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Percutaneous Fixation of Posterior Malleolar Fractures: A Contemporary Review

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Introduction

Posterior malleolar fractures (PMFs) are located in the posterior rim of the distal articular surface of the tibia and include a variety of fracture patterns, most frequently in the posterolateral corner of the tibia.[3,5,12] Although they can occur in isolation, they are most commonly associated with fractures of the medial and lateral malleoli.[25] Poor radiologic and functional outcomes have been described in patients with PMFs.[1,26]

The optimal treatment for PMF continues to be investigated and also varies by case. Historically, fixation has been indicated based on the fragment size (greater than 25%-33%) of the distal tibia articular surface on a lateral radiograph.[10,19] However, lateral radiographs can underestimate the fragment size of PMF,[7] and the use of computed tomography (CT) scans has been reported to change the surgical approach or patient positioning in 44% of cases.[11] Therefore, the CT scan plays a crucial role in the evaluation of PMFs. Other variables, such as fracture morphology, articular step-off, persistent talus dislocation, and syndesmotic instability, have also recently been linked to the decision-making process.[10,16]

PMF can be surgically treated by open reduction and internal fixation (ORIF) with screws or plates or through indirect reduction and screw fixation via a percutaneous approach. Traditionally, the percutaneous technique has been performed with an anterior-to-posterior (AP) lag screw, although the use of this technique has raised some concern about potential malreduction and interfragmentary compression ability.[17] In 2006, Strenge and Idusuyi published a modification of the AP percutaneous technique in which a posterior-to-anterior (PA) lag screw was used to improve these mechanical concerns.[24] Since that description, several publications have addressed the safety of this technique and proposed new surgical tips and modifications.

This review will provide an update regarding percutaneous screw fixation for PMF. In addition, recent developments regarding percutaneous PA lag screw fixation will be described.

Surgical Treatment of PMF

Several studies have demonstrated that ORIF with a posterior plate is biomechanically more stable than PA or AP screws in the management of PMF.[4,10,13,15,28] Furthermore, O'Connor et al[20] showed that a posterolateral buttress plate had better clinical outcomes than an AP cannulated screw. Similarly, subsequent studies have shown that the posterolateral approach has better radiologic and functional outcomes than the use of AP cannulated screws in patients with PMF.[23,29]

In a retrospective study of 243 patients with a mean follow-up of 18.9 months (range 12-36 months), Wang et al[30] demonstrated that in patients with a fragment size $\geq$15% of the articular surface, there was no difference in the AOFAS score or ankle motion between the posterior plate, AP, or PA screws. On the other hand, for fragments $\leq$15%, the posterior plate fixation had worse outcomes than did the AP or PA screw fixation. In that study, however, it is important to specify that the reduction of the posterior malleolus was performed under direct vision in all the techniques. Therefore, the results may not be comparable to those for percutaneous techniques.

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Despite the potential benefits of ORIF, it may not be recommended for patients with substantial soft tissue damage, poor bone quality, or specific comorbidities such as diabetes and smoking. Percutaneous fixation may be a safer alternative in these scenarios, especially for large and nondisplaced fragments and in the absence of impaction or intercalary fragments of the articular surface.[20]

Percutaneous Fixation

Traditionally, the most common indirect fixation technique for PMF has been the AP screw method.[2] This technique is associated with damage to the tibial and superficial peroneal nerves, extensor hallucis longus (EHL), anterior tibial tendon, and anterior tibial artery.[21,22] Moreover, AP screw fixation may not provide adequate purchase or compression of the fragment and could even displace it.[24] With smaller fracture fragments, the screw threads also may not cross the fracture line, thus failing to grip the PMF securely. To address these limitations, percutaneous posterior malleolar fixation using PA screws has recently gained popularity. Strenge and Idusuyi were pioneers in describing a PA percutaneous technique in which the starting point was medial to the anterior tibial tendon.[24] With their technique, a 0.62-inch Kirschner wire is inserted from anteromedial to posterolateral with the ankle dorsiflexed and the Achilles tendon displaced medially to avoid damage. Then, a partially threaded screw is inserted from posterior to anterior over the wire.

The correct insertion site is crucial for preventing cartilage damage when using a PA screw, as observed on lateral radiograph. Using a digital caliper, a prospective study of 100 dry tibia bones showed that screw placement parallel to the tibiotalar joint should be 6 and 5 mm above the distal rim of the posterior malleolus for males and females, respectively.[18] If the screw is inserted more distally, the authors concluded that the screw should be angled proximally by 18 and 15 degrees for males and females, respectively. Although the study was performed under direct visualization, the results can be extrapolated to the percutaneous technique.

