Staged Posterior Tibial Plating for the Treatment of Orthopaedic Trauma Association 43C2 and 43C3 Tibial Pilon Fractures

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Objective: Obtaining an accurate reduction of the posterior malleolar fragment in high-energy pilon fractures can be difficult through standard anterior or medial incisions, resulting in a less than optimal articular reduction. The purpose of this study was to report on our results using a direct approach with posterior malleolar plating in combination with staged anterior fixation in high-energy pilon fractures.

Design: Prospective clinical cohort.

Setting: A Level I trauma and tertiary referral center.

Patients/Participants: From January 1, 2005, to December 31, 2008, 19 Orthopaedic Trauma Association 43C pilon fractures (16 C3 and 3 C2) with a separate, displaced, posterior malleolar fragment were treated by the authors. Nine patients were treated with posterior plating of the tibia (PL) through a posterolateral approach followed by a staged direct anterior approach. Ten patients with similar fracture patterns were treated using standard anterior or anteromedial incisions (A) with indirect reduction of the posterior fragment. All 19 patients were available for follow-up at an average of 40 months (range, 28–54 months).

Intervention: All patients were treated with open reduction and internal fixation for their pilon fractures.

Main Outcome Measurements: Quality of reduction was assessed using postoperative plain radiographs and computed tomography. Serial radiographs were taken during the postoperative course to assess the progression of healing and the development of joint arthrosis. Clinical follow-up included physical examination and evaluation of the ankle using the American Orthopaedic Foot and Ankle Society Ankle & Hindfoot score, Maryland Foot Score as well as noting all complications.

Results: There were no differences in injury pattern or time to surgery between groups. Of the 10 patients who were in the A group, 4 (40%) had more than 2 mm of joint incongruity at the posterior articular fracture edge as compared with no patients in the PL group as measured on postoperative computed tomography scans. At latest follow-up, 7 (70%) patients in the A group had radiographic evidence of joint space narrowing compared with 3 (33%) in the PL group. Ankle range of motion for the A group was 35.8° versus 34.2° for the PL group (nonsignificant). There were 2 delayed wound healing complications in the A group with one deep infection in the PL group. No significant difference was seen in posttraumatic complications across both groups. The average Maryland Foot Score and American Orthopaedic Foot and Ankle Society Ankle & Hindfoot score for the PL group was 86.4/85.2 compared with 69.4/76.4 for the A group.

Conclusions: The addition of a posterior lateral approach offers direct visualization for reduction of the posterior distal fragment of the tibial pilon. Although the joint surface itself cannot be visualized, this reduction allows the anterior components to be secured to a stable posterior fragment at a later date. This technique improved our ability to subsequently obtain an anatomic articular reduction based on computed tomography scans and preservation of the tibiotalar joint space at a minimum 1-year follow-up. Furthermore, it correlated with an improvement in clinical outcomes with increases in Maryland Foot Score and Ankle & Hindfoot score for the posterior plating group. Although promising, continued follow-up will be needed to determine the long-term outcome using this technique for treating tibial pilon fractures.

Key Words: pilon, staged, posterior plating, plafond, open reduction internal fixation, intra-articular

Original Article

INTRODUCTION

Comminuted tibial pilon fractures present a difficult problem for the treating surgeon. These complex injury patterns are associated with significant articular cartilage and soft tissue damage. Although the goal of treatment is to obtain an anatomic joint reduction, this must be performed while maintaining soft tissue viability. Because of these soft tissue constraints, surgeons are often hesitant to perform a formal...
open reduction and internal fixation at the time of injury. These soft tissue limitations have led many authors to conclude that a staged management of the injury with initial external fixation of the fracture and delayed open reduction internal fixation of the plafond is the preferred approach to these fractures.\(^1,2\)

Typically, fixation of the articular surface and tibial shaft is addressed through a variety of anterior incisions (anteromedial, anterior, or anterolateral) with the patient supine. The goal of treatment is to reconstruct the crushed anterior surface by connecting these fragments to the stable posterior malleolus, which is used as a template for length, angulation, and rotation. Unfortunately, high-energy fracture patterns can often be associated with a posterior, posteromedial, or posterolateral fragment that is often displaced (Orthopaedic Trauma Association [OTA] 43C2, 43C3). When this occurs, obtaining an articular reduction from the front is exceedingly difficult because there is no stability of the posterior fragment. Furthermore, obtaining an accurate reduction of this posterior fragment can be difficult through standard anterior incisions because alignment must be obtained indirectly. Indirect reduction using closed or percutaneous methods is often difficult to perform as a result of impaction and three-dimensional rotation of the fracture fragments. On the other hand, once soft tissue swelling resolves, the surgeon may spend considerable time attempting an open anatomic reduction yet still fail in achieving this goal.

