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Systematic Review

Isolated posterior malleolus fractures: A systematic review

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ABSTRACT

Objective: To clarify the mechanism, evaluation, surgical indications, and outcomes of isolated posterior malleolus fractures without additional osseous injury.

Methods: A systematic review was conducted using PubMed, Cochrane, and EMBASE databases from their inception to March 31, 2023, focusing on isolated posterior malleolus fractures. Inclusion criteria included adult patients (≥ 18 years old), full-text articles, and studies on isolated posterior malleolus fractures.

Results: Of 1,193 screened articles, 25 met the inclusion criteria, comprising 117 patients. Among them, 28 (23.9%) underwent surgery, while 89 (76.1%) received non-operative treatment. Common surgical indications included fragment size, displacement, and syndesmotic instability. Two studies (n = 41) of non-operative management reported three cases of osteoarthritis at long-term follow-up.

Conclusion: Current literature on isolated posterior malleolus fractures is limited to case reports and small series. Diagnosis can be challenging, but accurate identification is crucial, as some patients benefit from surgical intervention. Non-operative management remains the standard approach, with excellent long-term functional outcomes; however, larger cohort studies with longer follow-up are needed to strengthen current knowledge.

Level of Evidence: Level IV; Therapeutic Studies- investigating the results of treatment; Systematic Review of Level III & IV Studies

Keywords: Posterior malleolus fracture; Ankle injuries; Fracture fixation, intramedullary; Fracture fixation, internal.

Introduction

The isolated posterior malleolus (IPM) fracture, in which there is no additional osseous injury, is typically a different entity than a PM fracture associated with an unstable bi- or tri-malleolar ankle fracture. In 1828, Henry Earle, an English surgeon, first described the avulsed posterior edge of the distal tibia in the setting of an ankle fracture-dislocation[1]. The first documented case report of an IPM ankle fracture was in 1908 by Meissner, involving a "3x1 cm fragment without major displacement." Hansen writes "the [isolated PM] injury is probably often hidden…as it only causes a few symptoms and usually has a very good prognosis with mobilizing treatment, [thus] it is rare that these cases are X-rayed." Only approximately six cases were reported between 1908 and 1919[2]. In 1943, the IPM fracture re-entered the literature, described as a "paratrooper fracture" by Captain William Tobin. In a series of 272 fractures among paratroopers, 12% of patients demonstrated an IPM fracture commonly "with no appreciable separation of the fragments." All were treated non-operatively with a mean of four weeks in a cast with a walking iron attached[3].

Large population-based studies have previously demonstrated that isolated medial or lateral malleolus fractures represent 58%-70% of all ankle fractures, but they did not

Study performed at the University of Michigan, Ann Arbor, MI, USA.

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report IPM fractures[4-6]. Although 7% to 44% of ankle fractures have a PM component[4-7], only 0.5%-7% of all ankle fractures contain an IPM fracture[8-10]. In a systematic review conducted by Veltman et al. of 661 PM fractures, the PM component was part of a trimalleolar fracture in 76%, a bimalleolar fracture in 18%, and isolated in 7% of injuries[10]. Because PM fractures are commonly associated with unstable ankle fractures—with a proximal fibular fracture, lateral malleolus fracture, and/or medial malleolus fracture—there is a paucity of data on their management in isolation, presenting a challenge for clinicians. Additionally, IPM fractures are commonly missed due to the challenges of diagnosis via physical examination and radiographic analysis[11-13].

The ankle joint is formed by the articulation of the talus with the tibial plafond, which is "wedged" between the medial and lateral malleolus to form a mortise[14-15]. The PM and posterior inferior tibiofibular ligament (PITFL) are mechanically important for the restraint of the talus, tibiotalar contact area, and rotational stability of the ankle. The PITFL is the strongest syndesmotic ligament, providing 42% of the stability[16-17]. The PITFL and PM work in conjunction to stabilize the talus, with the PITFL resisting lateral and axial translation and rotation, while the PM optimizes load transfer and prevents posterior translation[18-19]. The presence of a PM fracture in bi- and trimalleolar ankle fractures has been associated with poorer outcomes[20-23], but the current literature on IPM fractures remains limited. Most data on diagnosis, management, and outcomes are from case reports and small series. The aim of this systematic review is to clarify the mechanism, evaluation, surgical indications, and outcomes of isolated posterior malleolus fractures without additional osseous injury.

