

# Role of Intramedullary Fibular Fixation: Strategies for Addressing Complex Pilon Fractures

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## ABSTRACT

**Aim and background:** Pilon fractures are usually the result of a high-energy mechanism and are widely considered more of a soft tissue injury secondary to the high rates of soft tissue complications that arise from them. The majority of pilon fractures have an associated fibular fracture in which minimally invasive intramedullary fixation has been utilized to minimize soft tissue complications. In this manuscript, we present three different cases that highlight different intramedullary fixation techniques.

**Technique:** Cut flexible guidewire, standard cortical screw, intramedullary fibular nail.

**Conclusion:** Intramedullary fixation for associated fibular fractures in the setting of pilon fractures has been shown to be a viable technique for successful outcomes. There are a variety of options for intramedullary fixation that can be utilized, and guidewire, cortical screw, and intramedullary fibular nail techniques are demonstrated in our case examples with tips to help produce good outcomes.

**Clinical significance:** Using minimally invasive intramedullary fibular fixation can help mitigate risk of wound complications in high-risk pilon fractures.

**Level of evidence:** V (expert opinion).

**Keywords:** Fibula, Fibular, Intramedullary fixation, Pilon, Technique.

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## INTRODUCTION

Even with implementation of staged, definitive fixation, soft tissue complications following pilon fractures can occur at an unacceptably high rate.<sup>1,2</sup> Widely considered a severe soft tissue injury disguising a bony fracture, decision-making regarding the ideal surgical approach to treat the fracture while minimizing the risk of soft tissue compromise and wound complications can be challenging.

In these complex clinical scenarios, multiple approaches are often required, and additional strategies to minimize wound complications are necessary. These include the use of negative pressure wound dressings and intrawound vancomycin powder placement, as examples.<sup>3-5</sup> Additionally, with a high rate of pilon fractures consisting of an associated fibular fracture, limiting incisional burden on the lateral side may offer a strategic advantage in keeping the incisional footprint minimal, thus allowing for larger incisions elsewhere, hopefully minimizing complications postoperatively. This can be often achieved with intramedullary fibular fixation.

Here, in this manuscript, we present case examples of complex pilon fractures with associated fibular fractures that have patterns amenable to intramedullary fixation. We present three different types of fibular fixation that can be utilized based on availability. These include the use of a cut flexible guidewire, the use of a standard intramedullary cortical screw, or an intramedullary fibular nail.

## TECHNIQUE

### Case I

A 37-year-old male was a pedestrian struck, sustaining a right Gustilo–Anderson grade I open tibial plafond fracture with

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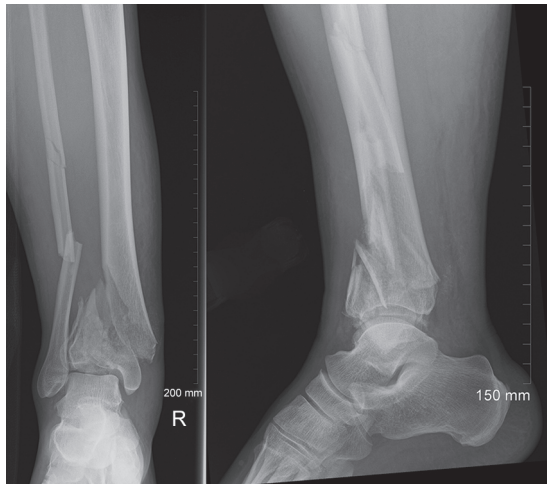
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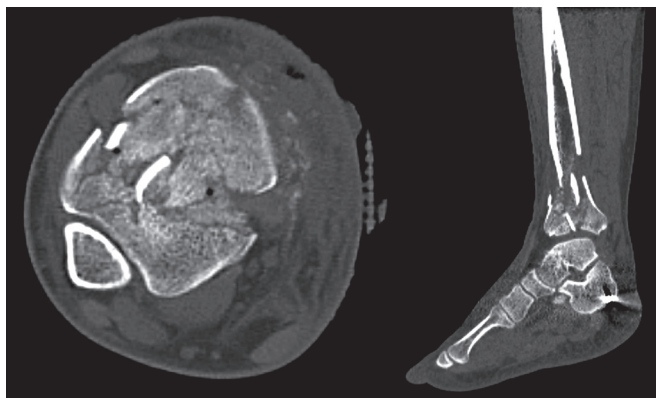
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concurrent segmental fibular shaft fracture (Fig. 1). The patient initially underwent an irrigation and debridement and was stabilized with an ankle-spanning external fixator. After debridement of the open wound, a 4 × 4 cm wound persisted over the medial aspect of the ankle proximal to the medial malleolus, accompanied by significant soft tissue swelling throughout the ankle. A staged fixation approach was decided upon, with the first stage addressing the anterior plafond through an anterior approach and the second stage would address the posterior aspect through a posterior approach (Fig. 2). Taking into consideration the soft tissue injury of the medial ankle and the main fracture line through the plafond exiting anterolateral with the apex of the diaphyseal extension



