The Modified Posteromedial Approach for Posterior Malleolar Fractures: Report of Soft Tissue Complications After Ten Years of Experience

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OBJECTIVES: To evaluate soft tissue complications and the incidence of neurovascular bundle (NVB) injury following the modified posteromedial approach (moPMA) for posterior malleolar (PM) fractures, and to describe its indications in clinical practice.

METHODS:

Design: Retrospective, observational case-series study.

Setting: Single center with a dedicated foot and ankle trauma unit.

Patient Selection Criteria: Consecutive adult patients who underwent open reduction and internal fixation (ORIF) of PM fractures (AO/OTA 44 or 43) using the moPMA between 2014 and 2024. Exclusion criteria were open or pathological fractures, prior surgery at other institutions, or incomplete clinical records.

Outcome Measures: Primary outcomes were incidence of soft tissue complications and NVB injuries, graded according to the modified Clavien–Dindo classification for foot and ankle surgery. Secondary outcomes included fracture classification according to AO/OTA and Bartoníček–Rammelt, associated procedures and approaches, surgical staging, fixation type, follow-up, and use of intraoperative imaging.

RESULTS: The mean age was 47 years (range 18–83 years), there were 14 male and 40 female patients. The mean time from injury to surgery was 5.9 days. According to the Bartoníček–Rammelt classification, 51.9% were type C, 31.5% type B, and 14.8% type D. Most cases (77.8%) were AO/OTA 44B3. The moPMA was used in the first surgical stage in 77.8% of cases. A second approach was required in 90.7%, most commonly for fibular fixation through a lateral approach (70.4%). Associated procedures were performed in 92.6%, with fibular osteosynthesis being the most frequent (66.7%). Fixation was plate-based in 92.5%. The mean follow-up was 63.1 ± 31.4 months. Hardware removal of the posterior fixation was performed in 37.1%. Soft tissue complications occurred in 4 patients (7.4%), all classified as grade IA. No NVB injuries or tibialis posterior tendon contractures were reported.

CONCLUSIONS: The modified posteromedial approach for fixation of posterior malleolar fractures demonstrated low complication rates and no neurovascular injuries, supporting its use in a wide range of posterior malleolar fractures.

KEY WORDS: modified posteromedial approach, moPMA, posterior malleolar fractures, soft tissue complications

LEVEL OF EVIDENCE: Level IV. Retrospective. Descriptive. Observational case-series study.

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INTRODUCTION

Because Rammelt and Bartoníček[1,2] provided a refined classification of posterior malleolar (PM) fractures and Rammelt's[3,4] work has deepened their biomechanical understanding, multiple approaches have been proposed for the treatment of these fractures.[5–7]

The Modified Posteromedial Approach (moPMA), first introduced by Assal et al[8,9] a decade ago, has become the gold standard approach for certain posterior malleolar fractures in several institutions.[5,10]

Although experts' opinions on alternative new approaches continue to emerge, there has been growing concern over the potential complications associated with the moPMA, particularly related to soft tissue healing and the risk of iatrogenic injury of the tibialis posterior neurovascular bundle (NVB).[11,12]

The main purpose of this study was to address the soft tissue complications, the incidence of iatrogenic tibialis posterior NVB damage, and discuss the main applications of the original technique during 10 years of experience.

METHODS

Study Design and Patient Selection Criteria

A retrospective, descriptive, observational case-series study was conducted on consecutive adult patients (≥18 years) treated with open reduction and internal fixation (ORIF) for posterior malleolar fractures (AO/OTA 44 or

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The study was approved by the institutional review board and conducted in accordance with the Declaration of Helsinki. The authors declare no conflicts of interest.

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43) using the modified posteromedial approach (moPMA) between January 2014 and June 2024. All procedures were performed by the same surgical team. Exclusion criteria included open fractures, pathological fractures, previous surgery using the moPMA at other institutions, or incomplete medical records.

