The Journal of Foot & Ankle Surgery 54 (2015) 365–369

Contents lists available at ScienceDirect

The Journal of Foot & Ankle Surgery

journal homepage: www.jfas.org

Radiographic Assessment of Posterior Malleolar Ankle Fractures

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A R T I C L E I N F O

Level of Clinical Evidence: 5

Keywords:
externally rotated projection
plain film radiography
surgical decision making
tibial plafond
Volkmann's fracture

A B S T R A C T

The anatomy of the posterior tibial malleolus plays an important role in the structure and function of the ankle mortise. With specific respect to ankle fractures, the presence, size, and displacement of posterior malleolar fractures (Volkmann's fracture) helps determine which will be amendable to operative fixation. The objective of the present study was to increase the body of knowledge with respect to the ability of foot and ankle reconstructive surgeons to assess posterior malleolar ankle fractures using plain film radiography. Three different variables were investigated on Sawbones® models: (1) differing size of posterior malleolar fractures (10%, 25%, and 50% of the tibial plafond), (2) differing displacement of posterior malleolar fractures (0 and 5 mm of proximal displacement), and (3) 2 different radiographic projections (standard lateral and externally rotated lateral projections). Accurate identification of the posterior malleolar fracture occurred on 86.67% (26 of 30) of standard lateral radiographs and 100% (30 of 30) of externally rotated lateral radiographs. Furthermore, the surgeons described the fracture with greater precision and had greater interclass correlation coefficient values with respect to measurement of sagittal plane displacement (0.977 versus 0.939) and percentage of involvement of the tibial plafond (0.972 versus 0.775) with an externally rotated lateral projection compared with a standard lateral projection. Our results provide evidence that an externally rotated lateral radiographic projection can provide surgeons with some additional information with respect to the presence, size, and displacement of posterior malleolar ankle fractures.

The posterior tibial malleolus plays an important role in the structure and function of the ankle mortise. However, the term *posterior malleolus* is a relatively general term that can refer to the posterior tibial tubercle forming the posterolateral margin of the incisura fibularis of the tibiofibular syndesmosis, the posterior aspect of the tibial plafond articular cartilage, and/or the entire posterior margin of the tibia extending from the incisura fibularis to the medial malleolus (1–3). In addition to osseous injuries that can occur with traumatic ankle fractures, the accompanying soft tissue injuries of this region can include disruption of 2 syndesmotic ligaments (the posterior inferior tibiofibular ligament and interosseous tibiofibular ligament), posterior fibers of the deltoid ligament, and the ankle joint capsule, which has been associated with contributing to adhesive capsulitis, arthrofibrosis, soft tissue impingement syndromes, and reduction of joint motion (1–5).

It has traditionally been accepted that posterior malleolar fractures involving less than approximately 25% of the tibial plafond do not require operative fixation (6); however, this belief has recently been called into question. A number of studies have confirmed the role of the posterior malleolus as an important contributor to the stability of the ankle mortise and syndesmosis (7–10), and others have demonstrated improved postoperative patient outcomes with posterior malleolar reduction and/or fixation (11–16).

Despite this increasingly important role in the treatment of ankle injuries, several studies have demonstrated inconsistency in the ability of surgeons to evaluate posterior malleolar fractures. Büchler et al (17) compared the evaluation of posterior malleolar fractures using plain film radiography versus computed tomography (CT) and found poor reproducibility, reliability, and accuracy in the interpretation of these fractures when considering CT as the standard reference. Ferries et al (18) performed a similar comparison of plain radiographs and CT scans and found poor inter- and intrarater reliability with the former. Finally, Ebraheim et al (19) reported on a case in which symptomatic posterior malleolar fracture nonunion was not visible on the standard anteroposterior and lateral radiographic views.