Methods

Study definitions

For this study, an "IPM fracture" is a fracture that involves only the PM (posterior distal tibia articular surface) without concomitant tibial or fibular fractures as shown on plain radiographs, computed tomography (CT), or magnetic resonance imaging (MRI). Isolated posterior malleolus fractures are often associated with ligamentous injuries and have been represented by different names in the literature, such as isolated Earle or Volkmann's fracture, paratrooper fracture, or isolated tibial lip or margin fractures.

Study strategy

A systematic review was conducted in accordance with the latest Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. PubMed, Cochrane, and EMBASE databases were searched for literature from database inception until March 31, 2023. The final search algorithm included: ('fracture' AND (('posterior malleolus' OR 'posterior malleolar' OR 'tibial lip' OR 'Maisonneuve' OR 'syndesmosis avulsion' OR 'syndesmotic avulsion') AND ('isolated' OR 'isolation' OR 'alone' OR 'intact fibula' OR 'no fibula'))) OR ('fracture' AND ('posterior tibial lip' OR 'volkmann' OR 'earle' OR 'paratrooper' OR 'hyperplantarflexion' OR 'PITFL avulsion')).

Inclusion and exclusion criteria

Article inclusion criteria consisted of adult patients (≥ 18 years old), articles evaluating surgical or non-surgical management of IPM fractures, any level of evidence, and available full-text articles. Exclusion criteria were pediatric patients (<18 years old), pathologies other than IPM fractures, books, systematic reviews, and commentaries.

Screening process

Article screening was performed by multiple authors using Rayyan, an open-source software for screening articles in systematic reviews[24]. Duplicate articles were removed manually. Articles were initially screened by title and abstract. Next, full-text articles were screened for inclusion using the previously described criteria. A comprehensive reference search was conducted across all included articles to identify any additional studies that met the inclusion and exclusion criteria.

Data extraction

Data extraction was performed by multiple authors. Collected variables included first author, year of publication, type of study, number of patients, mean patient age, mechanism of injury, category of management (operative vs. non-operative), delay in imaging, initial radiographic findings, fragment size, fragment displacement, associated injuries on further advanced imaging (such as ligament tears), type of non-operative treatment, type of operative treatment, final American Orthopedic Foot and Ankle Society (AOFAS) score, follow-up time, and surgical complications.

Statistical analysis

Frequency and descriptive statistics, including frequency-weighted means, were calculated to present the data. The Statistical Package for the Social Sciences (SPSS) version 29.0 (Armonk, NY: IBM Corp) was utilized for analysis. Due to heterogeneity in studies and small sample sizes, no formal meta-analysis was conducted.

Results

Search results

A total of 25 articles met the inclusion criteria from the initial 1,193 articles retrieved, comprising 117 patients with IPM fractures (Figure 1)[8,9,11-13,25-44]. The largest study included 25 patients[8]. Of the included articles, nine were cohort studies, 11 were case reports, and five were case series. Only six articles had more than five patients. The included studies were categorized into two tables according to whether patients were treated non-operatively (Table 1) or operatively (Table 2).

