Reduction Strategies Through the Anterolateral Exposure for Fixation of Type B and C Pilon Fractures

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Summary: The surgical management of pilon fractures has evolved over the last several years with treatment shifting from acute definitive fixation to delayed fixation. One of the driving forces behind this change was the high incidence of soft tissue complications in those patients with high-energy pilon fractures (Orthopaedic Trauma Association 43B and 43C) managed with acute stabilization. Meticulous soft tissue handling along with delayed definitive fixation based on the soft tissue envelope has decreased the short-term complications associated with treatment of these injuries. Anterolateral exposure to the distal tibial articular surface allows for adequate visualization of most fracture patterns, novel reduction strategies, and successful implant placements. This exposure is useful in certain Type C pilon fractures, anterior and anterolateral Type B pilon fractures, and some extra-articular distal tibial fractures. The anterolateral exposure is not suitable in fractures with medial comminution, medial crush, impaction at the medial shoulder of the joint, segmental medial malleolar injuries, or varus deformity at the time of injury. The exposure has the advantage of excellent visualization of the articular surface up to the medial shoulder of the plafond while avoiding dissection of the anteromedial tibial surface.

Key Words: pilon fracture, surgical approach, extensile anterolateral approach, soft tissue management, open reduction

INTRODUCTION

Surgical decision-making in the treatment of pilon fractures continues to be a source of debate among orthopaedic surgeons.1–10 Issues surrounding high-energy pilon fracture management include the decision to operate (versus non-operative treatment), the timing of intervention (acute or delayed), the type of intervention (external fixation, limited internal fixation, internal fixation, hybrid fixation), and the surgical exposure (anteromedial, medial, anterolateral, lateral, posteromedial, posterolateral, or combined). With improved soft tissue management and the increased implementation of delayed fixation, the soft tissue complications arising from surgical fixation of high-energy Orthopaedic Trauma Association Type B and C pilon fractures is improving. However, long-term outcomes of operative fixation of pilon fractures continue to be less than ideal.1,9,11

Long-term outcome data after staged surgical management (temporizing external fixation followed by definitive internal fixation) of high-energy pilon fractures using surgical exposures that focus on respecting the soft tissue envelope are limited. Although the extensile anteromedial, the posterolateral, and lateral approaches have been previously described, the anterolateral exposure to the distal tibial articular surface along with reduction strategies has not been well defined.2,3,6,12–15 The anterolateral exposure is useful in certain Type C pilon fractures and anterior and/or anterolateral Type B pilon fractures. Furthermore, certain extra-articular distal tibial fractures that can be stabilized with a plate placed beneath the anterior compartment may be amenable to reduction and fixation through an anterolateral exposure. The approach has the advantage of excellent visualization of the articular surface to the medial shoulder of the plafond while avoiding dissection of the anteromedial tibial face. However, impaction at the medial shoulder is difficult to reduce with this exposure. Proximal extension of this approach is also limited. The approach is ideally suited for accurate articular reduction combined with submuscular and subcutaneous plate applications spanning the metaphyseal and any associated metaphyseal comminution in patients without medial comminution or crush.

Surgical Exposure

The patient is positioned supine on a radiolucent operating room table with the feet brought to the end of the table. The ipsilateral hip is elevated with a small bump to assist with positioning the leg in neutral rotation. A tourniquet is placed on the ipsilateral thigh and antibiotics are administered before tourniquet inflation. If an external fixator is present, it is prepped into the sterile field to maintain stability of the soft tissues throughout the preparation and draping of the extremity.
If a fibula fracture is present and has not been operatively repaired at the time of external fixation application, the fibula is usually addressed before operative fixation of the tibia. By obtaining accurate reduction of the fibula with restoration of length, alignment, and rotation, the tibial reduction may be improved through ligamentotaxis as well as restoration of the lateral column of the distal lower extremity. In an effort to maximize skin bridges between the anterolateral incision and the fibular incision, a posterolateral surgical exposure is used to repair the fibula. The fibula can be repaired using a variety of techniques, including posterolateral plating, lateral plating, or intramedullary fixation depending on fracture pattern and surgeon comfort.

Once the fibular fracture has been addressed, the anterolateral incision is centered at the ankle parallel to the fourth metatarsal distally and between the tibia and fibula proximally as described by Herscovici et al (Fig. 1). Proximal extension of the incision of more than 7 cm from the ankle disrupts the origin of the anterior compartment musculature. Distally, the incision terminates slightly distal to the talonavicular joint. The distal extent of the incision is needed for visualization of the posterior aspect of the plafond and application of the universal distractor.

