Foot & Ankle Orthopaedics
2019, Vol. 4(4) 1-11
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DOI: 10.1177/2473011419887724
journals.sagepub.com/home/fao

Anatomy, Classification, and Management of Ankle Fractures Involving the Posterior Malleolar Fragment: A Literature Review

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Abstract

The posterior malleolar fragment is frequently involved in rotational ankle fractures, but diagnosis and definitive management remains controversial. Ankle fractures with a posterior malleolar component that are not identified and treated in a timely manner may contribute significantly to future comorbidities, including continued pain, instability, and the development of arthritis. This article highlights the anatomic features of posterior malleolar ankle fractures, the classification schemes used, and discusses the various nonsurgical and surgical methods currently used.

Level of Evidence: Level V, expert opinion.

Keywords: posterior malleolar fracture, ankle fracture, ankle anatomy

Introduction

It is estimated that posterior malleolar fractures are found in 40% of rotational ankle fractures, but they may also occur in isolation, as a component of pilon fractures, or as a component of a distal tibia fracture.[1,6,31,33] These fractures involve both the weight-bearing portion of the tibial plafond and the ankle syndesmosis, thus affecting tibiotalar load transfer, as well as posterior talar and rotatory ankle stability.[3,46,49] Recent attention has focused on the workup and management of this heterogenous group of fractures and their relationship to ankle and distal tibia fracture outcomes.[10,29,58] Unfortunately, numerous management controversies currently exist. In this review, we describe the pertinent anatomy, diagnosis, and treatment of posterior malleolus fractures.

Anatomy and Pathomechanics

Relevant Anatomy

The ankle joint includes the superior dome of the talus and the distal components of the tibia and fibula, forming the saddle-shaped mortise joint. The tibial plafond and talar dome make up the most of the joint interaction, with the fibula providing buttressing lateral support. The natural shape of the tibial plafond and talus forms the bony stability of the joint; however, competent ligamentous support is required for ankle stability. This stability at the distal tibiofibular joint results from the syndesmotic ligaments.[8,38] The distal tibiofibular syndesmosis can be divided into segments by location and attachments, and include the anterior-inferior tibiofibular ligament, the posterior-inferior tibiofibular ligament (PITFL), the interosseous ligament, and the transverse ligament (Figure 1). In posterior malleolar injuries, the transverse ligament and PITFL are frequently attached to the posterior fracture fragment.[45] Another study found that the PITFL is responsible for 42% of syndesmosis stability.[50] The superficial component of the PITFL spans across the posterior aspect of the ankle, stretching from the posterior aspect of the lateral malleolus of the fibula and attaching to the posterior malleolus of the tibia (Figure 2).[2,22] The transverse ligament mirrors a similar path as the PITFL, but originates and inserts inferiorly.[2,22] This allows it to form a labrum about the joint, thus preventing posterior talar

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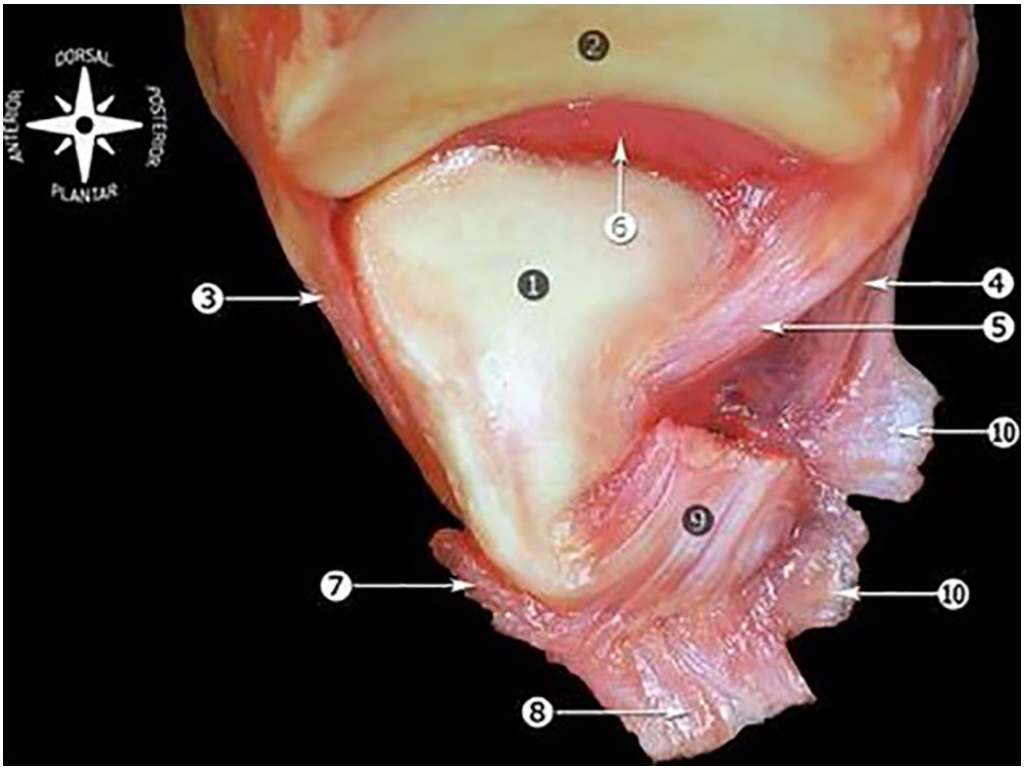

Figure 1. Medial view of the tibiofibular joint (os talus previously removed). Articular surface of the lateral malleolus (*1*); distal articular surface of the tibia (*2*); anterior tibiofibular ligament (distal fascicle) (*3*); superficial component of the posterior tibiofibular ligament (*4*); deep component of the posterior tibiofibular ligament or transverse ligament (*5*); fatty synovial fringe (*6*); anterior talofibular ligament (*7*); calcaneofibular ligament (*8*); posterior talofibular ligament (*9*); fibulotalocalcaneal ligament or Rouvière and Canela ligament (*10*). Figure and caption reprinted with permission from Golano et al.[22]

translation.[56] The lateral talofibular and calcaneofibular ligaments, as well as the medial deltoid ligament, stabilize the talus within the mortise. There is little literature surrounding the contributions of the remainder of the ankle joint capsule to overall stability, although a cadaveric study by Boardman and Lu demonstrated that a significant amount of anterior and lateral ankle stability depended on the anterolateral portion of the ankle capsule not defined as part of the anterior-inferior tibiofibular ligament.[4] The musculotendinous units that cross the ankle serve as active stabilizers. These include the peroneals laterally, the foot and toe flexors medially, as well as the ankle dorsiflexors and plantarflexors.[22,56]

