Decisions and Staging Leading to Definitive Open Management of Pilon Fractures: Where Have We Come From and Where Are We Now?

Frank A. Liporace, MD and Richard S. Yoon, MD

Summary: Historically, the treatment and outcomes related to pilon fractures have been variable despite anatomical reduction and fixation. However, with the advent of newer implant technologies, improved surgical techniques, and the management via a staged protocol, results have indicated encouraging clinical outcomes with minimization of postoperative complications. This review focuses and outlines the current strategies, decision-making processes, and definitive treatment options regarding the notoriously difficult to treat pilon fracture.

Key Words: pilon fracture management, plafond fracture management, open ankle fracture, intra-articular ankle fracture, review

Level of Evidence: Therapeutic Level V. See Instructions for Authors for a complete description of levels of evidence.

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INTRODUCTION

Named after its characteristic shape, the "pilon" or "plafond" fracture pattern is defined by the intra-articular involvement of the distal tibia with metaphyseal extension.[1–3] Although pilon fractures account only for a small percentage of tibial and lower extremity injuries, over 30% of pilon fractures stem from high-energy mechanisms of injury and are often associated with concomitant polytrauma with the presence of open wounds, degloving injuries, and severe soft tissue trauma, providing a notoriously difficult environment for injury management.[4–9]

Historically, treatment involving early acute open reduction and internal fixation (ORIF) led to dismal clinical outcomes with high complication rates (Table 1).[4,6,8,10–13] In an effort to minimize soft tissue complications, limited approaches and treatments involving external fixation exhibited minimal improvement, generating little enthusiasm (Table 1).[13–21] However, with the implementation of a delayed and staged surgical treatment protocol, along with the evolution of imaging, implant technology, and improved surgical techniques, complication rates have decreased with a coinciding increase in clinical and functional outcome (Table 1).[5,7,9,22–32] Although some recent authors have suggested that early definitive ORIF can have comparable results with staged protocols, it should be stressed that this has been performed by experienced trauma surgeons and may not be appropriate in all cases.[33] Also, these experts have indicated that in certain cases within their series, delayed definitive treatment was necessary.[33]

Thus, this review offers the current state of the treatment and management involved in the intricate decision-making process, staging, and surgical options offered in the definitive treatment of pilon fractures.

CLASSIFICATION

Initial assessment and thorough preoperative planning begin with radiographic examination. Analysis of the fracture pattern is performed with the 3 standard views of the ankle—anteroposterior, lateral, and mortise, along with centered orthogonal views of the joint above and below, due to the high rate of concomitant polytrauma found in pilon fracture patients. Full-length tibia and fibula films can also offer information on general alignment.[2,4,9,10] In certain cases, radiographs of the contralateral extremity can also be helpful, not only to provide a template for reconstruction for more complex pilons but also to notice any pre-existing anatomical or congenital variants that indicate a different "normal" baseline.

Theoretically, fracture classification systems are a tool for communication and information, relative to treatment decisions and prognosis. Reliability must be obtained with regard to consistent reproducibility, thereby into readily classifying various fracture patterns. Rüedi and Allgöwer[12] offered the original foundation for classification, indicating 3 fracture types that increase in severity, from low-energy non-displaced fractures of the tibia plafond to high-energy, severely comminuted, and impacted articular fracture patterns. However, poor reliability and agreement have been reported.[34–36]

Based on plain films alone, Martin et al[35] reported poor interobserver reliability of the Rüedi–Allgöwer classification system, with mean kappa values of 0.46, 0.38, and 0.56 for all, more-experienced, and less-experienced observers,

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From the Division of Orthopaedic Trauma, Department of Orthopaedic Surgery, UMDNJ—New Jersey Medical School, Newark, NJ.
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Reprints: Frank A. Liporace, MD, Division of Orthopaedic Trauma, Department of Orthopaedic Surgery, University of Medicine and Dentistry of New Jersy (UMDNJ)—New Jersey Medical School, 90 Bergen Street, Newark, NJ 07103 (e-mail: liporace33@gmail.com).

TABLE 1. Chronological Summary of Major Literature Regarding Treatment and Complications for Pilon Fractures

