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Does functional outcome depend on the quality of the fracture fixation? Mid to long term outcomes of ankle fractures at two university teaching hospitals☆

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ABSTRACT

Background: The aim of our study was to assess the adequacy of reduction and internal fixation of ankle fractures and the long-term functional outcomes of patients treated in two university teaching hospitals by general orthopaedic surgeons.
Method: We performed a retrospective study involving two large trauma units in the UK, reviewing all operatively treated unstable ankle fractures performed in one centre between 1st October 2006 and 31st December 2007 and another centre between 1st January 2009 and 31st December 2009. All patients were contacted by postal follow up at a minimum of 6-years using the Olerud–Molander Ankle Score (OMAS).
Results: 261 patients underwent operative treatment for ankle fractures during the study period at the two hospitals. 107 patients responded to the questionnaire. Analysis of patients' functional outcome by fracture type reveals that the outcome scores decrease as the complexity of the ankle fracture increases. A significant finding within subgroup analysis found that trimalleolar fractures (B3) have worse outcomes than bimalleolar fractures (B2 and C); which in turn have worse outcomes than isolated lateral malleolar fractures (B1). Analyzing the outcome of patients based on the severity of malreduction revealed that Pettrone's value was inversely proportional to the OMAS.
Conclusion: We have found a significant reduction in patient reported function in patients whose fractures were malreduced at time of surgery.

1. Introduction

Ankle fractures are a common trauma presentation with an incidence of approximately 187 fractures per 100,000 of the population per year [1]. With the high incidence of presentation, the general orthopaedic surgeon will frequently operate on such fractures, however there is very little research published regarding the outcomes of their management. Radiological analysis is routinely performed postoperatively to assess adequacy of reduction and fixation. Recently a Dutch Delphi study was conducted to obtain consensus on the most important criteria for the radiological evaluation of the reduction and fixation of wrist and ankle fractures [2]. Intra-articular aspects were considered the most important factor for the ankle with regards to the long-term outcomes. Broos and Bisschop in a similar study, found that the presence of a medial malleolar or posterior malleolar fracture worsened the overall outcome [3].

More definite criteria have been described previously by Pettrone et al. in 1983 [4]. For predicting good functional outcome, open reduction proved superior to closed reduction, and in bimalleolar fractures open reduction of both malleoli was better than fixing only the one side. A number of authors have presented high rates of malreduction in operatively treated ankle fractures treated by general orthopaedic surgeons, however the long term functional outcomes have not been obtained [5,6].

The aim of our study was to assess the correlation between the adequacy of reduction and internal fixation of ankle fractures and the functional outcomes of patients treated in two university teaching hospitals by general orthopaedic surgeons. Our nul hypothesis is that there is no correlation between adequacy of reduction and internal fixation and functional outcomes in operatively treated ankle fractures.

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2. Patients and methods

We performed a retrospective study involving two large trauma units in the UK, reviewing all operatively treated unstable ankle fractures performed in the units. Patients attending Leicester Royal Infirmary between 1st October 2006 and 31st December 2007 and patients attending Aintree University Hospital between 1st January 2009 and 31st December 2009 were considered for the study. Exclusion criteria included paediatric fractures; isolated medial malleolar fractures; polytrauma; and fractures involving the tibial plafond (pilon fractures) although posterior malleolar fractures of Mason et al. type 1 and 2 were maintained [7]. The fracture pattern was classified using the AO classification system. The operative treatments of these fractures were completed by surgeons of differing grade and experience on community trauma lists. Surgery was undertaken when the soft tissue envelope was satisfactory to proceed. Traditional AO fixation principles were used. The routine postoperative treatment in both departments was immobilization in a non-weight bearing plaster cast for 6 weeks, followed by mobilization. Physiotherapy referral was made if stiffness was a concern on removal of cast immobilization.

