■ FOOT AND ANKLE

Open reduction and internal fixation of posterior malleolar fractures using the posterolateral approach

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Aims

Involvement of the posterior malleolus in fractures of the ankle probably adversely affects the functional outcome and may be associated with the development of post-traumatic osteoarthritis. Anatomical reduction is a predictor of a successful outcome.

The purpose of this study was to describe the technique and short-term outcome of patients with trimalleolar fractures, who were treated surgically using a posterolateral approach in our hospital between 2010 and 2014.

Patients and Methods

The study involved 52 patients. Their mean age was 49 years (22 to 79). There were 41 (79%) AO 44B-type and 11 (21%) 44C-type fractures. The mean size of the posterior fragment was 27% (10% to 52%) of the tibiotalar joint surface.

Results

Reduction was anatomical in all patients with a residual step in the articular surface of ≤ 1 mm. In nine of the C-type fractures (82%), the syndesmosis was stable after fixation of the posterior fragment and a syndesmosis screw was not required. Apart from one superficial wound infection, there were no wound healing problems. At a mean radiological follow-up of 34 weeks (seven to 131), one patient with a 44C-type fracture had widening of the syndesmosis which required further surgery.

Conclusion

We conclude that the posterolateral surgical approach to the ankle gives adequate access to the posterior malleolus, allowing its anatomical reduction and stable fixation: it has few complications.

Take home message: Fixation of the posterior malleolus in trimalleolar fractures can be easily done via the posterolateral approach whereby anatomical reduction and stable fixation can be reached due to adequate visualisation of the fracture.

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The treatment of fractures of the ankle which involve the posterior malleolus remains controversial. Although there is some recent evidence that a fracture of the posterior malleolus will result in an increased incidence of post-traumatic osteoarthritis (OA) and therefore a worse functional outcome, there is no agreement as to how such fractures should be treated.[1-3] Usually the posterior malleolus is only fixed if the fragment exceeds 25% of the articular surface or if there is instability of the ankle joint after fixation of the medial and lateral malleoli.[4,5]

It has recently been shown that anatomical reduction is an important predictor of a successful functional outcome.[1-6] The disadvantages of percutaneous reduction with anterior to posterior (A to P) screw fixation of the posterior malleolus are that anatomical reduction is more difficult due to the interposition of soft tissue or loose bony fragments, that it is hard to assess reduction satisfactorily using an image intensifier, and that the fixation of small or comminuted fragments is technically difficult. Incomplete reduction leads to a residual step in the articular surface.[2,6] A recently published cohort study from our hospital showed a persisting articular step of > 1 mm in 42% of 131 cases after percutaneous reduction and A to P screw fixation of the posterior malleolus.[2]

We favour open, anatomical reduction of posterior malleolar fragments using a posterolateral approach with the patient in a prone position. In this article we describe the

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Table I. Basic characteristics (n = 52)

Age (yrs)	**49**
Men n, (%)	11 (*21*)
Follow-up (wks, mean, range)	34 (7 to 131)
ASA 1 n, (%)	20 (*39*)
ASA 2 n, (%)	25 (*48*)
ASA 3 n, (%)	7 (*13*)
Diabetes Mellitus n, (%)	4 (*8*)
Body Mass Index (mean)	29 (22 to 50)
Smoking n, (%)	16 (*31*)

ASA, American Society of Anesthesiologists

Fig. 1

Radiographs showing trimalleolar fracture, Lauge-Hansen type SE4.

Table II. Fracture characteristics (n = 52)

Fracture subluxation n, (%)	**40 (*77*)**
Size of posterior fragment (%)	*27*
Medial malleolar fracture n, (%)	43 (*83*)
Supination-External Rotation stage 3 n, (%)	2 (*4*)
Supination-External Rotation stage 4 n, (%)	38 (*73*)
Pronation-Abduction stage 3 n, (%)	1 (*2*)
Pronation-External Rotation stage 3 n, (%)	1 (*2*)
Pronation-External Rotation stage 4 n, (%)	10 (*19*)
AO-type B3 n, (%)	41 (*79*)
AO-type C2 n, (%)	5 (*10*)
AO-type C3 n, (%)	6 (*12*)

