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Reduction Quality in Posterior Malleolar Fractures Using a Modified Posteromedial Ankle Approach

Felipe Pino, MD[1,3], Leonardo Lagos, MD[2,3], Christian Urbina, MD[2], Fernando Vargas, MD[2,3], Mauricio Parra, MD[2], Francisco Bravo, MD[2], and Christian Bastias, MD[2,3]

Abstract

Background: Anatomical reduction of posterior malleolar fracture is a key goal in achieving good functional outcomes in patients with ankle fractures. Although there are many approaches for managing this type of fracture, no studies have shown reduction quality of posterior malleolar fracture in postoperative CT scan using the modified posteromedial ankle approach.

Methods: A retrospective case series of 66 patients of 2 health centers with type 2, 3, and 4 posterior malleolar fractures according to Bartonicek classification treated using the modified posteromedial ankle approach was performed. The postoperative CT scan was used to assess syndesmotic reduction and articular step-off and residual gap in posterior malleolus reduction.

Results: Reduction of posterior malleolus fracture was determined to be <2 mm in 62 patients and >2 mm in 4 cases. Syndesmotic reduction quality was considered to be anatomical in 61 patients. Four patients showed mild anterior fibular translation in the axial plane and were not reoperated. One syndesmotic malreduction was considered poor.

Conclusion: In this study, we found that 92% (61 of 66) of patients with posterior malleolar fracture were reduced with <2 mm step-off using this modified posteromedial ankle approach and fracture fixation strategy.

Level of Evidence: Level IV, case series.

Keywords: posterior malleolar fractures, posterior ankle approaches, reduction quality, CT scan

Introduction

Fractures of the posterior malleolus in the setting of Weber B and C ankle fractures have a reported incidence of about 46%.[10] If we consider that the functional outcomes of trimalleolar fractures have been reported to be worse compared with uni- and bimalleolar fractures,[4,17] almost half of this subgroup of patients may have a poorer clinical outcomes.[4,8,24,28] Historically, posterior malleolar fractures compromising more than one-third of the intra-articular surface were fixated.[23] With the advent of the CT scan and a 3D perspective of the fracture configuration, a new understanding of how the posterior malleolus stabilizes the ankle was born. Posterior incisura acts as a posterior buttress that prevents fibular rotation back out of the articulation,[15] even more, fixation of posterior malleolar fractures returns syndesmotic stability in more than 97% of cases.[16] This is

[1]Department of Orthopaedic Surgery, Hospital Barros Luco Trudeau, Santiago, Chile
[2]Hospital Clinico de la Mutual de Seguridad, Santiago, Chile
[3]Clínica Santa María, Santiago de Chile, Chile

Corresponding Authors:
Felipe Pino, MD, Department of Orthopaedic Surgery, Clínica Santa María, Hospital Barros Luco Trudeau, Gran Avenida 3204, San Miguel, Santiago, 750000, Chile.
Email: fpino14@gmail.com

Christian Bastias, MD, Department of Orthopaedic Surgery, Clínica Santa María, Hospital Clínico Mutual de Seguridad, Avenida Santa María 0500, Providencia, Santiago, 9160000, Chile.
Email: cibastias@gmail.com

why some suggest compromise of anatomic structures such as the incisura fibularis or the posterior malleolar tubercle is more important than the size of the posterior malleolar fragment.[2] Several studies have documented which of the posterior ankle approaches has the best exposure to the posterior malleolus.[18,25,30] However, no study has correlated the quality of posterior fragment reduction at CT scan using the modified posteromedial approach. This study aimed to assess the quality of reduction of posterior malleolar fractures in patients with trimalleolar ankle fractures operated with the modified posteromedial approach.[9]

