Percutaneous fixation of posterior malleolar fractures in patients with unstable ankle fractures treated with a fibular intramedullary nail

Percutaneous fixation of posterior malleolar fractures in patients with unstable ankle fractures treated with a fibular intramedullary nail: a description of a technique and review of outcomes

Dr Sarah J. Wordie BSc (Hons), MBChB (Hons) [1]

Mr Thomas H. Carter BSc (Hons), MBChB, MRCS (Ed) [1]

Mrs Deborah MacDonald BA (Hons), MCQI CQP [1]

Mr Andrew D. Duckworth MSc, PhD, FRCSEd(Tr&Orth) [1,2]

Mr Timothy O. White MD, FRCSEd(Tr&Orth) FFTEd [1]

[1] Edinburgh Orthopaedics – Trauma; Royal Infirmary of Edinburgh, Edinburgh, EH16 4SA, U.K

[2] Usher Institute, University of Edinburgh

Address all correspondence to:

Mr Thomas H. Carter BSc (Hons), MBChB, MRCS (Ed)

Senior Registrar & Orthopaedic Trauma Research Fellow

Edinburgh Orthopaedics - Trauma, Royal Infirmary of Edinburgh, Edinburgh, EH16 4SA, U.K

Email: carter.tom@doctors.org.uk

Telephone number: (+44) 131 2423459

Fax number: (+44) 131 2423480

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Conflicts Statement

One of the senior authors (TOW) has been involved in the design of the 2nd generation of the fibular nail manufactured by the company Acumed (Hillsboro, Oregon, USA). TOW has not received any payments or financial rewards for this. Acumed sponsored The Edinburgh International Trauma Symposium organised by the Scottish Orthopaedic Research Trust Into Trauma (SORT-IT, charity registration number SC142054), between 2009 and 2014, and have provided research grants to SORT-IT.

Abstract

Objectives: (1) To describe the percutaneous technique used to reduce and fix a posterior malleolar fracture with anteroposterior (AP) screws in patients managed with a fibular intramedullary nail, (2) describe the selection of patients to whom this technique can be applied, and (3) report the clinical and patient reported outcome of this intervention.

Design: Retrospective review.

Setting: Academic orthopaedic trauma center.

Patients: Thirty-two consecutive patients with a mean age of 65 years (range, 39-90) over a thirteen-year period identified from a prospective database.

Intervention: Unstable ankle fractures managed surgically with a fibular nail and percutaneous fixation of the posterior malleolar component.

Main Outcome Measurements: The primary short-term outcome was complications related to posterior malleolar fracture fixation. The primary mid-term outcome was the Olerud-Molander Ankle Score (OMAS). Secondary outcomes included the Manchester-Oxford Foot Questionnaire (MOXFQ), EuroQol-5D (EQ-5D), health, pain and satisfaction.

Results: Thirty of the 32 (94%) posterior malleolar fractures united uneventfully. Post-operative loss of talar reduction occurred in two patients (6.3%), which in one patient (3.1%) eventually required a hindfoot nail arthrodesis. There were no soft tissue complications related to the AP screws or the fibular nail fixation. At a mean follow-up of 3.7 years (range, 1-8) the median OMAS, MOXFQ, EQ-5D, health, pain and satisfaction scores were 80.0, 23.4, 0.85, 80.0, 85.0 and 87.5 respectively.

Conclusion: Percutaneous ankle fracture fixation with a fibular nail and posterior malleolar screws results in reliable fracture stabilisation, good patient outcomes and high treatment satisfaction.

Level of Evidence: III – Retrospective cohort study.

Introduction

Posterior malleolar fractures occur in up to 40% of all ankle fractures and in this patient group, functional and radiographic outcomes are poorer than in those without a posterior component to their injury.[1-3] There has been recent enthusiasm for buttress plate fixation of posterior malleolar fractures through a posterolateral and/or posteromedial approach as this permits an anatomical reduction of the posterior cortex (although not the articular surface) under direct vision.[4-8] However, this fixation approach is not without complications, including sural nerve injury, wound infection, malreduction and hardware removal.[1,9-12] A recent cohort study including 160 patients with surgically treated posterior malleolar fractures, predominantly with antiglide plating, reported complication rates of up to 30% with 21% requiring re-intervention.[12] At least one case exists of catastrophic ischaemia resulting in amputation in a fit young patient following such surgery.[9] Furthermore, optimal access is achieved by operating in the prone position, presenting its own risks,[13,14] and consequently may not be suitable for elderly and high-risk patients.