AO, Arbeitsgemeinschaft für Osteosynthesefragen

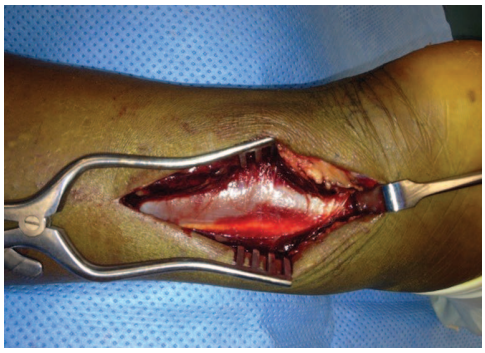

Fig. 2

Photograph showing posterolateral incision.

technique and its short-term outcome in 52 patients with a trimalleolar fracture who were treated using this approach.

Patients and Methods

Between 2010 and 2014, 52 patients with a trimalleolar fracture of the ankle were treated at our level one trauma centre using the posterolateral approach to reduce and fix the posterior malleolus. There were 11 men and 41 women with a mean age of 49 years (22 to 79). A total of 40 patients (77%) had a fracture subluxation. Baseline characteristics of these patients and their fractures are shown in Tables I and II.

The size of the posterior malleolar fragment was calculated as the percentage of the tibiotalar surface area involved. The anteroposterior (AP) diameter of the fragment was measured on the lateral radiograph, or CT scan if available, and divided by the total AP diameter of the tibiotalar articular surface.

The mean size of the posterior malleolar fragment was 27% (10% to 52%) of the joint surface (Table II). There was comminution of the fragment in 16 patients (31%). An external fixator was used prior to definitive reconstruction in 22 patients (42%) due to soft tissue swelling and/or blistering. The mean follow-up was 34 weeks (seven to 131).

The congruency of the joint (step-off) and the quality of reduction and fixation of the lateral, medial and posterior malleoli was assessed on the post-operative and follow-up radiographs by two of the authors (SV, JH). Reduction was considered anatomical if any displacement was ≤ 1 mm.

Ethical approval for the study was not deemed to be required by the local ethical committee.

Technique. The illustrated example shows a patient with a trimalleolar fracture, type AO 44B3 or Lauge-Hansen supination-external rotation 4 (Fig. 1) of the left ankle. The patient is prone for the operation. The distal part of the lower leg is placed on a foam cushion with the knee slightly flexed to allow maximal dorsiflexion of the ankle during reduction. A longitudinal incision is made between the lateral border of the Achilles tendon and the medial border of the fibula (Fig. 2). Fixation of the fibular fracture before fixation of the posterior malleolar fracture has its advantages and disadvantages. Fixation of the fibula first will, in most cases, lead to an adequate reduction of the posterior malleolar fracture. Sometimes, however, its fixation will limit the movement of the posterior malleolar fracture and therefore interfere with reduction. In our opinion, dissection of both fractures and careful anatomical reduction of both is the best strategy. Here, we describe the fixation of the fibular fracture first.

During blunt subcutaneous dissection onto the peroneal tendon, care is taken to avoid injury to the sural nerve. The posterior aspect of the fibula is easily reached through the interval just lateral to the peroneal tendon. After debriding the fracture, it can be reduced and fixed using lag screws

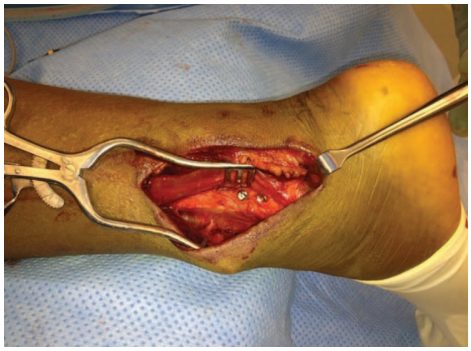

Fig. 3

Photograph showing lag screws placed to reduce the fracture of the fibula.

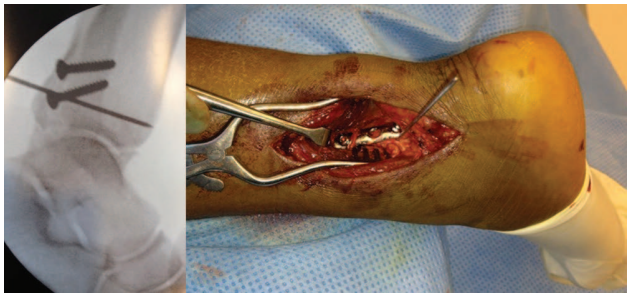

Fig. 5

Radiograph and photograph showing placement of temporary Kirschner wires followed by a buttress plate.

