Trimalleolar fracture: The endless posterior malleolus fracture debate, to repair or not to repair?

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Abstract

Ankle fracture is one of the most common fractures presenting in the emergency department. The fracture varies from unimalleolar, bimalleolar or trimalleolar. Involvement of the posterior malleolus is common and ranges from small avulsions to large intraarticular fragments causing subluxation of the talus. If left untreated, the resulting step-off, comminution or posterior talar subluxation may lead to osteoarthritis and further disability. To date, no consensus exists regarding the management of posterior malleolus fractures in the set-up of trimalleolar fractures. In this review we provide an overview of the literature on the available treatment options for posterior malleolar fracture in the set-up of trimalleolar fractures.

Introduction

Ankle fractures are considered one of the most common injuries encountered in the emergency department. The typical mechanism of injury is of rotational type. Posterior malleolus fractures (PMF) occur in 7%-44% of all ankle fractures. It is usually part of the trimalleolar injury and is rarely isolated.[1-4] The term *trimalleolar fracture* was first introduced by Henderson.[5] PMF within the setting of trimalleolar fracture should be differentiated between PMF within the setting of pilon fracture in which a supra-articular metaphyseal fracture is involved.

Indications for surgical fixation of the lateral and medial malleolar fractures are well-defined, while those of PMF are still debatable. The traditional indication is involvement of more than 25-33% of the tibial plafond.[6] Other studies argue that a persistent step-off in the articular surface is the most important predictor affecting outcome. Several approaches are described for reduction and fixation of the PMF. The posterolateral approach is still gaining in popularity. Surgical fixation is either done directly by open reduction and plate fixation, or indirectly, either by percutaneous anterior-to-posterior screws or by ligamentotaxis achieved by lateral malleolar reduction and fixation. To date, no consensus exists regarding the management of PMF.

Anatomy and biomechanics

The ankle joint is a complex ginglymoid joint, both the bony architecture and osseo-ligamentous complexes contribute to its stability. The posterior malleolus (PM) is the posterior lip of the plafond contributing to its concave shape, conferring congruency and stability to the ankle joint. The PM comprises the origin of the posterior inferior tibiofibular ligament (PITFL), a major component of the syndesmotic complex which contributes to 42% of the overall syndesmotic stability.[7] Fracture of the PM may contribute to posterior talus subluxation and ankle instability, leading to future development of osteoarthritis and disability.

Diagnosis

Initial assessment is done with conventional radiography. Lateral radiograph is best for identifying posterior talar subluxation and can give some appreciation of the PMF size.[8] Some authors claim that this can be accurately and reliably estimated based on radiographs alone.[9] This view was challenged by more recent studies. Zhang *et al*. compared six methods for evaluating articular involvement of PMF based on radiography and CT. The authors concluded that plain radiography is not reliable for determining PMF size. Instead, both 3-D linear and 3-D surface measurement methods are more reliable and reproducible methods. The CT offers other advantages, it delineates fracture size and comminution with high accuracy. Furthermore, some authors use it for the sake of classification based on fracture configuration. The most commonly used classification was described by Haraguchi *et al*.[10] They evaluated 57 fractures based on CT scans and divided them into 3 main types. Type 1 fractures consist of a single posterolateral fragment (66% cases). Type 2 fractures extend to involve the medial malleolus, and are usually multifragmentary (20%), while Type 3 fractures area small shell of PM. Some authors recommend using it for assessing all ankle fractures consisting of PMF.[11] Conversely, others argue that this approach seems excessive and involves ionizing radiation, in addition to its relatively high cost.[9] Furthermore, they argue that it does not necessarily provide clinically useful information in most cases and therefore its use is not justified for every patient with trimalleolar fracture.[12,13]

Management

Indications for PMF surgical fixation based on outcomes

It is widely agreed that the outcome of trimalleolar fracture is worse than the outcome of bimalleolar fracture.[14-16] The controversy goes on regarding what exactly affects the outcome and to what degree. Several factors related to PMF should be taken into consideration in order to settle this controversy. This includes primarily: PM fragment size, anatomic reduction of articular surface, syndesmotic stability, surgical approach and surgical fixation technique. We will discuss each factor separately and in detail.