Author (Year)	Management/Treatment	No. Fractures	Reported Complications and Rates
Bourne et al (1983)[4]	Primary ORIF	42	Infection: 4.8%
			Nonunion/malunion: 33%
Marsh et al (1991)[18]	Ex-fix (unilateral)	101	Reoperations: 5%
			Infection: 6%
			Loss of reduction during ex-fix: 21%
			Malunion: 3%
Tornetta et al (1993)[19]	Limited internal fixation, hybrid ex-fix	26	Superficial infection: 3.8%
			Deep infection: 3.8%
			Pin tract infection: 12%
			Malunion: 3.8%
Teeny and Wiss (1993)[13]	Primary ORIF	60	Major complication: 50% (at least one of the following—skin slough, wound dehiscence, infection, nonunion, malunion, and implant failure)
Bone et al (1993)[16]	Delta-framed ex-fix	20	Infection: 0%
			Delayed union/nonunion: 15%
			Malunion: 4.8%
Helfet et al (1994)[6]	Primary ORIF	34	Pin tract infection: 2.9%
			Deep infection:5.9%
			Malunion: 8.8%
Marsh et al (1995)[17]	Articulated ex-fix	49	Infection over tibia: 0%
			Infection over fibula: 4.1%
			Pin tract infection: 20%
Barbieri et al (1996)[15]	Hybrid ex-fix	37	Skin slough: 2.7%
			Pin tract infection: 13.5%
			Deep infection: 8.1%
			Nonunion: 8.1%
			Loss of reduction during ex-fix: 8.1%
Wyrsch et al (1996)[20]	RCT, primary ORIF versus ex-fix (with and without limited internal fixation)	ORIF: 18	Wound dehiscence/infection: 67%
			Amputation: 17%
		Ex-fix: 20	Nerve injury: 5%
			Pin tract infection: 5%
			Deep infection: 5%
			Malunion: 5%
Anglen (1999)[14]	Comparative, ORIF versus hybrid ex-fix (some soft tissue optimization in both groups via temporizing ex-fix)	ORIF: 19	Amputation: 5.3%
			Skin slough: 5.3%
			Sensory deficit: 5.3%
		Ex-fix: 29	Wire site infection: 24%
			Half-pin site infection: 10.3%
			Wound healing problems: 10.3%
			Tethered flexor tendon: 3.4%
			Nerve deficit: 3.4%
			Nonunion: 21%
Sirkin et al (1999)[7]	Staged protocol, soft tissue optimization	Closed: 30	Partial-thickness skin necrosis: 17%
			Osteomyelitis: 3.4%
		Open: 19	Wound dehiscence: 5.2%
			Osteomyelitis: 5.2%
Patterson and Cole (1999)[31]	Staged protocol, soft tissue optimization	22	No infections/soft tissue complications
			Malunion: 4%
			Nonunion: 4%
Grose et al (2007)[5]	Staged protocol, soft tissue optimization, lateral approach study	44	Deep infection: 4.5%
			Wound dehiscence: 4.5%
			Nonunion: 9%

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TABLE 1. (*continued*) Chronological Summary of Major Literature Regarding Treatment and Complications for Pilon Fractures

Author (Year)	Management/Treatment	No. Fractures	Reported Complications and Rates
White et al (2010)[33]	Primary ORIF (within 48 h: 98%)	95	Wound dehiscence or deep infection: 6% Delayed union or nonunion: 6%
Boraiah et al (2010)[56]	Staged protocol, soft tissue optimization	59 (all open)	Amputation: 1.7% Deep infection: 3% Superficial infection: 5%

respectively. Similarly, Dirschl and Adams[34] reported a mean kappa value of 0.46, indicating poor reliability; removing the PGY-3 data increased the kappa value, but only slightly, to 0.52.

Minimal improvements to classification agreement were observed with the development of the Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association (AO/OTA) classification system. Despite exhibiting higher reliability than the Rüedi–Allgöwer classification system, only moderate agreement between observers has been reported.[12,34,35,37] Specifically regarding fracture type, group and subgroup agreement, Swiontkowski et al[37] reported only modest values, with agreement occurring 57%, 43%, and 41% of the time, respectively. Furthermore, despite the use of a more powerful imaging modality in computed tomography (CT), Ramappa et al[36] reported similar reliability and agreement values for both the Rüedi–Allgöwer and the AO/OTA classification systems.

Realizing the inherent difficulty in stratifying outcomes based on unreliable classification systems, DeCoster et al[38] developed a rank order method, classifying patients via severity of the injury and reduction quality. Results exhibited 94% agreement in the ranking of the severity of the articular surface, 89% agreement in the ranking of the severity of the fracture pattern, 89% agreement in the ranking of the reduction concerning only the articular surface, and 88% agreement in the ranking of the reduction when considering the entire fracture pattern.[38]

Thus, although orthopedic surgeons might not necessarily agree on the specific classification of the pilon fracture pattern presented, there is reliably high agreement on assessing the severity of the injury and also in determining the quality of a poor or good reduction.

DECISION MAKING IN THE INITIAL PERIOD

Management in the immediate period after pilon fracture should focus on factors for an expedited medical optimization and clearance and soft tissue stabilization. Important considerations include the presence of an open wound and/or vascular injury.[39,40] A medical history involving diabetes or smoking can also be crucial to management decisions and potential avoidance of future wound complications.[11,33,41,42] In patients with complicated diabetics, Wukich et al[43] reported a 3.8 times increased risk for overall complications and a 5 times increased risk for revision surgery when compared to those with diabetics under tight control. Regarding the effects of smoking, a recent meta-analysis analyzing 6 randomized trials and 15 observational studies noted an overall decreased incidence of complications, especially wound complications, with prolonged smoking cessation.[42]

Certain clues, such as comminution, Tscherne class of injury, significant open wounds, and the presence of a fibula fracture serve the understanding of the amount of energy absorbed. The presence of a fibular fracture provides clues about the mechanism of injury and fracture pattern.[44] A present fibular fracture typically is associated with higher-energy injuries, but if the injury mechanism is known to have a high-energy etiology, the presence of the fracture contributes only to the direction of the mechanism, typically occurring with a valgus and axial load.[44] Conversely, the absence of a fibular fracture or tension failure of the fibula is associated with a varus and axial load injury pattern.[44]

After medical clearance and before definitive fixation, temporizing the extremity and restoring the mechanical axis, length, and alignment are pivotal to allow for soft tissue stabilization. Dunbar et al[45] also described a technique, offering early limited ORIF for AO/OTA Type C fractures that can present typically with a long, oblique metadiaphyseal spike. The authors offered data to suggest that early limited restoration of length, alignment, and rotation via ORIF of the oblique fracture spike not only provides soft tissue protection but also helps to simplify later definitive reconstruction without an increase in wound breakdown or complications (Figs. 1A, B).[45]