Posterior malleolar fractures, either as an isolated injury or in conjunction with a rotational component, lead to decreased joint contact area.[36] A cadaveric study by Macko et al demonstrated that increasing posterior malleolus fragment sizes lead to increased concentration of load.[39] The most significant reductions in total joint contact area occurred with osteotomies of one-third to one-half of the anterior-posterior margin of the joint surface, with between 65% and 80% of the total surface area lost in neutral foot position.[39] Contrary to these findings, Fitzpatrick et al demonstrated that peak contact pressures do not increase in simulated posterior malleolus fractures when involving half or less of the joint surface; however, they did show that contact stress shifts anteromedially.[15] In addition to reduced articular surface area interaction, complex fractures involving both the lateral and posterior malleoli resulted in clinically significant posterior instability of the ankle, most importantly with posterior fragments of 30-40% of the total articulating surface.[53] Interestingly, the study also showed that the distal fibula together with the anterior-inferior tibiofibular ligament serve as primary restraints to posterior translation of the ankle and could effectively stabilize the ankle joint when posterior fragments are 20% of the articulating surface or smaller. Regardless, it has been suggested that osteoarthritis, a common complicating event associated with posterior malleolar fractures, may be due to the increased contact pressures, decreased total contact area, and stresses in previously nonstressed areas.[24,30,39]

Another concern is the instability of the syndesmosis following ankle fractures that involve the posterior malleolus, as the PITFL is commonly attached to the fragment. Miller et al[46] improved syndesmotic stability in a higher proportion of patients with bi- and trimalleolar fractures via open reduction and fixation of the posterior malleolar fragment using prone positioning and a

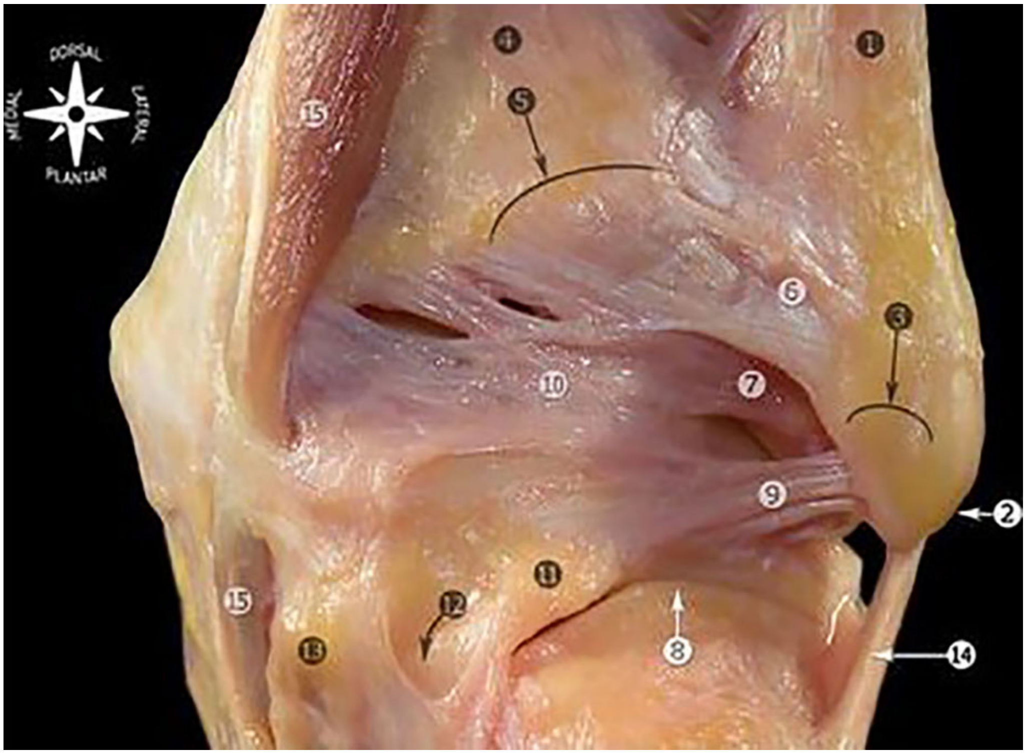

Figure 2. Anatomic dissection of the posterior ligaments of the ankle. Lateral malleolus (*1*); tip of the lateral malleolus (*2*); peroneal groove (*3*); tibia (*4*); posterior tubercle of the tibia (*5*); posterior tibiofibular ligament, superficial component (*6*); posterior tibiofibular ligament, deep component or transverse ligament (*7*); subtalar joint (*8*); posterior talofibular ligament (*9*); posterior intermalleolar ligament (*10*); lateral talar process (*11*); tunnel for flexor halluces longus tendon (tendon was removed) (*12*); medial talar process (*13*); calcaneoficular ligament (*14*); flexor digitorum longus (*15*). Figure and caption reprinted with permission from Golano et al.[22]

posterior approach versus a supine approach and initial reduction and fixation of the medial and lateral malleolar segments. Additionally, 27.2% of patients initially treated supine with fixation of the tibial and fibular malleolar fragments required further syndesmotic fixation, and another 24.5% required posterior fragment fixation to adequately stabilize the ankle syndesmosis.[46] This appears to support work previously done by Gardner et al[19] showing that restoration of the posterior fragment appears to restore ligamentous stability via the PITFL and secures the syndesmosis.

Mechanism of Injury

Ankle fractures usually involve rotational forces transmitted through the foot and talus and onto the overlying malleoli. The resulting fracture pattern and injured ligaments depends on the foot position and direction of external force at the point of injury (Figure 3). The well-known Lauge-Hansen classification of rotational ankle fractures is based on this principle.[36] Accurate characterization of the injury mechanism and limb positioning can aid the surgeon in predicting soft tissue and ligament involvement, applying appropriate reductive maneuvers, and helping inform appropriate surgical interventions.[26,55]

Posterior malleolar fractures most often result from external rotational injuries in either a pronated or supinated position, although some may result from pronated-abduction injury.[60] Some of the Lauge-Hansen classifications can result in posterior fragment fractures with sufficient energy. Supination-adduction (SA) fractures at stage II involve vertical or oblique fragmentation of the medial malleolus; although there is a high frequency of concurrent medial plafond involvement, estimated at 42% to 61% in stage II supination-adduction injuries, posterior malleolar fractures rarely occur.[1,43] A high-energy stage III supination–external rotation injury translates into the posterior aspect of the medial malleolar structures, causing either the PITFL to rupture or a posterior malleolar avulsion fracture to occur. Pronated-external rotation initially involves disruption of the deltoid ligament complex or medial malleolar fracture (stage I); further force may result in disruption of the anterior and posterior inferior tibiofibular ligaments or posterior malleolar avulsion fracture (stage II). Stage IV involves PITFL disruption and/or posterior malleolus fracture.

