Posterior tibialis tendon entrapment as a complication of posterior malleolar fractures in complex ankle fractures

a systematic review

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Aims
Posterior malleolar (PM) fractures are commonly associated with ankle fractures, pilon fractures, and to a lesser extent tibial shaft fractures. The tibialis posterior (TP) tendon entrapment is a rare complication associated with PM fractures. If undiagnosed, TP entrapment is associated with complications, ranging from reduced range of ankle movement to instability and pes planus deformities, which require further surgeries including radical treatments such as arthrodesis.

Methods
The inclusion criteria applied in PubMed, Scopus, and Medline database searches were: all adult studies published between 2012 and 2022; and studies written in English. Outcome of TP entrapment in patients with ankle injuries was assessed by two reviewers independently.

Results
Four retrospective studies and eight case reports were accepted in this systematic review. Collectively there were 489 Pilon fractures, 77 of which presented with TP entrapment (15.75%). There were 28 trimalleolar fractures, 12 of which presented with TP entrapment (42.86%). All the case report studies reported inability to reduce the fractures at initial presentation. The diagnosis of TP entrapment was made in the early period in two (25%) cases, and delayed diagnosis in six (75%) cases reported. Using modified Clavien-Dindo complication classification, 60 (67%) of the injuries reported grade IIIa complications and 29 (33%) grade IIIb complications.

Conclusion
TP tendon was the commonest tendon injury associated with pilon fracture and, to a lesser extent, trimalleolar ankle fracture. Early identification using a clinical suspicion and CT imaging could lead to early management of TP entrapment in these injuries, which could lead to better patient outcomes and reduced morbidity.

Take home message
- The posterior tibialis tendon entrapment is a rare, but very debilitating illness.
- Recognition among physicians and early identification, using a clinical suspicion and CT imaging, could lead to early management of tibialis tendon entrapment in these injuries, which could lead to better patient outcomes and reduced morbidity.

Introduction
The tendon of the tibialis posterior (TP) muscle is unique in the ankle as the only

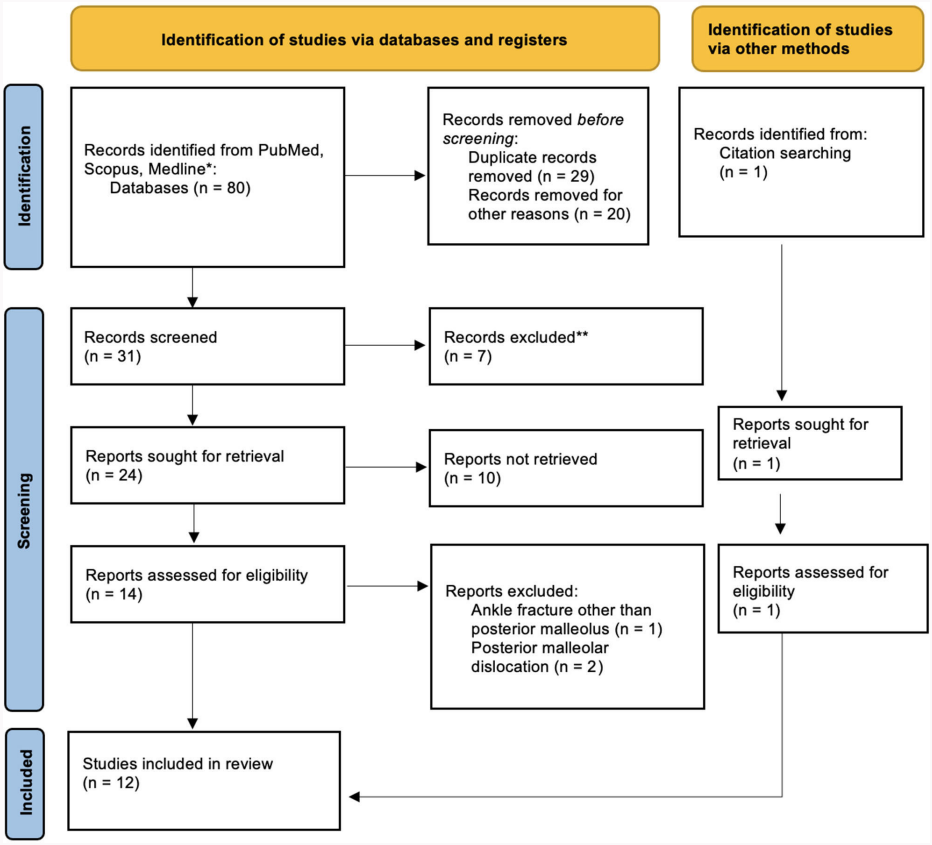

Fig. 1
PRISMA flow diagram and paper selection process.