Outcome Measures

Primary outcomes were the incidence of soft tissue complications (defined as delayed wound healing, wound dehiscence, superficial or deep infection, tendon contracture, hematoma formation, skin necrosis) and iatrogenic injury to the tibialis posterior neurovascular bundle. Secondary outcomes included fracture classification according to the Bartoníček–Rammelt system[1,2] and AO/OTA classification,[13] fixation methods, associated surgical approaches and procedures, follow-up, complication severity based on the modified Clavien–Dindo classification for foot and ankle surgery,[14] and the incidence of hardware removal.

Surgical Technique

All procedures were performed by the same surgical team using the moPMA described by Assal et al with the patient in prone position.[8,9] The surgical technique is illustrated in Fig. 1.[15]

This approach was selected as the primary access route in cases with any surgical PM fracture—Bartoníček–Rammelt types B, C, and D—and in some pilon fractures with posterior column involvement, with comminution, shortening, or malalignment, where restoration of length, axis, and rotation was required to facilitate anterior reduction. Additional incisions were chosen based on fracture pattern and soft tissue condition. These included a lateral approach for fibular fractures, a medial approach for medial malleolus fractures or deltoid ligament injuries, and anterior approaches (anteromedial, anterolateral, or minimally invasive) for Chaput fractures or anterior plafond fractures. A representative clinical case illustrating this approach is shown in Fig. 2, including preoperative imaging, intraoperative positioning and exposure through the moPMA, intraoperative imaging, and final radiographic outcome.

All complementary approaches were performed in supine position, either during the same procedure (with patient repositioning) or in a staged manner. The selection and sequencing of approaches aimed to provide adequate exposure while preserving soft tissue integrity and avoiding narrow skin bridges.[15,16]

Surgical treatment was performed in 1, 2, or 3 stages depending on fracture complexity and soft tissue status, with each stage performed on different days under separate anesthesia. In cases with significant edema or compromised skin conditions, the first stage consisted of temporary spanning external fixation to allow for soft tissue recovery. In all other situations, initial fixation of the posterior malleolus was performed as the first stage using the moPMA.

Postoperative Protocol

Postoperatively, patients were immobilized in a cast in neutral position for 3 weeks without weight bearing. This was followed by an Aircast boot for an additional 3 weeks with toe-touch weight bearing. Thereafter, weight bearing as tolerated and unrestricted range of motion were permitted. Clinical and radiographic follow-up was performed at immediate postoperative, 3 weeks, 6 weeks, 3 months, and 1 year.

Data Collection

Data collected included patient demographics (gender, age, side of injury), fracture classification, timing of surgery, fixation method (eg, screws, L-plates, T-plates), use of additional surgical approaches and postoperative complications such as delayed wound healing (>3 weeks), wound dehiscence, infection (superficial or deep), tendon contracture, hematoma formation, and neurovascular injuries (manifested as paresthesia, dysesthesia, or anesthesia).

Statistical Analysis

Continuous variables were reported as mean and SD or as median and interquartile range, depending on data distribution. Categorical variables were presented as absolute numbers and percentages.

RESULTS

From January 2014 to June 2024, the moPMA was utilized to surgically treat 54 patients with posterior malleolar fractures. There were 14 male and 40 female patients, with a mean age of 47.3 years (range 18–83 years). The follow-up period ranged from 10 to 135 months, with a mean of 63.1 ± 31.4 months. Demographic and clinical characteristics are presented in Table 1.

The average time from injury to the performance of the moPMA was 5.9 days (SD 3.63). Surgical treatment was completed in up to 3 different stages when necessary. In 77.8% of cases, the moPMA was performed during the first surgical stage. Ten patients required initial stabilization with an external fixator before definitive fracture treatment.

According to the Bartoníček–Rammelt classification, 51.9% of the fractures were type C, 31.4% were type B, and the remaining 14.8% were type D. Based on the AO/OTA classification, 77.8% of the fractures were classified as 44B3.