The use of the fibular intramedullary nail is supported by biomechanical and clinical studies.[15-20] With the adoption of this device in our center we have witnessed a decrease in soft tissue complications when compared to conventional plating, particularly in higher-risk patients; a finding that has been corroborated by others.[21-22] It seemed intuitive to address other components of the unstable ankle fracture percutaneously in the hope that similar advantages might be gained. This led to the implementation and development of a purely percutaneous technique, aiming anatomically to reduce and fix large posterior malleolar fractures through a maximum of three small stab incisions, with screws inserted from anterior to posterior across the reduced fracture. The patient remains supine throughout, which limits proning risks, minimises theatre and tourniquet time, whilst affording an excellent fluoroscopic view of both the fracture and plafond.

The aims of this study were to: (1) outline the percutaneous technique used to reduce and fix a posterior malleolar fracture with AP screws in patients managed with a fibular intramedullary nail, (2) describe the selection of patients to whom this technique can be applied, and (3) report the clinical and patient reported outcome of this intervention.

Patients and Methods

A trauma database between 2008 and 2020 that was previously examined to report on fibular nail outcomes between 2008 and 2016,[19] was retrospectively reviewed. This identified 32 consecutive adult patients who underwent fibular nail fixation and received percutaneous fixation of a large unstable posterior malleolar component of their injury, according to a well-defined surgical technique. Patient demographics, injury characteristics, radiographic parameters and surgical complications were recorded from review of patient records. Mid-term outcomes were collected via postal questionnaire or telephone interview for non-responders. This study was part of a large evaluation of operatively managed ankle fractures that was reviewed by the local Research Ethics Service and deemed exempt from ethical approval.

Radiographic analysis

Analysis of digitalised radiographs was performed using the Picture Archiving and Communication System (PACs, Rochester, NY, USA: Carestream Health, Inc). Pre-operative radiographs were classified according to the AO / updated 2018 Orthopaedic Trauma Association (OTA) classification and Lauge-Hansen systems.[23,24] The lateral radiograph of the ankle post-reduction was used to calculate the percentage of posterior malleolar fracture involvement relative to the plafond. Fluoroscopy images were examined to confirm adequacy of talar reduction, posterior malleolar fracture reduction and implant position. Post-operative radiographs were assessed for failure of fracture fixation, talar mal-reduction and non-union.

Selection of patients

Over the 13-year period, 560 patients underwent ankle fracture fixation with a fibular nail. Of these, 236 (42.1%) had a fracture of the posterior malleolus. Our policy is to consider addressing these surgically only if, in the assessment of the treating surgeon, they result in radiographic posterior displacement of the talus (Table 1 and Figure 1), and thus most small fractures were ignored (n=196; 83.1% of all posterior malleolar fractures, 35.0% of total cohort). No specific percentage figure for the proportion of the plafond affected is used for surgical planning, but we found that in all of the cases undergoing fixation, greater than 33% of the plafond was affected as judged by the lateral plain radiograph assessment (Figure 1). The patient cohort therefore comprised patients who both (1) were considered suitable for fibular nail fixation as a result of age (over 65) or compromised soft tissues (marked swelling, bruising, blistering or history of diabetes), and (2) had a posterior malleolar fracture associated with posterior subluxation of the talus on the presentation Emergency Department plain radiographs (Figure 1). Plain radiographs often underestimate the size of the fragment, but CT scans were not routinely used in this cohort. Of the patients with posterior malleolar fractures not undergoing fixation, there were a range of fragment sizes (Figure 2). In total there were 40 patients with a large, unstable posterior malleolar fracture fragment >33%, of whom eight were excluded from analysis (Table 1).

Indications for inclusion in this cohort	Number of cases
Compromised soft tissues prompting use of fibular nail	40
Radiographic evidence of posterior talar instability	40
Excluded from cohort	
Posterior buttress plating	2
In-situ fixation with no attempted posterior malleolar reduction	2
No posterior fixation with subsequent failure	3
No posterior fixation without subsequent failure	1

Table 1: Inclusion and exclusion criteria for the study cohort.