Fig. 4

Photograph showing medial retraction of the muscle belly of flexor hallucis longus; this will show the posterior fracture.

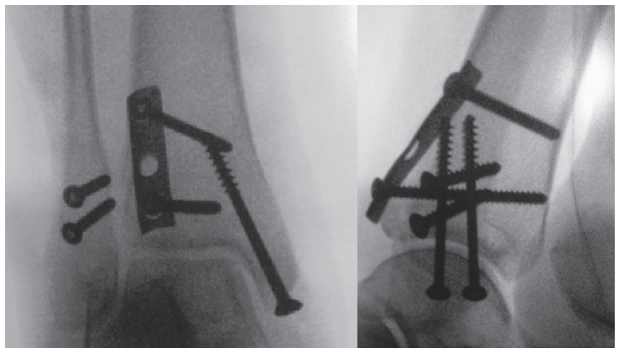

Fig. 6

Post-operative radiographs of the fixed trimalleolar fracture.

and/or a buttress plate (Fig. 3). The belly of flexor hallucis longus is bluntly dissected off the interosseus membrane and the lateral side of the tibia through the interval medial to the peroneal tendon. Particular care is taken to avoid injury to the peroneal artery and its smaller branches. By retracting the muscle belly medially, the posterior aspect of the tibia can be seen. The periosteum is incised to expose the posterior malleolar fracture (Fig. 4). It is important not to damage the posterior inferior tibiofibular ligament (PITFL) at this stage. The posterior malleolar fragment is almost always displaced in a craniolateral direction by traction from the PITFL. Loose fragments can be removed by levering the fragment distally. After maximal dorsiflexion of the ankle, a dental pick or bone tamp can be used to reduce the posterior fragment. An anatomical reduction is almost always achieved and is held temporarily by Kirschner (K-) wires. When anatomical reduction is confirmed on image intensification, fixation is undertaken using either lag screws or a slightly prebent three-hole buttress plate (Fig. 5). Placement of a lag screw through the most distal hole of the plate can help to close any possible gaps. By slightly internally rotating the lower leg, the medial malleolus can be approached and fixed. The incision is closed in layers after confirmation of reduction (Fig. 6). Post-operatively a cast or bandage is retained for a maximum of two weeks: non-weight-bearing continues for six weeks.

Results

In 12 patients (23%), the fragment was fixed using lag screws only: in 40 (77%) it was fixed using a buttress plate. After fixation, 50 ankles (96%) were found to be stable when clinically tested (Cotton test):[7] no additional syndesmosis screws were needed in these patients, even in those with AO type 44C fractures. A syndesmosis screw was required in two patients (4%).

Post-operative radiographs showed an anatomical reduction with a congruent ankle joint in all cases. There was one superficial wound infection, which was successfully treated with antibiotics. Two patients (4%) suffered from a temporary numbness in the distribution of the lateral sural cutaneous nerve. This resolved unremarkably in both within a few weeks. Congruency was lost in one patient with an AO-type 44C fracture, and a syndesmosis screw was introduced five days post-operatively which stabilised the ankle joint. Congruency was maintained after all other patients bore weight. One patient had a pulmonary embolus post-opera-

Fig. 7a

Fig. 7b

Pre-operative radiographs of AO-44C2 fracture with posterior fragment.

tively but recovered fully following six months of anticoagulation. One patient had a second injury within six months which caused a further trimalleolar fracture which was similarly treated.

In 15 patients (29%), the medial and lateral hardware was removed at a later date after consolidation of the fracture. All material used to fix the posterior malleolus was left in place.

A total of four patients developed post-traumatic osteoarthritis in this follow-up period as a result of cartilage damage of the tibial plafond and talus on lateral or mortise radiographs. One patient with grade three OA[8] of the ankle joint underwent prosthetic replacement two years after the initial trauma.

