



# JOURNAL CLUB

LOWER LIMB TRAUMA

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# INTRODUCTION

- Ankle fractures are common trauma presentation in our center
- Radiological analysis is routinely performed postoperatively to assess adequacy of reduction and fixation
- Malreduction is not uncommon in ORIF of ankle fractures.
- Is adequacy of reduction in ORIF of ankle fractures related to functional outcome?

# AUTHOR AND JOURNAL



## Foot and Ankle Surgery

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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 ☆

Veronica Roberts <sup>a</sup>, Lyndon W. Mason <sup>b</sup>  , E. Harrison <sup>b</sup>, Andrew P. Molloy <sup>b</sup>, Jitendra Mangwani <sup>a</sup>

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<https://doi.org/10.1016/j.fas.2018.04.008>

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- **Affiliated institutions:**

1. University Hospital of Leicester
2. Aintree University Hospital

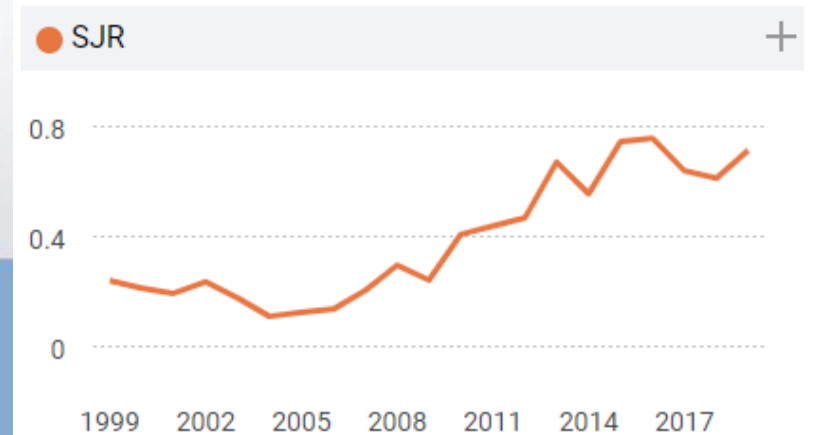
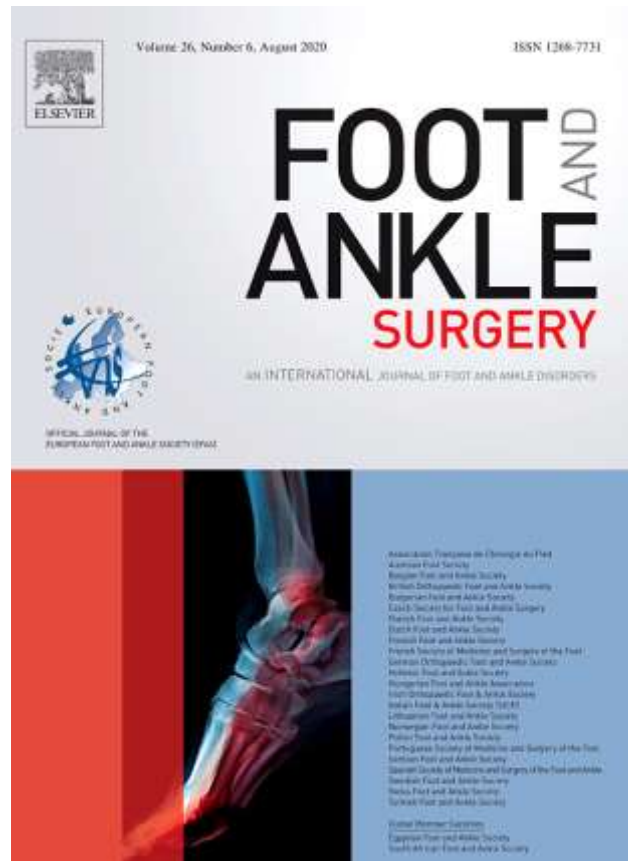
- **Journal:** Foot and Ankle Surgery (UK)

- **Impact factor 2019:** 1.776

- **SJR 2019:** 0.72

- **Cite score 2019:** 2.3

- **Circulation:** International



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- The two authors Mason and Molloy have given classification for posterior malleolar fracture and treatment algorithm as dictated by their classification.