Full-thickness skin flaps should be maintained while dissecting through the subcutaneous tissues. The superficial peroneal nerve will likely cross proximal to the ankle in the surgical field and should be identified, mobilized, and protected throughout the exposure (Fig. 2). The fascia over the anterior compartment of the distal tibia and the extensor compartment is incised sharply and the anterior compartment tendons are all retracted medially. These muscles and tendons are usually easily mobilized from the underlying anterior tibiofibular ligament, the periosteum of the distal tibia, and the joint capsule.

An arthrotomy can be performed at or close to the anterolateral fracture line to avoid devascularization of the distal tibia (Fig. 3). Care should be taken not to incise the anterior tibiofibular ligament. By continuing the arthrotomy distally over the talar neck and elevating the capsule from the anterior distal tibia, visualization of the articular segments can be accomplished.

Visualization and reconstruction of the articular surface can further be enhanced through the application of a laterally based medium universal distractor (Fig. 4). One 4-mm Schanz pin is placed in the talar neck. A second 4-mm Schanz pin is inserted laterally in the tibia proximal to the anticipated location of the plate through a separate small surgical incision over the anterior compartment. This proximal pin insertion can put the anterior neurovascular bundle and/or the superficial peroneal nerve at risk. By placing the threaded rod posterolaterally, the universal distractor itself does not impede reduction or imaging, and the force vector will distract and plantarflex the talus to maximize joint visualization from anterior to posterior.

**Reduction Technique**

With adequate exposure of the articular surface up to the medial shoulder of the distal tibia, reduction of the fragment(s) typically proceeds from posterolateral > posteromedial > central > anterior > anterolateral (Fig. 5). Visualization of the articular surface can be further improved by removing hematoma, debris, and early callus. Care should be taken not to remove any of the articular fragments during this process. Direct access to the articular fragments and the metaphysis can be gained by externally rotating the anterolateral segment on its ligamentous attachment. If a large posterior cortical spike contiguous with posterolateral articular segment exists, this fragment can be reduced to the intact tibia and held with Kirschner wires placed percutaneously and obliquely from the anterior tibia into the posterolateral fragment. Assuming an adequate posterior reduction can be obtained and maintained, the joint surface can then be built off this posterolateral piece. However, if the posterior reduction is not attainable or the reduction is not accurate, articular malreduction will result. In these cases, the joint surface should be reconstructed first.

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**FIGURE 1.** (A) Schematic and (B) clinical picture with the incision for the extensile anterolateral exposure centered over the ankle parallel to the fourth metatarsal distally and between the tibia and fibula proximally.
followed by fixation to the remaining tibia with great care to maintain sagittal alignment.

Multiple techniques exist to control and reduce the posterolateral articular segment, including use of a joystick placed from anterior to posterior directly into the anterior cancellous surface or by using a large pointed reduction clamp placed posterior to the fibula and onto the posterolateral tibia (Fig. 6). Alternatively, one tine of a pointed reduction clamp or a shoulder hook can be placed carefully through the syndesmosis to engage the proximal extension of the posterolateral fragment. The most accurate reduction may be through a separate posterior exposure to the posterior component. This may however require a separate operative procedure with the patient placed in the prone position. Regardless, the reduction of the posterolateral fragment determines the coronal and sagittal plane reductions of the remaining articular fragments and hence the joint. Therefore, accurate restoration of this fragment is critical. The commonly observed persistent rotational abnormality of the posterolateral segment that requires further reduction is dorsiflexion.

With the posterolateral piece reduced, the medial side can be reduced and stabilized with multiple Kirschner wires. The reduction read for this fragment is usually the sagittally oriented articular fracture that separates the medial fragment from the posterolateral fragment. Percutaneous Kirschner wires placed into the medial segment can assist with this difficult reduction.

After the posterolateral and medial plafond have been reduced and stabilized, the centrally impacted segments and osteochondral fragments can then be addressed with dental picks or Kirschner wire joysticks. It is these centrally impacted fracture patterns that often leave a void in the metaphysis requiring structural support with a bone graft or bone graft substitute. Our preference is packing crushed cancellous allograft into the void once accurate reduction has been obtained and stabilized. Once reduced and stabilized with Kirschner wires, the central articular surface can be reduced and secured with either strategically placed Kirschner wires or definitive minifragment (1.5, 2.0, or 2.4 mm) intraosseous screw(s). If intraosseous screws are not used, the anteroposterior Kirschner wires in the central osteochondral fragments should be replaced with medial to lateral or lateral to medial Kirschner wires to allow subsequent reduction of the anterior articular segments.

Last, the anterolateral segment is internally rotated and reduced to the remaining distal tibia. The entire plafond reduction can be confirmed after reduction of this anterolateral fragment because it should accurately match the extra-articular cortical read of the medial segment as well as all articular reads. Anterior distal tibial cortical fragments should be replaced to ensure accurate overall reconstruction of the anterior tibial length. The overall reduction can then be confirmed both visually and fluoroscopically.