Additional approaches were required in 90.7% of cases; the lateral approach was used in 70.4%. In 92.6% of cases, additional procedures were required, with fibula osteosynthesis being the most frequently performed procedure, accounting for 66.7% of all interventions. A syndesmotic screw was used in 9.3% of cases. Plates were the most used fixation method for the posterior malleolus, representing 92.5% of fixation methods. Hardware removal of the posterior fixation was performed in 37.1% of cases.

Detailed information on fracture patterns and treatment methods is provided in Table 2.

Regarding soft tissue complications, only 4 cases were observed, representing 7.4% of the total. Two patients experienced dehiscence in the distal region of the wound,

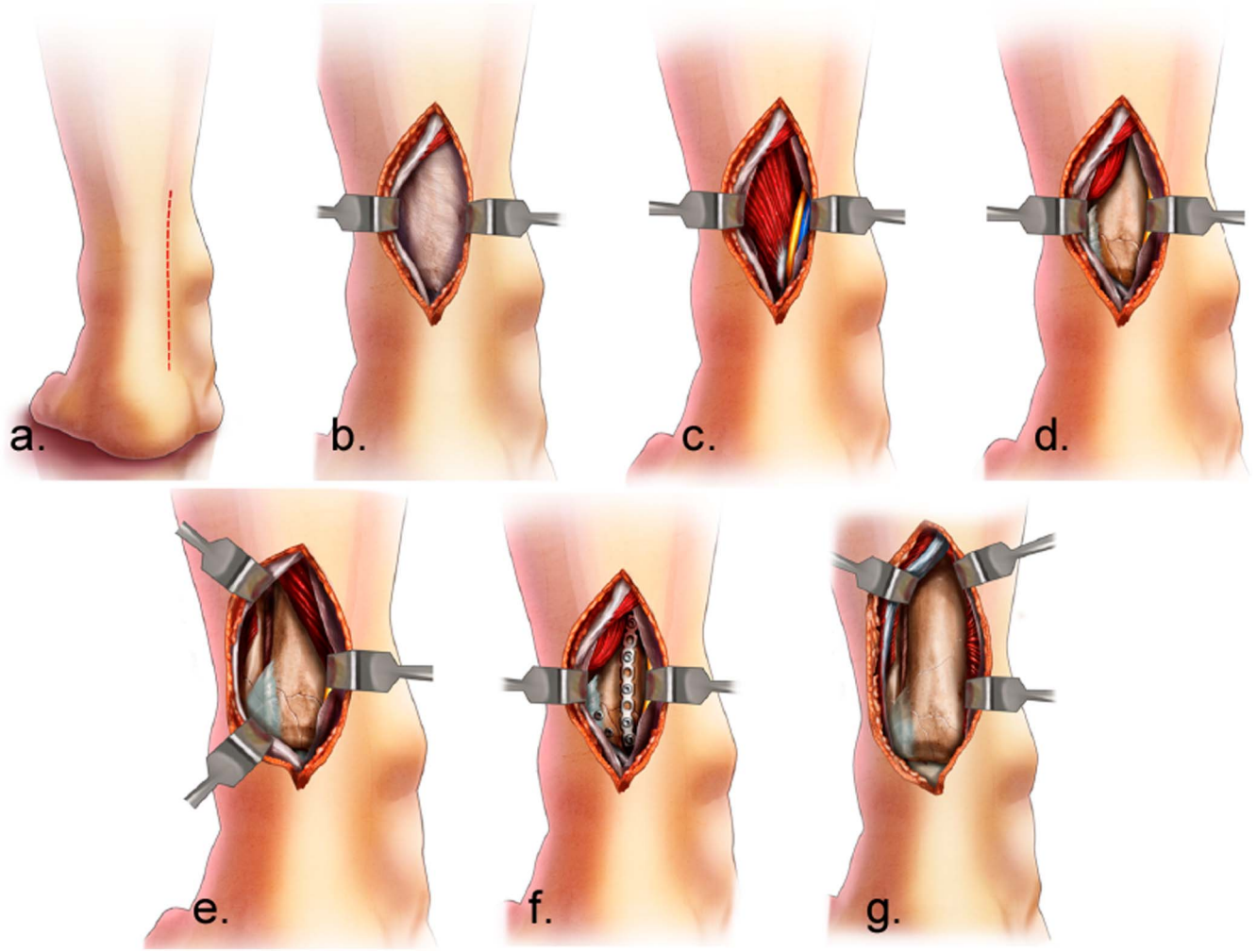

FIGURE 1. Surgical technique.[15] Adapted from: Assal M, Stern R, Ray A. *Atlas of Surgical Approaches to Pilon Fractures.* 2019. 2019, with permission from Mathieu Assal. A, Medial incision to the distal insertion of the Achilles tendon (AT), extending proximally for approximately 12 cm. B, Opening of the superficial fascia of the leg, exposing the AT and the distal portion of the soleus. Lateral retraction of the AT, preserving the paratenon. C, Longitudinal incision of the intermuscular septum to access the deep posterior compartment; visualization of the muscle belly of the flexor hallucis longus (FHL) and the posterior tibial nerve along the medial border of the FHL. D, The interval of this approach lies between the FHL and the posterior tibial nerve. The FHL is retracted laterally, leaving the posterior tibial nerve medially. E, This allows full access