Methods

A retrospective study was performed in 2 Health Centers between 2014 and 2021 for patients with ankle fracture-dislocations associated with type 2, 3, and 4 posterior malleolar fractures according to the Bartonicek classification.[2] As a group, we started using a Modified Posteromedial Approach that reflects the tibialis posterior and flexor digitorum longus tendons posteriorly for posterior malleolar fractures since 2012. This is different from the one described by Assal et al[1] because he described an approach that accesses the posterior malleolus between the flexor hallucis longus and the neurovascular bundle. Patients were included in the study if they had complete trauma ankle set radiographs and CT scans with axial, sagittal, and coronal planes in the pre- and postoperative stage; older than 18 years; in all of them a direct reduction and internal fixation of the posterior malleolus was performed using this modified posteromedial approach.[9] We excluded patients with previous foot and/or ankle surgeries; patients without complete ankle radiographic trauma set and patients with open fractures. All procedures were performed by 6 experienced foot and ankle surgeons. Sixty-six patients met the inclusion criteria (40 women and 26 men) with a mean age of 44 (range, 22-80) years. Seven patients required 2-stage management with an initial external fixation because of irreducible fracture-dislocations or soft tissue compromise and a second time the final open reduction internal fixation.

Surgical Technique

Surgery is performed with the patient in a supine position with a cushion under the leg and an ipsilateral buttock. We start with a direct lateral approach to achieve an anatomical reduction of the fibula fracture, Tillaux-Chaput fragment, and syndesmosis. Afterward, we remove the cushion under the buttock and rotate the limb externally. If rotation is insufficient, we flex the ipsilateral hip and knee with the abduction of the hip. A modified posteromedial approach[9] is made 1 cm behind the posteromedial border of the tibia. The incision can be curved anteriorly if the patient has a medial malleolus fracture. Both injuries are addressed before reducing and fixing the posterior malleolar fracture. We open the superficial and deep fascia, careful not to open the posterior tibialis tendon sheath completely. It can be seen from a cross-sectional ankle scheme (Figure 1), where the posterior tibialis tendon and flexor digitorum longus tendon are retracted posteriorly, protecting the neurovascular bundle. Then we identify the posterolateral and posteromedial malleolus fragments and remove the hematoma and small intercalary pieces. If it exists, the posteromedial fragment is fixed with screws or a third tubular plate. The posterolateral fragment is reduced and fixed with an anteroposterior compressive screw. In Bartonicek IV,[2] we use 2 anteroposterior compressive screws and, in some cases, a third tube plate (Figure 2).

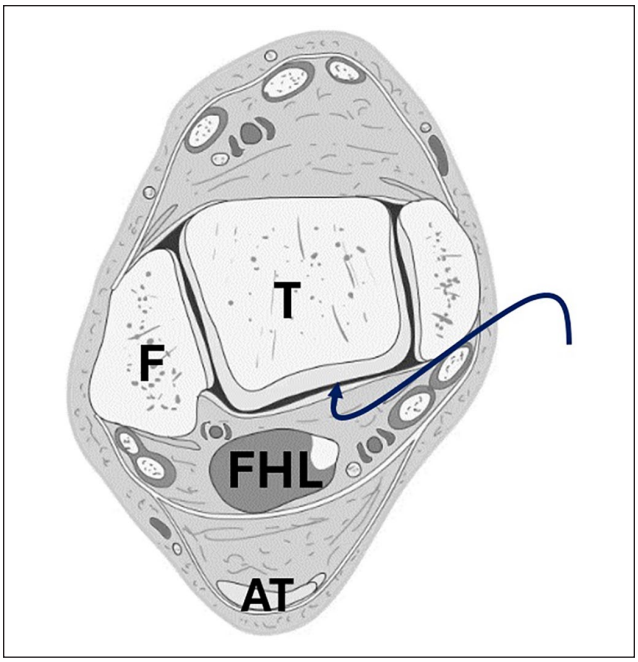

Figure 1. Cross-sectional anatomy ankle scheme showing the incision between the posterior margin of the distal tibia and the posterior tibial tendon.