**Fig. 1:** Case I—preoperative anteroposterior and lateral radiographs of right ankle demonstrating a right Gustilo-Anderson grade I open tibial plafond fracture with concurrent segmental fibular shaft fracture

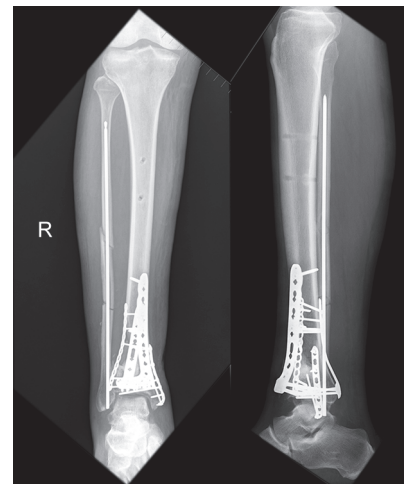


**Fig. 2:** Case I—preoperative axial and sagittal computer tomography of right ankle

being more posterolateral, an anterolateral and posterolateral incision was chosen to be utilized.

The proximal extent and segmental nature of the fibular fracture led to debate on the optimal fixation strategy. A separate direct lateral approach would provide an inadequate soft tissue bridge between the other planned incisions. An extended posterolateral approach with plate and screw fixation was considered; however, this would have resulted in more soft tissue insult. Thus, a minimally invasive fixation strategy using a long 3.2 mm guidewire was chosen to stabilize the fibula fracture (Fig. 3).

We began by measuring the desired length of the wire by overlaying the wire on the fibula and using fluoroscopy to mark the length from the distal tip of the fibula to the appropriate length (at least four cortices beyond the fracture) past the fracture proximally. The wire was cut utilizing large bolt cutters. A small stab incision was made at the distal tip of the fibula with subsequent blunt dissection to the bone. A 3.5 mm drill bit was used to predrill the path to the fracture line. Drill was then removed, and guidewire was advanced past the fracture. A small bone tamp and mallet were used to ensure the wire was flush with the tip of the fibula. Occasionally, a mini-open incision needs to be utilized to aid in fracture reduction prior to wire advancement.



**Fig. 3:** Case I—postoperative anteroposterior and lateral right tibia-fibula radiographs



**Fig. 4:** Case II—preoperative anteroposterior and lateral radiographic images demonstrating a closed right tibial plafond fracture with concomitant distal fibula fracture

## Case II

A 36-year-old female suffered a closed right tibial plafond fracture with concomitant distal fibula fracture after falling from a two-story height (Fig. 4). She also suffered a lateral compression type I pelvis fracture but did not meet indications for surgical management and was treated nonoperatively. Patient had significant soft tissue swelling to the right ankle after the incident, so she was placed in an ankle-spanning external fixator for stabilization the following morning. After 7 days, patient's soft tissue swelling had improved and was amenable to operative fixation.