# THE HYPOTHESIS

There is no correlation between adequacy of reduction and internal fixation and functional outcomes in operatively treated ankle fractures.

- **Population:** With ankle fractures
- **Intervention:** Open reduction and internal fixation
- **Comparison:** Adequate reduction and Malreduction
- **Outcome:** OMAS

## EVIDENCE BASE

- Pettrone et.al. (1984) had outlined a criteria to assess the radiographic reduction of ankle fractures.
- 4 factors were most significant: age, displacement of the medial or ateral malleolus, widening of the syndesmosis, and widening of the medial clear space.
- The prognosis worsened as the number of deranged structures increased.
- A simple linear-regression model that uses this information enabled prediction of the final result with an accuracy rate of more than 80 per cent.

**TABLE II**  
**CRITERIA USED TO IDENTIFY THE DISPLACEMENT OR DERANGEMENT OF EACH INJURED STRUCTURE**


Structure	Radiograph Used <sup>∗</sup>	Radiographic Criteria
Malleolus		
Medial malleolus	Anteroposterior	Fracture separation of at least 1 mm
Lateral malleolus	Anteroposterior and lateral	Fracture separation of at least 2 mm on the anteroposterior radiograph or at least 2 mm on the lateral radiograph
Posterior malleolus	Lateral	Fracture fragment includes at least 25 per cent of the tibial articular surface
Deltoid ligament	Anteroposterior	Medial clear space <sup>†</sup> at least 3 mm wide
Syndesmosis <sup>‡</sup>		Abnormal if syndesmosis A, B, or C is abnormal
Syndesmosis A	Anteroposterior	Tibiofibular clear space widened to 5 mm or more
Syndesmosis B	Anteroposterior	Tibiofibular overlap of less than 10 mm
Syndesmosis C	Mortise	Tibiofibular overlap of 1 mm or less


<sup>∗</sup> See text for definitions.

<sup>†</sup> The medial clear space was measured on the anteroposterior radiograph, as was done by Joy et al. and as is the preference at our institution.

<sup>‡</sup> See text and Fig. 2 for definitions and measurements of the syndesmoses.



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- Multimalleolar fractures, including the medial malleolus, have a worse prognosis than multimalleolar fractures without medial malleolar fractures.
  - Even after perfect internal fixation, the presence of a posterior fragment larger than one-third of the articular surface leads to a worse final result than a small unfixed fragment.

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- It is a general consensus that inadequate reduction and fixation of ankle fractures leads to poor clinical outcomes.
  - There are no well established criteria to evaluate the quality of surgical fracture fixation of ankle.
  - Paucity of literatures validating Pettrone's criteria to predict the functional outcome.
  - 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.

# STUDY DESIGN

- **Study type:** Retrospective cohort (Level of evidence III)
  - A prospective study design would have been better to validate the hypothesis.

Strength	Level	Design	Randomization	Control
High	Level 1	Randomized control trial (RCT)	Yes	Yes
		Meta-analysis of RCT with homogeneous results	No	
	Level 2	Prospective comparative study (therapeutic)	No	Yes
		Meta-analysis of Level 2 studies or Level 1 studies with inconsistent results	No	
	Level 3	Retrospective Cohort Study	No	Yes
		Case-control Study	No	Yes
		Meta-analysis of Level 3 studies	No	
	Level 4	Case Series	No	No
Low	Level 5	Case Report	No	No
		Expert Opinion	No	No
		Personal Observation	No	No

- **Study population:**

- UK
- 107 responders of 209
- Minimum sample size calculation not demonstrated
- Has not generalized the findings to the general population (not explicitly mentioned)

**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%



- **Participant allocation: Responders**

- Reduced cohort (68.9%)