PM fragment size

Traditionally, PM fragment size was

considered the major determining factor for affecting decision making and outcome. Several authors used the cut-off of 25-33% of the tibial plafond to guide their treatment decision. This was based mainly on both biochemical and clinical studies.[17-20] Hartford et al.[21] examined 16 fresh ankle specimens to evaluate the effect on the tibiotalar contact area in relation to PM size. The authors found that PM fragments larger than 33% significantly decreased the contact area, predisposing the tibiotalar joint to degenerative changes. In addition, a clinical study conducted by McLaughlin noted that the talus displaced posteriorly in trimalleolar fractures with a PMF larger than 25% that were treated in a cast.[22] Furthermore, Macko et al. noticed a correlation between large PM fragment size and decreased surface area of contact and a cut-off of 33% of distal tibia was found. Xu et al. compared outcomes of 102 patients sustaining PMF. Out of them, 42 patients had their PMF surgically repaired. The authors found that for fragments <25%, fixation of the PM did not greatly affect the treatment outcome.

Nonetheless, this cut-off has been challenged by both historical and more recent biomechanical and clinical studies. A biomechanical study conducted by Papachristou et al.[23] used photoelastic bone models which showed that the load was primarily concentrated in the mid50% of the articular surface during axial loading and not in the posterior 25% of the articular surface, indicating that the PM may not be involved in load-bearing. This finding was consistent with clinical studies. Harper et al.[24] conducted a retrospective study on 38 patients with PMF larger than 25%, all of whom had undergone fixation of the medial and lateral malleoli without addressing the PMF. The results showed not a single talar subluxation. Another study conducted by Langenhuijsen et al. (2002) evaluating 57 patients who underwent PMF fixation found that neither size nor fixation of the PMF affected the outcome.[25]

A survey for decision making was performed by 401 surgeons asking them what guides their PMF management. Fifty-six percent of trauma surgeons answered "depends on stability and other factors" while only 29% of respondents specified that a fragment-size cut-off of 25% is used as an indication of surgical management.[26]

Anatomical reduction and articular step-off

As with other intra-articular fractures, anatomical reduction of articular surface may also play a role in affecting the treatment decision in PMF. There is a growing body of evidence stressing the importance of anatomical reduction of the articular surface of PMF, making it the most important factor affecting the outcome.[27-29]

Fitzpatrick et al.[30] demonstrated that a step-off >1 mm on cadavers led to significant changes in peak distribution pressure at the talocrural joint; this increased pressure could predispose to secondary arthritis in the future. This was further stressed by a retrospective study evaluating 131 patients treated for an isolated ankle fracture associated with PMF. Patients were divided into different groups based on fragment size and articular step-off. A mean follow-up of 6.9 years showed that osteoarthritis occurred more frequently in patients with articular step-off >1 mm, whether the PM fragment was repaired or not.[31]

A recent comparative study by Baumbach et al.[32] evaluated 236 patients with PMF divided into 3 groups (untreated 48.3%, CRIF 18.6%, ORIF 33.1%). Results showed that the ORIF group had significantly better reduction quality compared to the other groups. The results were independent of size, concluding that all PMF should be treated with ORIF to achieve anatomical reduction and to restore syndesmotic stability. Another recent prospective comparative study argued that the fragment size has negligible effects on the outcome.[33] The authors evaluated the outcomes of 62 patients sustaining ankle fractures with PMF involving <25% of articular surface. All patients underwent ORIF of lateral and/or medial malleoli fixation, of them, 32 patients underwent PMF fixation as well, while the remainder did not have their PMF repaired. Results showed that the addition of PMF fixation was effective for fracture healing and showed improved clinical outcomes at 12 months follow-up. This result was consistent with other retrospective studies. Tosun et al.[34] evaluated retrospectively 49 patients sustaining trimalleolar fracture. In Group I (n=29), the PMF was not addressed. Group II (n=20) had their PMF repaired directly by either screws or plating. The results showed significantly better radiological and clinical results in Group I compared to Group II. The authors recommended that all PMF be repaired regardless of size.