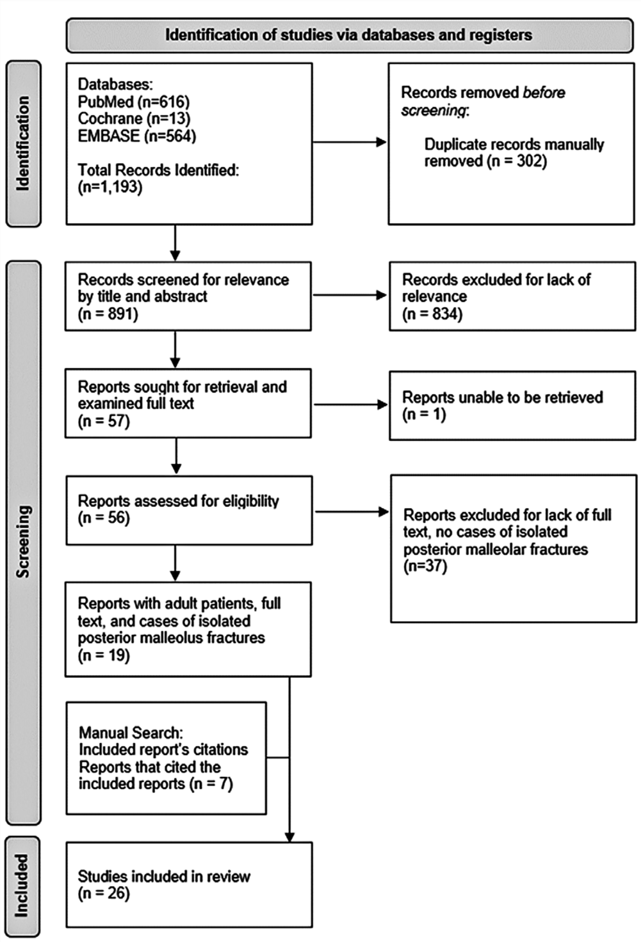

Figure 1. PRISMA flow diagram demonstrating the article selection process, including the initial search and the screening stages.

Patient demographics

The mean age of the included patients was 31.8 ± 5.0 years. Mean follow-up time from date of diagnosis was 70.9 ± 86.0 months (n = 97; 82.9%). Of the 76 patients (65.0%) with a reported mechanism of injury, the most common IPM fracture resulted from either a plantarflexed foot position followed by an axial compressive force (n = 51, 67%) or a non-specific rotational injury (n = 20, 26%). Twenty-eight patients (23.9%) underwent operative treatment, and 89 patients (76.1%) underwent non-operative treatment.

Radiographic findings

Among 93 IPM fractures with documented radiographs at the first medical evaluation, 24% did not demonstrate a fracture. Regarding fragment size in the non-operative group (n = 79), six patients had small avulsions of the posterior lip of the tibia, 61 patients had a mean of 17% involvement of the articular surface (range, 3%-47%), while four fractures involved less than 25%, and eight involved less than 33% of the articular surface. The operative group (n = 14) included three avulsions of the posterior lip of the tibia. Seven operative fractures with exact displacement measurements provided averaged 31% of the articular surface. An additional two had greater than 25% articular involvement, and two had less than 25%. One retrospective cohort of 19 patients reported a mean displacement of 4 mm (range, 1-15 mm),[9] whereas all other conservatively managed fractures were non-displaced or minimally displaced (n = 69 reported). Eleven of the operative cases (79%) were displaced.

Associated injuries

Associated injuries were confirmed via advanced imaging or intra-operative assessment. Suspected injuries were documented based on each author's discretion on a case-by-case basis. In the non-operative group, the most confirmed or suspected associated injury was an AITFL tear, found in 50/89 patients (56%). Additionally, six (7%) had lateral ligament injuries, and one (1%) had a partial deltoid injury. Only 16 (18%) had confirmed associated ligamentous injuries. In the operative cohort, 15/20 patients (75%) had confirmed AITFL injuries, three (15%) had confirmed deltoid injuries, one (5%) had a confirmed lateral ligament injury, and one (5%) had a flexor digitorum longus (FDL) and posterior tibial tendon (PTT) dislocation.

Treatment and outcomes

In the non-operative cohort (n = 89), 88 cases had documented treatment plans. Six fractures were diagnosed over six weeks post-injury and were treated with functional rehabilitation. Of the 82 remaining fractures, 64 (78%) were immobilized in a short leg cast or splint and kept non-weight bearing for a duration of one week [n = 13; Donken et al[9]], 2.5 weeks [n = 2; Nugent et al[25]], 2.8 weeks [mean, n = 22; Neumaier Probst et al[8]], three weeks [n = 2; Donken et al[9]], or six weeks [n = 25; Kurup et al[26], Miller et al[12], Sané et al[27], Lu et al[28], Zejjari et al[29], Kim at al[30], Boggs et al[31], Comat et al[11], Ozler et al[32], Silva et al[33]] post-injury followed by progressive weight-bearing.

In the operative cohort (n = 28), operative indications were listed for 20 cases. The most common indications included syndesmotic instability (14/20), fracture displacement (11/16), greater than 25% articular surface involvement (7/14), and nonunion (1/1).