- Malreduced cohort (31.1%):  $\geq 1$  of Pettrone criteria

- Fracture separation of medial and lateral malleolus  $\leq 1$  mm and  $\leq 2$  mm respectively
- Medial clear space  $\leq 3$  mm
- Tibiofibular space  $\leq 5$  mm, or tibiofibular overlap  $\geq 10$  mm on AP or  $\geq 1$  mm in mortise view

- No significant difference in demographics among the groups

- Comparable number of B2, B3 and C fractures but very low participant with B1 fractures in malreduced cohort (might be due to lower incidence of malreduction of B1 fractures)



- **Bias:**

- Possibility of cluster variance (multisite study)

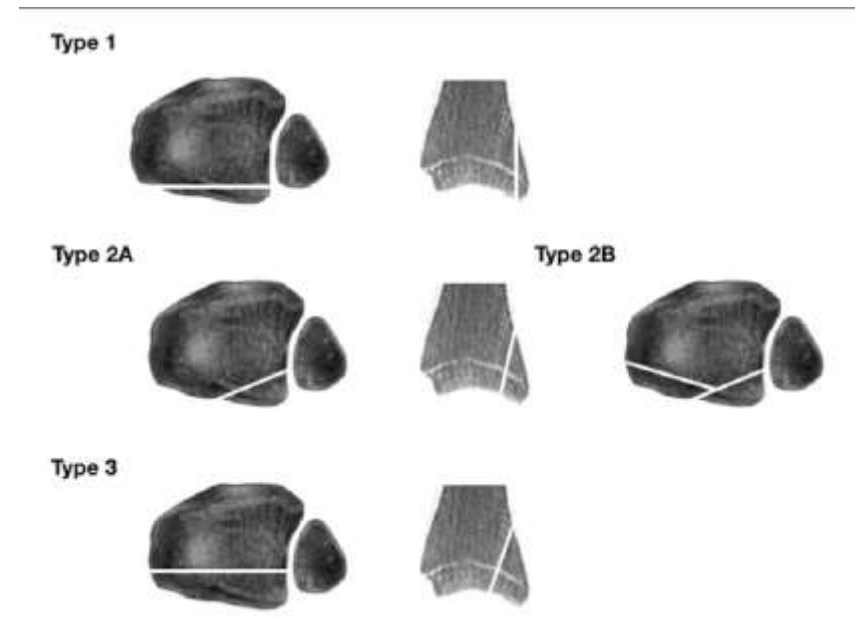
- Possibility of selection bias

- No randomization

- No blinding

- **Inclusion and Exclusion criteria:**


- 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
- Clearly stated
- No provision for homogenous distribution of posterior malleolar and medial malleolar fractures that have shown to influence the outcome



# METHOD

- Operative treatments were undertaken in two different hospitals and by surgeons of varying grade and experience (Risk of bias)
- 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 (Uniformity)
- Quality of anatomic reduction assessed using Pettrone criteria.
- Measurements using PACS (comparable to manual measurements from previous study).
- Minimum followup of 6 years (adequate duration to determine long-term functional outcome)



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- 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
  - P-value <0.05 considered significant
  - Statistical method appropriate
  - Power of the study has not been stated

# RESULTS

**Table 3**

Subgroup analysis of patients' functional outcomes using both Pettrone scores  $\geq 1$  and  $\geq 2$  for analysis, comparing with fracture types.

Fracture type	Pettrone score <1	Mean OMAS (range)	Pettrone score $\geq 1$	Mean OMAS (range)	Pettrone score $\geq 2$	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)

- Outcomes in trimalleolar group (B3) worse than bimalleolar fractures (B2 and C)
- B3 fractures are the only fracture where the functional scores do not significantly reduce when Pettrone scores of 1 are included in the analysis
- P-value not shown
- Between 0 and 1 Pettrone score: drop of ~ 5%
- Between 1 and 2 Pettrone score: drop of ~20% (talar-tibia congruency loss that may not occur until  $\geq 2$  criteria lost(i.e. both malleoli))

