken at the time of surgery grew methicillin-sensitive *Staph. aureus*. The patient was discharged on oral Keflex. He was then referred for treatment of his infection.

Fig. 6.1 (**a**) AP (left) and lateral (left center) radiographs of a 29-year-old male with a comminuted, closed pilon fracture. AP (right center) and lateral (right) fluoroscopic images following external fixation. (**b**) Lateral (left) and AP (left center) fluoroscopic images of initial posterior fixation of the tibia and fixation of the fibula through a posterolateral approach. Definitive fixation was performed after the soft tissues stabilized through an anterolateral approach. AP (right center) and lateral (right) fluoroscopic images are shown. (**c**) Immediate AP (left) and lateral (right) images were obtained following revision irrigation and debridement and temporary external fixation. (**d**) Following a 6-week antibiotic course, the patient underwent conversion to ankle arthrodesis. AP (left) and lateral (right) radiographs were obtained at 7 months showing a well-healed fracture and arthrodesis

Reasons for Failure

- Delayed recognition of infection/wound issues.
- Delayed and incomplete course of appropriate antibiotics.
- No stabilization of unhealed fracture was performed causing deformity.

Surgical Plan

- Stabilize fracture with external fixator.
- Repeat debridement with bone cultures.
- Removal of external fixator with arthrodesis after completion of antibiotics.

Approach

- Anterolateral ankle approach (previous)
- Percutaneous 7.3 mm lag screws

Implants

- External fixator
- 7.3 mm cannulated screws
- 3.5 mm reconstruction plate with 4.0 mm cortical screws

Pearls and Pitfalls

- The potential for encountering residual deep infection
  - Need intraoperative cultures
- Accounting for bone loss (infection) and post-traumatic cysts
- Need for correction of deformity (anterior translation of the talus)

Surgery

The patient was taken back to the operating room for repeat irrigation and debridement with intraoperative cultures. To provide stability, the patient was then placed into an external fixator (Fig. 6.1c). The patient had a PICC line placed and completed a 6-week course of culture-specific intravenous antibiotics. He was followed weekly in the clinic for evaluation of his soft tissues. One week after cessation of antibiotics, a repeat ESR, CRP, and WBC were obtained and were within normal limits. At this point revision surgical treatment with fusion was planned with repeat intraoperative bone cultures.

Intraoperatively, there were no overt signs of infection. His previous anterolateral ankle wound was used for exposure of the joint. All devascularized bone was removed and the ankle joint prepared for fusion. Autologous iliac crest bone grafting is performed, including bulk grafting for areas of bone loss. Deformity correction was performed and held temporarily with Steinmann pins. Two 7.3 mm cannulated screws were placed percutaneously across the ankle joint. Through the previous anterior ankle wound, a 5 hole, 3.5 mm reconstruction plate was contoured to the anterior joint and affixed to the tibia and talus using 4.0 mm cortical screws. The patient was placed on intravenous antibiotics awaiting final culture results. Cultures ultimately grew MSSA and methicillin-resistant coagulase-negative staphylococcus from his bone cultures. He was kept on intravenous antibiotics for an additional 6 weeks.

Postoperatively, he eventually healed all wounds. After completion of his antibiotics, his inflammatory markers remained within normal limits. He healed with a solid fusion of his ankle joint with good motion at this midfoot and subtalar joints (Fig. 6.1d). He was able to return to work at approximately 6 months following his revision surgery.

Case 6.2 Infection/Immunocompromised

History

A 46-year-old female with a PMH of stroke, lupus, diabetes, and tobacco abuse presented after a high-speed motor vehicle collision with a comminuted, open pilon fracture with a 4 cm anterior wound (Fig. 6.2a). The patient was taken to the OR the same day for formal irrigation and debridement as well as placement of an external fixator (Fig. 6.2b). At the patient's first post-op follow-up visit, she was noted to have erythema and serosanguineous drainage with wound breakdown. The patient was directly admitted to the hospital and started on IV antibiotics. Cultures obtained intraoperatively grew vancomycin-resistant *Enterobacter*. The patient completed the course of antibiotics and had progressive healing of her wound. Two weeks after the initiation of antibiotics, the uniplanar external fixator began to fail with loosening of the pins. At this point the patient was taken to the OR for external fixator removal and placement in a short leg cast. Intraoperatively the external fixator was removed and all pin sites thoroughly debrided. The leg was then stressed, and motion was noted across the fracture sites. The patient was casted for fracture stability. At her first postoperative follow-up, she was noted to have worsening of her wound and deformity, and follow-up CT scan revealed continued nonunion (Fig. 6.2c). She was referred for definitive treatment.