tendon that articulates directly with the tibia, wrapping around the posterior aspect of the medial malleolus. The TP tendon lies within a cartilage-lined retromalleolar groove on the tibia, and is stabilized within it by the medial flexor retinaculum.[1] In the region where it is in contact with the tibia, the structure of the tissue changes from the typical structure of a traction tendon to a structure of fibrocartilage with a specific 3D collagen fibril texture.[2] Anatomically, the TP muscle is in the deep posterior compartment of the lower leg. It originates from the posterior aspect of the interosseous membrane, posteromedially from the superior two-thirds of fibula and superior proximal tibia.[3] The TP is a powerful plantar and supinator of the ankle, being one of the main active sources of support for the medial longitudinal arch of the foot.[1]

Posterior malleolar (PM) fractures of the ankle joint are commonly associated with ankle fractures, pilon fractures, and to a lesser extent tibial shaft fractures.[4] The retromalleolar groove of the tibia is commonly entered following PM fracture.[5] There is limited evidence, however, on the effect this has on the TP tendon. The entrapment of the TP tendon is reported to be a rare complication of both ankle and pilon fractures involving the PM.[6] TP entrapment in patients with ankle or pilon fractures is not typically visualized with conventional imaging.[6,7] Therefore, it is reported to involve delayed presentations with complications.[8] Patients suffering with TP entrapment can manifest months to years later with poorer surgical outcomes.[9,10] TP entrapment has been noted in ankle fracture surgery when encountered with inability to reduce the ankle mortise intraoperatively.[11] In severe cases, the posterior neurovascular bundle travelling alongside the TP tendon has also been reported to be trapped within PM fracture fragments.[4] Complications reported include a reduced range of motion, pes planus foot deformity, multiple revision surgeries, and ankle instability.[7,9,10]

Our aim in this systematic review was to evaluate the evidence regarding the identification, outcomes, complications, and further management of TP tendon entrapment in patients with ankle and pilon fractures.

Methods

The electronic databases Scopus, PubMed, and Medline were used to identify the relevant publications regarding the TP tendon in PL and trimalleolar fractures.

The search terms included: "posterior tibialis entrapment AND posterior malleolar fixation"; "posterior tibialis entrapment AND ankle fractures"; "posterior malleolar fractures AND pilon fracture AND posterior tibialis"; "tibialis posterior entrapment AND ankle fixation"; "posterior tibialis AND ankle fractures"; and "trimalleolar fracture AND posterior tibialis". One paper was identified using cross-referencing.

There was no limitation added in relation to language or year of publication in order to gather information regarding the existing literature. There were a limited number of papers found with predominantly case reports of TP entrapment, and one of these papers was identified using cross-referencing.

The PRISMA flow diagram was used to select the papers by initially removing the duplicates from different search

engines and screening the titles and abstracts, followed by reviewing paper eligibility (Figure 1).[12] The PRISMA checklist has been included as Supplementary Material.

To critically appraise the papers, the Critical Appraisal Skills Programme (CASP) checklist was used to systematically assess the credibility, relevance, and validity of results. The literature was screened by two authors (AS, JA) independently, with the majority of the available literature being case reports followed by retrospective studies.

Results

There were 12 papers identified relevant to the aims of this systemic review, and 993 patients were included in this systematic review. Of these, there were 489 Pilon fractures, 77 of which presented with TP entrapment (15.75%), as shown in Figure 2. There were 28 trimalleolar fractures, 12 of which presented with TP entrapment (42.86%). The age range in TP entrapment cases was 17 to 80 years, and 123 female patients were included (25.15%). A total of eight case reports were collected, with the mean age of patients being 32 years (19 to 65). There were four retrospective studies. All the case report studies reported inability to reduce the fracture at initial presentation. The diagnosis of TP entrapment was made in the early period in two (25%) cases and delayed diagnosis in six (75%) cases reported. There were eight case reports included in this review, with six (75%) reports including complications secondary to delayed diagnosis of TP entrapment, such as equinus foot deformity, clawed toes deformity, pain and difficulty to weightbear, severe arthritis, persistent subluxation, and tenosynovitis. Using modified Clavien-Dindo complication classification, 60 (67%) injuries reported grade IIIa complications and the rest grade IIIb complications.[13] There were two cases of early detection and intervention following TP entrapment diagnosis, which did not result in complications. The fractures were sustained due to high-energy trauma such as falls, road traffic accidents, and work-related injuries. The tibia was the most fractured bone, followed by the fibula.