Only a few publications have addressed the use of the PA percutaneous technique for treating PMF. Kimball et al[14] analyzed 15 embalmed cadaveric specimens using the PA percutaneous technique. The starting point was anterior-to-anterolateral, and a guidewire was advanced in the posterolateral direction. The authors reported that the sural nerve and peroneal artery had a mean distance to the wire of 5.3 mm (range 0-12) and 5.7 mm (range 2-13 mm), respectively, with no traumatic piercings of any structure. The authors concluded that this technique is a safe alternative with a low risk of tendon and neurovascular injuries. The authors recommended this technique for noncomminuted and minimally displaced fractures and for patients with fragile soft tissue.

Clarke et al[8] aimed to identify a safe zone for percutaneous PA fixation throughout the posterolateral window. Using 7 cadaveric specimens, the authors showed a safe zone for fixing the posterior malleolus, 1 cm above the tip of the medial malleolus, just lateral to the Achilles tendon. In that cadaveric study, they did not report any neurovascular or tendon structure injuries.[8] Similarly, Czerwonka et al[9] aimed to determine the risk of damaging anatomic structures through the use of percutaneous PA screws in 10 fresh frozen cadaveric specimens through an anterior entry point in the supine position. The authors showed that the sural nerve was in contact with the wire in one specimen and transected in a second specimen. Moreover, the guidewire perforated the belly of the FHL in 4 of the 10 specimens but was not damaged by the screw. The risk of injury to the anterior and posterior neurovascular bundles was low. Given their results, the authors suggest the use of a mini-open approach to protect the sural nerve and recommend being cautious about the use of a washer or screws with a large head because of the risk of FHL injury.

The risks of percutaneous fixation are limited not only to tendons and neurovascular injuries but also to the distal lower extremity syndesmosis. When analyzing the trajectory of the percutaneous screw, there is a potential risk that the implant will protrude into the syndesmosis, especially when it is inserted from the posterolateral to anterolateral direction. Williams et al[31] aimed to analyze 10 cadaveric specimens to determine the position of the percutaneous PA screw relative to the posteromedial border of the syndesmotic joint under fluoroscopy. They found that the posteromedial vertical syndesmotic line (PVSL) represents the posteromedial border of the incisura fibularis on the mortise view. Therefore, the PA screw located medially to the PVSL does not penetrate the distal tibiofibular joint. The authors also concluded that the PA screw should be located 12 mm medial to the PVSL to avoid injury to the FHL tendon.[31]

PA vs AP Percutaneous fixation

Overall, the literature comparing PA vs AP percutaneous fixation for PMF is limited. Yu et al[32] evaluated 76 patients with trimalleolar ankle fractures with Haraguchi type I PMF. Patients were randomized to AP (36 patients) or PA (40 patients) percutaneous fixation, and the authors compared their clinical, radiologic, and patient-reported outcomes with a mean follow-up of 30 months. No differences between the groups were found in terms of operative time, range of motion, or visual analog scale score. However, severe posttraumatic ankle osteoarthritis and step-off rates were greater in the AP percutaneous group ($P < .05$). The authors concluded that PA percutaneous fixation is a reliable option for treating Haraguchi type 1 fractures. It is important to mention that in this investigation, surgeons verified the reduction of the posterior malleolus through the incision used for

ORIF of the medial malleolus. Also, the authors did not include Haraguchi types 2 and 3 in their study. However, no studies have described or investigated the feasibility of fixing percutaneously Haraguchi type 2 or 3 PMF.

Mansur et al[17] aimed to compare 4 types of fixation for PMF under physiological loading conditions using a finite element analysis model of (1) a one-third tubular 3.5-mm buttress plate with 1 screw, (2) the same plate with 2 screws, (3) 2 percutaneous 3.5-mm lag AP screws, and (4) 2 percutaneous 3.5-mm lag PA screws. The authors concluded that percutaneous PA screws were biomechanically more stable than AP screws and presented lower deformation forces and a lower fixation failure risk.

Finally, one recent study evaluated the clinical and radiologic outcomes of patients with trimalleolar ankle fractures who underwent AP (31 patients) and PA (29 patients) percutaneous fixation for Haraguchi type 1 PMF (mean follow-up, 25 months). The authors reported less step-off, less ankle osteoarthritis, and better clinical outcomes in the PA percutaneous group.[6]

Currently, there is no standard of care for the surgical management of PMF. As a result, there may be variations in how different surgeons treat the same fracture pattern. A nationwide survey of 151 orthopaedic surgeons in the Netherlands demonstrated this variability. Of those surveyed, 48% preferred to fix the posterior malleolus via an open posterior approach, whereas 39% of surgeons preferred an AP percutaneous approach.[27] Although PA percutaneous fixation was not mentioned in that study, we hypothesize that 19 (13%) surgeons who selected an alternative technique could have included the PA percutaneous option.