Final AOFAS scores of patients treated non-operatively and operatively, respectively, were 90 (43-100, n = 13) and 94 (63-100, n = 8). One study included Patient-Reported Outcome Measurement Information System (PROMIS) scores of patients treated operatively at one year, with a mean of 53 for the physical function score and 44 for the pain interference score of 44 (max score 100, n = 8), but did not provide any additional details regarding the individual cases[42].

Discussion

The results of this systematic review highlight the lack of published data on the management of IPM fractures. Only one

Table 1. Information on the included articles for patients with isolated posterior malleolus fractures managed non-operatively

Author (Year)	Study type	Patients (n)	Age (y)	Mechanism	Identified on initial radiograph	Fragment size	Fragment displacement	Associated injuries	Conservative treatment	Final AOFAS score	Follow-up
Neumair Probst (1997)[8]	Retrospective	22	32*	Plantarflexion with axial compression	21/22	5: Shell Avulsion 11: 10% 5: 20% 1: 40%	Non-displaced	22: suspected AITFL (none confirmed)	NWB SLS x 2.8wks (mean); walking cast/boot x 3.9wks (mean); Off work x 7.6 wks (mean)	-	4.7 years (mean)
Kurup (2005)[26]	Case Report	1	46	Plantarflexion with axial compression	Yes	0.3	Non-displaced	None identified, none suspected	NWB SLS x 6wks; progressive WB; no limitations at 1yr	-	12 months
Miller (2012)[12]	Case Report	1	19	Possible plantarflexion with axial compression	Yes	< 25%	Non-displaced	None identified	NWB SLC x 6wk followed by WBAT CAM boot x 2wks; no limitations at 20 weeks	-	2 months
Colding Rassmussen (2022)[44]	Case Report	1	26	Rotational	Yes	-	Non-displaced	None identified	WBAT removable ankle orthosis x 4wks; WB XRs at 10d demonstrated no displacement, stable syndesmosis	-	-
Fox (1962)[34]	Case Report	1	-	Paratroopers, plantarflexion with axial compression	Yes	-	-	-	-	-	-
Sané (2022)[27]	Case Series	1	19	Motorcycle ejection	Yes	< 25%	Minimally displaced	None identified	NWB flat boot x 6wks	100	48 months (mean)
		1	29	Plantarflexion with axial compression	Yes	< 25%	1mm displacement	None identified	NWB SLS x 6wks	100	48 months (mean)
		1	32	Plantarflexion with axial compression	Yes	< 25%	Non-displaced	None identified	NWB SLS x 6wks	100	48 months (mean)
Lu (2016)[28]	Case Series	1	21	Snowboarding	No	-	Non-displaced	Stable syndesmosis and deltoid ligament	NWB SLS x 6wks	-	12 months
Silva (2017)[33]	Case Report	1	39	Running	No	-	Non-displaced	None identified	Compressive wrap x 2 wks (delayed diagnosis). NWB SLS x 4wks, followed by rehabilitation	97	4 months
Zejjari (2015)[29]	Case Report	1	36	Plantarflexion with axial compression	No	-	Non-displaced	None identified	NWB SLS x 6 wks		6 months
Kim (2014)[30]	Case Series	1	36	Rotational	No	15%	< 2mm displacement	None identified	NWB SLC x 6 wks	77	≥ 1 year
		1	36	-	Yes	17%	< 2mm displacement	None identified	NWB SLC x 6 wks	100	-
Nugent (1990)[25]	Case Series	1	32	Rotational	Yes	10%-15%	Non-displaced	None identified	NWB SLS x 2.5 wks; WBAT SLC x 4 wks	-	6 weeks
		1	25	Rotational	Yes	-	Non-displaced	None identified	NWB SLS x 2.5 wks; WBAT SLC x 4 wks	-	6 weeks
Boggs (1985)[31]	Case Series	1	27	Hyperdorsiflexion	Yes	Avulsion	Non-displaced	None identified	NWB SLC x 6 wks	-	6 weeks
		1	41	Axial compression	Yes	33%	Non-displaced	None identified	NWB SLC x 6 wks	-	6 weeks
Ozler (2014)[32]	Retrospective	7	32	6: plantarflexion and axial compression; 1: unknown	No	17% (range, 12%-20%)	Non-displaced	4: ATFL tear	Protected WB with compression x 3wks (delay in diagnosis); NWB ankle brace x 3 wks	86 (range, 43-96)	1 year