The fracture lines in the plafond injury were in the traditional "Mercedes-Benz sign" orientation with anteromedial impaction of the articular surface (Fig. 5). The associated distal fibula fracture was minimally displaced and in a short oblique orientation. To address the anteromedial impaction for the plafond injury, an anteromedial approach was selected. Given the short oblique orientation and minimally displaced nature of the fibular fracture, a minimally invasive approach utilizing percutaneous insertion of an intramedullary 3.5 mm cortical screw was selected in an effort to minimize the insult on the soft tissues.



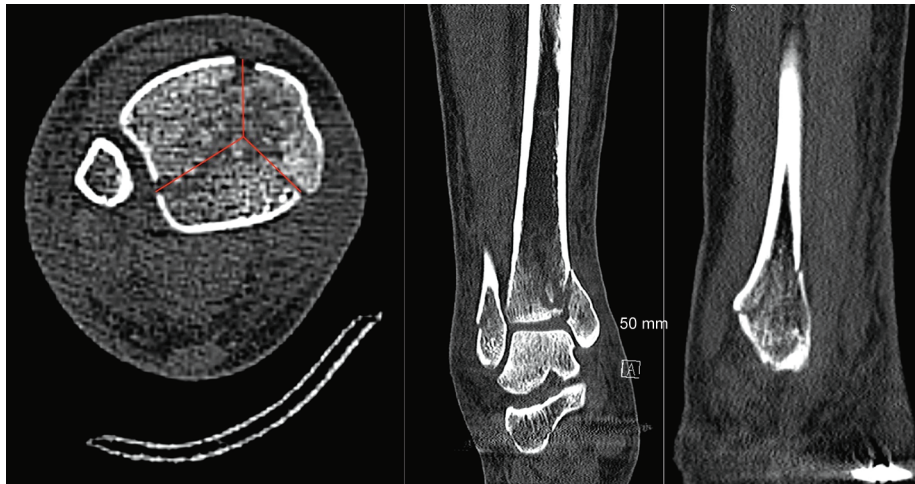


Fig. 5: Case II—preoperative axial (“Mercedes-Benz sign”), coronal, and sagittal computer tomography of right ankle

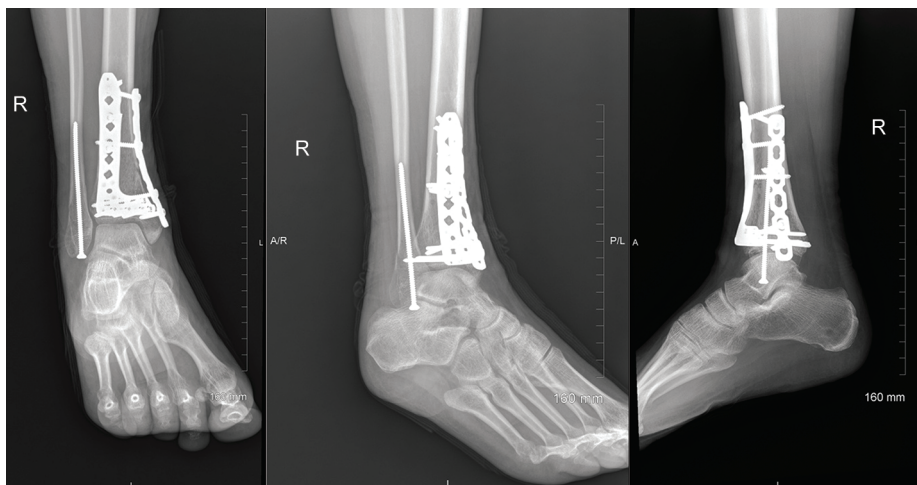


Fig. 6: Case II—postoperative anteroposterior, oblique, and lateral radiographic images