This article describes the initial results of a staged protocol to treat high-energy pilon fractures with initial application of an external fixator followed by a limited posterior open reduction internal fixation (ORIF) through a posterolateral approach. Using this incision, the fibula as well as the posterior malleolar fragment can be reduced initially. The soft tissues are then allowed to heal until an anterior approach can be used to reduce the anterior and medial fragments to a stable posterior fragment.

PATIENTS AND METHODS
Between January 1, 2005, and December 31, 2008, 28 patients with 28 high-energy pilon fractures (OTA 43C) were treated at our institution. All of the surgeries were performed by the senior author (R.W.S.). Nineteen of these fractures presented with an unstable posterior malleolar segment (16 OTA 43C.3 and 3 OTA 43C.2). Fourteen of these had an associated fibula fracture.

Nine fractures (8 OTA 43C.3 and one OTA 43C.2) were treated with posterior plating of the tibia through a posterolateral (PL Group) approach with fixation of the fibula through the same incision in 7 cases. A spanning ankle external fixator was then placed. There were 6 males and 3 females with an average age of 34 years (range, 19–48 years). There was one Gustilo Type II and one Gustilo Type IIIA open fracture. Plain radiographs of the ankle and computed tomography (CT) scans with reconstructions were obtained to delineate the injury pattern. Delayed ORIF of the anterior aspect of the pilon fracture was performed through a standard anterior midline incision at an average of 18.5 days (range, 13–25 days).

A cohort of 10 age- and sex-matched patients (8 OTA 43C.3 and 2 OTA 43C.2) with similar fracture patterns were selected for comparison. These fractures were treated previously using an older protocol with a standard anterior (A Group) incision and indirect reduction of the posterior fragment. There were 7 associated fibula fractures in this group. There were 2 open fractures (one Gustilo II and one Gustilo IIIA). All fractures initially underwent the application of a spanning external fixator at the time of injury with fixation of the fibula through a lateral incision in 5 cases. Fixation of the fibula was performed in 2 cases at the time of definitive fixation, again through a separate lateral incision. Plain radiographs of the ankle and CT scans with reconstructions were obtained to delineate the injury pattern. The average time for definitive fixation was 19.1 days postinjury (range, 15–24 days).

Both cohorts were managed similarly according to standard postoperative protocol for pilon fractures. Quality of reduction was assessed using plain radiographs and CT. Patients were followed for a minimum of 24 months. Clinical follow-up at final examination included range of motion, wound healing, notation of complications, healing of the fracture, and quality of reduction on x-ray examination. All patients underwent repeat ankle radiographs at the minimum 24-month review and outcome data using Maryland Foot and Ankle and American Orthopaedic Foot and Ankle Society scoring.

Technique
The patient is initially evaluated in the emergency room, and the limb is stabilized and placed into a well-padded splint. If radiographs reveal a pilon fracture with an associated fracture of the posterior malleolus, the patient is cleared for surgical stabilization and taken to the operating room. There are 2 options for the treating surgeon at this time. The first option is to place the patient supine and apply an external fixator. If this initial treatment is used, and there is an associated fibula fracture, the fibula should not be fixed, because the fracture pattern (and hence the required CT scan-based incisions) is not completely known. In this case, the procedure to be described subsequently can be performed in 3 to 5 days. We recommend that the fixation of the fibula and/or the posterior malleolar fragment be performed by the surgeon or team of surgeons who will perform the definitive fixation.