Reasons for Failure

- Multiple medical comorbidities/ immunocompromised.
- Inadequate fracture stabilization/external fixator construct.
- No stabilization of unhealed fracture was performed causing deformity.

Surgical Plan

- Stabilize fracture with external fixator.
- Repeat debridement with bone cultures.
- Staged autologous bone grafting.

Approach

- Anterior ankle approach (previous)
- Percutaneous lateral incision for fibular bone grafting

Implants

- Multiplanar external fixator

Pearls and Pitfalls

- The potential for encountering residual deep infection
  - Need intraoperative cultures
- Need for correction of deformity

Surgery

The patient was taken back to the operating room for irrigation and debridement with repeat bone cultures and placed back into an external fixator. Given the patients multiple comorbidities, it was felt she would benefit from placement into a multiplanar external fixator with a bypass frame to allow for early weight-bearing. A multiplanar fixator was applied, and correction of the deformity was corrected (Fig. 6.2d). Intraoperative bone cultures were negative at that time. She completed her intravenous antibiotic course, and inflammatory markers were negative. The patient was taken back to the operating room for treatment of her impending nonunion. The fracture site was accessed through a small extension of the previous open wound, and the fibrous tissue at the nonunion site was debrided. Then the nonunion site of the fibula was taken down as well at this time through a small incision. Both sites were bone grafted with iliac crest autograft. Final cultures taken from the OR were found to be negative.

Postoperatively, the patient was followed in the clinic. Once the wound was healed, the patient was allowed to bear weight through her fixator. At 5 months following placement of the fixator, A CT scan was obtained that revealed bridging bone across both the fibula and tibia fractures (Fig. 6.2e). The fixator was removed at 6.5 months. Final radiographs were obtained at 12 months which revealed a well-healed, well-aligned fracture (Fig. 6.2f). The patient reported no pain and had returned to work without restrictions.

Case 6.3 Delayed Presentation

History

A 43-year-old migrant worker male presents 2 weeks after injury for definitive fixation of his pilon fracture. He initially sustained his injury after reportedly being tackled while playing soccer (Fig. 6.3a). The patient was placed into a splint and instructed to follow up as an outpatient. He presented back to the ED for management almost 5 weeks from injury. The swelling was amenable to surgery, and the patient had minimal pain. Initial radiographs in his splint revealed significant deformity (Fig. 6.3b). A CT scan was obtained which revealed significant comminution and articular displacement.

Fig. 6.2 (**a**) AP (left) and lateral (right) images of a 46-year-old female with multiple medical comorbidities who sustained an open comminuted pilon fracture. (**b**) Initial irrigation and debridement and uniplanar external fixation was applied with improved alignment on AP (left) and lateral (right) fluoroscopic imaging. (**c**) The patient had wound dehiscence and loosening of her external fixator that required removal. AP (left) and lateral (center) show a continued nonunion with a large lucency at her calcaneal pin site best seen on the lateral image. A CT scan image (right) reveals persistent fracture lines at the articular surface and metaphysis. (**d**) The patient was placed into a mutiplanar external fixator. AP (left) and lateral (right) fluoroscopic images were obtained following repeat irrigation and debridement and stabilization of the fracture. (**e**) Coronal CT scan images reveal bridging bone at the level of the articular surface and metaphysis of the tibia (left) as well as healing of the fibula fracture (right). (**f**) AP (left), mortise (center), and lateral (right) radiographs were taken at 12 months showing a well-healed, well-aligned pilon fracture with minimal arthritic change