In Tables I and II, there is a summary of the results of each publication including the titles of the papers, the years published, and the main characteristics of each study. The largest study in the review was completed by Eastman et al,[4] who investigated 420 pilon fractures and found that in 40 cases of entrapped posterior medial structures, 95% of these had TP entrapment. Several other studies also investigated the incidence of tendon entrapment in ankle fractures, and found that the TP tendon was the commonest tendon injury associated with pilon fracture and, to a lesser extent, trimalleolar ankle fractures (Figure 2). However, they did not investigate the outcomes, revision surgeries, or definitive management.[14,15]

Discussion

The entrapment of the TP tendon is a rare complication in complex ankle fractures. An early recognition using clinical examination skills, surgical approach, and/or radiological images is vitally important. Depending on the fracture pattern, there are several types of ankle injuries more commonly associated with TP tendon entrapment.

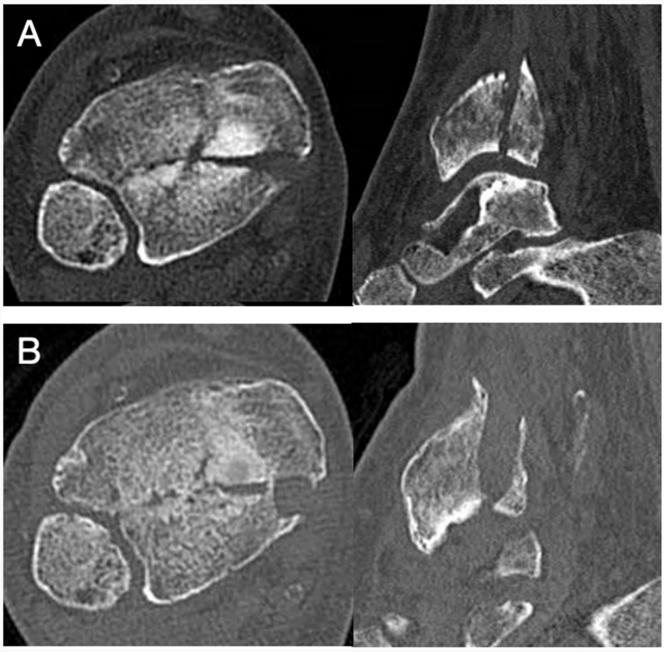

Fig. 2
CT scans showing a case of tibialis posterior tendon entrapment following fixation of a posterior malleolar fracture. a) Six weeks post-surgery. b) Encapsulated tendon forming its own tunnel in the healed fracture site.

Fracture types

The most associated injury with the TP tendon entrapment was in a pilon fracture.[4,14,15,19] Three retrospective single-centred cohort studies, using diagnostic CT in hindfoot and ankle fractures, revealed that pilon fracture was the commonest injury associated with tendon entrapment, with TP being the commonest tendon entrapped.[14,15,19] One retrospective study also found that trimalleolar fractures were the second most common ankle fractures associated with TP entrapment.[19] There were no reported TP entrapment cases involving PM fractures associated with tibial shaft fractures.

Identification

TP entrapments within the fracture segments in ankle fractures can often be identified early on preoperative surgical planning CT scans, but can also be clinically identified due to irreducibility of the fracture during the initial surgery. Alternatively, the entrapment of the TP can present late with eversion of the foot and ankle, pain on foot movement, and in severe cases pes planus foot deformity.[21–26]

Our review identified several case reports and retrospective studies, as shown in Tables I and II, which identified TP entrapment as a late complication following initial surgical management of the fractures and/or conservative management. There are several types of TP tendon entrapment within the fracture site reported in literature.[8,11,22] Entrapment has been reported in the PM fracture fragment, medial malleolus fracture fragment, interosseous space, and in the talocrural joint.[8,11,22,23]

Complications and further treatment

Traumatic osteoarthritis of the joint is a common complication of ankle fractures. In this systematic review, it was reported in two case studies.[21,26] In one case report by

Table I. The characteristics of retrospective studies and GRADE[16] analysis.