The second option was our protocol method of managing OTA 43C.3 fractures. The patient is bought into the operating room and placed in the prone position. A tourniquet is placed high on the extremity. The lower limb is then prepped and draped in sterile fashion. The authors routinely exsanguinate the limb with an Esmarch bandage and inflate the tourniquet to 350 mmHg (but this is optional and based on surgeon preference). A posterolateral incision is then made midway between the posterior border of the fibula and lateral aspect of the Achilles tendon. The length of the incision is dictated by the proximal extent of the posterior tibial fracture fragment as seen on a fluoroscopic image. Sharp dissection is carried down through skin and subcutaneous tissues. Care is taken to protect the sural neurovascular bundle. Dissection is carried down to the peroneal fascia. If the fibula is fractured, the fascia is split and the tendons...
are retracted medially to expose the posterolateral aspect of the fibula (Fig. 1A). The fibula is then reduced with reduction clamps. If appropriate, a lag screw is placed through the fibula and a neutralization plate applied. Often, there is significant comminution of the fibula and bridge plating is required. Care should be taken in placing the fibula to restore the proper anatomic length, alignment, and rotation. Anatomic fixation of the fibula is crucial to restoring the posterior malleolar fragment. Again, this can best be performed under fluoroscopic guidance.

Through the same incision, another fascial plane is created medial to the peroneal tendons. The flexor hallucis longus and associated soft tissue are retracted medially, exposing the entire distal, posterior aspect of the tibia (Fig. 1B). It is important to preserve the posterior tibiofibular ligament. This is done by dissecting superficial to the posterior capsular attachments. The posterior malleolar fragment typically has a metaphyseal–diaphyseal spike that can be reduced to the posterior aspect of the tibial shaft, but many times this “key” is fractured and care must be taken to reposition the malleolar fragment anatomically. This reduction is critical to the success of the procedure, because subsequent anterior reconstruction will be based on the proper position of the posterior malleolus. Anatomic reduction of the posterior malleolar fragment also restores the integrity of the ankle syndesmosis. Typically, a 3.5-mm one third tubular plate is then applied spanning the fracture in a buttress (antiglide) mode and secured proximally with 3.5-mm cortical screws. Also, smaller plates, 2.0 mm or 2.4 mm, can be used if the posterior fragments are smaller or require fixation into the distal fragment. If screws are required distally for stability of the posterior malleolar fragment(s), unicortical screws (10–14 mm) should be used to prevent interference with the subsequent reduction of the anterior fragments (for this reason, small fragment locking plates are ideal). After stabilization of the posterior aspect of the tibia, final images are obtained to evaluate for proper length of the posterior aspect of the tibia and fibula. At this point, the wound is thoroughly irrigated and layered closure is performed. The skin is closed with interrupted 3-0 nylon sutures.

After closure of the wound, the lower leg is flexed to 90° at the knee. Two 5.0-mm half-pins are placed proximal to the fracture site anteriorly. The pins should be placed well proximal to the estimated location of the proximal end of the plate that will be used for definitive anterior fixation. A transcalcaneal pin is placed under fluoroscopic guidance to complete the simple Delta frame. Additional pins in the first metatarsal or talus may be added, if needed for stability, and to prevent an equinus contracture. Bars and clamps are then placed, and gentle longitudinal traction is applied to pull the fracture out to length. Any bone fragments that are tenting the skin are manually pushed back into place to prevent pressure necrosis. The frame is then assembled and tightened. The tourniquet is released and the patient is taken to the recovery room.

Postoperatively, radiographs and a CT scan with reconstruction images are obtained to evaluate the reduction of the posterior fragment and the fibula as well as for planning of anterior fragment reduction maneuvers, choice of incisions, and implants. If minor adjustments are required of the posterior tibial reduction based on the CT, these can be performed at the time of definitive fixation. Patients with isolated injuries may be discharged home within 48 hours of surgery. They are then followed on an outpatient basis until the soft tissues have healed to the point where anterior surgery can be performed, approximately 2 to 3 weeks. Early motion at the first metatarsophalangeal joint is started early to prevent stiffness resulting from flexor hallucis longus scarring.