Sagittal plane alignment of the articular segments as well as the relationship of the entire articular block to the distal tibial metaphysis is difficult to assess during the initial
reduction maneuvers, and sometimes this can only be reliably accomplished after reduction of the entire articular block. If a persistent sagittal plane deformity of the posterior articular surface exists (typically extension with a central articular concavity), accurate reduction addressing the deformity should be performed. Often, an increase in plantarflexion of the posterior segments is required to correct this commonly observed dorsiflexion deformity of the posterolateral segment.

Surgical Stabilization

The choice and location of implants should be based on a preoperative plan that coincides with basic fracture fixation principles. Often, the original injury films along with the computed tomography scan performed after temporizing external fixation will be of the most value. The type of implant used is dependent on a number of factors, including the amount of cortical continuity, bone quality, initial failure direction of the distal tibia, soft tissue defects, and the size of the distal articular segment. Implant options can range from nonlocking to variable-angle locking to fixed-angle locking plates. In addition, there are a number of precontoured periarticular distal tibial implants that can be used or standard implants that can be contoured by the surgeon.

Submuscular plate placement extending from the anterior aspect of the articular segment to the lateral tibia proximally can be accomplished through the anterolateral exposure. Removal of the universal distractor is often necessary before plate insertion. A small elevator or the leading edge of the plate can be used to create a plane for plate placement. Often, multiple Kirschner wires or intraosseous screws maintaining the articular reduction can make screw placement challenging. Multiple points of fixation in the distal segment are required and the screw locations are dependent on the number and locations of the articular fragments (Fig. 7). The plate should be secured distally first to ensure that it fits the plafond and the screws address the articular component. Once the plate is fixed distally, proximal fixation can be undertaken. Plate balance is critical at the time of distal screw fixation. In addition, in situations of severe articular comminution or an inability to place small or minifragment fixation to support the articular surface, Kirschner wires can be left to hold the reduction. It is important to secure the Kirschner wires by bending them under the applied plate so that they do not migrate.

Depending on the original tibial deformity at the time of injury, comminution, and assessment of stability, a subcutaneous...
anteromedial plate can also be placed. This plate is inserted through a 2-cm incision proximal to the tip of the medial malleolus. The anteromedial implant can serve two functions: as an antiglide implant to prevent a secondary varus deformity or as a medial tension band implant to prevent a secondary valgus deformity (Fig. 8). The type of medial implant used (eg, one third tubular, small fragment, precontoured, fixed angle) is based on the intended function. However, our experience has been such that somewhat flexible implants are most useful when considering the balance between maintaining the reduction and minimizing implant prominence. By using a semiflexible implant, we are able to overcontour the plate with the initial application followed by placement of a screw just proximal to the metaphyseal flare to autocontour the flexible plate to the medial tibia. This is most applicable in patterns without significant medial crush, both the plate application and the anterolateral exposure. Strategies in plate application include using a longer plate to increase torsional rigidity, placing the primary screw just proximal to the medial fracture exit point, and inserting proximal screws using percutaneous techniques. The presence of a poor medial soft tissue envelope may preclude medial plate placement, and in this case, screws can be inserted through the medial malleolus into the proximal segment. Once the pilon fracture has been operatively stabilized and repaired and before soft tissue closure, the syndesmosis is assessed to determine if there is injury. The assessment involves use of an image intensifier and either a stress external rotation test or a Cotton test.

Repair of the extensor retinaculum is critical to prevent tendon bow stringing. This can usually be accomplished with a running 3-0 monofilament suture. The skin is closed with interrupted 3-0 nylon suture using the Allgöwer modification of Donati. Early limb elevation is important to minimize tension on the skin closure. Early ankle range of motion exercises are encouraged. Weightbearing is restricted for 12 weeks.

Clinical Summary
From January 2000 until December 2003, we treated 242 pilon fractures with open reduction and internal fixation.
that presented to our Level I trauma center. Of these, an anterolateral exposure was used in 131 patients. The average age of the patient was 39 years (range, 17–66 years). The right limb was involved in 65 cases. Sixty-two patients were injured from a fall from height, 30 patients during a motor vehicle collision, 19 patients as a result of motorcycle collisions, and 20 from assorted other causes. Fifty-three patients were smoking during the postoperative period. Seventy-five patients had additional orthopaedic injuries.

All pilon fractures in this group were categorized using the Orthopaedic Trauma Association fracture classification scheme. There were 53 Type 43-B fractures (23 B1, 17 B2, 13 B3) and 78 Type 43-C fractures (29 C1, 26 C2, 23 C3). Six 43-B fractures and 19 43-C fractures were open, only two of which required a soft tissue coverage procedure. A concomitant fibula fracture was present in 30 patients with Type B injuries (56%) and 65 patients with Type C injuries (83%).