Study details	Participants	Main outcome measurements	Results (investigations)	Results (interventions)	GRADE
Eastman et al.[4] Retrospective cohort review Single-centre	n = 394 420 pilon fractures between January 2005 and November 2011	Evidence of documented NV deficit in patient attending with pilon injury. Posterior medial incision when attempting to fix pilon injury and release any posteromedial structures. CT documented findings of interposed soft-tissue within pilon fracture.	9.5% of cases had entrapped posterior medial structures (n = 40/394). 95% of those with entrapped structures had PTT entrapment (n = 38). Perioperative NV deficit was present in 12% of cases of entrapment (n = 5). 20% of cases were identified to have entrapped structures within the fracture on CT (n = 8)	None assessed	Low
Sousa et al.[15] Retrospective cohort study Single-centre	n = 108 70 calcaneus fractures and 38 pilon fractures between January 2014 and December 2017	Evidence of incidence of tendon injuries (entrapment and dislocation) in pilon and calcaneal injuries. Functional outcomes depending on the severity of injury. AOFAS[17] and SF-36[18] scores were used for clinical analysis and long-term impact of injuries.	Tendon injuries were identified in 36% of CT scan analyzed cases: PTT entrapment (n = 20) and PTT dislocation (n = 24). Pilon fractures were eight times more likely to have tendon injuries (p = 0.005). In pilon fractures, there were tendinous injuries in 42% of cases (16/38), with PTT being the commonest (n = 10). In calcaneus fractures, there were tendinous injuries in 33% (n = 23/72) of cases, with the majority of injuries occurring in peroneal tendons (n = 14).	None assessed	Low
Cardoso et al.[19] Retrospective cohort study Single-centre	n = 85 Pilon fractures (44.7%), bimalleolar fractures (14.1%), and trimalleolar fractures (23.5%) between January 2012 and December 2017	Evaluation of the impact of associated tendon injuries on the outcome of ankle and hindfoot fractures. CT scans were used to review fractures and tendon injuries. Clinical outcome impact was assessed via the VAS and the MOXFQ[20] tools.	Tendon injuries were observed in 23 patients (27.1%), with tendon entrapment being the most common lesion. Fractures resulted predominantly from falls. The PTT was injured in 18 patients (21.2%), and comprised the majority (58.1%) of all tendon injuries. Tendon injuries, commonly PTT entrapment, were the most commonly associated with pilon fractures. Pilon fractures were most commonly associated with tendon injury (52.2%; n = 12), followed by trimalleolar fractures (17.4%; n = 4).	Mean reported VAS for patients with a tendon injury was 4.3 (SD 2.6; 0 to 8), and a mean MOXFQ score of 35.1 (SD 22.4; 5 to 80). Mean reported VAS for patients with a tendon injury was 3.9 (SD 2.5; 0 to 10) (p = 0.281), and a mean MOXFQ score of 34.3 (SD 26.0; 0 to 95) (p = 0.689). The difference between the two groups was not statistically significant.	Low
Ballard et al.[14] Retrospective study Single-centre	n = 398 Ankle and hindfoot fractures over a 41-month period	Evaluation of tendon entrapment and dislocation in ankle and hindfoot fractures using CT scans.	Of the 64 patients, 30 (46.9%) had 40 tendon entrapments, 31 had 59 tendon dislocations, and three had both tendon entrapment and dislocation. The most frequently entrapped tendon was the PTT, in 27 patients (27/30, 90.0%). All patients with tendon entrapments were seen with either pilon fractures and/or a combination of posterior, medial, or lateral malleolar fractures.	None assessed	Low

AOFAS, American Orthopaedic Foot and Ankle Society; MOXFQ, Manchester-Oxford Foot Questionnaire; NV, neurovascular; PTT, posterior tibialis tendon; SD, standard deviation; SF-36, 36-Item Short-Form Health Survey questionnaire; VAS, visual analogue scale.

Hikichi et al,[21] a 19-year-old patient at one year post-initial open reduction and osteosynthesis for an irreducible ankle fracture-dislocation presented with equinus foot deformity and malunion of the medial malleolus. As demonstrated on CT scans, the TP entrapment hindered the fracture reduction and subsequent healing, resulting in the foot deformity. An earlier case study by Anderson and Hansen[25] involved a 30-year-old patient four months post-surgical reduction and

Table II. Case study characteristics and outcomes.