The patient is then brought back to the operating room for definitive fixation. The patient is placed supine with a bolster under the operative leg. The frame is disassembled and the pins are left in place and prepped into the sterile field. The limb is exsanguinated and the tourniquet inflated to 350 mmHg. Although any of 3 incisions described may be used, the authors favor a straight anterior midline incision. This incision allows for complete visualization of the anteromedial and anterolateral surface of the distal tibia and allows for the placement of either a medial or anterolateral plate. It is also the author’s incision of choice for an ankle fusion or ankle replacement. The anterior midline approach consists of an 8- to 10-cm incision centered over the ankle with most of the incision proximal to the joint. Typically, the portion of the incision distal to the joint measures 3 to 4 cm and stops at the level of the talonavicular joint. After the skin incision is made, care must be taken to find and protect the superficial peroneal nerve, which crosses the wound from the lateral side distally. The extensor retinaculum is then incised in line with the skin incision, several centimeters proximal to the ankle exposing the anterior tibial and extensor hallucis longus tendons. Care must be taken to find the anterior tibial artery and deep peroneal nerve just medial to the extensor hallucis longus tendon at the level of the joint. This part of the dissection is best performed using a Metzenbaum or tenotomy scissors. The neurovascular bundle should be moved laterally with the extensor hallucis longus and the anterior tibial should be moved medially. This exposes the ankle capsule. The exposure of the joint should be through the major tears in the soft tissue envelope. If needed, the joint capsule can be incised with a knife in a longitudinal direction, in line with the skin.
incision at the level of the articular surface. If the skin incision is to be extended proximally to permit plate application to the medial shaft, the incision should stay slightly lateral to the anterior tibial crest to prevent a painful scar.

Once the fragments are identified, sequential articular reduction is performed in a back-to-front manner, because the posterior aspect of the tibia has been stabilized (Fig. 2A–D). If there is impaction of the posterior articular surface or the fragment is slightly extended, reduction of this should be addressed first. Articular fragments are temporarily reduced with 1.6 mm Kirschner wires. The joint must be reduced under direct visualization with fluoroscopic imaging used only as an aid. Free central osteochondral fragments can be stabilized using PLLA pins (SmartPin; Linvatec, Largo, FL) or held with compression using the anterior fragment to wedge these pieces into place. Cancellous graft should only be used in cases of metaphyseal crush, where a central metaphyseal defect is obvious. Local autograft from another portion of the distal tibia, allograft, or iliac autograft may be used. The reduction can then be maintained with additional 1.6-mm Kirschner wires or pointed reduction clamps or a combination of the two. The metaphyseal segment can then be reduced to the tibial shaft with reduction clamps.

Once the anterior tibia and its corresponding articular surface have been properly reduced, independent 2.7/3.5/4.0-mm screws should be used to lag the fragments together. Ideally, the anterior articular fragments should be lagged into the posterior fragment. After this is accomplished, a medial or anterolateral plate is applied to connect the metaphyseal fragment to the diaphysis. Medial malleolar fragments may be stabilized percutaneously using 4.0-mm screws with visualization obtained from the anterior wound. The femoral distractor or external fixator frame is removed, and the ankle is taken through a range of motion under fluoroscopic control. Once stable, anatomic reduction is obtained, external fixator pins are removed, and the wound is thoroughly irrigated. The retinacular layer should be closed with 0 Vicryl sutures and then a layered closure performed. The skin is closed with interrupted 3-0 nylon sutures. Dry sterile dressings are placed over the wound and the patient is placed into a posterior, well-padded splint. Postoperatively, plain radiographs and a CT scan with reconstruction images are obtained to verify joint reduction. The limb is then placed into a removable short leg boot before discharge, typically 2 to 3 days after surgery. Patients begin range-of-motion exercises at 10 days but are kept nonweightbearing. Sutures are removed when the wound is well healed, typically 2 to 6 weeks. Weightbearing is permitted only when the fracture is healed, based on in-office radiographs, typically at 10 to 12 weeks.

**RESULTS**

All patients were available for follow-up in both groups at a minimum of 2 years with an average follow-up of 40 months (range, 28–54 months). The average dorsiflexion range of motion for the PL Group was 8.2° ± 4.4° and the average dorsiflexion for the A Group was 8.5° ± 2.3°. The average plantarflexion range of motion for the PL Group was 26.0° ± 4.2° and the average for A Group was 27.3° ± 7.0°. The total arc of motion was similar across the 2 groups, 34.2° ± 7.2° in the PL Group and 35.8° ± 6.0° in the A Group.