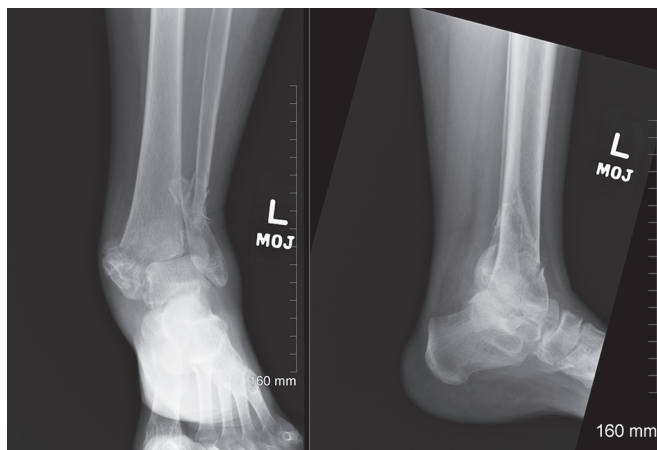


Fig. 7: Case III—preoperative anteroposterior and lateral radiographic images demonstrating a left comminuted tibial plafond fracture with concomitant comminuted distal fibula fracture

To start, a percutaneous stab incision is made at the tip of the distal fibula. A mini-open incision can be used as necessary for fracture reduction but was not required in this case. Under fluoroscopic guidance, a long calibrated 2.5 mm drill bit was used to

open up the cortex at the distal tip of the fibula. The drill bit is then oscillated up the canal to an adequate distance within the isthmus of the fibula. Screw length is then measured and inserted into the canal. Care is taken to not over-compress the fracture if it is oblique in nature (Fig. 6). An added benefit of this percutaneous technique is that it can be performed prior to inflating the tourniquet, saving on critical tourniquet time for the plafond fixation.

### Case III

A 65-year-old female with significant past medical history of poorly controlled diabetes mellitus mis-stepped off an escalator, causing a rotational injury to her left ankle with subsequent fall. On admission, patient had a hemoglobin A1c of 11.1 and was admittedly noncompliant with her medications. From the incident, she sustained a left comminuted tibial plafond fracture with concomitant comminuted distal fibula fracture (Figs 7 and 8). Patient was taken the following morning for placement of ankle-spanning external fixator for stabilization. Nine days following the placement of the external fixator, the patient was taken back for definitive fixation.

Deciding the appropriate treatment for this patient was made difficult by several factors, including her severely uncontrolled

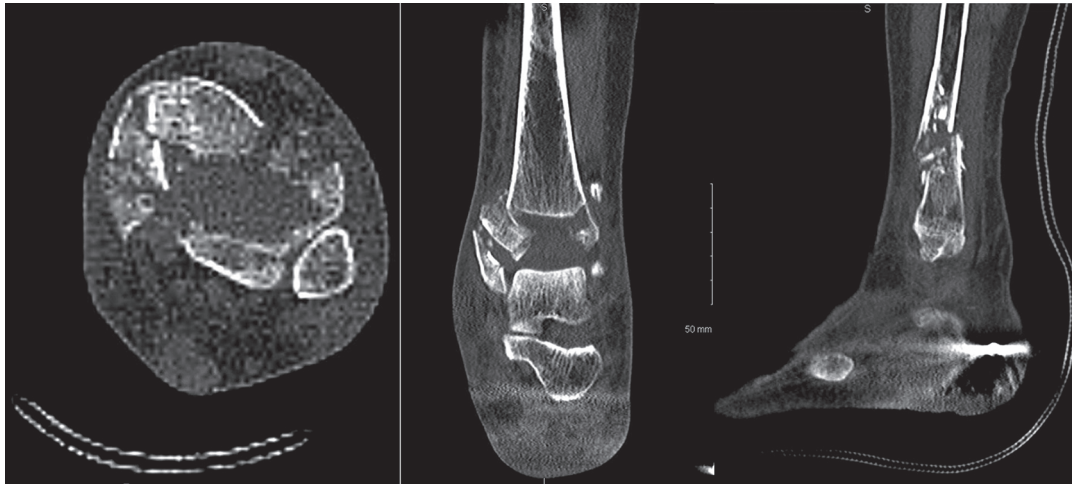


Fig. 8: Case III—preoperative axial, coronal, and sagittal computer tomography of left ankle