Postoperative Follow-up

A complete set of ankle trauma radiographs and CT scans are taken during the first postoperative day. Preoperative CT scans were used to classify fractures according to Bartonicek et al[2] and determine the presence, size, and localization of intercalary fragments and articular defects. In the postoperative CT scan, 3 parameters were assessed by a young foot and ankle surgeon who was not present in any surgery: Step-off as consequence of a malreduction or previous articular impaction, articular diastasis or gap following resection of an intercalary fragment, and syndesmosis reduction. Reduction of posterior malleolus was assessed

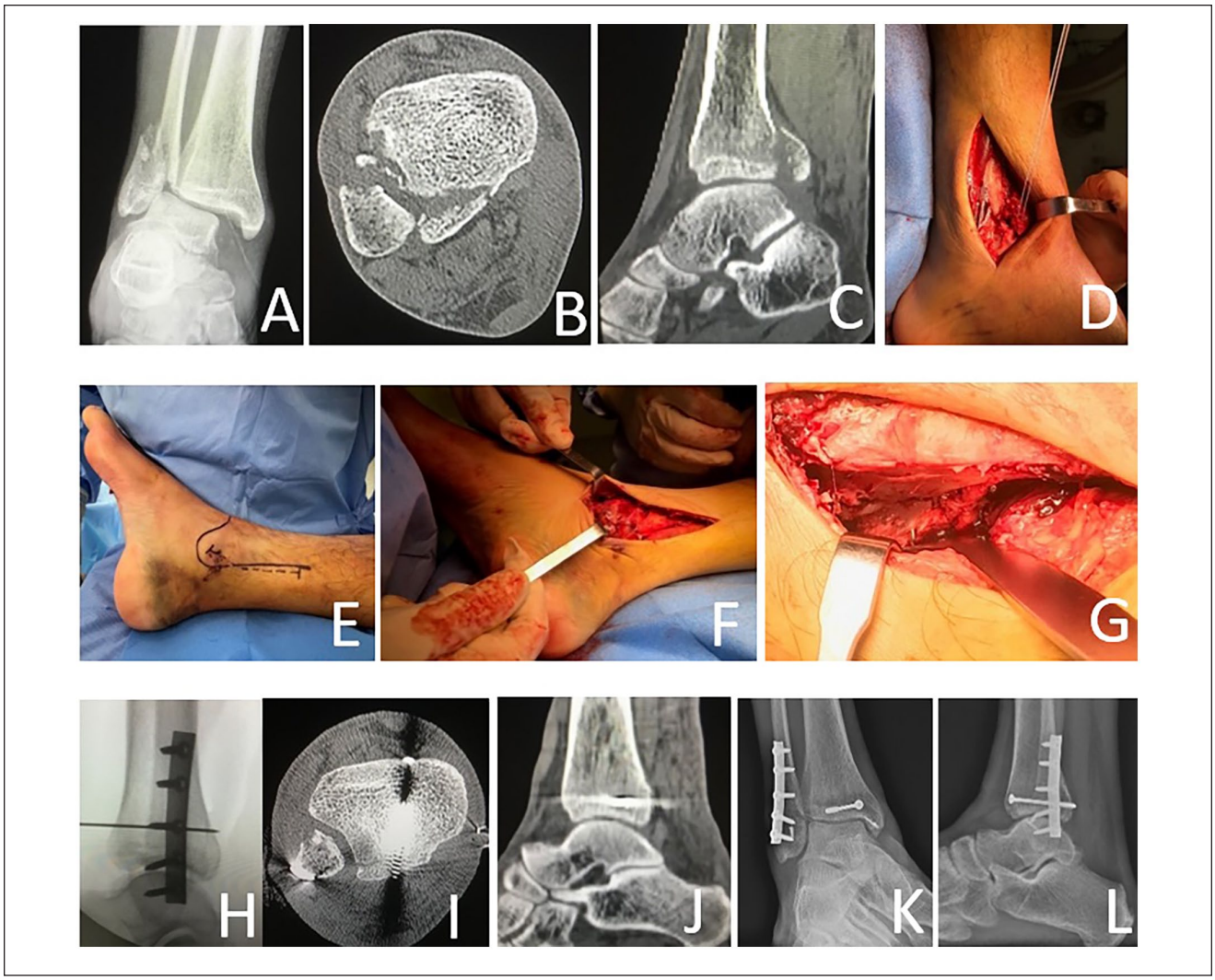

Figure 2. (A, B, C) Patient with a Bartonicek II posterior malleolar fracture. (D) Direct lateral approach to fix the fibula and repair the anterior-inferior talofibular ligament with an anchor. (E) Modified posteromedial approach. (F) Deltoid ligament repair. (G, H) Visualization of posterior malleolus fragment and transitory reduction of the posterior malleolus with an AP Kirschner (K)-wire. (I, J) Axial and sagittal postoperative computed tomographic scan showing anatomical reduction and stable fixation with an AP screw. (K, L) Standing postoperative radiographs showing stable reduction at follow-up time. AP, anteroposterior.