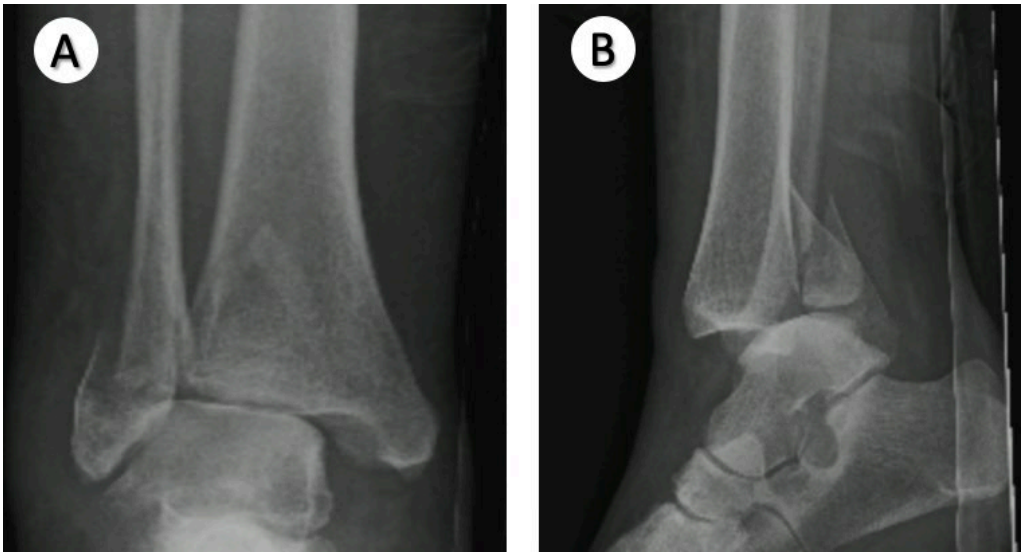

Figure 1: Anteroposterior (A) and lateral (B) radiograph of an obese female patient presenting with an unstable bimalleolar ankle fracture demonstrating evidence of posterior talar dislocation and a large posterior malleolar fracture.

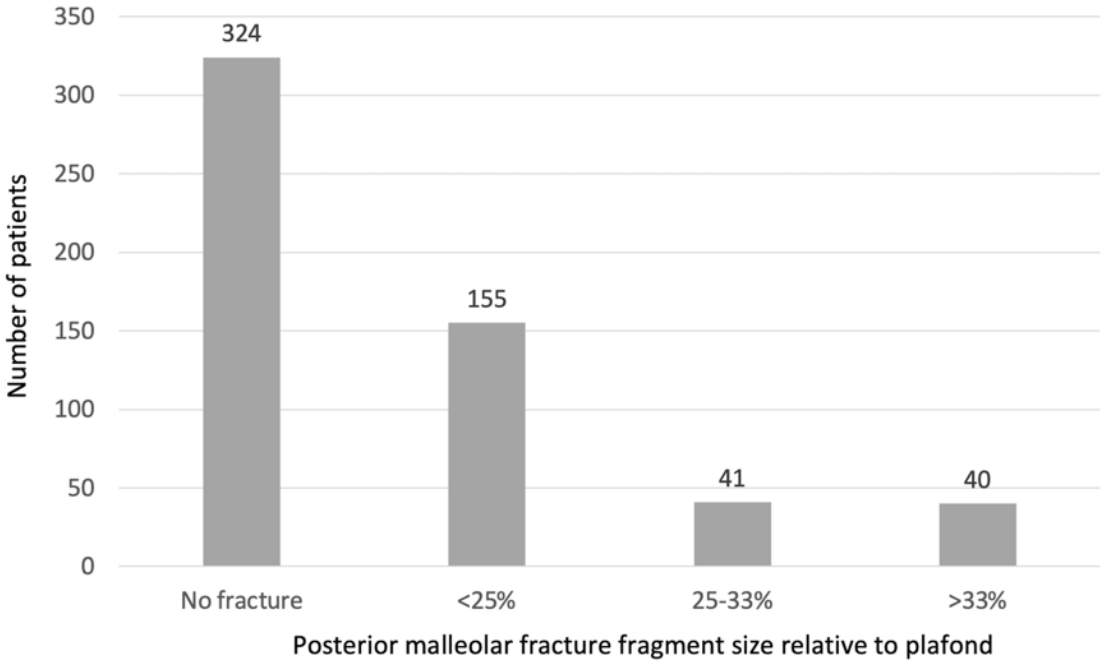

Figure 2: Number of posterior malleolar fractures by fragment size.