Fig. 6.3 (**a**) AP (right) and lateral (left) radiographs of a 43-year-old migrant worker who injured his leg. (**b**) The patient remained in a splint for 5 weeks following injury. AP (left) and lateral (right) images reveal continued displacement and significant articular comminution. (**c**) The patient was first placed prone and underwent stabilization of the fibula and posterior tibia through a posterolateral approach as seen on AP (left) and lateral (right) fluoroscopic imaging. (**d**) The patient was then placed supine and underwent ORIF with primary fusion through and anterior incision. AP (left) and lateral (right) fluoroscopic images reveal restoration of length and alignment. (**e**) AP (right) and lateral (left) radiographs were obtained at 8 months following surgery showing a healed ankle arthrodesis and fracture

Reasons for Failure

- Delayed presentation
- Inadequate initial fracture reduction
- Partially healed comminuted articular surface

Surgical Plan

- Use an external fixator to regain length.
- Posterior tibial ORIF.
- Anterior tibial ORIF.
- Ankle arthrodesis.

Approach

- Posterolateral
- Direct anterior approach

Implants

- Small fragment implants
- Small fragment “spoon” plate
- 4.0 mm cortical screws

Pearls and Pitfalls

- Need to deal with partially healed displaced fragments
- Have to plan on switching positioning from posterior to anterior
- Plan in place in case bone grafting is needed for the anterior comminution

Surgery

Given the length of time from injury, current deformity, and articular comminution, it was felt he would benefit from ORIF to correct the deformity and primary ankle arthrodesis, as obtaining an anatomic reduction of the articular surface was felt to not be possible. The patient was placed prone on the operating room table, and a posterolateral approach was performed. He had an external fixator placed which was used as a reduction tool. Attention was then turned to the posterior tibia which was reduced and stabilized with a T-shaped buttress plate, and the fibula was stabilized through the same incision (Fig. 6.3c). The patient was then placed supine, and a direct anterior approach was performed to access the joint. Initial reduction of the metaphyseal segment and joint was performed. This was performed with a 4.0 mm screws and temporary K-wire fixation. The articular cartilage was then removed from the comminuted tibia fragments as well as the talar dome. An anterior “spoon” plate was then applied across the joint, and 4.0 mm cortical screws were placed into the tibia and talus (Fig. 6.3d).

Postoperatively, the patient maintained non-weight-bearing precautions for 10 weeks. He then was transitioned to normal shoes. He was lost to follow-up until 8 months from surgery. Radiographs revealed a well-healed fusion (Fig. 6.3e). The patient reported minimal symptoms and had returned to work.

Case 6.4 Malunion

History

A 25-year-old female presents to clinic after a motor vehicle collision 10 weeks prior with an injury to her left ankle (Fig. 6.4a). She was treated with ORIF through a medial incision performed in a different state. She had maintained non-weight-bearing precautions after surgery and had recently began weight-bearing in a fracture boot. Current radiographs were obtained showing an articular malreduction with anterior translation of the talus (Fig. 6.4b). A CT was obtained to evaluate the deformity and fixation (Fig. 6.4c).

Reasons for Failure

- Poor understanding of the fracture pattern
- Incorrect incision used for reduction and stabilization
- Poor articular reduction

Surgical Plan

- Remove previous hardware.
- Tibial osteotomy to find displaced articular fragment.
- Revision fixation using an anterolateral reduction and plating.
- Medial spanning plate.

Approach

- Anterolateral ankle approach
- Percutaneous medial incision (portions of previous medial extensile approach)