Syndesmosis stability

Several biomechanical studies have confirmed the close relationship between the PITFL, the lateral malleolus and the PM and their contribution to ankle stability. Although the PITFL is still intact in most cases of PMF, the fracture itself is thought to disrupt the syndesmosis requiring operative fixation. Raasch et al. found that no posterior translation of the talus had occurred when loading the ankle joint with up to 40% osteotomy articular surface. When the AITFL was transected or the fibula broken, a significant posterior translation of the talus occurred with only 30% osteotomy of the articular surface. Gradner et al. examined 25 ankle fractures with syndesmotic injury after open reduction and syndesmotic fixation. Of those, 13 had fibular mal-reduction within the incisura diagnosed postoperatively and 38% of the mal-reduced cases had associated PMF. In another study, Gardner et al. evaluated 10 ankles of fresh cadavers after creating a pronation-external rotation fracture pattern with PMF. Five specimens were randomly assigned to receive PM fixation (with screws from posterior-to-anterior) and the remaining five specimens received trans-syndesmotic fixation. Results showed that PMF fixation restored stiffness in 70% of cases compared to only 30% after trans-syndesmotic fixation. Miller et al.[35] prospectively evaluated 31 patients with unstable ankle fractures requiring either PMF fixation or trans-syndesmotic screw fixation. The authors found that PMF fixation reduced the syndesmosis and this reduction was maintained at follow-up. Functional outcomes were at least equivalent to outcomes for the patients having trans-syndesmotic screw fixation.

Surgical approach

Two basic approaches are described for visualizing the PMF for open reduction. The posterolateral approach using the muscular interval between FHL and peroneal muscles. This approach is the most commonly used and is still gaining in popularity.[36,37] It is considered a safe approach allowing good exposure and stable fixation with minimal complications. Care should be taken not to injure the sural nerve.

The posteromedial approach is done less frequently. It offers the advantage of addressing a large PMF, especially those with medial extension. A recent study by Zbeda et al. performed 22 surgeries using the posteromedial approach to anatomically reduce and fixate the PMF with a plate. Their results showed complete healing in all but one patient.[38]

In general, the decision for choosing an approach is based on fragment size, fracture configuration and on the surgeon's experience. Gandham et al. analyzed 141 PM fractures retrospectively using CT scans to delineate fracture configuration, arguing that different incisions are necessary to fully expose and treat each fracture. This is con-

sistent with a recent study done by Vacas-Sánchez *et al.* which showed that the most adequate approach is chosen based on fracture pattern and the surgeon's own experience. Another comparative study compared the two approaches by retrospectively analyzing 48 patients sustaining trimalleolar fractures treated with ORIF. Results were satisfactory for both approaches. The authors recommended choosing the appropriate approach based on surgeon's experience.[39]

Reduction and fixation technique

There are several techniques for reducing and fixing PMF. This is performed either by indirect or direct reduction. Indirect reduction is performed by two methods. Either by anterior-to-posterior percutaneous screw fixation, or by indirect reduction via ligamentotaxis of the PITFL with fibular reduction. Direct reduction is performed by buttress plating or screw fixation via a posterior approach. From a biomechanical perspective, the buttress plating technique seems advantageous. Bennett *et al.* conducted a cadaveric study on 7 pairs of ankles with PMF involving 30% of the tibial plafond. One specimen in each pair was randomly assigned for fixation with either 2 antero-to-posterior lag screws or a one-third tubular buttress plate and then subjected to cyclic loading. The buttress plate group showed significant less peak axial displacement at all time points during cyclic loading.[40] Another biomechanical study evaluating 18 pairs of PMF specimens compared the mechanical fixation strengths between plating fixation and screw fixation. The fragment size was taken into consideration during the study. The authors found that if more than 25% of articular surface is involved, plate fixation is preferred over screw fixation to provide enough stability, otherwise, two screws are sufficient in PM fragment size <25% of articular surface.[41] Those biomechanical studies were also backed up by three comparative clinical studies.[42-45] These studies concluded that a step-off >1-2mm was significantly higher in the anterior-to-posterior percutaneous fixation than in open reduction and plate fixation. For example, Shi *et al.* evaluated 116 patients with PMF involving over 25% of the articular surface and divided them into two groups. One group received direct reduction while the other group received indirect reduction. Postoperative CT-scans for assessing the quality of reduction showed that the quality of fracture reduction was significantly better in the direct group and had better functional outcomes. A recent retrospective study done by McHale *et al.* evaluating 75