Postoperative CT scans were used to measure the quality of articular reduction. The maximum displacement seen on the sagittal cuts of the CT scan was used. They were graded as less than 1 mm, 1 to 2 mm, or greater than 2 mm stepoff. If there was a loss of congruity of the articular surface, those fractures were graded as greater than 2 mm as well (Fig. 3). Of the 10 fractures treated with traditional anterior tibial incisions (A Group), 4 had 2 mm or more of incongruity of the posterior articular fragment, 5 had 1 to 2 mm of incongruity, and one had 1 mm or less of incongruity in the posterior malleolar fragment on postoperative CT scan evaluations. In the PL Group, no fracture had 2 mm or more of incongruity, 2 fractures had 1 to 2 mm of incongruity, whereas the remaining 7 had 1 mm or less of incongruity of the posterior fragment. At the time of their last follow-up (minimum, 24 months), 6 patients in the A Group had some evidence of symptomatic arthritis compared with only 2 in the PL Group.

The Maryland Foot and Ankle and American Orthopaedic Foot and Ankle Society outcome data were obtained at 12 months from surgery and then at 6-month intervals. The final score for each patient was used for comparison across groups. The average American Orthopaedic Foot and Ankle Society score for the PL Group was 85.2 versus 76.4 (P < 0.01) for the A Group. There was also an increase in the Maryland Foot and Ankle scores to
86.4 for the PL Group compared with 69.4 (P < 0.01) in the A Group.

Complications
There were 4 postoperative complications in the A Group. One patient had a partial wound dehiscence, which healed without surgical intervention. One fracture went on to a nonunion that required bone grafting and healed without further complications. One fracture developed a metaphyseal malunion with 15° of valgus angulation but elected not to undergo correction. Two patients (both with 2 mm or more incongruity) required an ankle arthrodesis as a result of end-stage arthrosis after ORIF. In the PL Group, no patients experienced wound healing problems, nonunion, malunion, or required arthrodesis. One patient developed a deep infection secondary to his Gustilo IIIA open fracture. No patients required removal of the posterior tibial plate as a result of flexor hallucis longus irritation. Only one patient had stiffness at the first metatarsophalangeal joint, which was asymptomatic.

DISCUSSION
The modern treatment of pilon fractures has popularized the staged reconstruction of these fractures to minimize soft tissue complications. External fixation alone or in combination with percutaneous techniques, however, does not allow for visualization and anatomic reconstruction of the articular surface. Recent studies have therefore focused on staged fixation techniques that allow for initial external fixation of the fracture with stabilization of the fibula followed by delayed, formal ORIF of the plafond fracture.1,2

Although there remains an increased risk of complications with ORIF, it is crucial to visualize the articular surface to obtain an anatomic reduction. Several studies have shown that outcomes directly correlate to the quality of the joint reduction.3–7 The incisions therefore should be based on the fracture pattern and location of the greatest displacement on preoperative imaging. CT before open reduction has been instrumental in terms of preoperative planning. Tornetta et al7 found that CT scans changed the operative plan in 64% of patients.

Not surprisingly, there have been a number of surgical exposures described for the treatment of pilon fractures.8–13 These include single- and double-incision techniques. In high-energy fracture patterns such as the OTA 43C.3, there is usually an associated posterior, posteroomedial, or posterolateral fragment that is displaced. Obtaining an accurate reduction of this fragment can be difficult through standard anterior incisions.

The posterolateral approach has previously been proposed for the formal treatment of pilon fractures12–14 in an attempt to minimize the soft tissue complications associated with the anterior approach. Despite this, Bhattacharyya et al had a 31% incidence of postoperative wound complications.7 Both Konrath et al12 and Bhattacharyya et al13 used this as the main approach for the reduction of the articular surface. Although both authors stated that this did not compromise their ability to obtain a satisfactory reduction of the joint, they admitted that it was difficult to anatomically reduce an anterior crush from a posterior approach.