as excellent with step-off <1 mm, satisfactory with displacements between 1 and 2 mm, and poor with a step-off ≥ 2 mm evaluated in the sagittal plane in the maximum malreduction point of the articular surface as described by Tucek et al[27] and Ketz and Sanders[11] (Figure 3). Diastasis was assessed in the sagittal and axial plane to objectify displacements ≥ 2 mm secondary to the resection of a small intercalary fragment or small intercalary fragments interposed in the fracture (Figure 4). The axial CT scan evaluated the syndesmotic reduction, measuring the distance between the fibula and the anterior and posterior facets of the incisura along a line perpendicular to bone cortex. Distances between tibia and fibula of less than 2 mm were considered anatomic[7] (Figure 5).

Results

Evaluation of the fractured posterior malleolus morphology according to the Bartonicek et al[2] classification on the CT scan axial planes showed type II in 19 patients, type III in 36 patients, and type IV in 11 patients. Fracture characteristics and demographic variables are represented in Table 1. Step-off evaluation was assessed in the sagittal CT plane and showed excellent reduction in 56 patients, satisfactory reduction in 6 patients, and poor reduction in 4 patients. Of these 4 patients with poor reduction, 1 patient had an articular impaction in the articular surface of the posterior malleolar fracture of more than 2 mm unable to reduce, 1 patient with a significant articular defect secondary to an intercalary fragment removal, and