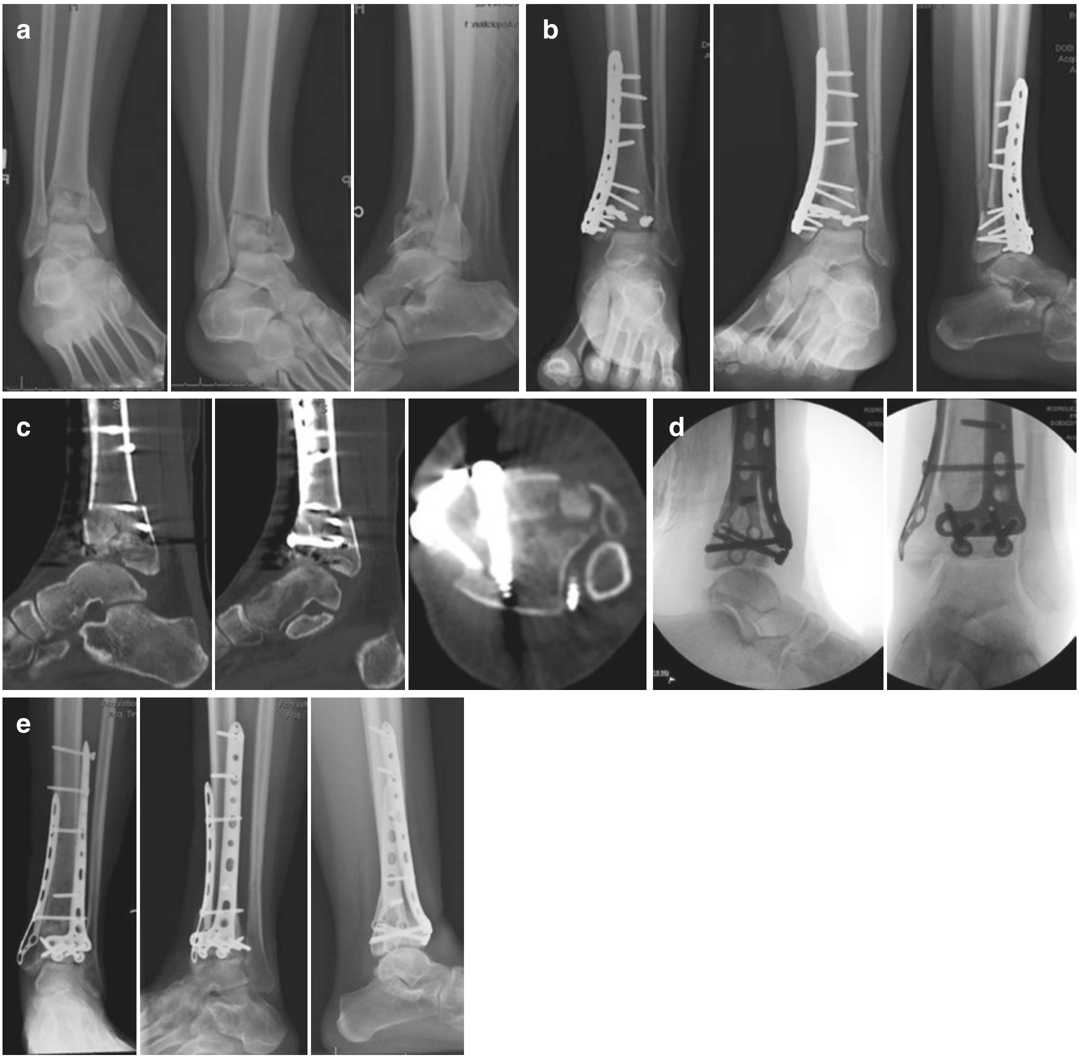

Fig. 6.4 (**a**) AP (left), mortise (center), and lateral (right) radiographs of a 25-year-old female involved in a motor vehicle collision with a comminuted pilon fracture. (**b**) The patient underwent ORIF at an outside facility through a medial approach. AP (left), mortise (center), and lateral (right) radiographs show articular malreduction with anterior translation of the talus best visualized on the lateral radiograph. (**c**) Sagittal CT images (left and center) show anterior translation with impacted articular fragments that remain proximally displaced. The axial image (right) shows no stabilization of the anterolateral articular segments and penetration of the percutaneous anterolateral screw into the syndesmosis. (**d**) The patient was taken back for revision ORIF with osteotomy and articular reconstruction. Lateral (left) and AP (right) fluoroscopic imaging reveals improved articular reduction with reduction of the talus under the plafond. (**e**) AP (right), mortise (center), and lateral (right) X-rays were taken at 2-year follow-up showing minimal arthritic progression