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Table 1. Information on the included articles for patients with isolated posterior malleolus fractures managed non-operatively

Author (Year)	Study type	Patients (n)	Age (y)	Mechanism	Identified on initial radiograph	Fragment size	Fragment displacement	Associated injuries	Conservative treatment	Final AOFAS score	Follow-up
Comat (2014)[11]	Retrospective	3	30.6*	Parachuting, plantarflexion, and axial compression	Yes	-	Non-displaced		3: NWB SLC x 6wks	-	28.8 months (range, 6-60 months)
		6	30.6*	Parachuting, plantarflexion, and axial compression	No	8 (CT&MRI group): < 33%	Non-displaced	2 (with CT arthrogram): Lateral ligament injuries	6: delayed diagnosis > 6wks post-trauma = continue functional treatment	-	-
		3	30.6*	Parachuting, plantarflexion, and axial compression	No XRs		Non-displaced		1: NWB SLC x 6wks; 2: delayed diagnosis < 6wks post-trauma = NWB SLC until 6wks	-	-
Donken (2011)[9]	Retrospective	19	31*	1: Traffic injury 9: Sports injury 6: Domestic injury 1: Work injury 2: Unknown	Yes	12% (range, 3%-47%)	4 mm (range, 1-15 mm)	-	4: SLC with progressive WB; 13: NWB SLC x 1wk, then progressive WB; 2 (largest & worst displacement): NWB SLC x3 wks, WB SLC x 3wks	-	20 years (range, 17-24 years)
Broström (1964)[37]	Retrospective	13	29.4*	Rotational	-	16% to 33%	Non-displaced	9: AITFL tear 1: AITFL tear and partial deltoid tear 3: no syndesmotic leakage	Walking cast x 3-4wks	-	-

Wks: Weeks; AITFL: Anterior inferior tibiofibular ligament; WB: weight-bearing; NWB: Non-weight-bearing; SLC: Short leg cast; SLS: Short leg splint; OAR: Ottawa Ankle Rules; AOFAS: American Orthopedic Foot and Ankle Score; CT: Computed tomography; MRI: Magnetic resonance imaging.
Key: *Mean among the entire study (including if there are operative and non-operative cases).

study followed patients for more than 20 years. Additionally, only six articles reported data on five or more patients.

The two most common mechanisms for IPM fractures were direct axial compressive force of the talus on the distal tibia in plantarflexion (67%) and non-specific rotational injuries (26%). The first described mechanisms of IPM fractures were proposed by Meissner and Hilgenreiner in 1908 and 1913, who hypothesized that the talus acted as a “chisel” to fracture the PM when a strong, axial force was applied with the foot in plantarflexion[2]. The plantarflexed position is considered less stable to posterior translation not only because the talus narrows posteriorly in the axial plane, thus it cannot engage the malleolus as it can in dorsiflexion, but also because the posterior talofibular ligament is relaxed[3]. For these reasons, Tobin[3] and later Fox[34] attributed the high incidence among paratroopers to their subconscious desire to “feel for the ground” by maximally plantarflexing, resulting in an unrestrained talus that shears the PM and causes a fracture. Although this mechanism continues to be cited[3,8,9,11,24,32,34-36], it does not account for IPM fractures resulting from rotational injuries. Lauge-Hansen described rotational mechanisms by which PM fractures can occur in supination-eversion (SER), pronation-eversion (PER), and pronation-abduction (PAB) ankle fractures[45]. Their classification suggested that a rotational mechanism can cause an IPM fracture via a PAB stage II fracture, with deltoid ligament and PM injuries, with or without an AITFL injury[35-36,46]. This can also occur in a SERIII injury, where there are lateral ligament (instead of a fibula fracture) and PM injuries, or in a PERIV injury where there are deltoid, AITFL, lateral ligament, and PM injuries.

These Lauge-Hansen variants would explain the high incidence of associated ligamentous injuries noted in our systematic review. Broström et al. performed arthrography in 18 patients with IPM fractures; 15 demonstrated contrast extravasation at the site of the AITFL, suggesting that the AITFL had ruptured[37]. There is controversy over whether IPM injuries can occur in isolation or are always associated with a concomitant ligamentous injury[32,35-36,46]. Ligamentous injury has also been reported during MRI evaluations of IPM fractures and hypothesized by the above mechanisms[40]. Although every case in this study, regardless of the mechanism, demonstrated an associated ligamentous injury when assessed operatively or via advanced imaging, not all required surgery to achieve a good outcome (i.e., concomitant AITFL injury did not indicate an unstable syndesmosis).