Previously, it had been popularized that acute fibular fixation provides restoration of length safely in the initial period without an increased risk for complications.[7,40] However, preoperative planning, including determination of the "work horse" surgical incision, is of paramount importance, especially when considering additional incisions with an appropriate skin bridge.[7,33,46] Classically, many surgeons have attested a minimum of a 7-cm skin bridge to minimize soft tissue and wound complications.[47–49] However, in a recent prospective study, using at least 2 skin incisions averaging 5.9 cm, Howard et al[46] have reported low soft tissue complication rates in 42 patients with 46 pilon fractures. In essence, the "work horse" incision is the main distal tibia incision that will allow for definitive ORIF, even if smaller ancillary incisions are used.[7]

If the surgeon is uncertain of the "work horse" incision, or is not the definitively treating surgeon, it might be prudent to defer fibular fixation until an external fixator has been placed to restore the general mechanical axis and length and a CT scan is subsequently acquired. In such cases, application of a simple joint spanning external fixator would achieve the initial goals and decrease the initial operative time (Fig. 2). We

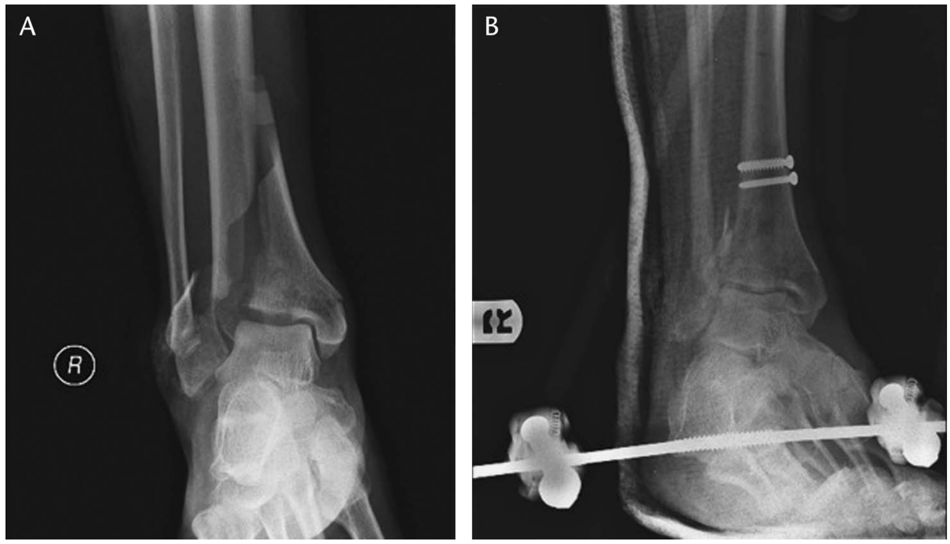

FIGURE 1. Preoperative (A) and postoperative (B) radiographs exhibiting early limited restoration of length, alignment and rotation via ORIF of an oblique fracture spike, providing soft tissue protection and simplifying later definitive reconstruction to minimize wound breakdown and complication.

typically use a delta frame construct with two 5-mm pins in the tibial shaft, of the zone of injury, and a 6-mm calcaneal transfixation pin in the posterior tuberosity of the calcaneus. Posterior splint supplementation or supplementary 4-mm metatarsal pins attached to the main delta frame can be advocated to maintain a plantigrade foot and avoid anteriorly prominent metaphyseal spikes of bone that can cause soft tissue pressure from deep while waiting for definitive internal fixation.[7,13,15,16,18,19,48]

Therefore, the knowledge we have gained through the past 5 decades makes it compelling to consider using multiple small incisions and staging 2, 3, or even 4 limited procedures from initial presentation of external fixator application through completion of definitive care. This may be the best way to decrease complications and potentially improve outcomes for patients with these injuries.

Anatomic considerations for placement of fixator pins are paramount. Proximally, pin placement should be just distal to the tibial tubercle in an attempt to avoid the proximal metadiaphyseal extent of the zone of injury, which will require surgical manipulation at the time of the definitive procedure. Distally, pin placement may be either transcalcaneal, to construct a "delta frame", or medially through the talar neck and the medial calcaneus (Figs. 3A, B). The lateral plantar nerve, the most posterior lateral plantar nerve, and the medial calcaneal nerve are the specific structures to avoid during transcalcaneal external fixator pin placement.[50] When considering medially based external fixators, close monitoring of the status of the medial talar neck pin must be done because if this pin becomes infected, contamination can result within close proximity to distal tibial incisions or into the ankle joint.

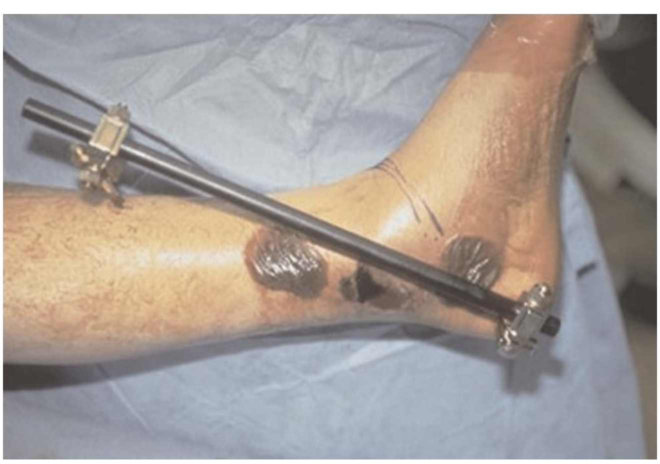

FIGURE 2. A simple joint spanning external fixator can help achieve the initial, early restorative goals in an efficient manner.