Implants

- Precontoured anterolateral tibial locking plate
- Low profile medial tibial plate
- Small fragment set
- Broken screw removal set (available)

Pearls and Pitfalls

- Need to plan anterolateral incision to maximize skin bridge from prior extensile medial incision
- Careful osteotomy to not affect/damage displaced articular fragment
- Need to address anterior talar translation

Surgery

Given the time from injury and the patient's age and activity level, revision ORIF with revision articular reduction was presented to the patient as well as conversion to fusion. She elected to proceed with revision ORIF. She was taken to the operating room, and the patient's hardware was removed percutaneously using portions of her previous extensile medial incision. An anterolateral incision was created, and dissection was performed to the level of the joint. Osteotomies were used to open the anterior tibial cortex. The large anterolateral fragment was then mobilized and reduced. Reduction of the fragment also helped to reduce the anterior talar translation. With the fragment held with temporary K-wires, a long anterolateral plate was placed using percutaneous techniques and affixed to the tibia. A separate percutaneous medial plate was placed through the previous medial incision (Fig. 6.4d).

Postoperatively, she was kept non-weight-bearing for 10 weeks, with range of motion exercises started at 2 weeks. At follow-up of 26 months, the patient has continued stiffness and discomfort with activities which are limited. She has maintained joint space and has not required conversion to fusion (Fig. 6.4e).

Case 6.5 Nonunion

History

A 47-year-old female with a PMH of significant tobacco use sustained a closed left ankle injury after falling 15 ft. from a ladder (Fig. 6.5a). She was initially taken to the operating room for initial surgical stabilization. She was placed prone, and her posterior tibia and fibula were treated with ORIF through a posterolateral approach (Fig. 6.5b). An external fixator was also placed to maintain the alignment of the anterior tibia. The patient underwent an uncomplicated ORIF at 2 weeks following injury (Fig. 6.5c). She was followed as an outpatient and at 16 months returned to the office with increased pain complaints. Radiographs revealed a failure of the hardware concerning for nonunion (Fig. 6.5d). A follow-up CT was obtained which revealed a healed articular surface with minimal arthritic change and only a metaphyseal nonunion (Fig. 6.5e).

Reasons for Failure

- Smoking
- Combined anterior and posterior approaches
- Poor biological ingrowth

Surgical Plan

- Remove hardware.
- Debridement nonunion site.
- Revision ORIF with anterolateral plate.

Approach

- Anterior ankle approach (previous)
- Iliac crest incision for bone grafting

Implants

- Precontoured anterolateral pilon locking plate
- Small fragment set
- Broken screw removal set (available)

Pearls and Pitfalls

- The potential for encountering residual deep infection
  - Need intraoperative cultures
- Inability to remove hardware
- Need to adequately debride nonunion site
  - Drill into the nonunion to restore intramedullary blood flow
- Bone grafting for atrophic nonunion

Surgery

The patient was felt to benefit from revision ORIF with hardware removal and autologous bone grafting given her atrophic nonunion with bone resorption. Preoperative laboratory workup revealed inflammatory markers were within normal limits. She went to the operating room, and the previous anterior approach was used. First, the hardware was removed, and intraoperative bone cultures were obtained. The metaphyseal portion of the joint was debrided back to healthy bleeding bone. Autologous iliac crest bone graft was then packed into the nonunion site. A long