Isolated posterior malleolus fractures are difficult to diagnose in part because of the lack of sensitivity of tenderness to palpation of the PM due to the soft tissue between the skin

Table 2. Information on the included articles for patients with isolated posterior malleolus fractures that were managed operatively.

Author (Year)	Study type	Patients (n)	Age (y)	Mechanism	Identified on initial radiograph	Fragment size	Fragment displacement	Associated injuries	Operative intervention	Final AOFAS score	Follow-up
Neumair Probst (1997)[8]	Retrospective	3	32*	Plantarflexion with axial compression	3/3	1: 20% 1: 30% 1: 40%	Displaced	AITFL rupture & partial IOL tear identified intra-operatively	Syndesmotic fixation	-	4.7 years*
Serbest (2015)[13]	Case Report	1	37	Plantarflexion with axial compression	No	> 25% articular surface	Displaced, 25% separation	None identified	1 P-A compression screw	96	2 months
Smeeing (2017)[35]	Case Report	1	26	Backwards fall	Yes, IPM with possible MCSW	< 25% articular surface	Minimally displaced	CT: syndesmotic instability and deltoid ligament injury	Syndesmotic fixation, 2 screws	-	4.5 years
Tomar (2022)[36]	Case Report	1	28	Rotational	Yes, IPM with possible MCSW	< 25% articular surface	Minimally displaced	CT: syndesmotic instability and deltoid ligament injury	Syndesmotic fixation, 1 screws	-	1 year
Duarte (2022)[38]	Case Report	1	43	Fall down stairs	No	> 25% articular surface	Non-displaced	MR: Partial tear of ATFL and AITFL	Operative Treatment not discussed	-	6 months
Kim (2014)[30]	Case Series	1	49	Rotational	No	24%	Displaced	None identified	2 P-A compression screw; PL approach	100	≥ 1 year
		1	41	Rotational	Yes	26%	-	None identified	PM approach	63	
		1	45	-	Yes	35%	-	None identified	PL approach	100	
		1	43	Motorcycle accident	Yes	41%	Displaced	None identified	2 P-A compression screws; PL approach	100	
Rellensman (2021)[39]	Retrospective	1	31	-	-	Avulsion	Displaced	MR: AITFL tear	Syndesmotic fixation: 1 suture button	-	-
		1	44	-	-	Avulsion	Displaced	MR: AITFL tear	Syndesmotic fixation: 2 suture buttons	-	
		1	29	-	-	-	Non-displaced	MR: AITFL tear	Syndesmotic fixation: 1 suture button; 1 A-P PM screw	-	
		1	37	-	-	-	Non-displaced	MR: AITFL tear	Syndesmotic fixation: 2 suture buttons; 1 A-P PM screw	-	
		1	44	-	-	Avulsion	Displaced	MRI: AITFL tear, deltoid tear	Syndesmotic fixation: 1 suture button; Deltoid suture anchor	-	
Gardner (2007)[40]	Case Series	1	45	External rotation followed by hyperplantarflexion	Yes	-	Displaced, ankle dislocation	AITFL and IOL tears	Syndesmotic fixation; Posterior and posteromedial plates	-	3 months
Veigas (2022)[41]	Case Report	1	19	High-energy trauma	Yes	-	Displaced	Flexor retinaculum avulsion, PTT/FDL dislocation, AITFL tear identified intra-operatively	PL approach: 2 P-A screws; PM approach: PTT and FDL reduction, flexor retinaculum suture anchors; Syndesmotic fixation with 1 suture button	90	1 year
Gilley (2020)[42]	Prospective	8	-	-	-	-	-	-	Operative Treatment not discussed	-	≥ 1 year
Harris (2022)[43]	Retrospective	1	24.5*	Rugby	Yes	-	-	AITFL tear, IOL partial tear	Internal brace to AITFL and PA screw via PL approach	100	27 months*; ≥ 17 months
		1	24.5*	Rugby	Yes	-	-	AITFL tear, IOL partial tear	Internal brace to AITFL and PA screw via PL approach	100	27 months*; ≥ 17 months