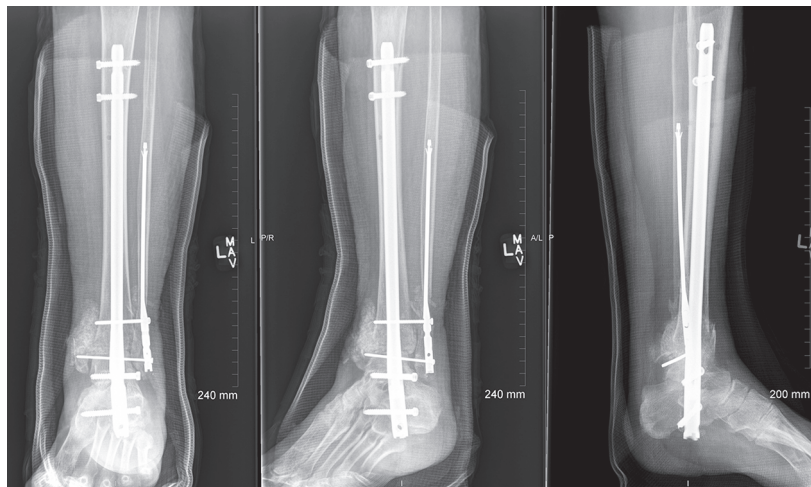


Fig. 9: Case III—postoperative anteroposterior, oblique, and lateral radiographic images

diabetes and the severity of the injury. It has been shown that patients with diabetes who are treated surgically for pilon fractures are at a significantly higher risk for developing infection postoperatively.<sup>6</sup> With these factors in mind, decreasing the risk of infection and minimizing chance of amputation were the main goals of treatment. This led to the decision to utilize a tibio-talar-calcaneal nail in the acute setting with the intramedullary fibular nail (FibuLock, Arthrex, Naples, Florida) (Fig. 9). These implants allow for minimal insult to the patient's soft tissue and decrease the risk of infection in the setting of the patient's poorly controlled diabetes.

An advantage of utilizing the fibular nail in this setting is not only for the percutaneous or mini open application of the device, but it allows for simple placement of syndesmotic fixation through the attaching jig. We recommend placing a sterile bump under the foot or ankle to create clearance between the jig and the operating table. Additionally, a finger reduction tool can be utilized to aid in accurate guidewire placement into the intramedullary canal.

## DISCUSSION

Pilon fractures, notorious for their associated soft tissue complications, continue to present significant challenges in

both the management of the fracture itself and minimizing the postoperative complications. In particular, complex fracture characteristics [Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association (AO/OTA) classification 43C] are often compounded by associated fibular fracture in up to 69% of cases.<sup>7</sup> The complex cases of pilon fractures described in this paper—involving patients with severe soft tissue injuries or significant medical comorbidities—highlight the potential benefits of a minimally invasive approach to managing these associated fibular fractures.