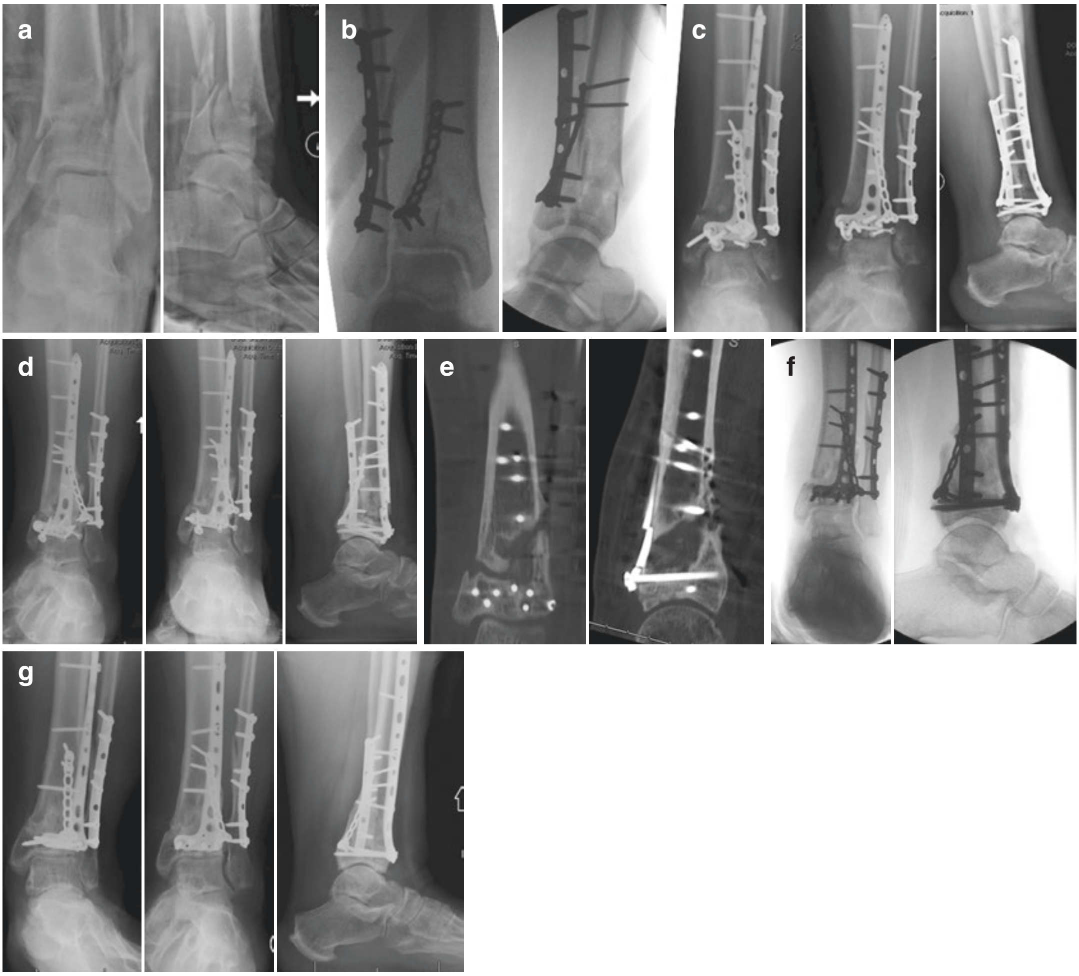

Fig. 6.5 (**a**) AP (left) and lateral (right) radiographs of a 47-year-old female who fell from height. (**b**) Intraoperative AP (right) and lateral (left) fluoroscopic images flowing external fixation with posterior stabilization of the tibia and fibula through a posterolateral incision. (**c**) AP (left), mortise (center), and lateral (right) postoperative radiographs following definitive ORIF at 2 weeks from injury. (**d**) AP (left) and mortise (center) radiographs were obtained at 16 months following surgery showing a persistent fracture line consistent with nonunion. Lateral (right) radiograph shows interval breakage of the anterolateral plate. (**e**) Coronal (left) and sagittal (right) CT reconstruction images reveal a metaphyseal nonunion with bone resorption. The articular surface is well healed with minimal arthritic changes. (**f**) AP (left) and lateral (right) fluoroscopic images following revision plating and autologous iliac crest bone grafting. (**g**) AP (left), mortise (center), and lateral (right) radiographs obtained at 12 months following revision surgery showing consolidation at the nonunion site

anterolateral plate was then placed across the nonunion site and stabilized with locking and nonlocking 3.5 mm screws (Fig. 6.5f).

Postoperatively the patients was placed on non-weight-bearing precautions for 8 weeks and then transitioned back into normal shoewear and activities. Follow-up at 12 months revealed a well-healed nonunion with no activity limitations (Fig. 6.5g).