DECISION MAKING FOR OPERATIVE TIMING

Originally, some had suggested that definitive operative management within 6 hours of injury may be safe. When re-evaluated, and in the setting of high energy mechanisms, ORIF that had been undertaken in the acute period yielded suboptimal results, leading to high complication rates and poor clinical outcomes.[4,10–13,48] It has been shown that soft tissue impairment due to inflammatory processes is potentially at its highest for up to 6 days postinjury.[51]

Proponents of definitive external fixator constructs cited slight improvements.[14–16,20] Wyrsch et al conducted a prospective randomized study comparing external fixation with ORIF, indicating superior results in the ex-fix cohort.[20] However, the ORIF cohort was operated on within 3–5 days, whereas the external fixator cohort with limited open fixation was definitively treated for more than 7 days after injury.[20] Tscherne emphasized the importance of soft tissue management.[52,53] His soft tissue classification system offers graded indicators of severe soft tissue damage, ranging from minimal superficial abrasions and degloving injuries to deep muscular and subcutaneous fat contusions, vascular injury, and compartment syndrome.[52] Despite determining 2 safe surgical windows—an early period, within 6 hours after injury, and a late period between 6 and 12 days after injury—operations

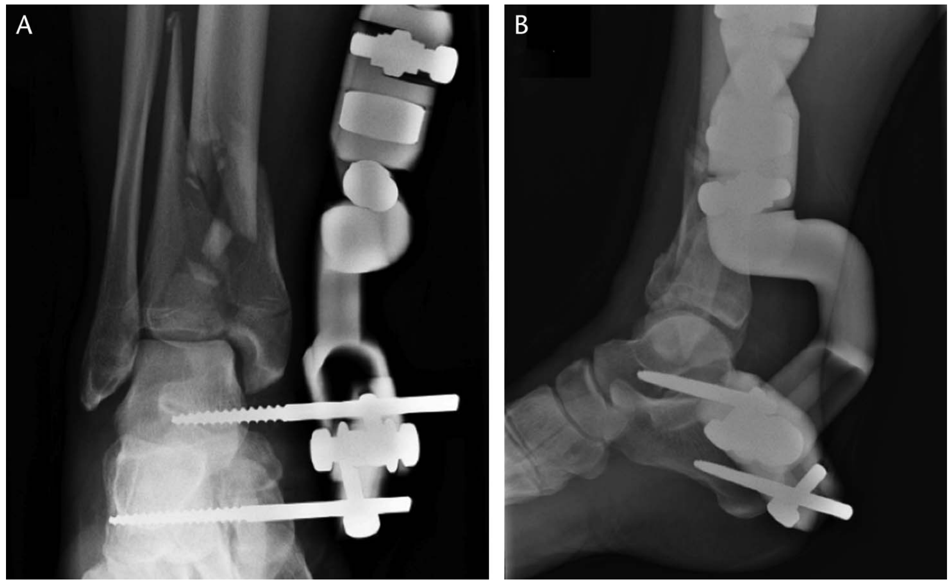

FIGURE 3. Anteroposterior (A) and lateral (B) views of right pilon fracture, after medial talus and calcaneus external fixation.

during this high-risk period still exhibited consistently high complication rates and subpar clinical results.[13,20,52–54]

Staged protocol management has yielded improved results, with lower complication rates and higher clinical outcomes.[5,7,30] Using a staged protocol that consisted of acute external fixation and delayed definitive reconstruction, Sirkin et al[7] focused particularly on optimization of soft tissues. Specifically, the authors waited for edema to subside, ranging anywhere from 7 to 14 days, indicating subsidence with the presence of skin wrinkling.[7] Applying the staged protocol on the management of 56 pilon fractures, Sirkin et al reported only 2 deep infections and the healing of all surgical wounds, with rates significantly lower than previous reports.[7,13,20] Furthermore, the presence of blisters, which occur at a relatively high rate in accordance with pilon fractures, offer more clues to the awaiting definitive management.[20,55] When especially faced with blood-filled blisters, which indicate a complete separation of the dermis from the epidermis, Giordano and Koval recommended waiting for full re-epithelialization before operative intervention.[55] Resolution of edema is often indicated by the absence of shiny skin, with normal skin creases or "wrinkles" being predominately exposed. Staging treatment and awaiting soft tissue optimization have also reported favorable results in a more recent study concerning ORIF in open pilon fractures.[56] Boraiah et al have reported results on 59 open pilon fractures, reporting excellent clinical outcomes at a minimum follow-up of 2 years with 88% union and 9% delayed union, with only 3 deep infections, 2 superficial infections, and 1 amputation after a failed free flap transfer.[56]

Despite the success of the staged protocol, proponents for early ORIF still remain.[33] White et al[33] performed ORIF within 48 hours in 95 patients with good clinical outcome measures at 1 year. Overall, there was a 19% complication rate, including open- and closed-type C fractures and excluding those with "local soft tissue factors" not specifically defined. Considering closed fractures specifically, their complication rate was only 2.7%. Of note, the authors stress that the cases must be done in "the right setting" and that all the resources must be available. They do state that this should not be done if the above are not available or if the patients "present late or beyond an early window"; although one is not defined. The authors suggest that "medical judgment" must be utilized.[33]

When planning for definitive fixation, CT scans are an invaluable tool. To allow for the highest yield in defining the articular fragments and for the purpose of definitive surgical approaches, we advocate that the CT scan should be acquired only after the extremity's length and mechanical axis are restored with external fixations. This will disimpact the talus from the distal tibia to allow for better visualization of the articular injury.