Discussion

In recent years increased attention has been paid to the importance of anatomical reduction and internal fixation of the posterior malleolus.[4-6,9,10]

It is assumed that a congruent ankle joint without a step in the articular surface is needed to achieve a good functional outcome in patients who undergo surgical treatment for a fracture of the ankle. Inadequate reduction of the posterior malleolar fragment with a persistent articular step diminishes the tibiotalar articular surface and leads to altered biomechanics in the ankle joint. A change in peak pressure distribution probably plays an important role in the development of post-traumatic OA.[1,11] There is no consensus about the main cause of post-traumatic OA after a fracture of the ankle.[12]

According to the AO guidelines,[13] a posterior malleolar fragment is usually only reduced and fixed if it involves > 25% of the tibiotalar articular surface or when there is persistent instability after fixation of the medial and lateral malleoli.[13] The recommendations are partially based on biomechanical studies.[11] Clinical studies are not consistent in the recommendation of the size of posterior fragment that requires fixation. De Vries et al[14] and Langenhuijsen et al[15] recommend fixation of posterior fragments which are larger than 25% or 10%, respectively. Mingo-Robinet et al[5] suggest in a retrospective study involving 45 trimalleolar fractures, that anatomical reduction, and not size of the fragment, was the most important determinant of outcome.

In 2013 we conducted a retrospective study of 131 patients, in whom outcome was assessed using the American College of Foot and Ankle Surgeons (AOFAS) score, at a mean of 6.9 years (2.5 to 15.9) after internal fixation of a trimalleolar fracture of the ankle. Patients with a persistent articular step of > 1 mm after fixation of the posterior malleolus were significantly more likely to develop post-traumatic OA than those with no articular step (46% *versus* 25%, p = 0.02). This was the case in patients with medium-sized posterior malleolar fragments (5% to 25% of the articular surface) as well as in those with large (> 25%) fragments. The size of the fragment (larger than 25% of the involved articular surface) was the leading indication for fixation of the posterior malleolus. In the sub-group of patients (24 patients) who underwent fixation of the posterior fragment, the functional outcome was no better than in the sub-group without fixation. There was a persistent articular step of > 1 mm in ten (42%) of the fixed posterior malleolar fragments, compared with 46 (55%) of those in whom the posterior malleolar fragment was not fixed. In the study period, nearly all posterior fragments which were fixed were reduced by ligamentotaxis and fixation was undertaken percutaneously in an AP direction.[2] The results of this retrospective study strengthened us in our belief to strive for an anatomical, open reduction.

Similar results have been published in a recent Chinese study which described 102 patients with a trimalleolar fracture.[3] Mean follow-up was 2.8 years (0.5 to 8.5 years). In all, 42 patients underwent fixation of the posterior fragment, 23 of them posterior to anterior fixation. Fixation of the posterior fragment was performed if fragment was around or larger than 25% of the involved articular surface as measured on plain lateral radiographs. Functional outcome was assessed by the AOFAS score and osteoarthritis was assessed on plain radiographs. A persistent articular step of > 1 mm was seen in 24 (24%) patients and this correlated with a worse functional outcome.[3] In the fixation group a persistent articular step of >1 mm was seen in 14 (33%) patients.

Anatomical reduction and fixation of the posterior malleolar fragment also reconstructs the fibular notch and the syndesmosis. Cadaver studies show that this technique is biomechanically superior to the use of syndesmosis screws in injuries proximal to the syndesmosis.[9] In AO type 44C fractures, even small posterior malleolar fragments can be fixed. Syndesmosis screws are not needed if the syndesmosis is clinically stable after fixation.[10]

In Figures 7 to 9, we present a case (AO-44C2 fracture) with a relatively small posterior fragment, shown on preoperative CT scans with comminution and several intra-articular fragments (Fig. 8). The fibula was dislocated. After fixation of the posterior fragment with a buttress

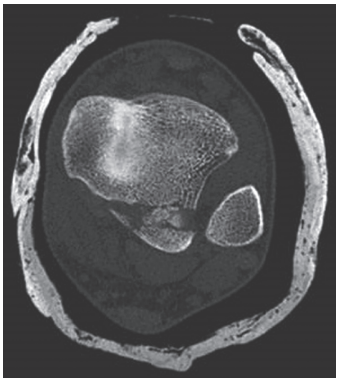

Fig. 8a

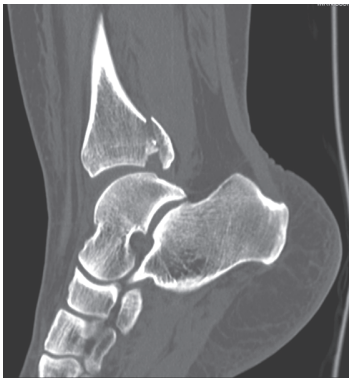

Fig. 8b

Radiograph and CT scan showing comminution of the posterior fragment with several intra-articular fracture fragments. The fibula is rotated out of its notch on the tibia.