Classification

Rare reports have been made describing isolated posterior malleolar fractures, termed Volkman or Earle fracture,

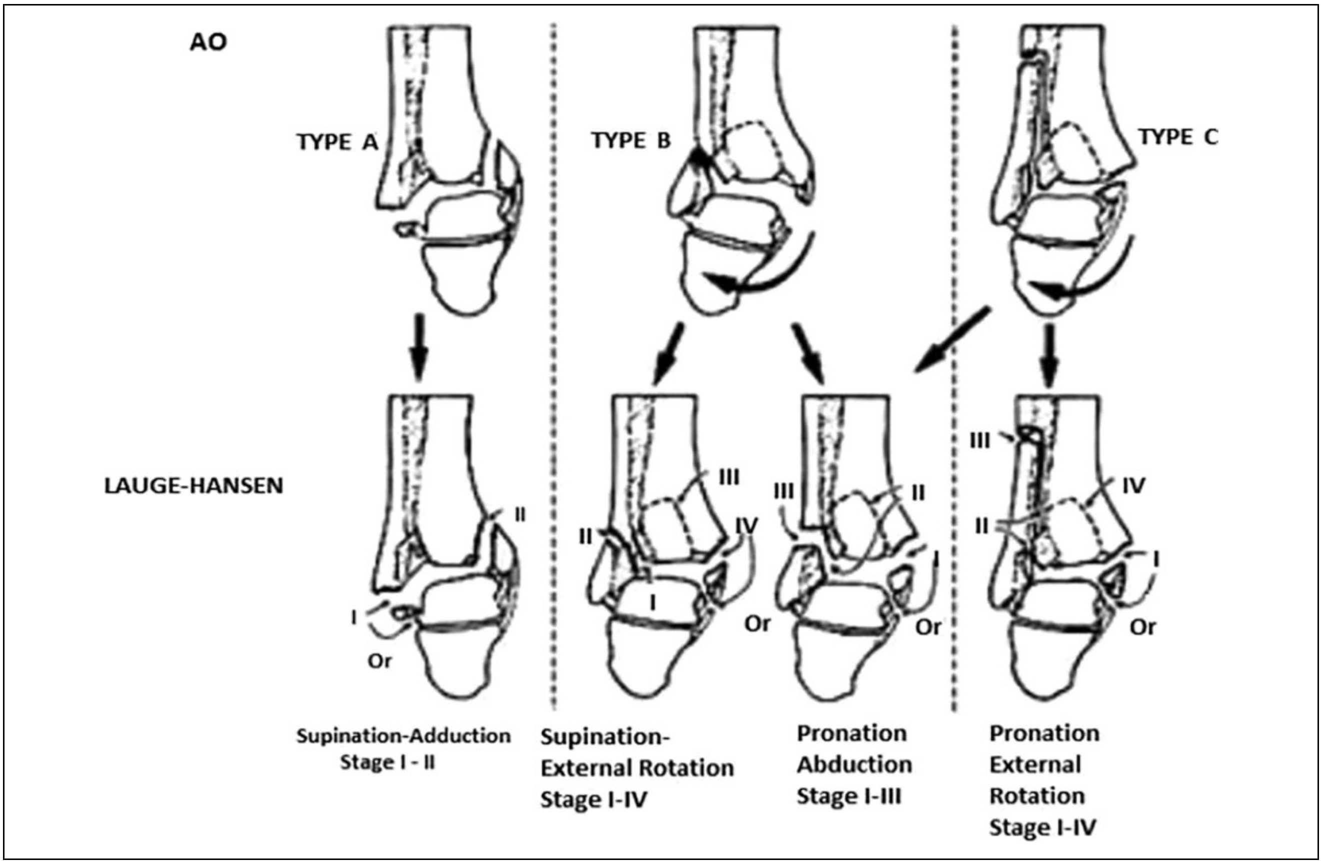

Figure 3. Classification of Ankle Fractures. Figure and caption reprinted with permission from Singh et al.[57]

with rough estimates in the literature of between 1% to 4% of all ankle fractures.[12,59] The mechanism of injury is unclear for these types of isolated fractures, but is likely either due to hyperflexion of the ankle or a significant vertical loading force.

More recently, work by Haraguchi et al[23] has helped classify posterior malleolar fragment fractures. Within their study, they identified 3 major fracture patterns: type I involves a wedge-shaped posterior fragment extending across the tibial plafond and exiting posteromedially through the posterior malleolus; type II was defined by a transverse fracture line extending from the fibular notch of the tibia into the medial malleolus; and type III fractures, so-called "shell fractures," were single or multiple fragments of superficial tibial bone from the posterior malleolar lip (Figure 4).[23] Importantly, type I fracture fragments were found to involve, on average, 11.7% of the tibial plafond, whereas type II fractures were usually more extensive, on average involving 29.8%.[23] This may have an impact on determining surgical intervention via internal fixation; larger fragment involvement may result in a less stable ankle and less-than-satisfactory patient outcomes.[21,32] In contrast, type III "shell" fractures did not include a significant enough percentage of the tibial plafond to warrant measurement.[23]

Later work by Mason et al[42] has attempted to further reorganize work done by Haraguchi et al[23] and reclassified ankle fractures involving the posterior fragment by mechanism of injury and increasing severity. In the Mason and Molloy system, type 1 fractures resulted from an avulsion-type fracture of the posterior malleolar fragment due to pulling forces from the PITFL; this was theorized to be due to a plantarflexed ankle with rotational forces applied. This may be analogous to a stage III supination–external rotation ankle fracture–type injury.[42] Type 2 fractures were broken into 2 subtypes: type 2A fractures involve the Volkmann area of the posterior tibia and likely result from rotation of the talus on the tibial plafond, similar to Haraguchi's type I posterior malleolus fractures; type 2B fractures, on the other hand, involve increased rotational force that results in a secondary fracture via continuation through the medial component of the tibia and are most similar to Haraguchi's type II fractures.[42] Importantly, both Haraguchi and Mason and Molloy indicate that these fractures (type II and 2B, respectively) may result in 2 or more fragments; the wary surgeon should evaluate imaging carefully if this type of fracture is seen in order to correctly identify all involved components during presurgical planning.[23,42] Type 3 fractures are characterized as complete separation of the posterior tibial component via a coronal plane fracture, which frequently resulted from a high oblique fracture through the adjacent fibula and continuing in a similar plane.[42]