The quality of anatomical reduction was recorded from the immediate post-operative radiographs using the lateral, anteroposterior and mortise views. The quality of anatomic reduction was assessed using the criteria described by Pettrone el al. [4]. To classify the fixation as satisfactory, the following four criteria had to be met: fracture separation of medial and lateral malleolus to be $\leq$ 1 mm and $\leq$2 mm respectively; to ensure deltoid ligament integrity, a medial clear space $\leq$3 mm; and to ensure the restoration of the syndesmosis, there was a tibio-fibular space $\leq$5 mm, or tibio-fibuar overlap $\geq$10 mm on AP or $\geq$1 mm on Mortise view. An example of a malreduced ankle fracture fixation can be seen in Fig. 1. The measurements were accomplished using the graphics package present on the hospitals Picture Archiving and Communication System (Carestream Vue PACS, Kodak®). The quality of fixation was recorded in addition to original criteria set out by Pettrone et al. [4].

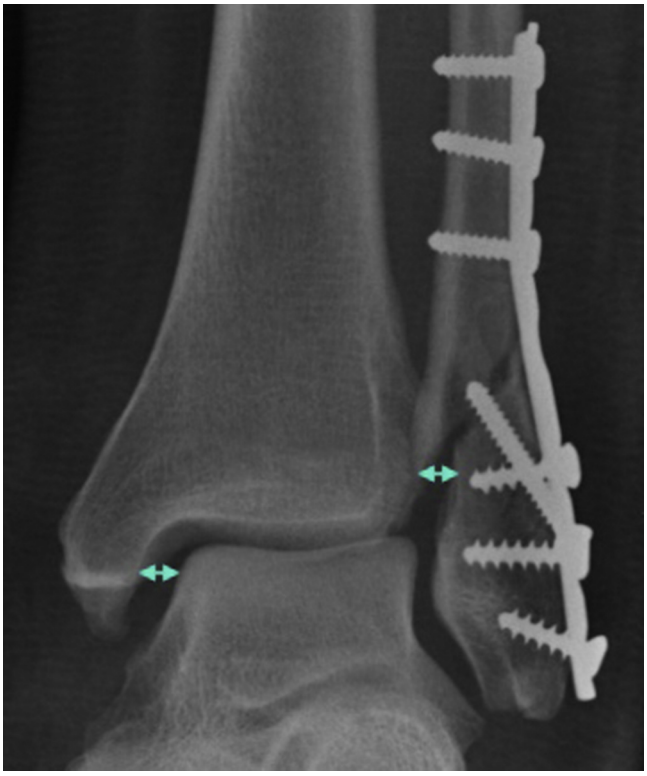

Fig. 1. A postoperative radiograph illustrating an example of a malreduced ankle fracture fixation, with an increase in medial clear space of >3 mm and a lateral malleolar fracture separation of >1 mm.

All patients were contacted by postal follow up at a minimum of 6-years using the Olerud–Molander Ankle Score (OMAS) [8] patient related outcome measure. The OMAS is scored out of 100, with higher scores indicating better outcomes. Patients who did not respond to initial questionnaire, were followed up with repeat postal questionnaire and telephone call. Post-operative complications and further surgery at follow-up were obtained from the case notes.

All data was assessed using SPSS Inc. 20.0 (IBM, New York 10504-1722). Numerical data was tested using a Student t-test if parametric or a Mann–Whitney test if non-parametric. Logistic regression was performed upon age and gender with regards to functional outcome. Given that the Kappa coefficient is a pair-wise statistic, the average pair wise agreement for each category of the Pettrone criteria was also determined.

3. Results

Two hundred and sixty-one patients underwent operative treatment for ankle fractures during the study period at the two hospitals. At follow-up, 209 patients were alive and traceable. After repeat mailing of the questionnaire 106 patients responded to the questionnaire. An analysis of the demographics revealed there were 141 females and 120 males with a mean age of 48 years (17–91years). Assessment using the AO classification to establish the type of ankle fractures showed that 194 cases were type B: with 67 B1 fractures; 87 B2 fractures; and 40 B3 fractures. The remaining 67 cases were grade C injuries. Reviewing the demographics of the 107 responders showed that there was an even distribution between the reduced cohort and the malreduced cohort, with 34% of responders having a malreduced fracture, representative of the cohort as a whole (Table 1). The overall mean OMAS was significantly lower in the malreduced cohort ($p < 0.05$) compared to the reduced cohort (malreduction defined as a Pettrone score $\geq$1). Further subgroup analysis revealed that the more complex fractures were more likely to be malreduced (illustrated in Table 2). There was no significant difference in demographics amongst the groups.