Surgical technique

Surgery was supervised by one of five fellowship-trained orthopaedic trauma surgeons and surgery was either performed by a staff surgeon (n=11) or a supervised senior resident (n=21). Intravenous antibiotics were given, and a thigh tourniquet was applied, but only inflated intraoperatively if visualisation of medial malleolar reduction was impaired. The injured extremity was first prepped and draped, then elevated above the level of the contralateral extremity on a radiolucent foam block to improve access for fluoroscopy (Figure 3). A perfect lateral projection was obtained. In order to visualise the posterior malleolar fracture and confirm optimal reduction, this component of the injury was fixed first. Attempted closed reduction of the fracture through ligamentotaxis was performed first by dorsiflexing the ankle (Figure 4). This is commonly unsuccessful, and a stab incision was then made at the posteromedial border of the tibia approximately 10cm proximal to the medial malleolar tip (Figure 5). Tissues deep to the incision were carefully bluntly dissected and a periosteal elevator was then slid down the posterior aspect of the tibia to reduce and stabilise the fragment (Figures 4 & 5).

Figure 3: Surgical set-up of the injured extremity and fluoroscopy.

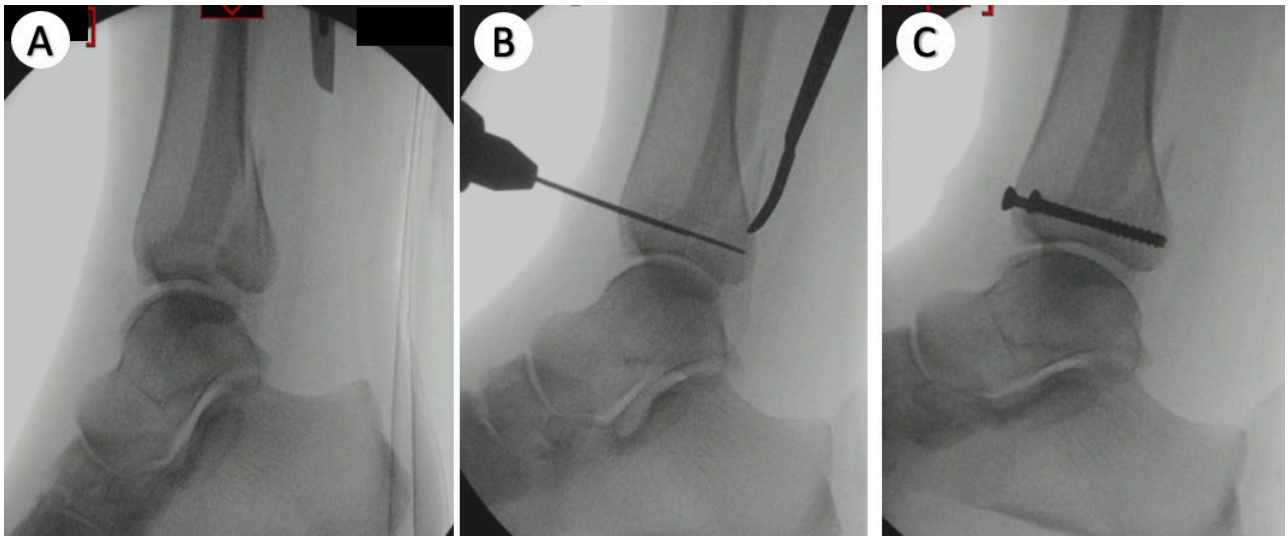

Figure 4: Intra-operative fluoroscopy imaging demonstrating an unreduced posterior malleolar fracture (A); reduced with assistance of a periosteal elevator (B) and fixed (C). In this case, two partially threaded 4.0mm cannulated screws were inserted over a 1.3mm guidewire.