Gaps in the Literature

There are still several gaps in the literature regarding percutaneous fixation of PMF. It is unclear whether 1 or 2 percutaneous screws should be used. We estimated that using 2 screws could be possible for wide and nonshearing PMF. In shearing fractures, we prefer to use an anti-glide plate. Moreover, whether the starting point should be anteromedial (medial to the anterior tibial tendon) or anterolateral (lateral to the peroneus tertius tendon) has not been fully investigated. Most likely, this depends on the fragment size, the orientation of the fracture line, and the position of the Achilles tendon in relation to the fracture location. For example, an anteromedial entry for the guidewire may be more desirable if the fracture line is more oblique. Thus, the PA screw could be inserted perpendicular to the fracture line.

Authors' Preferred Surgical Technique for Percutaneous PA Fixation

Preoperative planning. Anteroposterior, lateral, and mortise radiographs are essential for diagnosing and classifying ankle fractures. Likewise, a preoperative ankle CT scan can be an important tool for further characterizing the fracture and for surgical decision making. Imaging is essential to understanding the nature and location of posterior malleolar fractures; identifying the primary fracture line, intermediate fragments, and fragment size; and establishing the surgical plan, including the length and trajectory of the screw in the sagittal and axial planes.

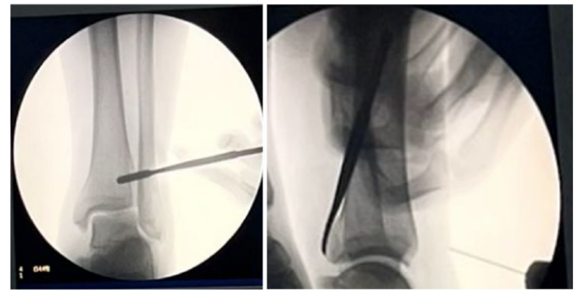

Figure 1. Periosteal elevator holding the posterior malleolus fragment in place through the lateral approach.

If there is malreduction of the posterior malleolus on preoperative images, the surgeon must be prepared for failure of ligamentotaxis reduction after fibular fixation. In this case, a periosteal elevator can be inserted through the lateral approach posterior to the fibula to reduce the posterior malleolus (Figure 1). This maneuver must be performed before fibular fixation because a fibular plate could obstruct visualization of the reduction on the lateral fluoroscopic view. If anatomic reduction of the PMF is not possible, we recommend an open posterior approach.

Positioning and landmarks. The patient is positioned supine, with the ankle in neutral. A bump under the ipsilateral hip and lowering of the contralateral leg are used to facilitate intraoperative imaging. The medial and lateral malleoli, the articular surface, and Achilles tendon are identified, as is the anteromedial or anterolateral entry point.

Guidewire entry point. Under fluoroscopic guidance, the entry point for the guidewire is identified, usually cephalic to the physeal scar and within the lateral third of the anterior distal tibial articular surface. In this step, we utilize the posteromedial vertical syndesmotic line (PVSL) described by Williams et al,[31] which represents the posteromedial border of the incisura fibularis on the mortise view, to avoid violating the syndesmosis. A longitudinal, 1-cm incision is created and the subcutaneous tissues are dissected with a hemostat until the tibial cortex is reached. The neurovascular bundle and extensor tendons must be protected.

Guidewire positioning. With a soft tissue protector, a guidewire is advanced toward the center of the posterior

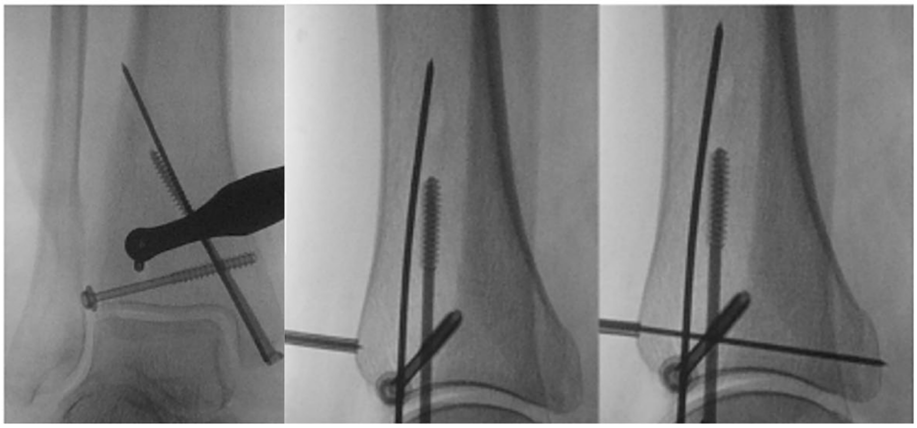

Figure 2. Left and center images: mortise and lateral radiographs showing the K-wire positioning starting point. Right image: lateral radiograph showing the K-wire reaching the posterior cortex of the PMF.

malleolar fragment, usually with a low cephalic to caudal inclination, as shown on the lateral view (Figure 2). We recommend holding and pushing the fragment from posterior with an elevator to avoid displacement when the guidewire enters it (Figure 1). It is important to note that the use of the elevator to maintain reduction is possible when there is a fibular fracture that requires a formal lateral approach. If there is no associated fibula fracture, a percutaneous pointed reduction clamp can be used to maintain the reduction.