Analysis of patients' functional outcome by fracture type reveals that the outcome scores decrease as the complexity of the ankle fracture increases. A significant finding within subgroup analysis found that trimalleolar fractures (AO classification B3)

Table 1
Demographics of study cohort. Malreduction defined as a Pettrone score $\geq$1.

	Malreduced cohort	Reduced cohort
Number	88	173
Gender (M:F)	1:1.7	1:1
Number of respondents	34	73
Percentage of respondents per cohort	39%	42%
Mean OMAS (range)	57.3 (0–100)	71.2 (0–100)

Table 2
Subgroup analysis of all ankle fractures included in study showing with increase in complexity, the rate of malreduction increases. Malreduction defined as a Pettrone score $\geq$1.

Fracture type (AO)	Number	Malreduced	Percentage
B1	67	10	15%
B2	87	33	38%
B3	40	16	40%
C	67	28	42%
Total	261	88	34%

Table 3
Subgroup analysis of patients' functional outcomes using both Pettrone scores ≥1 and ≥2 for analysis, comparing with fracture types.

Fracture type	Pettrone score <1	Mean OMAS (range)	Pettrone score ≥1	Mean OMAS (range)	Pettrone score ≥2	Mean OMAS (range)
B1	26	79.2 (15–100)	4	48.8 (5–85)	1	60
B2	21	65.0 (0–100)	13	59.2 (5–100)	6	45.8 (5–100)
B3	8	54.3 (10–100)	7	54.2 (5–100)	2	38.9 (5–60)
C	18	74.4 (15–100)	10	60.0 (0–100)	4	38.8 (0–85)

have worse outcomes than bimalleolar fractures (B2 and C); which in turn have worse outcomes than isolated lateral malleolar fractures (B1). B3 fractures are the only fracture where the functional scores do not significantly reduce when Pettrone scores of 1 are included in the analysis, however there is a comparable drop-off in outcomes to other fracture types when a Pettrone score of 2 or greater is used to define malreduction (Table 3).

Using Pettrone's scoring system, a fracture can be malreduced in more than one criterion; the inference being that the more criteria malreduced the more severe the degree of malreduction. Analyzing the outcome of patients based on the severity of malreduction revealed that Pettrone's value was inversely proportional to the OMAS. This is illustrated in Table 4. Comparison of the difference between groups was statistically significant ($p < 0.5$).

Twenty patients had further surgery on their ankle. Ten of these cases were removal of metalwork including removal of syndesmotic screws. Three patients subsequently had arthrodesis surgery, of which 2 were from the reduced ankle fracture cohort. Seven patients had revision surgery: six as a consequence of malreduction that were either identified at follow-up as being inadequate with subsequent loss of fixation. The patient from the reduced fracture cohort that required revision surgery had repeat trauma eighteen months later to this ankle. The most significant complication, was in one patient who underwent revision surgery that was complicated by wound infection and ultimately led to a below knee amputation.

4. Discussion

This study has identified three key points. Firstly more complex ankle fractures are more likely to be malreduced, with B3 and C fractures having a malreduction rate of 42%, compared to B1 type fractures which have a malreduction rate of 15%. This finding indicates that each ankle fracture should be reviewed on a case by case basis, with the more complex fractures operated on by either specialists in this field or those experienced in achieving a good reduction in such fractures. The second key point to be highlighted is that fractures involving the posterior malleolus have significantly worse outcomes, even when reduced well. Odak et al. [9] published a systematic review of posterior malleolar fractures reporting poor outcomes with these fractures. A number of authors are reporting specific elements to these fractures that are unique to these injuries, including posterior syndesmotic injuries [10] and posterior ankle subluxation [11]. We therefore recommend that for these injuries, surgeons skilled in this fracture pattern rather than general surgeons undertake their treatment, as the nuances for their treatment is still under investigation [12,13]. The third key factor, although seemingly obvious, is that the more radiographic criteria that are malreduced the lower the functional score of the patient. Between 0 and 1 Pettrone scores we see a drop of approximately 5%, compared with the almost 20% drop between 1 and 2. This is possibly explained by the talar-tibia congruency loss that may not occur until at least 2 criteria of Pettrone's score is lost (i.e. both malleoli) [14,15]. We therefore reject our nul hypothesis, as there is a correlation between adequacy of reduction and fixation of ankle fractures, and their overall functional outcome.