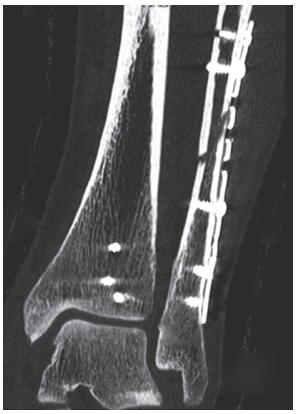

Fig. 9a

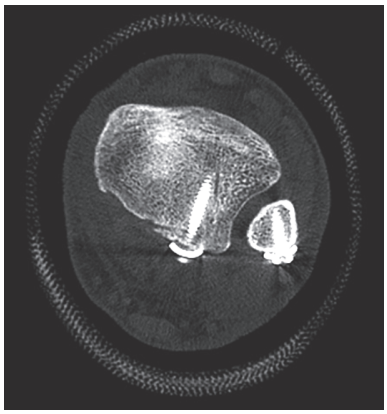

Fig. 9b

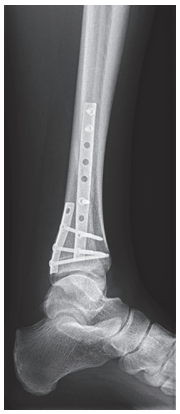

Fig. 9c

Post-operative CT-scans (a and b) and radiograph (c) showing adequate reduction of the syndesmosis.

plate the joint was congruent and the fibula was reduced (Fig. 9). The syndesmosis was stable.

One patient developed an incongruent ankle and a syndesmosis screw was introduced at a further operation. This emphasises the need for adequate clinical testing at the end of the operation. When there is any doubt about the stability of the ankle after fixation of the posterior malleolar fragment there should be a low threshold for using a syndesmosis screw.

There are several limitations to this study. First, it is retrospective with data gathered from the notes. This aim was to describe the technical advantages of the posterolateral approach with better radiological outcome and the study was not designed to report functional outcome. Secondly, the size of posterior fragment and articular step in the ankle joint was measured on plain radiographs in most patients because this is daily practice world-wide. CT scans were not available for most patients. In our opinion, measurement on a plain radiograph is not as good as measurement by CT scans. Future studies should only use CT scans when assessing articular congruency.[16] Another limitation is that only trimalleolar fractures which were fixed using a posterolateral approach are included. There are no data available on unfixed posterior malleolar fragments or those treated with 'anterior to posterior' percutaneous fixation.

Little has been published on the subject of the technique of reduction and fixation for these fractures. Traditionally an indirect reduction technique by ligamentotaxis or percutaneous reduction using a Weber clamp followed by percutaneous screw fixation in an AP direction is used.[17,18] This technique does not lead to anatomical reduction of the fragment in many patients. The correct positioning of the screw in smaller fragments can be difficult. In recent years, several authors have recommended the posterolateral approach with the patient in a prone position with open reduction of the posterior malleolar fragment followed by internal fixation with lag screws and/or a buttress plate, reporting few complications and a good functional outcome.[2,3,10,19-21] We confirm these findings in this study.

This technique gives an adequate view of the fracture, an anatomical reduction in most cases and sound fixation of the posterior malleolar fragment.[19,20] Another advantage is that small fragments are easier to fix and small intra-articular fragments can be removed from the site of the fracture. There has, as yet, been no prospective study to investigate the functional and radiological outcome after anatomical reduction and fixation of medium-sized posterior malleolar fragments (those involving between 5% and 25% of the articular surface). Whether anatomical reduction and fixation of these fragments leads to a better functional outcome and a reduced rate of post-traumatic OA therefore remains unknown. We are currently involved in two multicentre, randomised trials, which are attempting to answer this question (the POSTFIX and POSTFIX-C trials).

Author contributions:
S. M. Verhage: Data collection, Data analysis, Writing the paper.
F. Boot: Data collection, Data analysis, Writing the paper.
I. B. Schipper: Data analysis, Writing and correcting the paper.
J. M. Hoogendoorn: Data analysis, Performed surgeries, Writing the paper.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

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