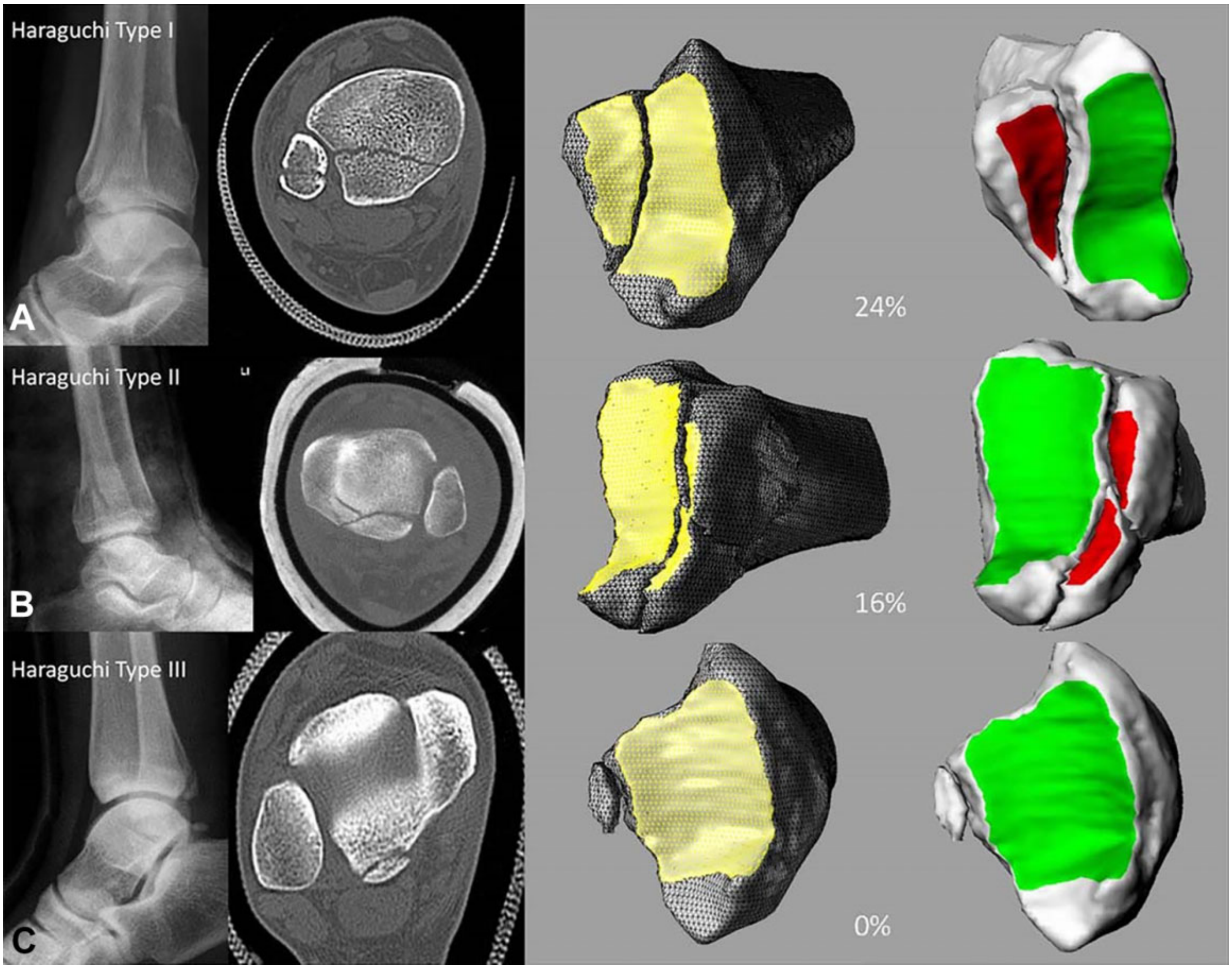

Figure 4. Original classification as coined by Haraguchi et al based on transverse 2DCT in 2-mm or 3-mm increments from the proximal extent of the fracture line of the posterior malleolus to the inferior border of the lateral malleolus. Posterior malleolar fracture (A) type I, (B) type II, and (C) type III were studied using Q3DCT-modeling to characterize 3D posterior malleolar fracture morphology and to quantify fragment size (in cubic millimeter) and articular involvement (in square millimeter) to correlate to the original Haraguchi classification. Figure and caption reprinted with permission from Mangnus et al.[41]

Initial Management

Physical Examination and Closed Reduction

On initial encounter, a thorough history should be taken, and include a complete understanding of the mechanism of injury, which might help the evaluating surgeon identify possible patterns of injury and predict the involved anatomy. Physical examination should include identification of soft tissue changes, including swelling, skin tenting, open wounds, and blanching. An assessment of neurovascular status should also be performed prior to initial reduction attempts.

Prior to reduction, radiographs should be obtained in order to determine if the fracture is severe enough to require immediate reduction, help the surgeon determine what maneuvers should be used and the appropriate splinting position, and to avoid obscuring injury details with plaster. Reduction is commonly performed initially in the emergency department; it should be performed under anesthesia, which may involve either local intra-articular block or conscious sedation. This decision can be made based on clinical judgment and patient tolerance. After reduction, a short leg splint or cast is applied. This varies based on the injury type, urgency, and surgeon and patient preference. Bimalleolar and trimalleolar fractures can be particularly unstable.[54] If reduction cannot be maintained with traditional plaster casting, external fixation devices can be used.[52,54]

Postreduction Imaging

Anteroposterior, lateral, and mortise (15-degree internal rotation oblique) radiographs should be obtained following reduction maneuvers in order to confirm successful reduction and to guide surgical planning and management.

Though commonly used, radiographs have not been shown to adequately assess ankle fractures in their totality, to include involvement of the posterior fragment, presence of intra-articular loose bodies, or malreduction. Ferries et al[14] demonstrated that computed tomography (CT) is more accurate at predicting the size of posterior malleolar fracture fragments than traditional radiographs, and that fragments were usually oversized based on lateral radiographic estimates. In contrast, a study by Buchler demonstrated good accuracy by experienced trauma surgeons in determining posterior malleolus fragment size with a lateral ankle radiograph.[7] However, radiographs were poor at determining osteochondral fragments and impaction.[7] This may be due in part to the highly complex and variable fracture patterns associated with posterior malleolar fractures; a study by Haraguchi et al[23] showed that plain radiographs may miss fracture extensions into the medial malleolus, which may occur as often as 20% of the time. In the same study, the majority of posterior malleolus fractures were posterior oblique (67%), with shell-type fractures accounting for 14%.[23] Because posterior malleolus fracture morphology was variable and may affect approach and fixation strategies, these authors recommended post-reduction CT scans.[23] At our institution, CT scans are routinely obtained for ankle fractures with posterior malleolar involvement, ankle fracture-dislocations, and distal tibia shaft fractures with a suspected intra-articular component. We agree that CT scans are good for evaluating free osteochondral fragments and impaction and can influence approach and planned fixation.