Anterior percutaneous stab incisions were made over the distal tibia followed by blunt dissection down to bone, taking care not to injure local neurovascular structures and extensor tendons. Fracture reduction was confirmed fluoroscopically (Figure 4). Once reduced, two partially threaded 3.5mm cancellous (n=26, 81.3%), fully threaded 3.5mm cortical (n=4, 12.5%) or 4.0mm cannulated partially threaded (n=2, 6.2%) screws were inserted according to surgeon preference (Figure 4), after drilling under fluoroscopic control (Figure 5). Washers were used in cases of poor bone quality.

Figure 5: Fracture reduction with periosteal elevator whilst drilling screw hole under fluoroscopic control.

The fibula fracture was then stabilised using an intramedullary nail (1st generation Acumed fibular nail; Hillsboro, Oregon, USA) as per the technique outlined by Bugler et al (Figure 6).[25] Treatment of a medial malleolar fracture was at the discretion of the operating surgeon and when present (n=25) included non-operative management (n=5), screw fixation (n=17), tension band wire (n=2), or plate fixation (n=1). The percutaneous incisions (Figure 7) were closed according to surgeon preference. Post-operatively, patients were placed in a removable orthosis or cast and allowed to mobilise fully weightbearing, with the exception of those with a syndesmotic injury or established peripheral neuropathy who were not permitted to weight bear for between six and eight weeks.

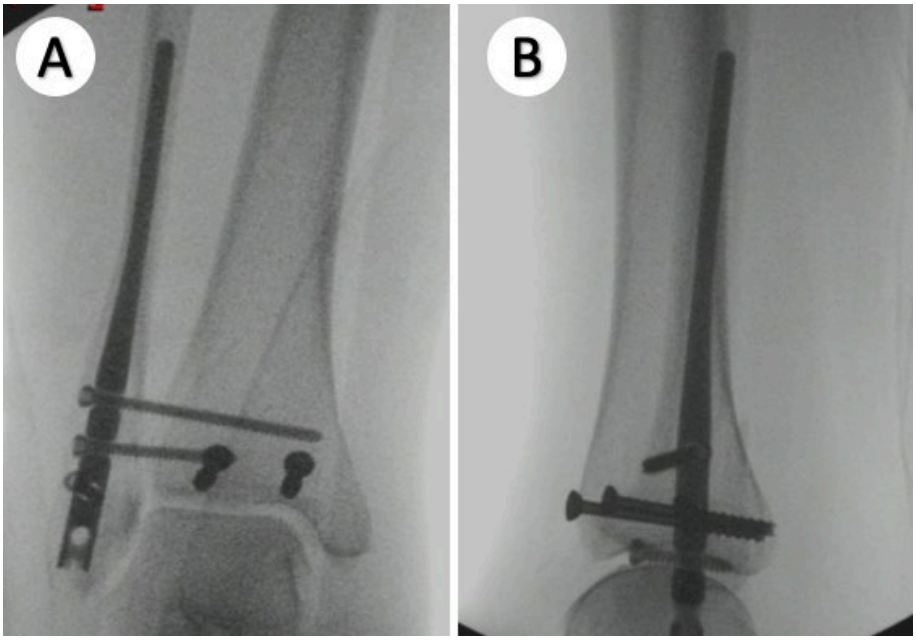

Figure 6: Anteroposterior (A) and lateral (B) radiographs demonstrating the final surgical construct.

Figure 7: Percutaneous incisions used for the technique with the advantage of minimizing trauma in an often vulnerable soft-tissue envelope.

Short-term outcome

The primary short-term outcome was complications related to posterior malleolar fracture fixation, including maintenance of talar reduction to union, revision fixation, soft tissue complications and symptomatic hardware requiring removal. Radiographic reduction quality including talar reduction was classified as "anatomical," "fair," or "poor" according to the criteria described by Burwell and Charnley.[26] Patients underwent short-term follow-up assessment at single trauma center. This consisted of a minimum of two post-operative clinical and radiographic reviews; two weeks and then between six and eight weeks. Mean short-term follow-up was nine months (range, 6.1 weeks - 2.1 years). Subsequent review, including physiotherapy, was at the discretion of the treating surgeon. Hardware was only removed if the patient was symptomatic.