Study details	Presenting injury and symptoms	Investigations	Interventions	Clinical outcome
Hikichi et al.[21] Case report and systematic review	Irreducible ankle fracture-dislocation, persistent left ankle pain, and restricted left ankle dorsiflexion. Equinus foot deformity (left). Malunion of the medial malleolus (left).	At 1 year post-injury, CT scan demonstrated PTT entrapment. CT scan showed malunion of medial malleolus.	Several procedures were performed, including reduction of PTT entrapment and talus dislocation, tibiofibular ligament augmentation, and gastrocnemius recession.	Severe osteoarthritis. Achieved plantigrade stance. At 2-year follow-up, the patient showed improvement in Japanese Society for Surgery of the Foot ankle/hindfoot scale,[21] from 42 to 82 points.
Amouyel et al.[22] Case report	Bimalleolar fracture (displaced lateral malleolus fracture and non-displaced posterior malleolus fracture). At 10 years post-injury, presented with persistent medial ankle swelling and pain, stopping the patient from working.	CT scan showed that a medial retromalleolar bone tunnel containing the PTT was entrapped. Evaluation of MRI scan showed PTT tenosynovitis of the PTT and anterior talofibular ligament thickening.	Open resection of the posteromedial part of the tunnel to release the PTT and debridement.	At 6 weeks, the patient could walk with normal shoes. At last follow-up at 12 months, patient reported no pain and had returned to work (within 3 months), and had no limitation in exercise.
Sato et al.[23] Case report	Medial malleolar fracture and bimalleolar dislocation of left ankle. Mechanism: motorbike accident. Symptoms: difficulty in ankle inversion.	In medial malleolus fixation surgery, the PTT entrapment was identified and released. CT and MRI scans showed abnormal PTT following the initial release.	The PTT components were restored to their normal anatomical position. The plantaris muscle tendon was reconstructed.	The contractile ability of the TP tendon was restored at 3 months post-surgery. The patient was able to perform ankle inversion and full weightbearing.
Thoreau et al.[11] Case report	Severe ankle syndesmosis injury, fibula fracture, loss of tibiofibular overlap, and anterolateral displacement of the talus. Mechanism: traffic accident collision.	Radiographs showed irreducible fracture and ankle mortise distortion following open reduction and internal fixation.	PTT release was performed by exaggerating the initial fracture, followed by fracture fixation and deltoid ligament repair.	Not assessed.
Fantry et al.[8] Case report	Closed bimalleolar fracture dislocation (oblique lateral malleolar fracture and large posterior malleolar fracture). Mechanism: fall on ice while jogging.	CT scan showed PTT entrapment within the posterior malleolar fracture.	Open reduction, release of PTT entrapment, and internal fixation of the fracture.	The patient had full strength of the PTT without subluxation or dislocation at 6-week follow-up. He initiated physiotherapy to return to his day-to-day activities.
Khamaisy et al.[24] Case report	Medial malleolar fracture. Symptoms: pain on walking, limited left foot movement (eversion).	CT 2 years post-initial management showed PTT entrapment in medial malleolar fracture and tendon calcification.	PTT release and repair, which restored full eversion and inversion ankle movement.	Symptoms and range of motion improved over 6 months post-surgery, and this improvement was sustained at 3.5-year follow-up.
Anderson and Hansen.[25] Case report	2,000 lb stack of drywall material fell on the lateral aspect of left ankle. Neurovascular intact. Radiographs revealed an incompletely reduced pronation/eversion-type fracture dislocation, with a large displaced intra-articular fracture of the anterolateral tibial tubercle.	Radiographs of the ankle joint.	Initial management: open reduction internal fixation using two medial screws and a lateral plate incorporating a syndesmotic screw as initial management. Post-surgery radiographs showed displacement due to PTT entrapment. Definitive management was the PTT release and removal of scar tissue surrounding the tendon.	The outcomes following the definite management relieved the equinus contracture, restoring the ankle plantarflexion to 30°. The ankle arthrodesis resulted in solid union. The patient was able to walk pain-free in a regular tennis shoe with a rocker-bottom sole, and he returned to everyday activities.
Pankovich.[26] Case report	Mechanism of injury: two-car collision. Bimalleolar fracture (medial and lateral) and dislocation of the ankle with neurovascular and soft-tissue entrapment over the medial malleolar region. There was a lack of posterior tibialis and dorsalis pedis pulses and reduced sensation.	Radiograph showed bimalleolar fracture.	Syndesmosis fixation of the ankle joint and plate fixation of the medial and lateral malleolus.	Weightbearing after 8 weeks and fully neurovascular intact at 10 weeks. Full range of ankle motion was present. Ankle pain occurred due to degenerative arthritis of the ankle.

PTT, posterior tibialis tendon; TP, tibialis posterior.