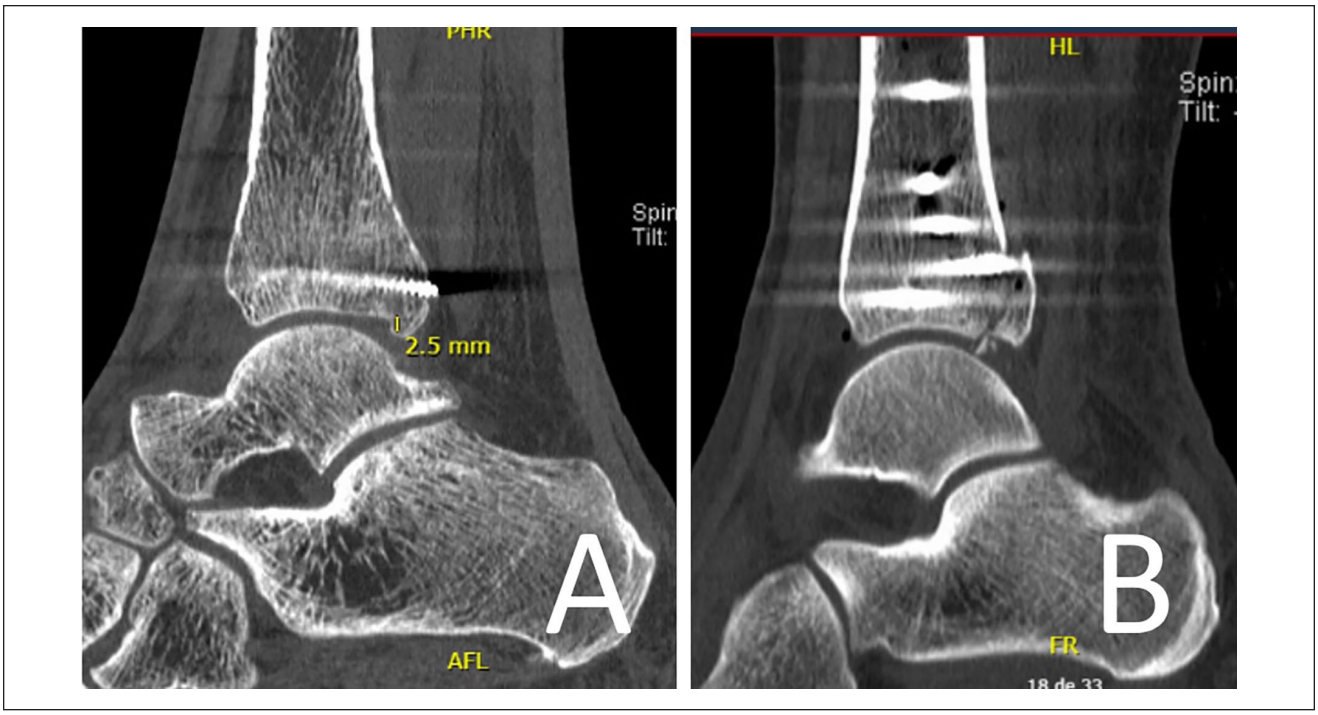

Figure 3. Sagittal computed tomographic scan showing how we measure step-off. (A) Malreduction secondary to articular impaction. (B) Step-off secondary to a posterolateral fragment malreduction.

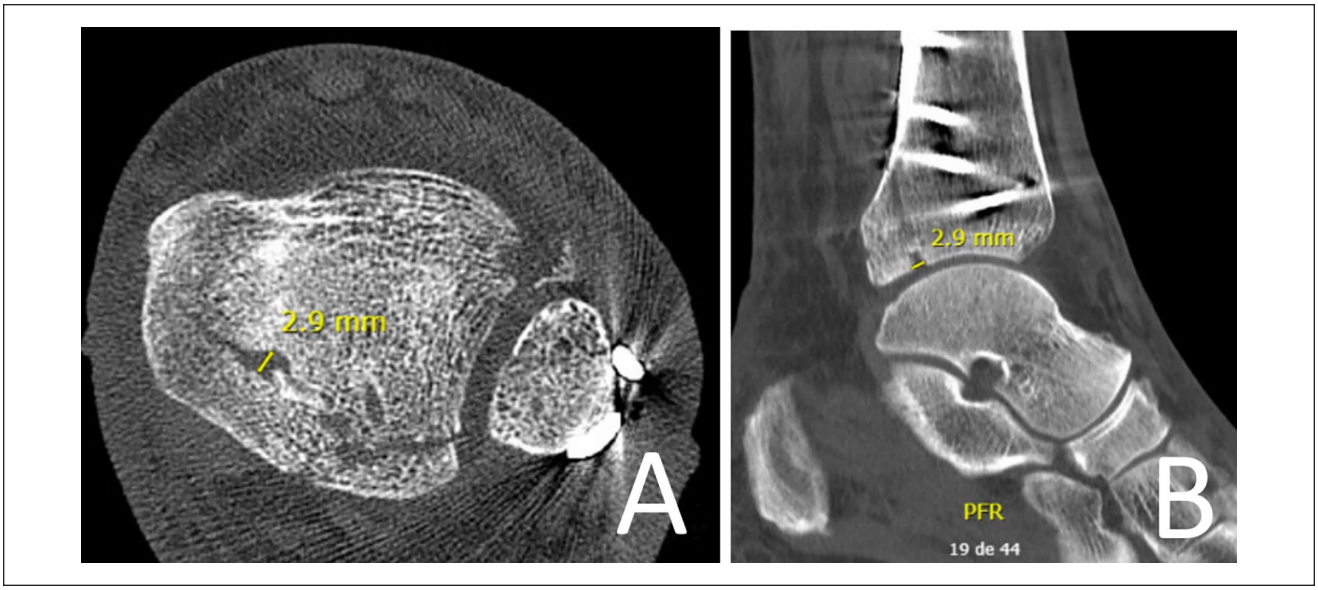

Figure 4. Coronal and sagittal computed tomographic scan showing how we measure articular gap. (A, B) Articular gap secondary to nonresection and nonreduction of intercalary articular fragment.