to the posterior malleolus, the posterior ankle capsule, the syndesmosis, and the posterior regions of both the medial and lateral malleoli. F, Due to the extensive exposure, various types of osteosynthesis materials can be placed. G, Continuing the dissection proximally within the same interval exposes the posterior metaphyseal-diaphyseal tibia and the more proximal portion of the posterior column, as needed.

which resolved with conservative treatment without requiring antibiotics nor additional surgical procedures. One patient developed hypertrophic scarring, managed successfully with physical therapy, and another reported dysesthesia in the scar area, which resolved by the sixth postoperative month without any treatment. No injuries to the posterior tibial NVB or tendon contracture were observed.

According to the modified Clavien–Dindo classification for foot and ankle surgery complications, all complications were classified as grade IA, the mildest category.

A detailed summary of complications is presented in Table 3.

DISCUSSION

This retrospective series of 54 patients treated over a 10-year period evaluated soft tissue complications and neurovascular safety associated with the modified posteromedial approach (moPMA) for posterior malleolar fixation. The observed soft tissue complication rate was 7.4% (4/54), with all events classified as Clavien–Dindo IA according to the foot and ankle modification.[14] No injuries to the posterior tibial neurovascular bundle or tibialis posterior tendon contractures were identified. Most fractures were Bartoníček–Rammelt type C (51.9%) and AO/OTA 44B3 (77.8%). Fixation was plate-based in 92.5% of cases.