In 2006, Haraguchi et al (20) published a descriptive classification of posterior malleolar fractures from a retrospective review

Financial Disclosure: Dr. Fleming is a consultant for Stryker.
Conflict of Interest: None reported.
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1067-2516/$ - see front matter
http://dx.doi.org/10.1053/j.jfas.2014.08.005

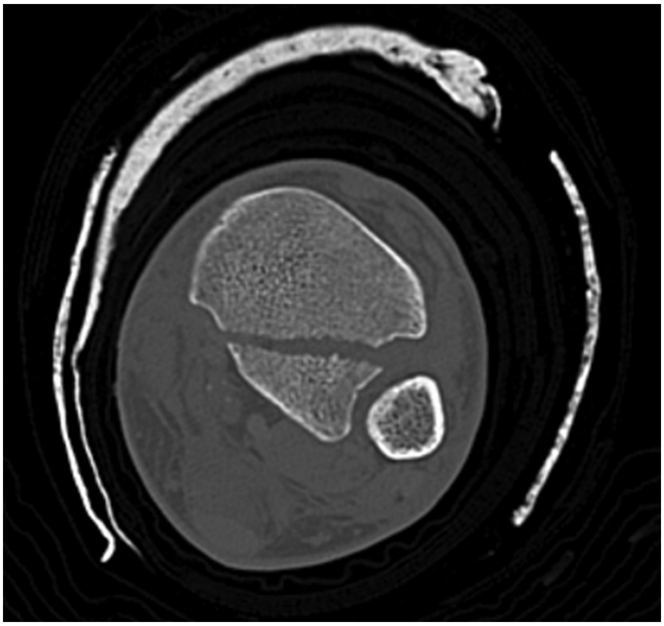

Fig. 1. Computed tomography classification of posterior malleolar fractures. Haraguchi et al (20) proposed a descriptive classification system for posterior malleolar fractures using computed tomography findings. In their study, most posterior malleolar fractures (67%) were so-called type 1 injuries involving a triangular-shaped fragment of the posterolateral corner of the tibial plafond, including the posterior tubercle of the incisura fibularis and posterior inferior tibiofibular ligament. They also reported that the mean angle between the primary fracture line and the bimalleolar axis was 20.9° ± 9.4° (20).

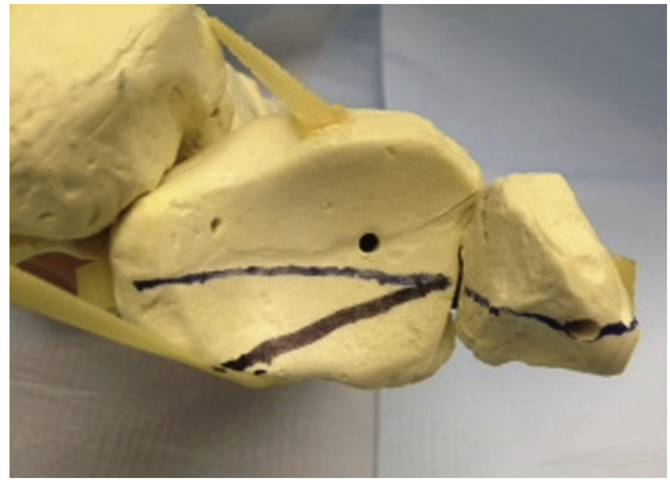

Fig. 2. Sawbones® model with posterior malleolar fracture planning. The blue line represents the bimalleolar axis and the black line, the most common plane of a posterior malleolar fracture, along a line approximately 21° to the bimalleolar axis.

of 57 patients undergoing preoperative CT after ankle fractures involving a posterior fragment. Most posterior fractures (66.67%; 38 of 57) were triangular-shaped fragments involving the posterolateral corner of the tibial plafond, including the posterior tubercle of the incisura fibularis and posterior inferior tibiofibular ligament. This was termed a *type 1* fracture pattern (Fig. 1). Two other patterns were observed, including one characterized by a fracture line extending from the fibular notch to the medial malleolus along the bimalleolar axis (19.30%; 11 of 57) and a third, small, shell-shaped fragment at the posterior lip of the tibia (14.04%; 8 of 57). They further described from their data set that the angle between the fracture line of type I posterolateral fractures and the bimalleolar axis was a mean of 20.9° ± 9.4°.