Information on specific areas of articular involvement, comminution, and impaction cannot be seen on plain films (Figs. 4A, B).[32] Tornetta and Gorup[32] studied the impact of CT on the management of pilon fractures and noted that CT information had changed the management in 64% of the patient cohort.[32] Additionally, the operative surgeons reported that information derived from the CTs had improved their understanding of the fracture pattern in 82% of patients besides shortening the operative time in 77% of patients.[32] Intuitively, the analysis of the surrounding soft tissue via soft tissue windows on the CT scans can also offer valuable information, such as potentially entrapped tendonous or neurovascular structures (Figs. 4C, D).

DECISION MAKING FOR DEFINITIVE MANAGEMENT

The original principles of Rüedi and Allgöwer concerning pilon fracture management and reconstruction have not seen drastic changes over the past 40–50 years.[12,57] The treatment algorithm, which places emphasis on restoration of length with fibular reconstruction, reconstruction of the metphyseal shell and articular joint, bone grafting, and medial

FIGURE 4. Operative planning can be greatly enhanced as degrees of comminution, impaction, or displacement, not elucidated on plain radiographs (A, B), can be seen clearly via CT (C). CT bone windows may also be enhanced with soft tissue windows, which may exhibit entrapped tendonous structures (arrow, posterior tibialis tendon and flexor digitorum longus tendon) or neurovascular structures (D).

buttress to stabilize metaphysis for the diaphysis reconstruction, still applies. Some advances in the surgical approach options and implant technology have facilitated the surgeons in their quest of achieving goals.[5,22,24,26–29,45,58]

Classically, the standard approach to the tibial plafond is described as a 2-incision technique, an anteromedial incision for the tibia and a posterolateral incision for the fibula.[12,57,59] However, depending on preoperative planning with identification of the major fracture fragments and lines via CT and remembering to utilize an adequate skin bridge, additional surgical approaches can be used to maximize exposure and the ability to address specific articular issues.[7,27–29,32,46]

Anterior approaches to the tibial plafond are based on principle reconstruction from posterior to anterior, after "opening the book.".[58–60] Utilization of the posterolateral (Volkmann) fragment as the "constant fragment" often relies on the assumption that the fibula was anatomically and stably reduced in terms of alignment, length, and rotation.[2,60] Each anterior approach, anteromedial, anterolateral, and direct anterior, holds unique advantages and disadvantages.

To facilitate the ability to evaluate articular fragments and their reduction, the external fixator or femoral distractor can be helpful through any of the anterior approaches (Fig. 5). One must keep in mind that relative to the midsagittal plane of the tibia, the position of the transcalcaneal pin in a "delta" frame can cause a dorsiflexion moment of the foot with significant attempted distraction. This can inhibit direct visualization of the joint when there is significant anterior or central comminution. When the femoral distractor is applied with a pin in the talar neck and another one in the tibia, a plantarflexion moment will yield excellent visualization of the joint, but once the articular surface is stabilized, excessive distraction must be removed to allow appropriate reduction of the metadiaphyseal component that may have been deformed in the sagittal plane with the distractor. Also, care must be taken when applying the distractor to have the talar neck pin parallel to the superior dome of the talus to avoid "dialing-in" a coronal plane deformity.

The classic anteromedial approach, as described by Tile, is typically used for AO/OTA 43B and C fractures.[6,48,57,59,60]

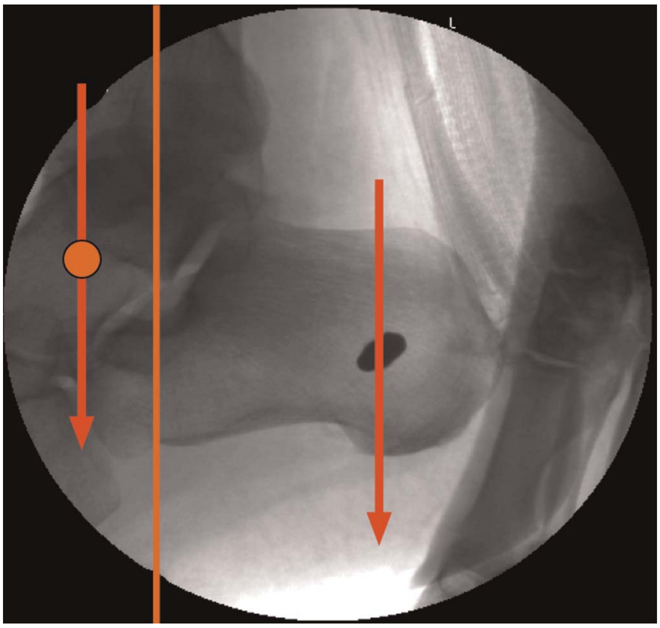

FIGURE 5. Through the anterior approach, a femoral distractor or an external fixator can assist in achieving necessary length and visualization. However, important consideration must be paid to the potential plantarflexion moments (left arrow) or to the dorsiflexion moments (right arrow), when manipulating along the midsagittal (central line) axis.