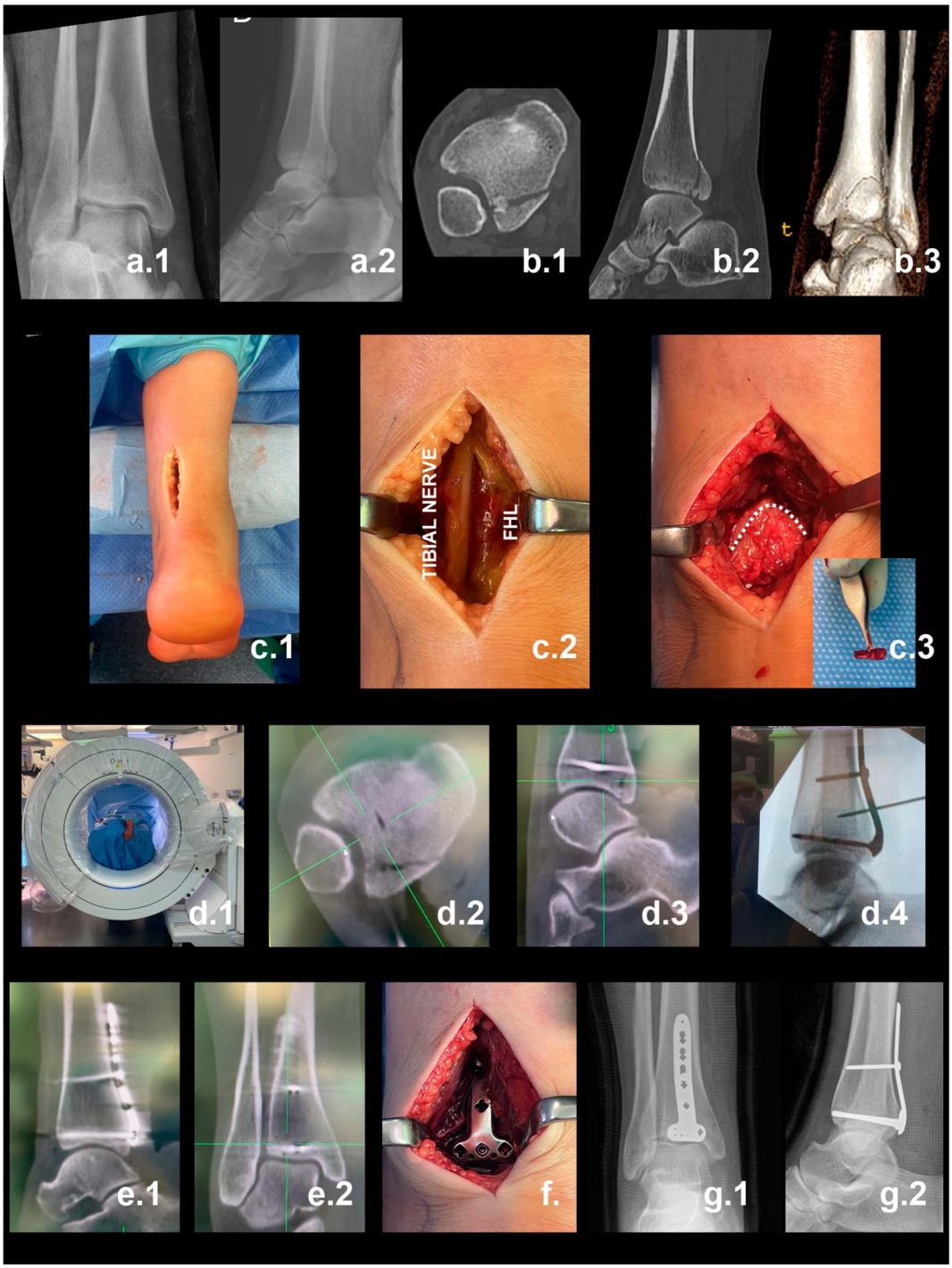

FIGURE 2. Clinical case. 50-year-old female patient with a history of right ankle trauma due to a fall from stairs. A.1–A.2, Anteroposterior and lateral radiographs of the ankle. B.1–B.3, Axial, sagittal, and 3D CT reconstructions showing a posterior malleolar fracture classified as type B according to the Bartoníček–Rammelt classification. ORIF was performed using the moPMA. C.1, Patient in prone position, with the foot at the edge of the table and the toes hanging free to avoid equinus; a bolster is placed under the distal tibia. 12-cm longitudinal para-Achilles medial incision. C.2, Surgical interval between the FHL laterally and the tibial nerve medially. C.3, Intraoperative view of the posterolateral malleolar fracture and intercalary fragment. D.1, Temporary fixation with K-wire after reduction of the intercalary fragment and the PM fragment, with intraoperative CT control using the O-Arm. D.2–D.3, Axial and sagittal intraoperative CT scans showing proper reduction. D.4, Fluoroscopic control for plate positioning. E.1–E.2, Intraoperative CT control of final osteosynthesis. F, Intraoperative clinical image showing placement of the inverted T-shaped plate. G.1–G.2, Postoperative anteroposterior and lateral radiographs.