- Severity of malreduction revealed that Pettrone's value was inversely proportional to the OMAS (mentioned as significant finding)
- Individual P-value calculation not showed
- Age and gender vs functional outcome analysis has been omitted in the results
- NULL HYPOTHESIS rejected

**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

# DISCUSSION AND INTERPRETATION

## 3 Key Points:

- More complex ankle fractures are likely to be malreduced
- Fractures involving posterior malleolus have significantly worse outcomes even when reduced well
- The more radiographic criteria that are malreduced the lower the functional score of the patient

**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.”*

- The results support the conclusion of the study.
- Have not exceeded the scope of evidence base in the preceding literatures.
- Have well acknowledged the relevant literatures.
- The statistically significant findings are also clinically significant (non of the findings seem to be due to error and the clinical difference is significant as we move from Petron score 2 → 3 → 4)
  - **MICD:** OMAS difference >4.4 [Nilsson, G.M., Eneroth, M. & Ekdahl, C.S. The Swedish version of OMAS is a reliable and valid outcome measure for patients with ankle fractures. \*BMC Musculoskelet Disord\* \*\*14\*\*, 109 \(2013\). <https://doi.org/10.1186/1471-2474-14-109>](https://doi.org/10.1186/1471-2474-14-109)
  - **MCD:** OMAS difference >10 [Carter TH, Oliver WM, Graham C, Duckworth AD, White TO. Medial malleolus: Operative Or Non-operative \(MOON\) trial protocol - a prospective randomised controlled trial of operative versus non-operative management of associated medial malleolus fractures in unstable fractures of the ankle. \*Trials\*. 2019 Sep 12;20\(1\):565. doi: 10.1186/s13063-019-3642-7. PMID: 31514744; PMCID: PMC6739910.](https://doi.org/10.1186/s13063-019-3642-7)
- Have declared that there was “no conflict of interest”



- **Strengths:**

- One of the largest medium-long term studies encompassing all unstable ankle fractures in UK
- Initial audits in both centers had similar rates of mal-reduction as mentioned by the authors
- Used Pettrone criteria which have been used in few other literatures as well
- OMAS is a validated lower limb outcome score used in large trials concerning ankles
- Any disparity in Pettrone's score amongst observers was discussed and an agreement reached.

## Claimed as strengths:

- OMAS in reduced ankle fractures comparable to other studies in UK
  - Equivalent to UK based AIM trial with 6 months OMAS scores 64.5 for operatively treated ankle fractures and 66 in plaster treated ankle fractures (equivalent to B2 ankle fractures in this study) – **this study included only those >60 years and took OMAS at only 6 months** [Keene DJ, Mistry D, Nam J, Tutton E, Handley R, Morgan L, Roberts E, Gray B, Briggs A, Lall R, Chesser TJ, Pallister I, Lamb SE, Willett K. The Ankle Injury Management \(AIM\) trial: a pragmatic, multicentre, equivalence randomised controlled trial and economic evaluation comparing close contact casting with open surgical reduction and internal fixation in the treatment of unstable ankle fractures in patients aged over 60 years. Health Technol Assess. 2016 Oct;20\(75\):1-158. doi: 10.3310/hta20750. PMID: 27735787; PMCID: PMC5075748.](#)
  - Reported 6 month-5 year OMAS in Weber B (UK based study) for operatively treated ankle fractures was 97 [Van Schie-Van der Weert EM, Van Lieshout EM, De Vries MR, Van der Elst M, Schepers T. Determinants of outcome in operatively and non-operatively treated Weber-B ankle fractures. Arch Orthop Trauma Surg. 2012 Feb;132\(2\):257-63. doi: 10.1007/s00402-011-1397-z. Epub 2011 Sep 30. PMID: 21959696; PMCID: PMC3261401.](#)
  - Reported 2 year OMAS in another study (Germany) in type B ankle fracture was 90 (Without syndesmotic rupture) and 84 (With syndesmotic rupture) [Keene DJ, Mistry D, Nam J, Tutton E, Handley R, Morgan L, Roberts E, Gray B, Briggs A, Lall R, Chesser TJ, Pallister I, Lamb SE, Willett K. The Ankle Injury Management \(AIM\) trial: a pragmatic, multicentre, equivalence randomised controlled trial and economic evaluation comparing close contact casting with open surgical reduction and internal fixation in the treatment of unstable ankle fractures in patients aged over 60 years. Health Technol Assess. 2016 Oct;20\(75\):1-158. doi: 10.3310/hta20750. PMID: 27735787; PMCID: PMC5075748.](#)