Mid-term outcome

Patients were contacted via postal questionnaire or telephone interview by one of two authors ([redacted]) to complete a series of validated general and lower limb specific patient reported outcome measures (PROMs). The primary mid-term outcome was the Olerud-Molander Ankle Score (OMAS),[27] with a score of 100 indicating the best outcome. Secondary outcome measures included the Manchester-Oxford Foot Questionnaire (MOXFQ),[28] with a score of 0 indicating the best outcome and the EuroQol-5D (EQ-5D),[29] with a score of 1 indicating the best outcome. Health, pain and treatment satisfaction were measured using a visual analogue scale (VAS), with a score of 100 indicating the best possible outcome.

Statistical analysis

Data were analysed using IBM SPSS software version 24.0 (Armonk, NY: IBM Corp). Given the small sample size, continuous data are presented as medians and interquartile ranges.

Categorical data are presented as frequency and ratios. Comparison of continuous data were analysed with a Mann Whitney U test for two independent groups or a Kruskal Wallis test for three or more independent groups. Spearman's rank test was used to assess the strength and direction of correlation between two continuous variables. A p-value of <0.05 was deemed statistically significant.

Results

Demographics and injury characteristics

The mean age at surgery was 65 years (range, 39-90) and there were 26 women (81.3%). Twenty-six patients (81.3%) had one or more comorbidities, with a median number of three per patient (interquartile range, 1-4). Fifteen patients (46.9%) suffered from hypertension, seven patients (21.9%) had ischaemic heart disease, four patients (12.5%) had diabetes mellitus, of which three were insulin dependent and another two patients (6.3%) had established peripheral neuropathy. Six patients (18.8%) had a background of alcohol excess and nine (28.1%) were smokers. All patients sustained their injuries after falling from standing height. One patient presented with an open fracture.

According to the AO/OTA classification, there were 20 (62.5%) 44-B3.2, eight (25.0%) 44-B3.1, three (9.4%) 44-C2.3 and one (3.1%) 44-C1.3 fractures. According to the Lauge-Hansen classification there were 28 (87.5%) supination-external rotation (SER), three (9.4%) pronation-abduction (PAB) and one (3.1%) pronation-external rotation (PER) type fractures. A radiographic syndesmotic injury was present in six (18.8%) cases. The mean percentage of posterior malleolar fracture fragment relative to the plafond was 41% (range, 34-56). The talus was posteriorly subluxed or dislocated in all presenting radiographs.

Short-term outcome – surgical complications

Thirty of the 32 (94%) posterior malleolar fractures united uneventfully. Post-operative loss of talar reduction occurred in two patients (6.3%), which in one patient (3.1%) eventually required revision to a hindfoot nail arthrodesis. The other patient was functioning well and declined further surgery. Learning points from these two cases are discussed below. There were no cases of wound dehiscence or infection, nerve injury or tendon dysfunction related to the AP screws or the fibular nail fixation. In four cases (12.5%) there was an isolated medial

malleolar wound infection following medial malleolar fixation. One patient (3.1%) underwent removal of the AP screws in addition to all hardware due to ongoing ankle pain. Three further patients (9.4%) requested elective removal of screws from the fibular nail, one of whom also had the medial malleolar screws removed, but none of these patients required removal of the AP screws. Of the 196 patients presenting with a smaller posterior malleolar fracture that was not fixed, there were five cases (2.6%) of post-operative loss of talar reduction.

Failure cases

The patient experiencing a catastrophic failure was 80 years of age and presented with an open unstable trimalleolar ankle fracture. She had a past medical history of atrial fibrillation on warfarin, ischaemic heart disease, aortic valve replacement, previous thoracic aortic aneurysm stenting and cognitive impairment. The initial fixation failed rapidly within the first week and she was converted to an external-fixator and required wound debridement and vacuum assisted closure (VAC) and underwent a hindfoot nail arthrodesis 10 weeks after her injury. Review of her presentation radiographs indicated that the injury had been underestimated and was in fact a pilon variant with a large posteromedial comminuted fragment. In retrospect, a hindfoot nail would have been the appropriate initial procedure.

The patient who experienced displacement but did not require revision was 75. She had peripheral neuropathy and was insensate from the level of the mid-shin down. She also suffered from ischaemic heart disease, cerebrovascular disease and chronic obstructive pulmonary disease. She was in receipt of daily social care services, used walking sticks indoors but was wheelchair dependent outwith the home. Again, in retrospect, a hindfoot nail would have been the more appropriate initial procedure.