2 patients secondary to malreduction. In relation to patients with satisfactory reduction, 2 of them showed mild residual impaction either in the posteromedial or posterolateral fragment. These patients showed small intercalary pieces with mild impaction (1 mm) from the beginning, and we decided to leave those fragments (Figure 6). The rest of them were secondary to malreduction.

Five patients showed diastasis or gap ≥2 mm (axial and sagittal plane), 4 of them as a consequence of interposed fragment nonresected but without step-off (Figure 3). In

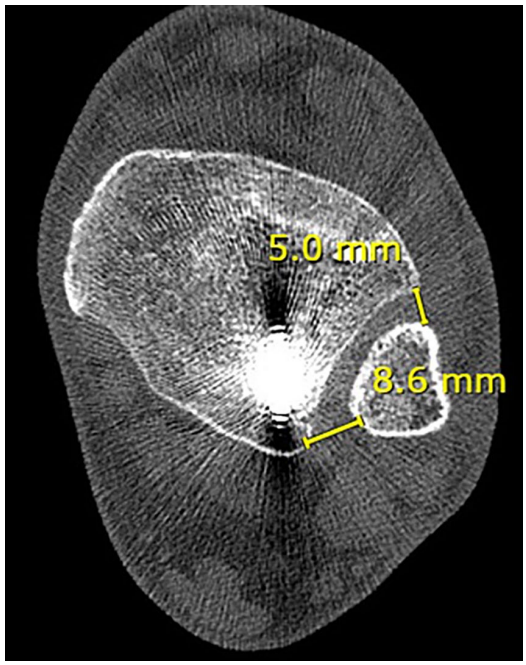

Figure 5. Axial computed tomographic scan showing how to evaluate syndesmotic reduction quality.[7]

Table 1. Demographic and Injury Characteristics.

Characteristics	Values[a]
Age, y, mean (range)	44 (22-80)
Sex, female	40 (60.6)
Side, left	35 (53)
Lauge-Hansen	
SAD	0 (0)
SER	53 (80.3)
PER	9 (13.6)
PAB	3 (4.5)
ISO	1 (1.5)
Weber	
A	0 (0)
B	53 (80.3)
C	12 (18.1)
ISO	1 (1.5)
Bartonicek and Rammelt	
I	0 (0)
II	20 (30.3)
III	36 (54.5)
IV	10 (15.5)
V	0 (0)

Abbreviations: ISO, isolated; PAB, pronation abduction; PER, pronation external rotation; SAD, supination adduction; SER, supination external rotation.
[a]Unless otherwise noted, values are n (%).

relation to the remaining patient, articular gap of 4 mm was secondary to intercalary fragment resection.

Concerning syndesmotic reduction, 61 patients showed a congruent reduction according to Gardner et al.[7] In relation to the 5 patients with incongruent reduction, 4 showed mild anterior translation of the fibula with no revision indication. The remaining patient was 73 years old with a nonfixable Tillaux-Chaput fragment, showing anterior translation (2 mm) and 10 degrees of external rotation of the fibula, taking into consideration bad bone quality, we decided not to reoperate this patient and consider him in the poor reduction group.

These results are summarized in Table 2.

Discussion

Although there are multiple posterior approaches described in the literature, there is no consensus on what approach is best for posterior malleolus management. Therefore, several studies have compared posterior approaches to assess the best exposure to the posterior malleolus.[18,25,30] Philpott et al[25] conducted a cadaveric study that evaluated the posterior malleolus exposure of 3 different approaches: posterolateral, posteromedial, and modified posteromedial. They found that the modified posteromedial approach gave the best area of exposure of the distal posterior tibia; nevertheless, it was unable to show the posterolateral fragment. Therefore, they conclude and suggest that in posterior malleolar fractures, Mason and Molloy type 2B and 3[14,19] (Bartonicek and Rammelt types III and IV),[2] a modified posteromedial approach should be used in association with a posterolateral approach to have a complete vision of the posterior tibial plafond. Mitsuzawa et al,[18] in a cadaveric model, compared 4 posterior approaches to the ankle in terms of posterior malleolus exposure: posteromedial, modified posteromedial, achilles tendon splitting, and posterolateral. They found that the modified posteromedial approach gave the best exposure with the ankle in a neutral or flexion position to visualize the medial and lateral portions of the posterior malleolus. In our experience, the modified posteromedial approach[4] has some advantages over others. We substantiate this argument in 2 points: First, given that it is not an approach that accesses the ankle directly from posterior, desperiostization of the distal plafond is minimal. Although we access the posterior region in the plane between the posterior tibial rim and the posterior tibial tendon, we do not open its sheath. Finally, using this approach we can assess how the metaphyseal posterior fragment reduces in relation to distal posterior tibia. This indirectly shows us how anatomical is our articular reduction. Almost always if we see a good congruence here, our reduction is adequate. Concerning the