Surgical Treatment

Size of the posterior malleolar fragment has historically determined operative fixation, with greater than 25% of the plafond surface being an indication.[11] Evidence for this threshold has been supported by several small case series.[25,35,51] A study by Langenhuijsen et al[35] recommended achieving joint congruity via reduction with or without surgical intervention whenever the posterior malleolar fracture involved more than 10% of the articular surface of the tibia. A more recent trend for posterior malleolus fixation is a focus on restoring the syndesmosis structure. Gardner et al[19] demonstrated a 70% restoration of the syndesmotic strength with posterior malleolus fixation compared with 40% strength via transsyndesmotic screw fixation. Moreover, using CT scans, Gardner et al[20] showed that use of transsyndesmotic screws resulted in a 52% malreduction rate. This has also been substantiated by Miller et al,[44] who confirmed that fixation of the posterior malleolar fragment could restore stability to the syndesmosis. Finally, posterior talar subluxation is an important indication for posterior malleolus fixation in order to restore ankle congruity. As previously discussed, work by Miller et al[46] and Gardner et al[19] have demonstrated significantly improved ankle stability with fixation of the posterior fragment. Further, Karaca et al[32] found good clinical and functional outcomes of ankle fractures when repair included open reduction and fixation of the posterior fragment, including in elderly patients with less-than-ideal bone quality. Surgeons should further be wary that small fracture fragments can interfere with reduction of the posterior malleolus if done following fixation of the fibula.

Even with this information, the decision on whether or not to fix the posterior malleolus continues to be nebulous. Survey data indicate that 56% of trauma surgeon's fixation indications are based on ankle stability rather than the size of the fragment.[21] Size seemed to be universally agreed upon for fixation when greater than 50% of the plafond was involved, whereas less than 10% involvement would be fixed by only 9% of surgeons.[21] DeVries et al[11] support fixation of posterior fragments >25% in size with good long-term outcomes. However, work done by Drijfhout van Hooff et al[13] indicates that fixation of posterior fragments of medium (5%-25%) and large size (>25%) should be fixated in anatomic position in order to reduce long-term development of osteoarthritis. At our institution, ankle stability (syndesmotic instability or talus subluxation) determines whether we fix the posterior malleolus fragment. In our experience, a posterior malleolus fragment of greater than 25% of the plafond will more often than not have some form of instability.

Approaches

Of the various approaches, we find that the posterolateral approach is best, as it can be used for direct visualization of the fracture (Figure 5). This is supported by good patient outcomes, as well, as shown by Forberger et al.[17] This approach can be done with the patient in either prone or lateral position; preference is for the prone position if there is a concurrent medial malleolar fracture. An advantage of this approach is that the fibula can also be reduced and plated through this approach. A longitudinal incision can be made at the median point between the distal fibula and Achilles tendon and is extended proximally from the tip of the fibula.[9] Care should be taken to avoid lacerating the sural nerve, which typically runs parallel to the incision.[9] The space between the FHL and peroneal muscles is best accessed by working through the peroneal tendon sheath.[29,60] Access to both the posterior and lateral malleoli can be reached between the peroneal tendon bundle and the posterior aspect of the fibula. Although this approach does not address the medial malleolar component, this can be resolved by a traditional medial incision.

There are several advantages to the posterolateral approach. Primarily, it provides direct access to and visualization of the posterior fragment, which allows evaluation of the chondral surface and inspection for intra-articular bony fragments. Obviously, this also allows the surgeon direct access to the injured fragment, allowing him or her to simultaneously clear out the remaining hematoma and periosteum and better restore the articulating surface of the

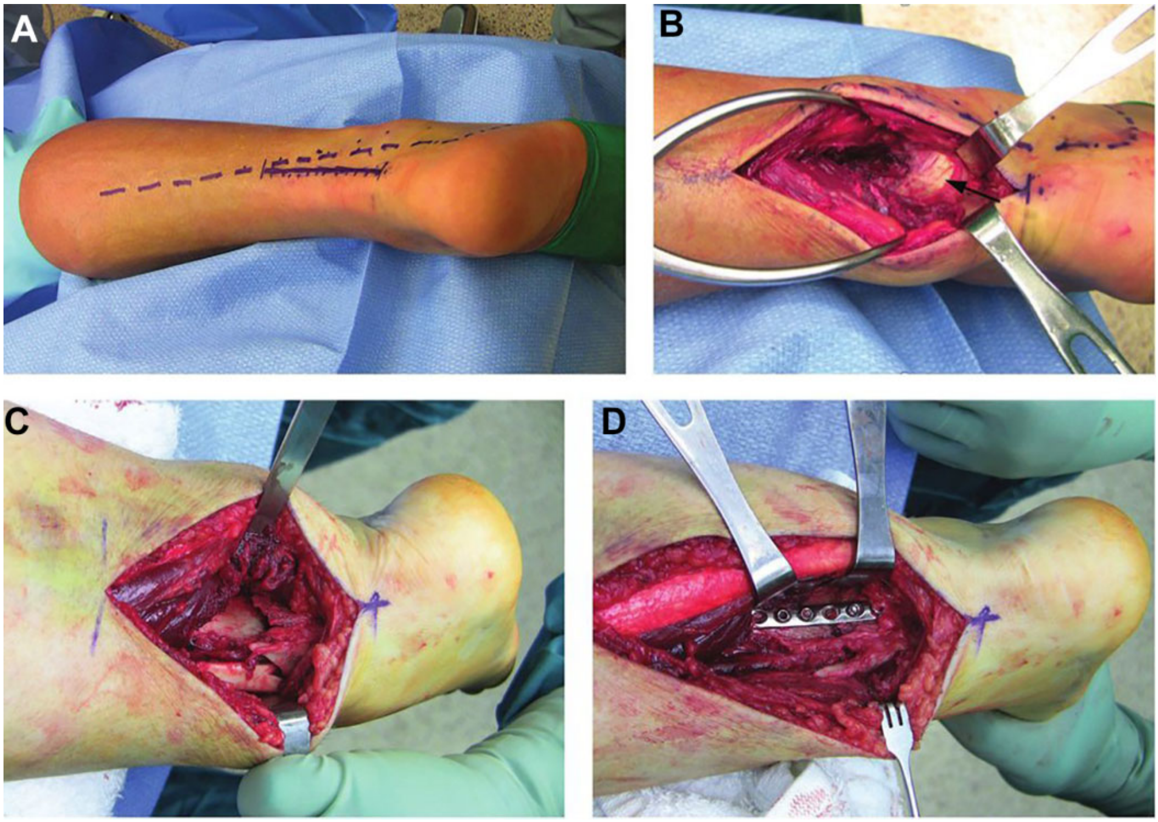

Figure 5. Intraoperative photographs depicting fixation of a posterior malleolus fracture through a posterolateral approach. (A) Posterolateral incision with the patient in the prone position. Note the expected course of the sural nerve (dashed line). (B) The flexor halluces longus-peroneal muscle interval. The arrow identifies intact fibers of the posterior inferior tibiofibular ligament. (C) Displaced posterior malleolus and fibula. (D) Fixation with a one-third tubular plate. Note the screw at the apex of the fracture, which is creating an antiglide effect. Figure and caption reprinted with permission from Irwin et al.[29]

joint. This was supported by Huber et al,[28] who demonstrated a significantly greater success rate of anatomical reduction of the posterior fragment with the direct approach vs indirect fixation. It is important to place hardware on the posterior malleolus first, as one can easily evaluate the reduction and hardware position without obstruction from hardware on the fibula or medial malleolus. Furthermore, prone positioning allows gravity to be an assistive component for the surgeon, helping reduce the ankle and foot into a more anatomic position without the need of an aid. This approach also inherently avoids approaching the major neurovascular bundle (posterior tibial artery and vein, tibial nerve) on the medial aspect of the ankle.