Mid-term patient reported outcome

Out of the total cohort, three (9.1%) patients were deceased at the point of outcome score collection, leaving 29 for review. Patient reported outcome measures were collected from 24 patients (75.0% total cohort, 82.8% available cohort) at a mean follow up of 3.7 years (range, 1-8 years). Patient reported outcome according to the OMAS was a median score of 80.0 (IQR, 68.8-90.0). Secondary outcome measures are presented in Table 2. Fracture pattern according to the AO/OTA classification and reduction quality of the final operative construct were not associated with a statistically significant difference in patient outcome according to any of the outcome measures in Table 2 (all $p>0.05$). Patients who smoked had a significantly poorer outcome according to the mid-term OMAS ($p=0.037$). There was no significant difference in the OMAS with respect to age, sex, syndesmosis injury, alcohol excess, peripheral neuropathy, diabetes mellitus, obesity, surgeon grade, post-operative infection, or re-operation (all $p>0.05$).

Outcome Measure	**Median (IQR)**
OMAS	80.0 (68.8-90.0)
MOXFQ	23.4 (3.1-36.7)
EQ-5D	0.85 (0.66-1.00)
VAS – Health/100	80.0 (67.5-100.0)
VAS – Pain/100	85.0 (68.8-95.5)
VAS – Satisfaction/100	87.5 (80-91.3)

Table 2: Patient reported outcome measures at mid-term follow-up. IQR: Interquartile range, OMAS: Olerud-Molander Ankle Score, MOXFQ: Manchester-Oxford Foot Questionnaire, EQ-5D: EuroQol-5D, VAS: visual analogue scale.

Discussion

This study outlines the percutaneous technique for the reduction and fixation of large unstable posterior malleolar fractures in a cohort of high-risk comorbid patients managed with a fibular intramedullary nail. We recommend this percutaneous paradigm for cases where there is concern regarding the soft tissue envelope (patients over the age of 65, or those with significant bruising or swelling, or comorbidities such as diabetes), and where the presentation radiographs show a posterior malleolar fracture causing posterior instability of the talus from the mortise. Although fragment size is not the prime indication, our data indicate that this seems to apply to fragments over 33% of the plafond on the lateral radiograph. Our data suggest a substantial rate of failure when a fragment >33% is not fixed (3/4 cases, excluded from this cohort of fixed fractures; Table 1). Although smaller fragments of <33% may justify fixation on their individual merits, we found a failure rate of 5/196 (2.6%) amongst such patients, which compares well with the available literature on redisplacement of bimalleolar ankle fractures (that is, those without a posterior malleolar component) in this vulnerable group.

We report a low complication rate with respect to the percutaneous aspect of the technique and in particular no cases of percutaneous wound infection or associated nerve or tendon injury. The four cases of superficial wound infection occurred in relation to the medial malleolar fracture fixation wound, not the AP fixation screws nor the fibular nail. In five cases, an associated medial malleolar fracture was felt to be well reduced after fixation of the posterior and lateral malleoli and was left without fixation. Prospective work investigating the necessity of fixation of these fractures is currently being undertaken.[30] Whilst the results presented relate to this defined cohort, we believe the technique is equally safe and applicable for younger, fitter patients treated with plate fixation of the fibula.

The fixation technique described was associated with a low rate (3.1%) of secondary intervention for talar displacement. The case requiring revision had, in retrospect, an injury

that was not suitable for this technique: a pilon variant with a large posteromedial region of plafond disruption. We recommend that our described technique is limited to single large posterior malleolar fractures. In our practice, patients with pilon variants are carefully considered for possible complex reconstruction with posteromedial or posterolateral plating, based on axial imaging and an assessment of their state of health and level of activity. For patients with minimal functional requirements and a compromised soft tissue envelope, it may be more appropriate to proceed directly with retrograde tibio-talar calcaneal (TTC) nailing. Previous authors have reported excellent results with TTC nails in case-series studies,[31,32] and prospective multi-center data on this topic are awaited.[33] Further surgery for lateral or medial hardware removal was required in four patients (12.1%), which is comparable to the results presented by others. Jeyaseelan et al reported hardware issues in 15% of 160 patients treated with either screw or buttress plate fixation of the associated posterior malleolar fracture, who ultimately required secondary surgery.[12] One potential disadvantage of the percutaneous technique is damage to local tendon or neurovascular structures over the dorsal aspect of the ankle. One cadaveric study has demonstrated potential risk of injury to the dorsalis pedis artery and superficial peroneal nerve when inserting AP screws.[34] We did not encounter any such complications but do recognise the potential risk, which is minimised through careful soft tissue dissection.