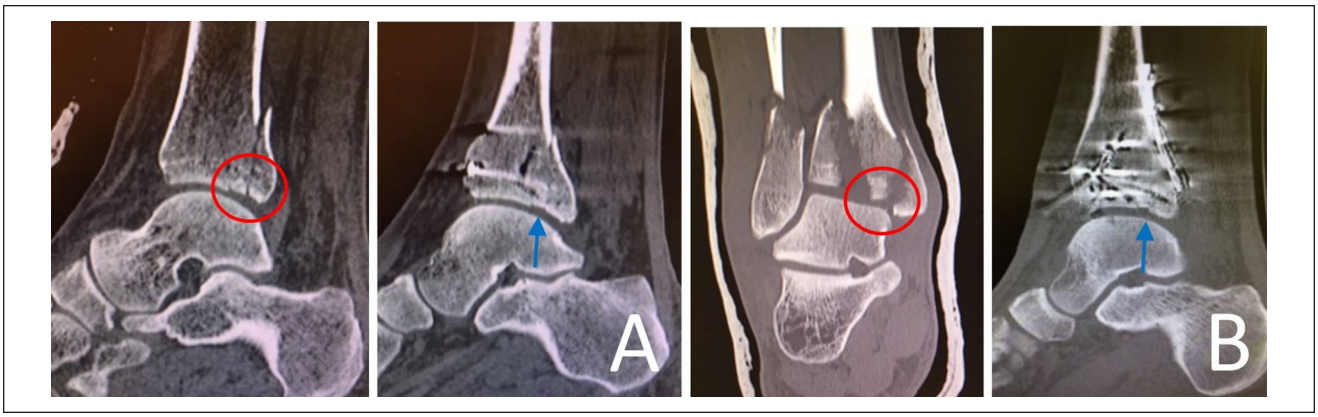

Figure 6. (A, B) Computed tomographic scan showing 2 patients with small intercalary fragments with mild impaction that we decided not to reduce to avoid resecting them.

Table 2. Reduction Results With CT Evaluation per Posterior Malleolar Fracture Classification (Bartonicek and Rammelt[2]).

	Step-Off			Gap Syndesmosis No Step-Off	
Classification	Excellent (<1 mm)	Satisfactory (1-2 mm)	Poor ≥2 mm		
I	–	–	–	–	–
II	14	4	2	2	0
III	32	2	2	1	5
IV	10	0	0	1	0
V	–	–	–	–	–

posterolateral fragment, even though we know that we did not achieve a perfect exposure of the component, our approach allows us to see the metaphyseal reference to achieve an anatomical reduction, which is consistent with our results.

Second, the patient is positioned supine; this helps to have a direct approach to the fibula without turning over the patient. In addition, this allows us to access the posterior malleolar fracture at the same time. Our surgical act starts with fibular reduction and fixation through a direct lateral approach that gives complete exposure to the fibula and allows anatomical reduction even in complex fractures. Anatomical reduction of the fibula is critical because it allows the Volkmann fragment to return to its position pulled by the PITFL and have an accurate metaphyseal reference of the position of this fragment. Furthermore, the direct lateral approach enables direct visualization and reduction of a Wagstaffe or Chaput fracture if present, and direct visualization of syndesmotic reduction. A posteromedial modified approach is made with the patient in a supine position, allowing a direct lateral approach to the fibula and obtaining an adequate reduction independently of the fracture pattern.[9]