In our PL Group, we had no wound complications. We believe that this is probably the result of the staged approach and the fact that we were not trying to fix the anterior joint through the posterolateral approach. In our experience using the posterolateral approach, there is poor visualization of the anterior articular surface, and anatomic reduction would be difficult, especially in high-energy patterns that typically have extensive anterior comminution. The posterolateral approach did give excellent visualization of the posterior aspect of theibia and posterior malleolar fragment as well as the posterolateral aspect of the fibula without creating extensive surgical flaps. Importantly, the authors believe that the use of the posterolateral approach in OTA 43C.3 fractures initially with fixation of the posterior tibia and fibula allows for restoration of the lateral column of the ankle and stabilizes the posterior aspect of the tibia. This not only relaxes the soft tissues because of greater inherent osseous stability, but allows the surgeon the opportunity to build in a front to back fashion against a stable construct that is anatomically reduced at the time of definitive fixation.14

Many have documented combined anterior and lateral approaches to fix the tibial plafond, but they rely on anatomic fixation of the fibula to indirectly reduce the posterior fragment.9,10 This is difficult to achieve because the fibula is often comminuted and therefore difficult to anatomically reduce. The main goal of the fibular reduction is to restore alignment and rotation of the lateral column. The secondary goal is to reduce the posterior malleolar fragment when fractured. In both cases, if the fibula is not fixed initially,
shortening of the limb with posterior scarring can leave that fragment displaced superiorly, making subsequent reduction extremely difficult, even at 3 weeks postinjury. Additionally, if the posterior malleolus is fixed indirectly, syndesmotic disruptions may not be anatomically reduced. If Volkmann’s ligament is intact and the posterior malleolus is not reduced, fixation of the syndesmosis with laterally placed screws may in fact malreduce the distal tibia–fibula joint. A posterolateral approach will directly access and accurately treat this injury.

The most important task of the surgeon treating a displaced articular fracture is the ability to obtain an anatomic reduction. Without perfect congruity, the joint will deteriorate. To maximize this congruity, direct visualization is necessary, and this can only be obtained through open reduction. When performing this reduction, however, a stable constant fragment is needed to build on. For example, in acetabular fractures, the sciatic buttress is required, whereas in calcaneal fractures, the sustentacular fragment is needed. In pilon fractures, a stable posterior malleolus is the key to a good articular reduction. Even with this technique, difficulty arises when there is significant posterior tibial comminution and there is no cortical “key” that allows for anatomic reduction. In this scenario, smaller plates (2.0 mm/2.4 mm) with locking capabilities are beneficial to allow for locked fixation in the distal fragment with short screws. This provides restoration of the posterior buttress and improves angular stability of the distal fragment. The postoperative CT should then be evaluated critically to ensure anatomic alignment posteriorly. If a significant amount of displacement is found, this is best addressed acutely, whereas minor adjustments to the alignment can be made at the time of definitive fixation.

We have found promising results using the staged, posterolateral approach for pilon fractures. In our study, we noted that the articular reductions were significantly improved compared with the previous protocol, which used anterior incisions with indirect posterior reductions. Although patients noted no improved motion at the ankle with this newer protocol, functional outcomes were significantly improved in the postoperative CT should then be evaluated critically to ensure anatomic alignment posteriorly. If a significant amount of displacement is found, this is best addressed acutely, whereas minor adjustments to the alignment can be made at the time of definitive fixation.

Although the poor outcomes associated with the treatment of OTA 43.C2 and 43.C3 fractures is clearly multifactorial, it is logical to believe that if the posterior fragment was anatomically and stably reduced, the fracture would now be converted into a simpler OTA 43B fracture, which has significantly better outcomes. Our series certainly had better overall results than a matched pair cohort, especially with respect to articular reductions, indicating that staged treatment may offer the surgeon a solution to these complex fractures. In addition to better articular reductions, the functional outcomes were significantly improved in the posterior plating group. The limitations of the study were that it was a small series of patients, which underwent posterior tibial plating. Also, there is limited follow-up for the patients in both groups, and the functional outcomes and necessity for additional procedures (ie, arthrodesis) may change with longer follow-up. Despite these limitations, the initial results of this study are encouraging and may improve the outcomes for patients sustaining these severe injuries, which often lead to significant impairment.

REFERENCES