The main alternative to screw fixation is buttress plating, through a posterolateral or posteromedial approach. A recent report highlighted that 72% of trauma-trained orthopaedic surgeons preferred the direct open reduction technique in comparison to percutaneous fixation.[35] Although potentially offering biomechanical advantages,[36] complication rates of 23% following buttress plate fixation in a group of patients with a mean age of 51.5 years (13.5 years younger than the current cohort) have been reported and were primarily soft tissue in nature, including both superficial and deep infection.[12,37] Cases of significant wound

breakdown requiring skin grafting and post-operative compartment syndrome resulting in amputation have been reported.[9,33] Conversely, in the current study presented we experienced no wound healing complications secondary either to AP screws or fibular intramedullary nailing.

According to our mid-term primary outcome (OMAS; median score 80.0), the results presented in this study are comparable to those previously published for this patient group. Mason et al reported a mean OMAS of 75.9 in 50 patients after ORIF of an associated posterior malleolar fracture through a combination of posterolateral and posteromedial approaches.[38] Ruo-kun et al reported a mean OMAS of 82 in 32 patients with a mean age of 48 years treated with a posterolateral approach and buttress plating.[39] One of our secondary outcome measures was the MOXFQ, which has also been reported in a large study by Jeyaseelan et al. Of the 160 patients treated with posterior malleolar fixation, the mean MOXFQ was 20.1,[12] which is comparable to 25.2 reported in this study. With the mid-term patient reported outcomes presented, we believe that percutaneous fixation with AP screws provides equivalent outcome without the associated risks of patient positioning and soft tissue complications. Similar advantages have been demonstrated when comparing the percutaneous fibular nail with traditional plate fixation of distal fibular fractures.[18]

This study has limitations. The first relates to patient selection and the contentious issue of which fractures should be fixed at all. Our findings are specific to a group of patients with a large fracture fragment (all >33%), which was seen to result in posterior talar displacement. It is not routine practice in our center to fix smaller posterior malleolar fractures, especially once stability had been restored following fixation of the lateral and medial malleoli respectively. There has been extensive interest in the configuration of posterior malleolar fractures, and several classification systems have been proposed based on CT elucidation,[40,41] allowing fragment-specific approaches and plate fixation. The practice remains contentious,

and recent clinical studies have both supported,[38,42] and cautioned against,[1,43], widespread fixation. Although high-level evidence is awaited regarding the efficacy and cost-effectiveness of this approach, we do follow a similar principal specifically in younger, fitter patients with more complex fractures. We tend to avoid using simplistic estimations of fragment size using percentages based on plain radiographs but considered it helpful in this context to indicate the patient group, and degree of instability being described. It is beyond the scope of this work to advise on which smaller fractures to fix, or to provide guidance on fragment specific fixation. As mid-term outcome scores were collected remotely, we are unable to include radiographic outcomes such as post-traumatic osteoarthritis. However, the outcome scores in general were supportive of the technique and patients were offered clinical review if they were experiencing problems; no patient requested this. We do acknowledge though that we cannot comment on the incidence of early posttraumatic arthritis in these patients, and this could have been a factor that influenced patient outcome. We were unable to contact five patients whom we understood to be alive at the time of collecting scores and we cannot assume that their outcome was comparable to those included. However, upon searching regional electronic patient episodes and the national imaging archives, we confirmed that no additional complications had occurred that had not already been included.

In conclusion, this study outlines a safe technique for percutaneous reduction and fixation of large posterior malleolar fractures in patients managed with a fibular intramedullary nail. We have demonstrated a low complication rate, alongside encouraging patient reported outcomes and treatment satisfaction. This technique is particularly advantageous when treating the elderly and high-risk patients presenting with ankle trauma.

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