Alternatively, the posterior malleolus can be accessed via a posteromedial approach, especially if there is medial extension of the fracture consistent with a Haraguchi type II or Mason and Molloy type 2B fracture. This requires an incision tracking along the posterior aspect of the medial malleolus parallel and over the posterior tibialis tendon. Then, the flexor retinaculum is divided and the flexor digitorum longus and posterior tibialis tendons are reflected anteromedially, exposing the posterior malleolus.[43] Concurrent with reflection of the posterior tibialis is protection of the saphenous nerve and vein, and reflection of the tendon of the flexor digitorum longus will help protect the neurovascular bundle of posterior tibial artery, vein, and tibial nerve.

Findings by Bois and Dust support this approach when approaching the patient with medial malleolar involvement; although osteoarthritis was evident at follow-up in 67% of the small series of patients, clinical outcomes as graded by the Foot and Ankle Outcomes Score (FAOS) on average was 87 points.[5] Furthermore, there did not appear to be any complications with wound healing. This technique is particularly useful when the patient also has a large fragment from the posterior tibial plafond and a concurrently disrupted PITFL, which has been relied on to aid with partial to complete tibial fragment reduction via the traditional approach of first reducing and fixating the fibula; this disruption prevents sufficient reduction of the posterior fragment without direct manipulation.

Both posterolateral and posteromedial approaches allow for direct visualization of the posterior malleolus and are extensive enough for hardware application, which is important when considering the current focus of ankle fracture repair is to "directly fix what is broken, and directly repair what is torn."[40] Additionally, both approach incisions are not directly over hardware and avoid the issue of hardware prominence. Recent evidence has shown significant numbers of iatrogenic malreduction of the syndesmosis with the standard lateral approach for fibular repair without direct visualization of the posterior malleolus reduction.[18,63]

Outcomes

Malreduction

It is well known that insufficient reduction, or malreduction, of the articular surfaces of the involved joint are a major factor in the outcome of operatively managed ankle fractures.[3] Outcomes are related to the degree of restoration of the articular surface itself and any remaining tibiotalar subluxation following surgical intervention.[49] Reduction of the posterior malleolus in an injury with concurrent syndesmotic instability may lead to improved syndesmotic reduction as malreduction of the syndesmosis is common.[18] This is likely because the congruity of the tibial articular surface is restored and the syndesmosis is likely reduced through an intact PITFL; fibular length may also be obtained.[58] Fitzpatrick et al[16] showed in a cadaveric model that posterior malleolus malreduction leads to syndesmotic malreduction in the medial/lateral direction. Miller et al[44] showed that posterior malleolus reduction led to improved syndesmosis reduction by utilizing postoperative CT scan for assessment.

Hardware Selection

Vidovic et al[62] compared direct reduction of the posterior malleolar fragment and use of posterior-to-anterior (PA) screw fixation utilizing a posterolateral approach against an indirect reduction using anterior-to-posterior (AP) screw fixation. Excellent reduction was seen in 79% of those with PA screws vs 45% of the those receiving AP screws.[62] Zhou found that use of cannulated screws or a buttress plate to secure the posterior malleolus produced 82.3% excellent and good results.[64] Importantly, the posterolateral approach was used, thereby supporting use of this approach in repair of large posterior fragments. This appears to reflect results reported by Miller et al[46] who showed a 13-fold higher rate of syndesmotic instability with regard to patients initially positioned supine in comparison to prone-positioned patients who underwent posterior malleolus fixation. As described earlier, biomechanical analysis revealed that posterior malleolus fixation confers more syndesmotic stability than transyndesmotic fixation.[17]

Patient Outcomes

It is generally agreed that ankle fractures with some degree of posterior malleolar fracture involvement tend to portend worse functional outcomes. Verhage et al indicated that medial malleolar fractures with a concurrent posterior malleolar fragment of 5% or greater of the joint surface are generally associated with worse long-term outcomes, with osteoarthritis most likely to be identified in those with trimalleolar fractures.[61] Mingo-Robinet et al demonstrated that patients with posterior fragments of <25% of the articular surface tended to have better outcomes overall, probably because of the smaller loss of joint surface contact area.[47] Importantly, they did not see a difference in outcomes when repairing posterior fragments when compared to those with nonanatomic reductions, regardless of fragment size.[47] In contrast, Langenhuijsen et al[35] demonstrated that anatomic reduction of fragments 10% and greater of the articular surface resulted in better patient VAS scores, indicating that patients do not have disabling pain or loss of function.

Levack et al[37] revealed that having a posterior malleolus fracture in a rotational ankle injury may not portend a worse outcome when compared with PITFL injury when using FAOS scores; there was no significant difference between groups at 12.8 and 16.3 months.[18] Unstable ankle injuries with syndesmotic injuries and a fractured posterior malleolus had similar functional outcomes when either the syndesmosis was fixated or the posterior malleolar fragment was reduced and fixed, regardless of the size of the fracture component.[45] Importantly, FAOS scores were similar between patients with either ankle fracture involving the posterior malleolus or with higher-energy injury (fracture-dislocation, extensive soft tissue involvement) when compared with those with ankle fractures that did not involve the posterior malleolus.[45]

As previously discussed, stability and useful function of the ankle also requires careful restoration of the associated soft tissues supporting the ankle. Weening and Bhandari concluded that anatomic reduction of the syndesmosis accounted for a significant improvement in functional outcomes for patients.[63]

Tibial Shaft Fractures With Posterior Malleolus Component

It is known that rotational tibial shaft fractures can have associated posterior malleolar fractures.[27,34] Hou et al demonstrated that almost 10% of spiral-type tibial fractures are associated with these types of concurrent injuries, and advised routine CT scans to identify them.[27] Kempegowda et al[33] reported that 9% of nailed tibial shaft fractures had a posterior malleolar fragment in what is the largest series in the current literature. Mitchell et al[48] determined that the posterior malleolus fractures associated with distal tibia fractures were usually coronal and involved the posterolateral aspect of the plafond. When approaching this type of injury, Kempegowda et al[33] demonstrated that 2% of tibial shaft fractures were malreduced when including a posterior malleolus component that was reduced and fixed prior to tibial nailing. Up to 44% of posterior malleolar fragments were poorly reduced when the tibia was nailed first, with obvious displacement of the fragment after nail placement in 31%.[33] No functional outcomes were reported in this study as their evaluation was purely radiographic. We recommend provisional clamp fixation of the posterior malleolar fragment followed by tibial nailing. By using the clamp, one can avoid hardware obstruction of the nail path. Finally, hardware can be applied after nail placement after first ensuring maintenance of the posterior malleolar fragment. Our preferred fixation is anterior to posterior screws, as this can be easily performed in the supine position required for tibial nailing.