As an articular fracture, reduction quality evaluated with CT scan is crucial and necessary, because evaluating reduction quality with radiography is inaccurate and can drive surgeons to misinterpret the results.[3,5,26] Different studies have evaluated reduction quality through CT scan. Tucek et al[27] reviewed reduction quality with CT in 19 patients with Bartonicek-Rammelt type IV[2] posterior malleolar fractures. They found an anatomical reduction in 14 patients and a satisfactory reduction in 5. Levack et al,[13] in a retrospective cohort analysis, evaluated 178 patients with SER IV and PER IV ankle fractures, of whom 122 had posterior malleolar fractures operated with a posterolateral approach. Almost all the patients (96.7%) had a postoperative CT scan. They found articular incongruity (gap and/or step-off ≥2 mm) in 25%, the most common reason being articular step-off and articular comminution or impaction. In our review, 56 patients showed excellent posterior malleolus reduction, 6 patients satisfactory reduction, and 4 patients a poor quality reduction.

Intra-articular impacted fragment (IAIF) or intercalary fragment defined as an independent fragment with an articular surface between the posterior malleolar fracture and the remaining stable plafond has progressively gained importance because of the high risk of osteoarthritis and malreduction.[29] In our review, 4 patients showed a postoperative gap because of a nonresected interposed fragment but without step-off. The maximum diameter of these IAIF was 4 mm, and even though they did not cause a step-off, it remains to be proven whether residual gap causes ankle

osteoarthritis. Xie et al[29] suggested that IAIF with a maximum diameter of 2 mm did not affect posterior malleolus fragment fixation, and that maximum diameters ≥5 mm should be reduced and fixed. All the IAIFs in our study had a size between 2 and 5 mm, so we think those fragments should be removed during surgery to prevent malreduction. Of these IAIFs, 3 were located in zone 8 and 1 in zone 1, both of which according to Mueller et al[20] are the most frequent zones where IAIFs are found.

Concerning the syndesmosis reduction, 61 patients showed adequate fibular reduction at the fibular notch and 5 malreductions. In the 4 cases with mild anterior fibular translation, direct intraoperative inspection showed a stable syndesmosis, so no revision surgery was indicated. Different studies have shown that previously published CT malreduction parameters reported incorrect estimated thresholds because they did not consider incisura asymmetry in the native patient anatomy.[6,12,21,22] Kubik et al[12] reviewed 213 bilateral CT scans of uninjured ankles and found an incisura asymmetry rate of 89% in unilateral CT assessment and that 35% of normal ankles would be considered malreduced by those previously published parameters threshold. In addition, considering how difficult is to correlate syndesmotic malreduction and its clinical significance, those 4 patients were not revised. Finally, only 1 patient had syndesmotic malreduction.

The strength of this study is that it is a relatively large retrospective cohort study with postoperative CT scan quality reduction assessment in patients with posterior malleolus fracture managed with a posterior ankle approach. To our knowledge, the cohort published by Tucek et al[27] is the largest one with assessment of quality reduction by using a postoperative CT scan, but only included type 4 posterior malleolar fractures according to the Bartonicek et al[2] classification.

There are several weaknesses in our study. First of all, it is a retrospective case series with no control group using another posterior approach to compare reduction quality. Second, only 6 surgeons with years of training in this approach participated in this study, which reduces the external validity of this work because it makes it less reproducible to have the same results in other surgeons who do not have experience in this approach. Third, even though we did not discuss complications related to using this approach, we only had problems related to superficial wound infection in 4 patients.

Conclusion

In conclusion, the modified posteromedial approach we describe herein is a good option to manage trimalleolar fractures, because we were able to achieve a near anatomical posterior malleolar fracture reduction with <2 mm step-off in 62 of our 66 patients.

Ethical Approval

Ethical approval for this study was obtained from Comité Ético Científico Clínica Santa María (approval number/ID: 212612-22).

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. Disclosure forms for all authors are available online.

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ORCID iDs

Felipe Pino, MD, https://orcid.org/0000-0002-3957-1834
Fernando Vargas, MD, https://orcid.org/0000-0002-4283-2900
Christian Bastias, MD, https://orcid.org/0000-0001-9018-7021

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