- Overall malreduction incidence was 33% (claimed as comparable to UK study with 54% malreduction, hence not an outlier – but this was among 5.5% of those who came for re-operation which is not the same) [Walsh AS, Sinclair V, Watmough P, Henderson AA. Ankle fractures: Getting it right first time. Foot \(Edinb\). 2018 Mar;34:48-52. doi: 10.1016/j.foot.2017.11.013. Epub 2017 Nov 28. PMID: 29287221.](#)
- Reported malreduction rates in a previous literature range from 16-52%) [Vetter, S.Y., Beisemann, N., Keil, H. et al. Comparison of three different reduction methods of the ankle mortise in unstable syndesmotic injuries. Sci Rep 9, 15445 \(2019\). https://doi.org/10.1038/s41598-019-51988-y](#)
- A study has reported incidence of only 1.6% (79/5071) of malreduction [Ovaska MT, Mäkinen TJ, Madanat R, Kiljunen V, Lindahl J. A comprehensive analysis of patients with malreduced ankle fractures undergoing re-operation. Int Orthop. 2014 Jan;38\(1\):83-8. doi: 10.1007/s00264-013-2168-y. Epub 2013 Nov 20. PMID: 24252973; PMCID: PMC3890139.](#)
- The sample may not be representative of UK or the world





- **Limitations:**

- Retrospective study in 2 different centers (probability of cluster variance and selection bias)
- Traditional methods apparent within this study being superseded with new methods (e.g. non-weight bearing mobilization)
- Poor response rate of 52%
- fibular malreduction is likely to not be picked up with simple radiology


# CLINICAL CONTEXT

- This has showed that adequacy of anatomic reduction has influence on mid-long term functional outcome in ankle fractures
- We can use Pettrone's criteria to evaluate adequacy of anatomic reduction and predict the functional outcome in ORIF of ankle fractures (a study in Nepalese or Indian context would be better)
- Each ankle fracture should be reviewed on a case by case basis
- Better outcome may be expected with experienced surgeons operating complex fractures and those with posterior malleolar fractures
- A prospective study would help to minimize bias and validate the findings

# QUESTIONS FROM THIS STUDY: HOW CAN OUTCOME BE IMPROVED IN POSTERIOR MALLEOLAR FRACTURES?

TABLE I - Posterior Malleolar Treatment Algorithm as Dictated by the Mason Classification 

Classification	Treatment	Surgical Approach to Posterior Malleolus
1	Syndesmotic fixation	
2A	Open reduction and internal fixation	Posterolateral
2B	Open reduction and internal fixation, posteromedial fragment first	Posteromedial or posterolateral and medial posteromedial
3	Open reduction and internal fixation	Posteromedial

TABLE II - Functional Results of Posterior Malleolar Fixation Techniques, Comparing the Current Study with Our Previous Multicenter Ankle Fracture Outcome Study 

Study	No. of Patients	Age* (yr)	Sex (M:F)	Olerud-Molander Ankle Score† (points)
Roberts <sup>11</sup>	16	52.9 (20 to 69) <sup>‡</sup>	3:13 <sup>‡</sup>	54.3 (33.9 to 74.7)
Current study	50	46.8 (21 to 87) <sup>‡</sup>	22:28 <sup>‡</sup>	74.1 (69.1 to 79.1)

\*The values are given as the mean, with the range in parentheses.