patients with PMF, all of whom had undergone internal fixation by posterolateral approach. The authors concluded that anatomical reduction and surgical fixation is to be done of all PMF involving more than 10% of articular surface.[44] One recent study conducted by Mertens *et al.* challenged the validity of this view. The authors prospectively evaluated 50 patients with PMF that were treated with plate fixation. Those patients were compared with 85 patients retrospectively who didn't undergo PMF fixation. The results showed that the outcome of both groups was equal, and both fracture type and plate fixation were independent drivers of the outcome. The authors concluded that there is no indication for routine plate osteosynthesis of all PMF.

Indirect reduction of PMF through ligamentotaxis of the PITFL by fixation of the associated fibular fracture in SER type injuries can be also achieved. The disadvantages of this reduction, like other indirect reductions, is that it cannot assure anatomical reduction. A recent study by Solan *et al.*[45] argued that although anatomical reduction and fixation of the lateral malleolus could also reduce PMF, anatomical reduction cannot be assured. In addition, even if the fragment is successfully anatomically reduced at surgery, it may be displaced secondarily post-operatively.

The preferred fixation sequence between LM and PM

There is no agreement on which fracture should be addressed first. Some advocate addressing the lateral malleolus first, arguing that it restores length and makes PM reduction easier due to its attachment with the PITFL. Conversely, other studies argued that addressing the lateral malleolus first may limit and adversely affect PMF reduction, making it stiffer. Thus, it was suggested that both fractures be reduced anatomically at the same time with the choice of which to fix first made on a case-by-case basis.[46]

Summary and recommendations

To date, there are four systematic reviews. Three of them were unable to recommend clear guidelines for the treatment of PMF. This was due to the lack of standardization of functional outcomes. Furthermore, the evidence for efficacy of surgical fixation was mainly limited to small case series. Nonetheless, there was one clear non-debatable indication for surgical fixation of PMF, which is in the case of talar subluxation.[47-49] The fourth and most recent systematic review was conduct-

ed by Verhage *et al.*[50] The systematic review included 17 studies (2 prospective and 15 retrospective) on PMF treatment in trimalleolar fractures. They concluded that PMF size offers no clear indication for operative fixation, while the anatomical and intra-articular reduction has far more impact on clinical outcome. The study didn't address the question of syndesmotic stability.

Conclusions

In conclusion, we recommend that the indication for operative fixation needs to be made on a case-by-case basis, taking into consideration all the previously mentioned related factors. This could be summarized as follow.

PM fragment size: evidence shows that the size still matters and affects the outcome. Nonetheless, a clear cut-off between 25%-50% is still debatable and currently lacks solid evidence.

Anatomical reduction of articular surface: there is solid evidence supported by both biochemical and clinical studies showing that articular step-off of more than 1-2 mm adversely affects the outcome, especially with a large PM fragment. The best way to achieve anatomical reduction is by open reduction and plate fixation using the posterior approach. The posterolateral approach offers the advantage of giving access to both the LM and PM.

Syndesmosis stability: there is evidence that PMF fixation offers several advantages over trans-syndesmotic fixation with a screw, in cases with syndesmosis instability.

Furthermore, randomized prospective clinical trials are needed for setting clear and widely agreed-upon guidelines for treatment of this challenging fracture.

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