Case 6.6 Nonunion Metaphyseal and Articular Necrosis

History

A 43-year-old male sustained an open pilon when he fell off a ladder and got his leg caught in the rungs. On physical exam he was noted to have an 8 cm medial wound with exposed bone.

The same day he had a formal debridement in the operating room along with placement of an external fixator and fixation of the fibula through a posterolateral incision (Fig. 6.6a). Four days later, the patient had a repeat irrigation and debridement with fixation of his fibula through a posterolateral approach (Fig. 6.6b). Three weeks later, after his soft tissues had adequately recovered, definitive fixation of the fracture was performed. An anterolateral approach was used for ORIF, given the medial traumatic wound (Fig. 6.6c). The patient had an uncomplicated perioperative course. At 7 months, he reported increased pain. Repeat imaging at that office visit showed intact hardware and alignment with minimal bony healing and arthritic changes at the tibiotalar joint. A CT scan was obtained that showed nonunion at the metaphyseal and articular surface. The articular surface had sclerosis with collapse and extensive post-traumatic arthritis (Fig. 6.6d). Inflammatory workup revealed no evidence of infection.

Reasons for Failure

- Open fracture, soft tissue compromise
- Poor biological ingrowth

Surgical Plan

- Remove indwelling hardware.
- Autologous iliac crest bone grafting.
- Debridement of ankle and metaphyseal nonunion site.
- Revision plating spanning the ankle and nonunion site.

Approach

- Anterolateral ankle approach (previous)
- Percutaneous medial and lateral incisions for lag screws
- Percutaneous approach for medial screw removal

Implants

- 7.3 mm cannulated screws
- Small fragment "spoon" plate
- Small fragment set
- 4.0 mm cortical screws
- Broken screw removal set (available)

Pearls and Pitfalls

- The potential for encountering residual deep infection
  - Need intraoperative cultures
- Accounting for bone loss resorption at nonunion/ankle sites
- Potential issues of hardware removal

Surgery

The patient had a nonunion at the metaphysis as well as early traumatic arthrosis of the ankle joint. Due to this, he was felt to benefit from ankle arthrodesis with open repair of his nonunion with autologous bone grafting. The patient's previous anterolateral incision was used for exposure. The prior hardware was removed including the medial malleolar screw to allow for debridement of the joint. The ankle joint was exposed, and the anterior nonunion fragments were nonviable and necrotic. Intraoperative cultures were sent and were found to be negative. The joint was denuded of the cartilage and any subchondral bone perforated. Tissue from the nonunion site was also sent for intraoperative gram stain and found to be negative for infection. After both areas were prepared, the ankle joint and metaphyseal nonunion was grafted with iliac crest autograft. The ankle was fixed with a medial and lateral 7.3 mm cannulated screw through percutaneous

Fig. 6.6 (**a**) Lateral (left) radiograph of a 43-year-old male who fell off of a ladder. AP (center) and lateral (right) fluoroscopic images after irrigation and debridement and placement of an ankle spanning external fixator. (**b**) AP (left) and lateral (right) fluoroscopic images were obtained when the patient was brought back in 2 days for repeat irrigation and debridement and posterolateral plating of his fibula. (**c**) AP (left) and lateral (right) fluoroscopic images following ORIF through a small anterolateral incision performed 3 weeks after injury. (**d**) At 7 months the patient had worsening pain with a persistent fracture line and arthritic changes at the tibiotalar joint seen on lateral (left) and AP (left center) radiographs. Coronal CT images provide further detail of the articular collapse (right center) and a persistent metaphyseal nonunion (right). (**e**) AP (left) and lateral (right) fluoroscopic images following removal of hardware and iliac crest bone grafting and application of a "spoon" plate spanning the ankle joint and nonunion site. (**f**) AP (left), mortise (center), and lateral (right) radiographs obtained at 12 months from surgery show consolidation at the ankle fusion site and metaphyseal nonunion site

incisions. A plate was contoured and placed to cross the nonunion site and ankle joint (Fig. 6.6e).

Postoperatively, the patient had an uncomplicated postoperative course and went on to heal both his fracture and fusion with minimal symptoms (Fig. 6.6f).