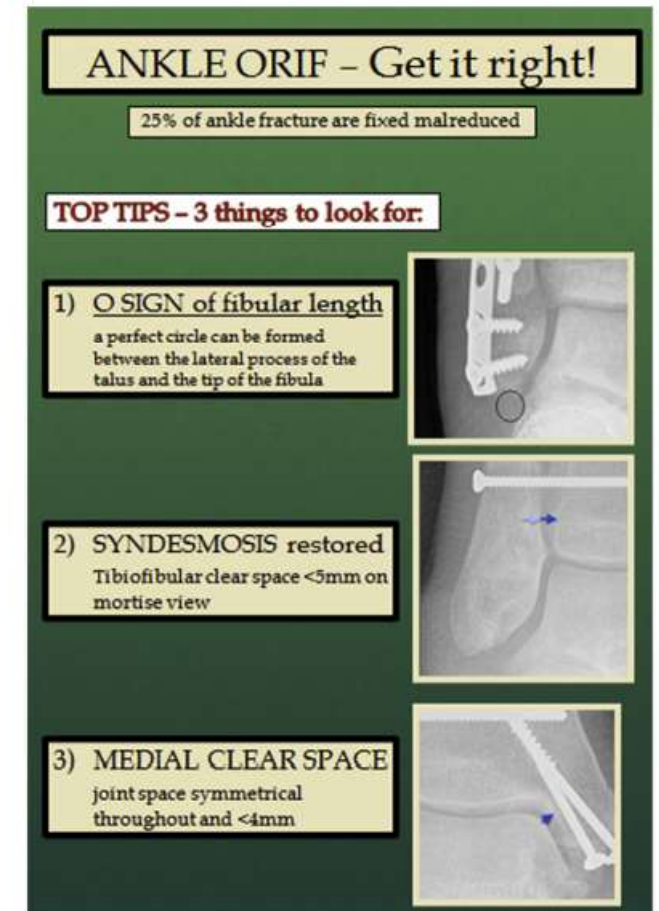
†The values are given as the mean, with the 95% CI in parentheses.

‡The comparison of the means was significant at  $p < 0.05$ .

# QUESTIONS FROM THIS STUDY: HOW CAN WE REDUCE THE INCIDENCE OF MALREDUCTION OF ANKLE FRACTURES?

- **Intervention:** Educational intervention and dissemination of poster infographics describing three parameters from Pettrone's criteria for radiological assessment of anatomic reduction of the ankle fractures during surgical fixation
- 25% malreduction vs 9.4% malreduction ( $p = 0.015$ )

Kheiran A, Roberts V, Rana B, Mangwani J. Audit changes practice-a simple education intervention can lead to better outcome in ankle fracture surgery. J Clin Orthop Trauma. 2020 May-Jun;11(3):422-425. doi: 10.1016/j.jcot.2020.03.022. Epub 2020 Apr 8. PMID: 32405202; PMCID: PMC7211824.



**Picture 1.** Infographic poster describing the result of phase 1 audit and 3 steps (top tips) to guide adequate anatomical reduction.

## FURTHER READING

- **Appraised study:** Roberts V, Mason LW, Harrison E, Molloy AP, Mangwani J. Does functional outcome depend on the quality of the fracture fixation? Mid to long term outcomes of ankle fractures at two university teaching hospitals. *Foot Ankle Surg.* 2019 Aug;25(4):538-541. doi: 10.1016/j.fas.2018.04.008. Epub 2018 May 8. PMID: 30321948.
- **Original Pettrone Criteria:** Pettrone FA, Gail M, Pee D, Fitzpatrick T, Van Herpe LB. Quantitative criteria for prediction of the results after displaced fracture of the ankle. *J Bone Joint Surg Am.* 1983;65(5):667-677.
- **How to prepare for and present a journal club:** Bowles P, Marenah K, Ricketts D, Rogers B. How to prepare for and present at a journal club. *Br J Hosp Med (Lond).* 2013 Oct;74 Suppl 10:C150-2. PMID: 24145599.

Thank

you!