Once the guidewire reaches the posterior cortex of the posterior malleolus, the screw length is measured (Figure 3). The wire is then passed medially or laterally to the Achilles tendon and through the skin. The Achilles can be translated as needed to protect it while the wire is advanced. Gentle ankle plantar flexion is performed to ensure that the Achilles is free. The wire is secured to a mosquito before being overdrilled (Figure 3).

Anterior-to-posterior drilling. A cannulated drill is passed from anterior to posterior over the guidewire, penetrating both the anterior and posterior cortices (Figure 3). Again, we recommend pushing the PMF from posterior with an elevator (through the lateral approach, behind the fibula) or percutaneous reduction clamp when drilling to avoid displacement.

Screw placement. An assistant may hold up the patient's leg to obtain a comfortable workspace. Then, a stab incision is made around the posterior exit point of the guidewire, followed by blunt dissection with a small hemostat toward the posterior malleolus. A partially threaded cannulated screw is then inserted over the wire from posterior to anterior (Figure 4) until the screw head engages the posterior cortex. At this point, the screw position and length are confirmed via lateral radiograph (Figure 5). The use of a washer is

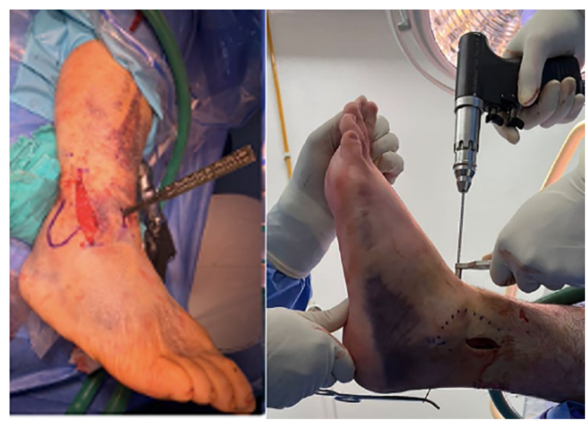

Figure 3. Left image: Measuring the K-wire length. Right image: Drilling from anterior to posterior with a mosquito securing the K-wire.

optional. Given the risk of damaging the FHL belly, however, we do not recommend using one.

Closure. The procedure only requires closure of the skin, and for this we use nylon sutures.

Summary

Posterior malleolar fractures may occur in isolation or in association with fractures of the lateral and medial malleoli. Although not as biomechanically stable as plate fixation, percutaneous fixation of these fractures is often performed. As described above, there are several potential advantages to percutaneous fixation techniques that entail posterior-to-anterior screw placement.

Figure 4. Screw placement from posterolateral to anterolateral.

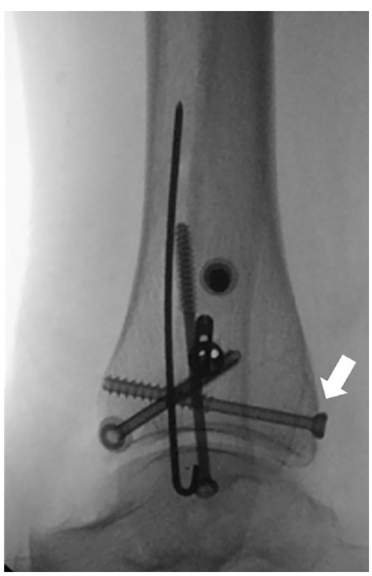

Figure 5. Lateral ankle radiograph showing the final position of the percutaneous PA screw (white arrow).

In conclusion:

- The ideal fracture for percutaneous fixation has a noncomminuted fragment that is minimally displaced and has no secondary, intercalated fracture fragments.
- Considering its advantages and low risk of neurovascular and tendon injury, we suggest PA instead of AP fixation for percutaneous treatment of posterior malleolar fractures.
- Further prospective clinical studies evaluating the functional outcomes and complications of such percutaneous techniques are needed.

Ethical Approval

Ethical approval was not sought for the present study as no patients or cadaveric specimen were involved in this review article.

Declaration of Conflicting Interests

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