Starting approximately 5 cm proximal to the tibio-talar joint line and just lateral to the tibial crest, the anteromedial incision can extend distally to form around the medial mallelous or continue distally with the tibialis anterior (TA) tendon toward the talonavicular joint.[2,60,61] Careful consideration must be made to avoid violating the TA tendon sheath because it will readily accept grafts, unlike the tendon itself, especially in the case of a wound dehiscence.[62] Preservation of the periosteum in an already vascularly tenuous area is also of high priority. Although this incision offers great access for medial and anterior hardware application, it lacks in the ready access to the anterolateral (Tillaux–Chaput) fragment (Fig. 6).[58,60]

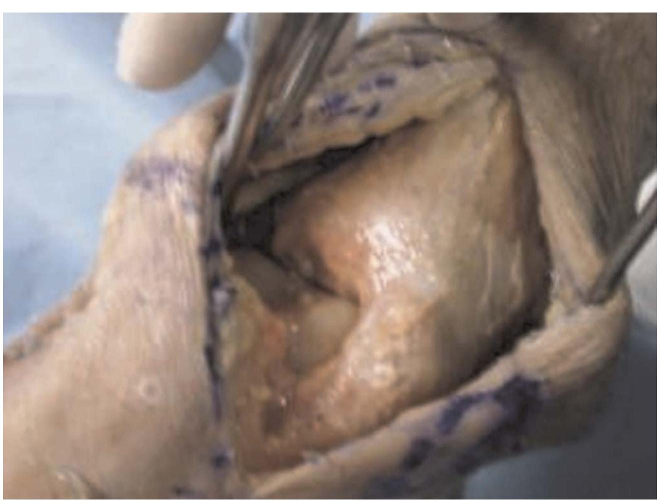

FIGURE 6. The anteromedial incision offers great access for medial and anterior hardware application but lacks the ready access to the anterolateral (Tillaux–Chaput) fragment.

Böhler's anterolateral approach to the tibial plafond allows direct access to the Tillaux–Chaput fragment unlike the anteromedial approach.[22,27] Additionally, depending on concomitant foot and ankle injuries, the approach can be extended to provide direct visualization of the anterior talar dome, talar neck, lateral talonavicular, subtalar, and calcaneocuboid joints.[27] The incision is inline with the fourth metatarsal when the foot is in neutral dorsiflexion, starting 5 cm proximal to the tibio-talar joint.[27] Identification and protection of superficial peroneal nerve branches are imperative.[27] Herscovici et al[27] described this incision, noting that, if needed, extension of the incision both in the proximal and in the distal directions can be obtained without an increase in wound complications and maintenance of straightforward closure.[27] Although some surgeons have criticized the approach due to lack of access to posterior fracture elements, Mehta et al[30] described successful total articular reconstruction with the use of a bony distractor, a headlamp, and an intraoperative imaging via the anterolateral and a second more medially based incision. Using an alternative extensile approach from the lateral plafond and crossing medially to reach the anterior, Grose et al[5] reported good results and low complication rates, especially regarding deep infection (4.5%) and wound dehiscence (4.5%).

Alternatively, the direct anterior approach can offer access to both the anteromedial and the anterolateral fragments of a pilon fracture, with a straightforward linear incision centered over the tibio-talar joint. One must be aware of the deep neurovascular bundle as it crosses the tibio-talar joint and its changing relationship with the TA, extensor hallicus longus (EHL) tendons, and extensor digitorum longus (EDL) relative to the tibio-talar joint. Traditionally used for ankle arthrodesis, this approach can be used to treat pilon fractures, and if necessary, future fusion (Figs. 7A–E). In a recent retrospective review of 49 pilon fractures, McCann et al[63] have noted the low complication rates with minimal soft tissue disturbance in the direct anterior approach.

Posterior approaches to the pilon are used in select situations, when goals cannot be accomplished through any of the anterior approaches. Of note, direct articular reduction is not possible and relies on cortical reduction and fluoroscopic assistance.[29,53,64] Benefits of the posterolateral incision lie in its utility in rebuilding the constant fragment, especially if found with significant impaction and/or rotation (Figs. 8A–D).[2,29,60]. This can also convert a "C-type" fracture to a "B-type" fracture. Then the surgeon can use an anterior approach to rebuild the plafond from posterior to anterior.[45]

Furthermore, classically, the posterolateral approach, which exploits the interval between the lateral and posterior compartment musculature, was thought to offer a lower complication rate.[2,29,60] However, Bhattacharyya et al[64] have noted a high complication rate via this approach, which includes nonunions and wound problems leading to fusions and suboptimal clinical outcomes. Of note, the authors have attempted complete fixation of patients through one surgical approach.[64] When required, the posterolateral tibia can be