Conclusion

Posterior malleolar fractures are frequently involved in the pathology of ankle fractures and contribute to instability of the joint. We recommend routine use of CT scans to help detect these injuries and allow the orthopedic surgeon to better determine the appropriate surgical approach and treatment. Evidence supports direct posterior malleolar vs trans-syndesmotic fixation. Controversy continues to exist regarding the minimum size of the posterior fragment that requires fixation; however, fragments greater than 50% certainly should be repaired and we recommend fragments greater than 25% be fixed. Sufficient fixation of the posterior fragment frequently results in improved syndesmotic and ankle joint stability, and improved functional outcomes.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article. ICMJE forms for all authors are available online.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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References

1. Alluri R, Hill J, Donohoe S, et al. Radiographic detection of marginal impaction in supination-adduction ankle fractures. *Foot Ankle Int*. 2017;38(9):1005-1010.
2. Bartonicek J. Anatomy of the tibiofibular syndesmosis and its clinical relevance. *Surg Radiol Anat*. 2003;25:379-386.
3. Berkes MB, Little MTM, Lazaro LE, et al. Articular congruity is associated with short-term clinical outcomes of operatively treated SER IV ankle fractures. *J Bone Joint Surg Am*. 2013; 95(19):1769-1775.
4. Boardman D, Liu S. Contribution of the anterolateral joint capsule to the mechanical stability of the ankle. *Clin Orthop Relat Res*. 1997;341:224-232.
5. Bois A, Dust W. Posterior fracture dislocation of the ankle: technique and clinical experience using a posteromedial surgical approach. *J Orthop Trauma*. 2008;22(9):629-636.
6. Boraiah S, Gardner MJ, Helfet DL, et al. High association of posterior malleolus fractures with spiral distal tibial fractures. *Clin Orthop Relat Res*. 2008;466(7):1692-1698.
7. Buchler L, Tannast M, Bonel HM, et al. Reliability of radiologic assessment of the fracture anatomy at the posterior tibial plafond in malleolar fractures. *J Orthop Trauma*. 2009;23(3): 208-212.
8. Clanton T, Williams B, Backus J, et al. Biomechanical analysis of the individual ligament contributions to syndesmotic stability. *Foot Ankle Int*. 2016;38(1):66-75.
9. Cooper A. A treatise on dislocations and on fractures of the joints. London: Longman, Hurst, Rees, Orme, Brown, and Green; S. Highley; T. and G. Underwood; Burgess & Hill; & Cox & Son. 1824.
10. Court-Brown CM, Caesar B. Epidemiology of adult fractures: a review. *Injury*. 2006;37:691-697.
11. DeVries J, Wijgman A, Sierevelt I, et al. Long-term results of ankle fractures with a posterior malleolar fragment. *J Foot Ankle Surg*. 2005;44(3):211-217.
12. Donken C, Goorden A, Verhofstad M, et al. The outcome at 20 years of conservatively treated "isolated" posterior malleolar fractures of the ankle. *J Bone Joint Surg*. 2011;93(12): 1621-1625.
13. Drijfhout van Hooff C, Verhage S, Hoogendoorn J. Influence of fragment size and postoperative joint congruency on long-term outcome of posterior malleolar fractures. *Foot Ankle Int*. 2015;36(6):673-678.
14. Ferries J, DeCoster T, Firoozbakhsh K, et al. Plain radiograph interpretation in trimalleolar ankle fractures poorly assesses posterior fragment size. *J Orthop Trauma*. 1994;8(4):328-331.
15. Fitzpatrick DC, Otto JK, McKinley TO, et al. Kinematic and contact stress analysis of posterior malleolus fractures of the ankle. *J Orthop Trauma*. 2004;18(5):271-278.
16. Fitzpatrick E, Goetz JE, Sittapairoj T. Effect of posterior malleolus fracture on syndesmotic reduction: a cadaveric study. *J Bone Joint Surg Am*. 2018;100(3):243-248.
17. Forberger J, Sabandal PV, Dietrich M, et al. Posterolateral approach to the displaced posterior malleolus: functional outcome and local morbidity. *Foot Ankle Int*. 2009;30(4): 309-314.
18. Franzone J, Vosseller J. Posterolateral approach for open reduction and internal fixation of a posterior malleolus fracture hinging on an intact PITFL to disimpact the tibial plafond: a technical note. *Foot Ankle Int*. 2013;34(8):1117-1181.
19. Gardner MJ, Brodsky A, Briggs SM, et al. Fixation of posterior malleolar fractures provides greater syndesmotic stability. *Clin Orthop Relat Res*. 2006;447:165-171.
20. Gardner MJ, Demetrakopoulos D, Briggs SM, et al. Malreduction of the tibiofibular syndesmosis in ankle fractures. *Foot Ankle Int*. 2006;27(10):788-792.
21. Gardner M, Streubel P, McCormick J, et al. Surgeon practices regarding operative treatment of posterior malleolus fractures. *Foot Ankle Int*. 2011;32(4):385-393.
22. Golano P, Vega J, de Leeuw PA, et al. Anatomy of the ankle ligaments: a pictorial essay. *Knee Surg Sports Traumatol Arthrosc*. 2010;18(5):557-569.