CT: Computed tomography; MRI: Magnetic resonance imaging; IPM: Isolated posterior malleolus; MCSW: Medial clear space widening; AITFL: Anterior inferior tibiofibular ligament; ATFL: Anterior talofibular ligament; WB: Weight-bearing; NWB: Non-weight-bearing; SLC: Short leg cast; SLS: Short leg splint; OAR: Ottawa Ankle Rules; PA: Posterior-anterior; IOL: Interosseous ligament; PL: Posterolateral; PM: Posteromedial; FDL: Flexor digitorum longus; AOFAS: American Orthopedic Foot and Ankle Score.
Key: *Mean among the entire study (including if there are operative and non-operative cases).

and fracture, but also because 24% of them were missed on initial radiographs due to the obliquity of IPM fractures[11-13]. Fractures were ultimately diagnosed using external rotation-lateral radiographs or advanced imaging modalities, suggesting their utility in the initial medical evaluation when clinical suspicion is high[32,47-48]. After diagnosis, it is important to obtain full-length tibia-fibula radiographs as the rate of missed proximal fibula fractures (Maissoneuve fractures) ranges from 14.28%-44.4%[49-51].

Numerous studies have reported increased pain and poor functional outcomes for larger PM fracture size and articular step-off[10,20-23]. Although there is debate regarding operative indications for PM fractures, most authors agree on fragment size greater than 25%-33%, 2 mm of articular step-off, and syndesmotic instability as criteria for surgery due to instability and an increased likelihood of post-traumatic arthritis from the significant decrease in tibiotalar contact area[10,22,52-54]. The degree of comminution and impaction of the PM fracture, as well as syndesmotic instability, is difficult to fully assess radiographically, and CT scans[55] can aid surgical decision-making.

Although there are no established operative indications for IPM fractures, biomechanical studies, CT-based classification systems, and limited evidence support operative intervention in non-IPM fractures. These studies have been applied to IPM fractures based on their morphology and the presence of associated ligamentous injury, resulting in individualized treatment plans[8,13,31,35-36]. This review demonstrates that the presence of syndesmotic instability, PM fragment size greater than 25%, and fracture displacement over 2 mm were the primary indications for operative treatment of IPM. Classification systems have been developed to account for these factors by categorizing PM fracture morphology. The Bartoníček classification was created in 2015[56], has been validated with near-perfect inter- and intra-observer reliability[57], and can guide direct treatment[58]. Specifically, operative management is recommended for displaced, large posterolateral fragments (Type IV, greater than 33% of the fibular notch involved) and two-part posteromedial and posterolateral fragments (Type III), in which posterolateral (PL) and combined PL and posteromedial approaches are suggested[59].

Drijfhout et al. demonstrated that there was more evidence of radiographic osteoarthritis at long-term follow-up with medium (5%-25%) and large (> 25%) fracture fragments and with articular step-off greater than 1 mm, whether the PM was fixed or not[20]. Donken et al. followed 19 patients for 20 years, and only one patient had a radiographic osteoarthritis score of less than excellent or good[9]. This corresponds with Horisberger et al.'s cohort, suggesting up to a 20-year latency before the development of post-traumatic ankle arthritis after PM fractures[60].

Conclusion

Isolated posterior malleolus fractures involve the posterior distal tibia articular surface and occur from an axial load in hyperplantarflexion or non-specific rotational injuries. Many IPM fractures have been treated non-operatively with good outcomes. Posterior malleolus fractures typically occur in bimalleolar, trimalleolar, or Maissoneuve ankle fractures; therefore, an IPM fracture should raise suspicion for a more complex injury, particularly a proximal fibula fracture, deltoid injury, or AITFL injury. An IPM fracture, regardless of size, should raise concern for syndesmotic instability given the high rate of concomitant AITFL injury associated with a functionally destabilized PITFL from the fracture. In cases of large fragment size (> 25%-33% of the articular surface), fracture displacement (> 2 mm), or talar subluxation, open reduction and internal fixation has been advocated; however, further studies are needed to supplement our current understanding of IPM fractures given the lack of data in the literature.

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