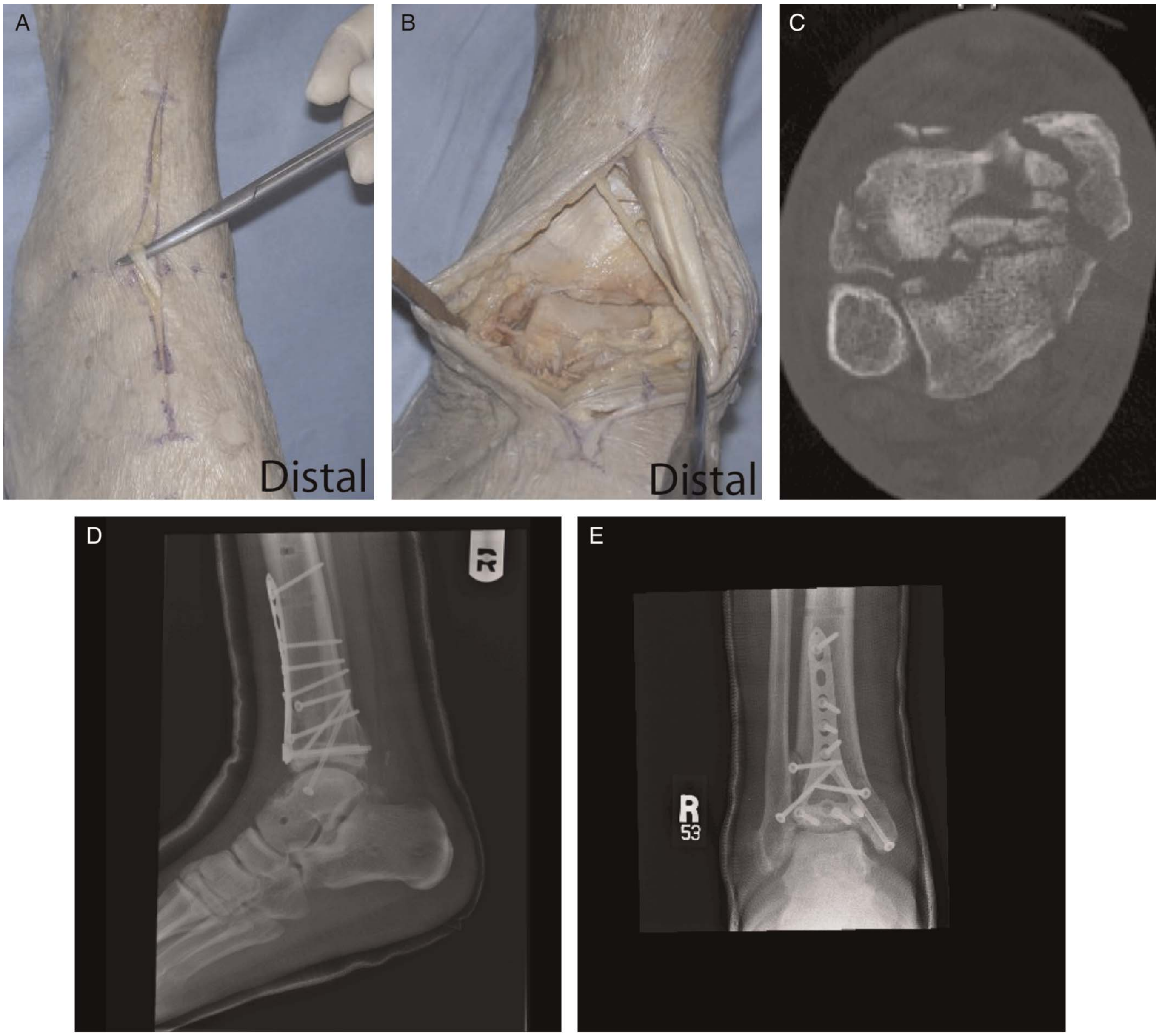

FIGURE 7. Traditionally used for ankle arthrodesis, the direct anterior approach can be used to treat pilon fractures. A, Incision should be made at the center of the mortise, providing access to the anteromedial and anterolateral aspects of the joint. Avoid the branches of the superficial peroneal nerve and incise the extensor retinaculum. B, Intervals include the EHL/TA, EHL/EDL, and the EDL/peroneus tertius. Remember that proximal to the tibio-talar joint, the neurovascular bundle lies between EHL/TA, whereas distal to the tibio-talar joint, the bundle lies between EHL/EDL. Excise the anterior ankle capsule and the intra-articular fat to expose the joint. C, At times, the fracture pattern and location can obviously dictate the use of a direct anterior approach. Anteroposterior (D) and lateral (E) radiographs of definitive ORIF via a direct anterior approach. However, despite good reduction and stable reconstruction, arthrodesis secondary to arthritis is still possible. Direct anterior approach facilitates future ankle fusion, if necessary.

addressed between the peroneus longus and the flexor hallucis longus, whereas the fibula can be addressed posteriorly by going anterior to the peroneus brevis.

The posteromedial approach is helpful when addressing tendon or neurovascular bundle entrapment.[28] The incision lies at the midpoint between the medial malleolus and the posteromedial aspect of the Achilles tendon. Identification of the tendinous and neurovascular structures is paramount to allow for safe development of intervals based on fracture pattern. Using both posteromedial and posterolateral approaches on the same patient should be approached with caution based on their relative proximity and need for extensive deep surgical dissection. Typically, the majority of the posterior aspect of the distal tibia can be addressed through either approach, and the area that requires more direct manipulation should be chosen. In select cases, when a small window is required for