Table 4
Functional outcome analysis of mean OMAS functional outcome compared with increasing Pettrone's value.

Pettrone's value	Number of patients	Mean OMAS score	Range
0	73	71.2	0–100
1	20	66.8	5–100
2	9	47.2	5–100
3	2	55.0	50–60
4	2	10	0–20

There are a number of limitations to this study. A retrospective study completed in two units with different surgeons and different populations raises the possibility of cluster variance and selection bias, however it is much more likely to be representative of general surgical treatment of ankle fractures in the general population. This is the base of pragmatic studies utilized in current large multicentre trials. The two centres worked closely to minimize treatment disparity between the departments. A number of traditional methods apparent within this study are being superseded with new methods (e.g. non-weight baring mobilization) however we feel the treatments provided are still representative of the nationwide ankle fracture treatment. As a retrospective study the long term data collection was affected. The final response rate of 52% is poor, however we did find that there was no bias in our responders: 33.5% of the original cohort were malreduced and 31.1% of our responders were malreduced. Norquist et al. [16] reported an expected response rate in long-term studies of 50%, which we are equivalent to.

Pettrone's criteria is an established and comprehensive system that allows one to assess the quality of ankle fracture reduction [8,17]. However, the fibular malreduction is likely to not be picked up with simple radiology, although the Pettrone's criteria has showed significant prognostication in this study. There are obvious difficulties when applying any radiographic assessment tool, with the accuracy of observers in estimating fracture angulation has proven poor agreement with themselves and others with mean error of 8–9° [18]. As this data was nominal in nature, any disparity amongst observers was discussed and an agreement reached.

This is one of the largest medium-long term studies encompassing all unstable ankle fractures presenting to two UK trauma units. This collaboration is the result of initial audits in both departments finding similar rates of mal-reduction. The overall malreduction rate was 33%. Studies in other centres have also found similar malreduction rates, indicating that our two centres are not outliers, but representative of the typical operative management of ankle fractures in the UK [6]. Because of these findings, both hospitals have altered their practice: one centre started an education program for consultants and trainees to help them assess on table reduction and instigated ongoing audit; and at the second centre there was a significant system change, including treatment algorithms for certain fracture types and employment of a foot and ankle trauma lead [19].

The OMAS was specifically developed for symptom evaluation after ankle fractures and is an ordinal scale that consists of nine domains. The score was validated by Nilsson et al. [8] in 2013, who found that a difference in OMAS scores of 4.4 points should be regarded as indicative for true change beyond measurement error

and applied as the smallest difference between two measurements. In our study, the overall OMAS dropped by 14 between reduced and malreduced fractures where a malreduction was defined as a Pettrone score of $\geq$1. This indicates a significant clinical and statistical difference in mid-longterm outcomes, where ankle fracture reduction has not been adequately achieved. The OMAS found in this study in reduced ankle fractures are equivalent to published studies on ankle fracture outcomes. The 6 months functional scores in the AIM trial were OMAS scores of 64.5 in operatively treated ankle fractures and 66 in plaster treated ankle fractures. This is equivalent to our B2 ankle fractures in this study.

5. Conclusion

We have found a significant reduction in patient reported function in patients whose fractures were malreduced at time of surgery. We aim to dispel the ethos of ankle fractures being a junior surgeons operation, and complex ankle fractures not to be done by general orthopaedic surgeons, in an effort to do right for our patients first time. Revision surgery for malreduction or loss of fixation in malreduced fractures has considerable risks for the patients, as exemplified by one of the patients in this study who underwent a below knee amputation. By auditing practice and highlighting deficiencies within that practice; we will improve the outcome for our patients.

Conflict of interest

All authors confirm that there are no financial or personal relationships with other people or organisations that could inappropriately influence (bias) our work on this article.

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