TABLE 1. Demographic and Clinical Characteristics of the Patients Studied

Variables	
Age media (IQR)	47.3 (18–83)
Sex N (%)	
Men	14 (25.9)
Women	40 (74.1)
Side N (%)	
Right	26 (48.1)
Left	28 (51.9)
Time from the injury to moPMA (d) mean SD	5.9 (3.6)
Stages of the surgery N (%)	
1 stage	35 (64.8)
2 stages	14 (25.9)
3 stages	5 (9.3)
Surgical stage where the moPMA was performed N (%)	
1 degree stage	42 (77.8)
2 degrees stage	11 (20.4)
3 degrees stage	1 (1.9)
Use of external fixator N (%)	10 (18.5)
Follow-up (mo) mean SD	63.1 (31.4)

TABLE 2. Fracture Patterns and Treatment Methods

Bartoníček–Rammelt Classification N (%)	
B	17 (31.5)
C	28 (51.9)
D	8 (14.8)
AO/OTA classification N (%)	
43B1	1 (1.9)
43B2	1(1.9)
43C3	8 (14.8)
44B3	42 (77.8)
44C1	2 (3.7)
Associate procedures N (%)	**50 (92.6)**
Fibula osteosynthesis	36 (66.7)
Medial malleolus osteosynthesis	24 (44.4)
Deltoid reconstruction	9 (16.7)
Syndesmotic screw	5 (9.3)
Chaput osteosynthesis	6 (11.1)
Strayer	24 (44.4)
Associated approaches N (%)	**49 (90.7)**
Lateral	38 (70.4)
Medial	28 (51.9)
Anterolateral	8 (14.8)
Anteromedial	1 (1.9)
MIS medial	2 (3.7)
MIS lateral	2 (3.7)
Method of fixation N (%)	
Plate	50 (92.5)
L	14 (25.9)
T	23 (42.6)
⅓ tube	7 (13)
Screw	1 (1.9)
Combination: plate + screw	3 (5.6)
Hardware removal N (%)	20 (37.1)

In most cases (92.6%), the moPMA was performed alongside additional procedures, with fibula osteosynthesis being the most common (66.7%), followed by medial malleolus osteosynthesis (44.4%) and deltoid reconstruction (16.7%). The approach was also frequently combined with others (90.7%), particularly the lateral (70.4%) and medial (51.9%) approaches. Notably, these combinations did not result in increased soft tissue morbidity, underscoring the versatility and adaptability of the moPMA. Hardware removal was performed in 37% of cases through the index incision without soft tissue or neurovascular complications. These data summarize the clinical performance of the moPMA in this cohort.

Published complication rates for this approach range from 5% to 16.6%.[12,17,18] The 7.4% rate observed in this study falls within this range, and all complications were minor. Reported complications have included delayed wound healing, superficial infection, wound dehiscence, and transient paresthesias. Khandge et al[19] reported 2 superficial infections among 21 patients, whereas Zhong et al[20] recorded 1 superficial infection and 1 wound dehiscence among 20 patients. Bali et al.[21] noted transient medial forefoot paresthesia in 1 of 15 patients, which resolved within 3 months.

Complication rates reported for alternative posterior approaches are similarly low but vary with exposure and technique. For posterolateral exposures, a systematic review by Heyes et al.[22] identified superficial infection, skin necrosis, and nerve injury at 4.5% each. Porta et al.[12] reported an 8.2% complications rate, whereas Khandge et al.[19] and Zhong et al.[20] each recorded a single superficial infection that resolved completely without surgical intervention. For posteromedial exposures, similar patterns of superficial wound complications have been described without major neurovascular injuries.[21–23] The current complication profile is consistent with these reports, confirming the moPMA as a safe corridor in experienced hands.