Of the 131 fractures, 106 were managed using a staged protocol, which included initial external fixation. In the remaining 25 patients, no external fixator was used because of minimal soft tissue swelling, an intact fibula, anatomic alignment, and/or surgeon preference. Definitive reconstruction using an anterolateral exposure was performed at an average of 14 days after the date of injury (range, 0–87 days). This included 21 patients with minimal soft tissue swelling that were definitively managed within 7 days of injury. Sixty-seven patients had an additional surgical exposure to address their distal tibia fracture (37 percutaneous medial, 17 open medial, 10 posteromedial, three posterolateral). The average tourniquet time during operative fixation of the fractures was 109 minutes, 99 minutes for the Type B patterns and 117 minutes for the Type C fractures.

Of the 131 patients, we were able to follow up 112 patients in the immediate 3 months for surgical complications related to the incision. There were three wound infections requiring operative débridement and irrigation in patients with closed fractures. There were seven patients who had iatrogenic superficial nerve palsy postoperatively, of which only two did not have return of function. Planned early (defined as less than 12 weeks) bone grafting procedures were performed in nine patients with open fractures complicated by bone loss. There were no issues surrounding avascularity of the medial/anteromedial bone fragment from dual plating that were obvious on plain radiographs. Of the patients with closed injuries, none required flap coverage at the time of their fixation or in a delayed fashion.

DISCUSSION

The difficulty in treating high-energy Orthopaedic Trauma Association 43B and 43C pilon fractures is well recognized, but recent advancements in soft tissue management, particularly with delaying definitive stabilization and using novel surgical approaches, has improved the short-term
outcomes of this injury pattern. The goals of operative management of articular fractures include anatomic reduction, stable fixation, and early joint motion. Previous techniques using minimally invasive fixation or combined external and percutaneous screw fixation, while limiting soft tissue complications, provided limited access to and inaccurate reduction of the articular surface.

Our current treatment strategy involves early stabilization of a high-energy pilon fracture with either external fixation alone or fibular fixation in conjunction with a medially based external fixation construct. The computed tomography scan is obtained after length restoration through ligamentotaxis, allowing an improved understanding and interpretation of the fracture configuration and sites of impaction. Definitive fixation is delayed for 10 to 25 days until swelling has diminished, fracture blisters have resolved, and the skin displays “wrinkling.” Our average time from injury until fixation was 14 days. This delay was identical to the findings of both Sirkin et al and Patterson and Cole. We feel that this played a large role in our ability to manage the soft tissue postoperatively and limit our operative infection rate to 3% in the patients with closed fractures. Often, the quality of the soft tissue envelope (eg, presence of fracture blisters) dictated the timing of repair, but not necessarily the exposure used. If it was felt that an anterolateral exposure was needed for optimal fixation of the plafond, the authors would have waited until the soft tissue resolved and the skin was considered surgically ready. Preoperative planning of definitive fixation involves review of the computed tomography scan to choose which surgical exposure will facilitate access to the articular fragments, provide optimal reduction opportunity, and ideal plate placement.

Previous series have suggested that exposure based on the primary fracture line centered over the lateral pilon may not suffice for complex injuries that extend medially. Our experience would suggest the contrary, that an extensile anterolateral exposure with a defined reduction strategy allows for accurate reduction of the entire tibial plafond with the exception of impaction at the medial shoulder of the distal tibia. Other authors suggest that this exposure does not allow access to posterior fragments and does not allow for visualization of the articular surface. With the application of the universal distractor as described, along with pharmacologic relaxation, the use of a headlamp, and judicious use of intraoperative imaging, the entire articular surface can be visualized, reduced, and stabilized.

Although the anterolateral exposure may not be suitable in all clinical scenarios, it does provide an alternative to the anteromedial exposure previously described. The anterolateral exposure is not suitable in fractures with medial comminution, medial crush, impaction at the medial shoulder of the joint, segmental medial malleolar injuries, or varus deformity at the time of injury. Reduction strategies such as the application of a universal distractor, the use of intraosseous lag screw fixation, and Kirschner wire provisional fixation allow for accurate articular reconstruction. As a result of the location of the anterolateral incision, a second, medially based incision can be used for reduction of separate medial malleolar fractures and for percutaneous medial plate application.

Ultimately, the surgical exposure used and the reduction strategies used will be based predominantly on the fracture configuration, best analyzed on two-dimensional computed tomography scans and reconstructions, and any associated soft tissue compromise or open wounds.

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REFERENCES