23. Haraguchi N, Haruyama H, Toga H, et al. Pathoanatomy of posterior malleolus fractures of the ankle. *J Bone Joint Surg Am*. 2006;88(8):1835.
24. Hartford JM, Gorczyca JT, McNamara JL, et al. Tibiotalar contact area: contribution of the posterior malleolus and deltoid ligament. *Clin Orthop Relat Res*. 1995;320:182-187.
25. Heim U. Trimalleolar fractures: late results after fixation of the posterior fragment. *Orthopedics*. 1989;12:1053-1059.
26. Helfet D, Haas N, Schatzker J, et al. AO philosophy and principles of fracture management—its evolution and evaluation. *J Bone Joint Surg Am*. 2003;85(6):1156-1160.
27. Hou Z, Zhang Q, Zhang Y, Li S, Pan J, Wu H. A occult and regular combination injury: the posterior malleolar fracture associated with spiral tibial shaft fracture. *J Trauma*. 2009; 66(5):1385-1390.
28. Huber M, Stutz P, Gerber C. Open reduction and internal fixation of the posterior malleolus with a posterior antiglide plate using a postero-lateral approach: a preliminary report. *J Foot Ankle Surg*. 1996;2:95.
29. Irwin T, Lien J, Kadakia A. Posterior malleolus fracture. *J Am Acad Orthop Surg*. 2013;21(1):32-40.
30. Jaskulka R, Ittner G, Schedl R. Fractures of the posterior tibial margin: their role in the prognosis of malleolar fractures. *J Trauma*. 1989;29(11):1565-1570.
31. Jung KJ, Chung CY, Park MS, et al. Concomitant ankle injuries associated with tibial shaft fractures. *Foot Ankle Int*. 2015; 36:1209-1214.
32. Karaca S, Enercan M, Özdemir G, et al. Importance of fixation of posterior malleolus fracture in trimalleolar fractures: a retrospective study. *Turk J Trauma Emerg Surg*. 2016;22(6): 553-558.
33. Kempegowda H, Maniar HH, Richard R, et al. Posterior malleolar fractures associated with tibial shaft fractures and sequence of fixation. *J Orthop Trauma*. 2016;30(10):568-571.
34. Kukkonen J, Heikkila JT, Kyyronen T, et al. Posterior malleolar fracture is often associated with spiral tibial diaphyseal fracture: a retrospective study. *J Trauma*. 2006;60(5): 1058-1060.
35. Langenhuijsen J, Heetveld M, Ultee J, et al. Results of ankle fractures with involvement of the posterior tibial margin. *J Truama*. 2002;53:55-60.
36. Lauge-Hansen N. Fractures of the ankle II: combined experimental-surgical and experimental-roentgenologic investigations. *Arch Surg*. 1950;60(5):957-985.
37. Levack A, Warner S, Gausden E. Comparing functional outcomes following injury-specific fixation of posterior malleolar fractures and equivalent ligamentous injuries in rotational ankle fractures. *J Orthop Trauma*. 2018;32(4):e123-e128.
38. Lilyquist M, Shaw A, Latz K, et al. Cadaveric analysis of the distal tibiofibular syndesmosis. *Foot Ankle Int*. 2016;37(8): 882-890.
39. Macko VW, Matthews LS, Zwirkoski P, et al. The joint-contact area of the ankle: the contribution of the posterior malleolus. *J Bone Joint Surg Am*. 1991;73(3):347-351.
40. Mak M, Stern R, Assal M. Repair of syndesmosis injury in ankle fractures. *EFORT Open Rev*. 2018;3(1):24-29.
41. Mangnus L, Meijer D, Stufkens S, Mellema J, Steller E, Kerkhoffs G, Doornberg J. Posterior malleolar fracture patterns. *J Orthop Trauma*. 2015;29(9):428-435.
42. Mason L, Marlow W, Widnall J, Molloy A. Pathoanatomy and associated injuries of posterior malleolus fracture of the ankle. *Foot Ankle Int*. 2017;38(11):1229-1235.
43. McConnell T, Tornetta P. Marginal plafond impaction in association with supination-adduction ankle fractures: a report of eight cases. *J Orthop Trauma*. 2001;15(6):447-449.
44. Miller AN, Carroll EA, Parker RJ, et al. Direct visualization for syndesmotic stabilization of ankle fractures. *Foot Ankle Int*. 2009;30:419-426.
45. Miller AN, Carroll EA, Parker RJ, et al. Posterior malleolar stabilization of syndesmotic injuries is equivalent to screw fixation. *Clin Orthop Relat Res*. 2010;468(4):1129-1135.
46. Miller MA, McDonald TC, Graves ML, et al. Stability of the syndesmosis after posterior malleolar fracture fixation. *Foot Ankle Int*. 2018;39(1):99-104.
47. Mingo-Robinet J, López-Durán L, Galeote J, Martinez-Cervell C. Ankle fractures with posterior malleolar fragment: management and results. *J Foot Ankle Surg*. 2011;50(2):141-145.
48. Mitchell Phillip M, Harms KA, Lee AK, Collinge C. Morphology of the posterior malleolar fracture associated with a spiral distal tibia fracture. *J Orthop Trauma*. 2019; 33(4):185-188.
49. Odak S, Ahluwalia R, Unnikrishnan P. Management of posterior malleolar fractures: a systematic review. *J Foot Ankle Surg*. 2016;55:140-145.
50. Ogilvie-Harris DJ, Reed SC, Hedman TP, et al. Disruption of the ankle syndesmosis: biomechanical study of the ligamentous restraints. *Arthroscopy*. 1994;10(5):558-560.
51. Papachristou G, Estathopoulos N, Levidiotis C, et al. Early weight bearing after posterior malleolar fractures: an experimental and prospective clinical study. *J Foot Ankle Surg*. 2003; 42:99-104.
52. Payne R, Kinmont JC, Moalypour SM. Initial management of closed fracture-dislocations of the ankle. *Ann R Coll Surg Engl*. 2004;86(3):177-181.
53. Raasch WG, Larkin JJ, Draganich LF. Assessment of the posterior malleolus as a restraint to posterior subluxation of the ankle. *J Bone Joint Surg Am*. 1992;74(8):1201-1206.
54. Regan DK, Gould S, Manoli A 3rd, et al. Outcomes over a decade after surgery for unstable ankle fracture: functional recovery seen 1 year postoperatively does not decay with time. *J Orthop Trauma*. 2016;30(7):e236-e241.
55. Russo A, Reginelli A, Zappia M, et al. Ankle fracture: radiographic approach according to the Lauge-Hansen classification. *Musculoskelet Surg*. 2013;97(suppl 2):155-160.
56. Sarrafian SK. *Anatomy of the Foot and Ankle. Descriptive, Topographic, Functional*. 2nd ed. Philadelphia, PA: Lippincott; 1993:159-217.
57. Singh R, Kamal T, Roulohamin N, Maoharan G, Ahmed B, Theobald P. Ankle fractures: a literature review of current treatment methods. *Open J Orthop*. 2014;4(4):292-303.
58. Solan MC, Sakellariou A. Posterior malleolus fractures: worth fixing. *Bone Joint J*. 2017;99(11):1413-1419.

59. Smeeing DPJ, Houwert RM, Kruyt MC, et al. The isolated posterior malleolar fracture and syndesmotic instability: a case report and review of the literature. *Int J Surg Case Rep*. 2017; 41:360-365.
60. Switaj P, Weatherford B, Fuchs D, et al. Evaluation of posterior malleolar fractures and the posterior pilon variant in operatively treated ankle fractures. *Foot Ankle Int*. 2014;35(9):886-895.
61. Verhage S, Schipper I, Hoogendoorn J. Long-term functional and radiographic outcomes in 243 operated ankle fractures. *J Foot Ankle Res*. 2015;8(1):45.
62. Vidovic V, Elaber E, Muskardin I. Posterior fragment in ankle fractures: anteroposterior vs. posteroanterior fixation. *Injury*. 2017;5:S65-S69.
63. Weening B, Bhandari M. Predictors of functional outcome following transsyndesmotic screw fixation of ankle fractures. *J Orthop Trauma*. 2005;19(2):102-108.
64. Zhou Q, Lu H, Wang Z, et al. Posterolateral approach with buttress plates and cannulated screw fixation for large posterior malleolus fractures. *J Foot Ankle Surg*. 2017;56(6): 1173-1179.