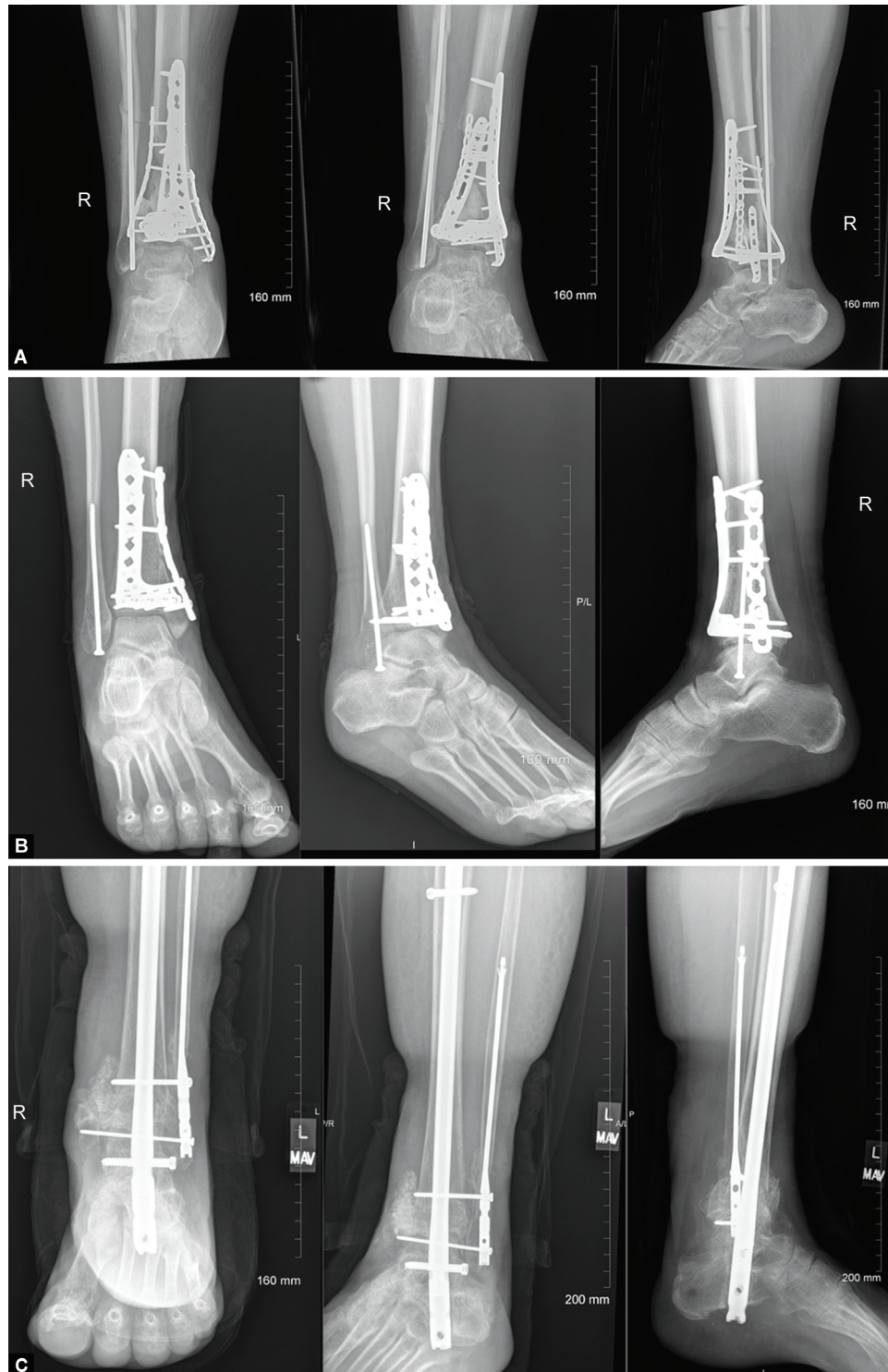
Despite advances in surgical protocols for these complex fractures, including the development of a staged protocol for fixation for these fractures, there is still a high risk of soft tissue-related complications.<sup>1,8–10</sup> Sirkin et al. utilized a staged protocol in both open and closed pilon fractures.<sup>2</sup> For the closed pilon fractures, 17% had partial thickness skin necrosis postoperatively. In the open fracture group, 10% experienced partial-thickness wound necrosis, and 10% developed deep infections requiring multiple debridement. Bhattacharyya et al. reported a 47% complication rate utilizing the posterolateral approach, with most complications related to wound problems and even 10% resulting in infected nonunion.<sup>1</sup> In a comparative study, Blauth et al. analyzed outcomes across groups treated with different techniques—(1) primary initial



fixation, (2) minimally invasive fixation with long-term external fixator placement, and (3) two-stage procedure with minimally invasive fixation and temporary external fixator placement. Despite the varying methods, an overall infection rate of 25% was noted across the three groups, and a trend toward lower infection rate of 12.5% in the staged fixation group was noted.<sup>8</sup> These articles highlight that irrespective of the approach or technique, pilon

fractures, especially open fractures, pose a high risk for soft tissue complications.