It has been our experience that the presence, size (as assessed by the percentage of involvement of the tibial plafond), and degree of displacement of posterior malleolar fractures are initially assessed by reconstructive foot and ankle surgeons using the lateral ankle projection with plain film radiography. The objective of the present study was to increase the body of knowledge with respect to the ability of foot and ankle reconstructive surgeons to assess posterior malleolar ankle fractures using plain film radiography. Specifically, we attempted to quantify their ability to recognize

1. The presence or absence of posterior malleolar fractures
2. The size of the posterior malleolar fracture
3. The degree of posterior malleolar fracture displacement with 2 different lateral radiographic projections

We hypothesized that an externally rotated lateral radiographic projection along the fracture line of the posterior malleolus would provide a better assessment of these fracture characteristics.

Materials and Methods

Supination-external rotation type ankle fractures were first created on Sawbones® models (Pacific Research Laboratories, Inc, Vashon, WA). These consisted of a spiral oblique fracture of the fibula, a transverse avulsion fracture of the anterior colliculus of the medial malleolus, and a posterior malleolar fracture. We chose to create the posterior malleolar fracture as a type I pattern, such as described by Haraguchi et al (20), involving a triangular-shaped fragment of the posterolateral corner of the tibial plafond (Fig. 2). We created differently sized posterior malleolar fracture fragments on different models that involved 10%, 25%, and 50% of the articular cartilage of the tibial plafond.

We chose to create this fracture along a line 21° to the bimalleolar axis, in concordance with the findings from Haraguchi et al (20). We are unaware of any other investigations providing descriptive statistics of these fractures relative to the bimalleolar axis. From a group of our own patients, a post hoc analysis of a previously used data set of preoperative CT scans obtained in the setting of ankle fracture with a posterior malleolar fracture ($n = 23$) demonstrated 9 type I fracture patterns (39.13%). Of these 9, 6 were best classified as a supination-external rotation mechanism, and our mean angle relative to the bimalleolar axis was 22.3° ± 10.7° (range 3.6° to 43°).

Plain film radiographs were then taken of the models. First, a standard lateral projection was performed, defined as the foot positioned perpendicular to the lower leg with the film placed vertically within the well of the orthoposer (radiographic stand) and the tube head angulated 90° from vertical. The medial aspect of the model was positioned against the orthoposer such that the bimalleolar axis of the ankle joint was perpendicular to the cassette. The central beam was aimed at the center of the talar body (21). Next, a similar lateral projection was performed with the ankle positioned in 21° of external rotation relative to the standard lateral projection. This externally rotated lateral projection was intended to be along the plane of the posterior malleolar fracture line. Standard lateral and externally rotated lateral projections were taken with the posterior malleolar fracture fragment both reduced in the sagittal plane and with 5 mm of proximal displacement (Figs. 3 and 4).

Thus, 3 different variables were created with the models:

1. Size of the posterior malleolar fracture (10%, 25%, and 50% of the tibial plafond)
2. Displacement of the posterior malleolar fracture (0 and 5 mm of proximal displacement)
3. Type of radiographic projection (standard lateral and externally rotated lateral projections)

Evaluation of the radiographs was then performed by 5 board-certified reconstructive rearfoot/ankle surgeons. The evaluations were performed independently, and the surgeons were unaware of the specific variable parameters. For each radiograph, the surgeons were asked a series of questions:

1. Do you see a posterior malleolar fracture on this radiograph?
2. If yes, please estimate what percentage of the tibial plafond is involved.
3. If yes, please estimate any displacement of the tibial plafond in an anteroposterior direction.
4. If yes, please estimate any displacement of the posterior malleolus in the sagittal plane.