Fig. 3
Case of tibialis posterior (TP) entrapment following fixation of a pilon fracture. a) and b) Initial CT scans show that the fracture enters the TP sheath. c) and d) Postoperative and intraoperative fixation of the pilon. e) and f) Axial CT scans showing not only the encapsulated tendon forming its own tunnel in the healed fracture site, but also a screw encroaching on the TP from the anterior plate fixation.

fixation following fracture-dislocation of his right ankle, who presented with difficulty in walking, severe calf atrophy, and equinus contracture. An MRI image showed TP entrapment and severe ankle joint arthrosis. Revision surgery included an ankle arthrodesis performed at one year post-initial surgery.[25] In 1976, Pankovich[26] reported on a 27-year-old female with an ankle fracture dislocation following a high-impact road traffic collision, who presented with posterior neurovascular supply disruption and TP entrapment. After initial surgical reduction and fixation management, the patient gained full range of motion; however, long-term degenerative changes were present.[26]

The late diagnosis of TP entrapment reported in this systematic review resulted in patients undergoing several revision surgeries to release the TP tendon and repair numerous other injured structures in proximity to the ankle joint, such as repair of the deltoid ligament, gastrocnemius recession, ankle arthrodesis, plantaris muscle reconstruction, tibiofibular ligament augmentation, and others.[11,21,23,25,26] Early identification and management of TP entrapment in these injuries would have, on the balance of probabilities, resulted in good outcomes.

Outcomes

Using patient-reported outcome measures, a retrospective single-centre study evaluated tendon injury outcomes of 38 patients with pilon fractures, 20 patients with trimalleolar fractures, and 12 patients with bimalleolar fractures, and observed that TP tendon entrapment was the commonest of the lesions in pilon fractures.[19] The outcome measures analyzed the relationship between the foot and ankle tendon injury patterns associated with specific types of ankle fractures, and assessed their relationship to clinical outcomes. However, the clinical outcomes in terms of day-to-day functionality as assessed by questionnaires were not statistically significant between the patients with tendon injury and those without tendon injury at the last follow-up questionnaire.[19] There are different reasons that could explain the statistically insignificant differences between the groups. First, it is important to consider that the high energy of the sustained trauma can also have a great impact on functional outcomes of these lesions. Second, all of the 18 TP tendon injuries were treated surgically upon identification in the emergency setting as shown in Figure 3, and therefore the functional outcomes are expected to be improved after early tendon repair.[19] Third, the outcome measurements in patients with TP entrapment were not evaluated separately to other TP injuries.[19] Last, the MOXFQ is a subjective assessment of the outcome measure for foot and ankle surgery.[20] This is a single-centred study evaluation, and further studies in the field with longer follow-up periods are required to add to the evidence regarding TP entrapment outcomes in complex ankle fracture management.

Surgical management of TP entrapment associated with fractures

In general, there are three common surgical approaches described in the literature for fixing PM fractures: the posterolateral (between fibular- and tendo-Achilles); posteromedial (interval between flexor hallucis longus and tendo-Achilles); and the medial posteromedial, either between TP and flexor digitorum longus or TP and tibia.[27–29] One case report, which described the delayed presentation of TP entrapment in a 19-year-old patient, mentioned that the reduction of the TP was performed via a medial approach, after failing to reduce it with a posterolateral approach.[21] Fantry et al[8] described the posteromedial approach chosen to release the TP tendon entrapment in a 67-year-old patient, in early presentation, within 30 days following her fall. Another case report, by Thoreau et al,[11] described persistent joint subluxation following attempts to reduce this using medial approach incisions. Lastly, with the aid of CT, the TP tendon entrapment was identified running in the tibiofibular space lateral side of tibia.[11] A further anterolateral incision was performed in order to release the TP tendon from the scar tissues in the anterior aspect.[11] Delayed release of the

entrapped TP tendon was associated with complications such as scar tissue formation, which hindered the release of the TP tendon in subsequent surgeries and necessitated the need for a full-length TP tendon exposure and longer incision. Provided that early identification of the TP entrapment is evident on CT imaging, approach to the TP tendon is best used through the medial posteromedial approach, which can give access to the largest portion of the posterior tibia compared with the other approaches.[28,29]

In conclusion, the TP tendon entrapment within the fracture segments in pilon and complex ankle injuries can lead to complications resulting in further surgical management and morbidity. Early identification using CT scans of the entrapped tendon and appropriate surgical approach management of the PM fracture fragment in pilon and trimalleolar fractures, shown in Figure 3, may alleviate morbidity and prevent complications.

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Supplementary material

PRISMA checklist.

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