Several perioperative principles were applied to mitigate wound morbidity: surgery was delayed until the wrinkle sign appeared, staged protocols were used soft tissue condition warranted. A potential advantage of the moPMA —reduced medial retraction force to access the posterior malleolus relative to posterolateral and conventional posteromedial routes—has been demonstrated anatomically and may contribute to soft tissue safety while providing the greatest percentage of posterior malleolar exposure among the studied corridors.[9,11,23] This wide exposure facilitated application across Bartoníček–Rammelt types B, C, and D and allowed extension to more complex injuries, including AO/OTA 43C3 pilon patterns, where restoration of length, axis, and rotation of the posterior column can aid subsequent reductions. Fixation flexibility was preserved, with the use of plates (L, T, and 1/3 tube), screws, or combined constructs tailored to fracture morphology.

In most cases (92.6%), the moPMA was performed alongside additional procedures, with fibula osteosynthesis being the most common (66.7%), followed by medial malleolus osteosynthesis (44.4%) and deltoid reconstruction (16.7%). The approach was also frequently combined with

TABLE 3. Complications

Complications, N (%)	4 (7.4)	Modified Clavien–Dindo Foot and Ankle Surgery Complication Classification
Dehiscence	2 (3.7)	IA
Hypertrophic scar	1 (1.9)	IA
Scar dysesthesia	1 (1.9)	IA

others (90.7%), particularly the lateral (70.4%) and medial (51.9%) approaches. Notably, these combinations did not result in increased soft tissue morbidity, underscoring the versatility and adaptability of the moPMA.

A recognized limitation of posterior ankle approaches is the inability to directly visualize the entire articular surface, complicating assessment of reduction. Consequently, the posterior tibial cortical line was relied upon intraoperatively as an indirect indicator of articular alignment, including rotation, displacement, and diastasis. The moPMA improved exposure of the posterior tibial plafond,[9] which may facilitate accurate reduction under direct vision of key landmarks. Although restoration of the posterior malleolus and the posterior inferior tibiofibular ligament complex has been reported to provide robust syndesmotic stability without routine need for trans-syndesmotic fixation,[24–26] syndesmotic screws were still required in 9.3% of patients based on intraoperative tomographic assessment[27] and the Cotton test.

The incision was reused for implant removal in 37% of cases. Indications included implant prominence, patient preference after union, or coordinated removal of other implants. Although hardware removal was not considered a complication for analysis, the reoperation rate is clinically relevant and should be discussed with patients. No wound or neurovascular complications occurred during implant removal through the same incision, supporting the safety of reusing the moPMA for this purpose.

This study has several limitations. Its retrospective design and single-center setting may limit generalizability, and the absence of a comparative group precludes direct conclusions regarding relative safety versus other approaches. Functional and radiographic outcomes were not systematically analyzed, and follow-up duration varied. Nevertheless, soft tissue morbidity associated with the moPMA was low and within published ranges, with no posterior tibial neurovascular injuries identified. The approach provided broad exposure, could be safely combined with other incisions or reused for implant removal, and proved reliable for posterior malleolar fixation across a wide spectrum of fracture patterns.

CONCLUSIONS

The modified posteromedial approach was associated with a low rate of soft tissue complications and no observed neurovascular injuries over a 10-year period. Its ability to provide broad exposure of the posterior malleolus supports its use in a wide range of fracture patterns, including Bartoníček–Rammelt types B, C, and D, and complex injuries such as AO/OTA 43C3 pilon fractures. The versatility of this approach allows for adaptation to various fixation methods based on fracture characteristics. These findings support the continued use of the modified posteromedial approach in the surgical management of posterior malleolar fractures.

ACKNOWLEDGMENTS

Figure 1 was adapted from a previously published figure: Assal M, Stern R, Ray A. Atlas of Surgical Approaches to Pilon Fractures. 2019. ©2019, with permission from Mathieu Assal.

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