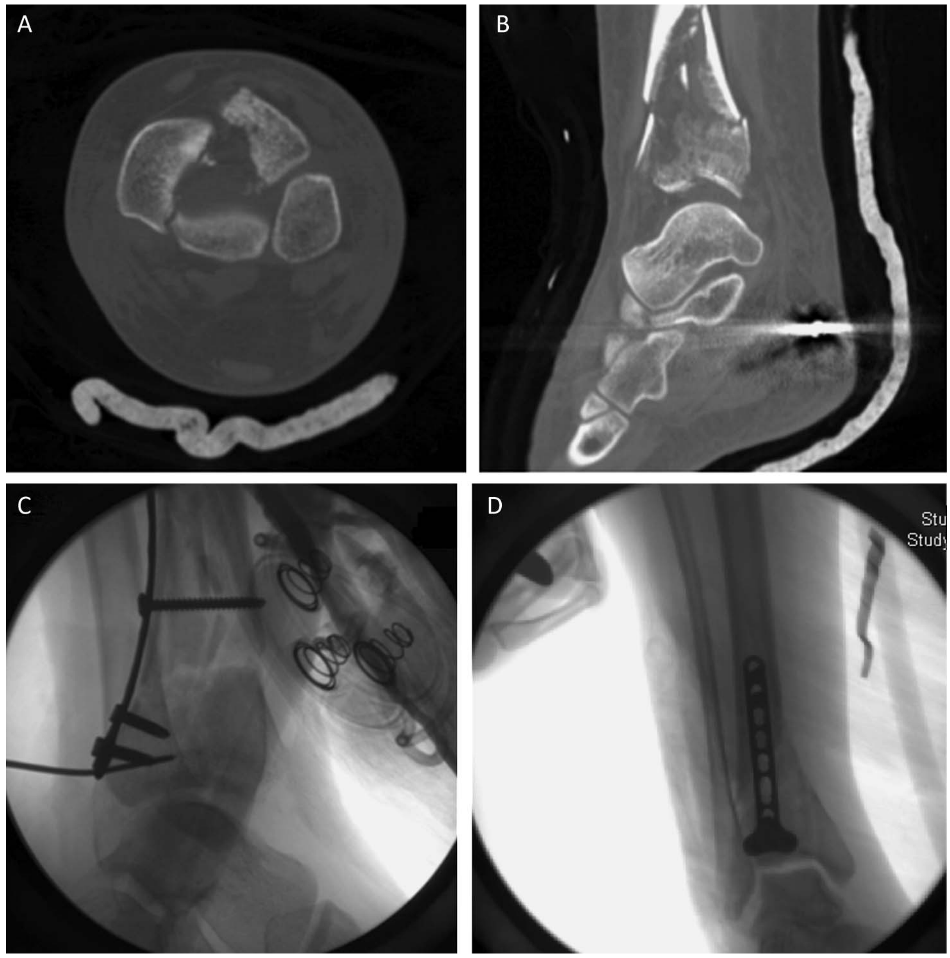

FIGURE 8. The posterolateral incision allows for constant fragment reconstruction, especially if found with significant impaction and/or rotation (A, B). Derotation and rebuilding of the constant fragment with limited fixation can act as a bridge to staged anterior ORIF (C, D).

the placement of a reduction aid and so on, this can be considered, but with great respect for the soft tissues.

The multitude of surgical approaches and advancements in small fragment, mini-ragment, and bioabsorbable fixation have provided improved ability to specifically address articular fragments in previously irreconstructible situations.[22–25,28,29,40,65] Locking plate constructs may obviate the need for bone grafting in select situations and provide added stability in comminuted or osteoporotic scenarios.[2] Also, such fixed-angle constructs can help decrease the number of plates required based on fracture pattern and comminution while providing adequate stability to allow for protracted healing that may be encountered.

Future implant modifications may further improve clinical results. The role of intramedullary nailing (IMN) for pilon fractures has not yet been extensively studied. Studying the results of IMN for distal tibial fractures, Vallier et al[66] have found complication rates and union rates comparable with plating. When considering limited ORIF with IMN for fixation of fractures of the plafond, careful study of the CT scan and understanding of the fracture is imperative. First, stable articular reduction and independent screw fixation are required, while leaving access for appropriate placement of an IMN. This technique is only recommended for simple articular fractures without impaction for experienced surgeons. In select patients with "irreconstructable" pilon fractures or significant comorbidities precluding safe direct fixation, consideration for primary fusion can be made. The metaphyseal defects should be addressed primarily with bone graft to limit the chance of nonunion.[67,68]

SUMMARY

In summary, although staged-protocols and advancements in technique and technology move forward, the original principles regarding pilon fracture management remain intact. Restoration of length with fibular fixation, reconstruction of the articular surface, bone grafting, and buttress of the metadiaphyseal reconstruction still remain the foundation of optimal management. Modifications include the importance of soft tissue management, with particular focus paid to soft tissue edema and blister resolution. Furthermore, strategic preoperative planning via the use of CT and selection of appropriately bridged surgical incisions may together facilitate an easier perioperative period and desired postoperative outcome. To stage the subsequent incision, the definitively treating surgeon should initiate the first "workhorse" incision. Knowing the pros and cons of each surgical approach will also

facilitate increased chances of desired clinical results. Future protocol changes, implant technologies, and the role of IMN in the management of pilon fractures may be subject to further research, but the principles of pilon restoration will most likely remain the same.

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Erratum

A Biomechanical Comparison of a Locking Plate, a Nail, and a 95° Angled Blade Plate for Fixation of Subtrochanteric Femoral Fractures: Erratum

In the article that appeared on page 334 of the June 2012 issue of the *Journal of Orthopaedic Trauma*, the list of contributing authors was inadvertently abridged. The correct authors of the article are Daren P. Forward, FRCS, Christopher J. Doro, MD, Robert V. O'Toole, MD, Hyunchul Kim, MS, John C. P. Floyd, MD, Marcus F. Sciadini, MD, Clifford H. Turen, MD, Adam H. Hsieh, PhD, and Jason W. Nascone, MD. The article originally published without the names of the final 3 contributing authors. This error has since been corrected online. The publisher regrets these errors.

REFERENCE

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Meeting Announcement

October 1, 2012
WTA Annual Meeting Abstract Deadline
The abstract system for the 43rd Annual Meeting of the Western Trauma Association opened on July 1, 2012 and will close on October 1, 2012. For meeting information and abstract submission, go to http://www.westerntrauma.org

March 3–8, 2013
Western Trauma Association 43rd Annual Meeting
Snowmass, CO
For meeting information and abstract submission, go to http://www.westerntrauma.org