Case 6.7 Metaphyseal Malunion

History

A 46-year-old male was involved in a motor vehicle accident and sustained a pilon fracture that was treated with ORIF using an anterolateral approach. The patient had an uncomplicated course and went on to heal his fracture. He had ongoing pain with continued pain, instability, and lateral foot overload. He had previously undergone hardware removal with his initial treating surgeon. He was referred for continued pain. Clinical evaluation revealed cavus foot alignment (Fig. 6.7a). Initial radiographs revealed a varus malunion of his pilon fracture (Fig. 6.7b). Preoperative CT scan revealed a healed fracture with minimal arthritic changes, and preoperative infection workup was negative.

Reasons for Failure

- Poor surgical planning
- Poor initial reduction (varus)

Surgical Plan

- Anterolateral approach to expose distal tibia and fibula
- Open wedge osteotomy of distal tibia
- Potential need for fibular osteotomy
- Autologous tricortical bone grafting
- Surgical stabilization of distal tibia +/− fibula

Approach

- Anterolateral ankle approach (previous)

Implants

- Small fragment metaphyseal locking plate
- Small fragment set

Pearls and Pitfalls

- Need to accurately restore the joint line with the osteotomy
  - K-wires can be used to mark out the osteotomy and can be used to judge correction.
- Need to plan for a fibular osteotomy in case correction cannot be achieved with an isolated tibial osteotomy
- Accounting for structural bone requirements for the opening wedge osteotomy
  - Wait until the joint is corrected to measuring for tricortical graft.

Surgery

The patient went back to the operating room for supramalleolar osteotomy. The patient's previous anterolateral approach was used. K-wires were placed to mark out the osteotomy, and the osteotomy was created using drill holes and osteotomies. To improve mobility of the malunion, the fibula was also osteotomized at the same level using the same incision. A lamina spreader can then be used to open the tibial osteotomy site and correct either the varus or valgus deformity (Fig. 6.7c). The osteotomy site was filled with a tricortical iliac crest autograft. A metaphyseal plate was contoured to the anterolateral tibia and secured above and below the osteotomy site. Following fixation of the tibia, a compression plating technique was performed using a 1/3 tubular plate on the fibula.

Postoperatively, the patient was kept non-weight-bearing for 8 weeks. The patient went on to heal without complications. Final follow-up at 12 months revealed a healed osteotomy with near anatomical alignment and minimal arthritic changes (Fig. 6.7d). The patient also had improved clinical alignment (Fig. 6.7e).

Fig. 6.7 (**a**) Medial standing clinical image of a 46-year-old male who had sustained an open pilon fracture with residual cavus deformity. Image courtesy Michael Swords, DO. (**b**) Weight-bearing lateral (left) and AP (right) radiographs showing a well-healed pilon fracture with varus metaphyseal malunion. The ankle joint remains relatively well preserved. Image courtesy Michael Swords, DO. (**c**) Intraoperative fluoroscopic images that reveal a lateral opening wedge tibial osteotomy (left). Lamina spreaders are then used to correct the deformity bringing the joint surface perpendicular to the long axis of the tibia. Image courtesy Michael Swords, DO. (**d**) At 8 months, AP (left) and lateral (left) radiographs reveal correction of the deformity with preservation of the joint space. Image courtesy Michael Swords, DO. (**e**) Medial standing clinical image showing improvement of the cavus deformity. (Image courtesy Michael Swords, DO)

Summary

Revision surgery for pilon fractures is complicated, and several factors must be taken into account prior to formulating a surgical plan. Patient factors and expectations play a significant role in this. Patients with significant medical comorbidities should understand the potential for complications and wound issues. As with any revision surgery, preoperative infection workup should be performed to plan for the potential of persistent infection. The current condition of the articular cartilage must be taken into account to determine if it is possible to salvage the joint. Once proper preoperative planning has been completed, the surgeon must concentrate on surgical techniques and plan for potential problems during reconstruction. Planning for hardware removal and deformity correction is paramount. The need for bone grafting or orthobiologics should be evaluated on a case-by-case basis. Postoperatively, patients should be followed closely and evaluated for complications.

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