There have been several reported benefits of using intramedullary fixation for fibula fractures. Poutoglidou et al. compared plate vs intramedullary fixation of fibula fractures in setting of a pilon fracture.<sup>11</sup> They included 87 patients—45 treated with a one-third tubular plate, while the remaining 42



**Figs 10A to C:** Postoperative follow-up radiographic images; (A) Case I at 5 months; (B) Case II at 2 months; (C) Case III at 4 months demonstrating fracture healing and maintenance of implant alignment and positioning



were treated with percutaneous rush nail. While they found no statistically significant difference in the rates of deep tissue infection, nonunion, and malunion between the two groups, there was a significant decrease in the rate of superficial infection in the group treated with rush nails. Furthermore, Faber et al. compared patients treated with intramedullary fibular fixation in the setting of either an ankle or pilon fracture, finding no difference in complication rates between the two groups.<sup>12</sup> This suggests that the use of intramedullary fixation in higher-energy pilon fractures still maintains a low complication rate. Evans et al. conducted a retrospective study of 38 patients who were treated with an intramedullary device for fibular fracture with associated pilon fractures. In their study, the intramedullary devices were either 3.5 mm fully threaded cortical screw or 2.5 mm humeral intramedullary nailing guidewire chosen at the surgeon's discretion. All fibula fractures healed within 3 months, and fibular alignment did not shift by  $>1^\circ$  from the immediate postoperative reduction.<sup>13</sup> Huang et al. compared the outcomes of 156 patients undergoing either plate fixation or intramedullary fixation for distal fibula fracture in the setting of a pilon fracture.<sup>14</sup> They found that intramedullary fixation, which was achieved using a long K-wire (2.0 mm, but adjusted to 1.8 or 2.4 mm depending on fit), offered comparable functional outcomes to plate fixation at 1 year postoperatively. Collectively, these studies show that intramedullary fixation, regardless of the specific choice of implant, can yield favorable outcomes.

In certain cases, two separate incisions are required to adequately address the pilon fracture. Adding a third invasive incision to address the fibular fracture would risk aggravating the already precarious state of the soft tissue, potentially leading to further complications. As highlighted in our case examples and the preceding discussion, there are various techniques that can be used for intramedullary fixation of the fibula. Each technique, in its unique way, enables the surgeon to reap the benefits of decreased wound and infection risk with the minimally invasive technique while obtaining adequate fracture reduction and fixation to address both the pilon and fibular fracture with good functional outcomes. In the case examples discussed in this article, the minimally invasive intramedullary technique was employed to decrease soft tissue insult and potential wound complications. This choice was particularly advantageous in either a poor healing host, as in case III, or as predetermined by the initial injury, like in case I, with the open medial injury. Determining the appropriate implant size and length varies by fracture morphology and necessary construct stability. Prissel et al. performed a cadaveric study on distal fibular intramedullary canals for assisting in this determination.<sup>15</sup> They reported a mean diameter of 4.02–4.99 mm for lengths between 60 and 80 mm, proposing a device with a diameter between 4.5 and 5 mm and length of 60–80 mm to achieve sufficient bony purchase and anticipated bony compression. As depicted in cases I and II, a 3.2- and 3.5-mm device was utilized, respectively, with good fracture healing via relative stability. In our cases, encompassing a variety of pilon fracture severities, we successfully utilized different intramedullary techniques for fibular fixation (Figs 10A to C). This was done by approaching the pilon fracture as a soft tissue injury and minimizing the insult to the soft tissues by staging the treatment and utilizing a minimally invasive intramedullary technique for fibular fixation.

## CONCLUSION

Complications following surgical fixation of pilon fractures can be as high as 47%, the majority of which stem from soft tissue complications. Intramedullary fixation of fibula fractures has been shown to be a viable fixation option in the setting of these high-energy pilon injuries, with the added benefits of reduced wound and infection risks. Our case examples illustrate the use of various options for intramedullary fixation, including guidewire, cortical screw, and intramedullary fibular nail techniques, with accompanying tips and tricks to provide a tailored surgical plan that accommodates patient-specific factors and injury characteristics.

## Clinical Significance

Using minimally invasive fibular fixation with intramedullary techniques can help mitigate the risk of wound complications in high-risk pilon fractures by allowing for longer incisions for the other planned areas of fixation. This is significant given the substantial rate of soft tissue complications associated with these injuries. By reducing soft tissue disruption, patient recovery may be enhanced, potentially leading to improved functional outcomes.

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