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Research Article

Plain Radiographic Interpretation in Trimalleolar Ankle Fracture Poorly Assesses Screw Misplacement at the Fibular Notch

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Abstract: Intra-articular hardware penetration and cartilage damage are potential disadvantages related to screw fixation in proximity to joint surfaces, reducing the chances of successful outcome. Intraoperative recognition of screw protrusion may be difficult due to the challenge of adequate interpretation of specific radiographic views. We therefore conducted the present study to investigate the accuracy of intraoperative radiographic images. The materials and methods in dis study the Data for the present double blind study were collected prospectively and evaluated retrospectively, including a total of 29 patients with ankle fractures over an inclusion period of 18 months. All patients underwent surgery for an ankle fracture with a posterior wedge, fixated with screws. X-rays and CT scans (lateral and Mortise views) were evaluated by different independent physicians. In results there was a poor level of agreement between x-rays and CT scans. 29 patients with ankle fractures surgery for posterior wedge fixation were performed. Intraoperative x-rays showed a satisfactory screw placement. CT scans of the ankle joint, performed afterwards, revealed 10 (34.48%) out of 29 patients with intra-articular hardware protrusion at the tibia-fibular notch. Mean protrusion of the screw was 4.36 mm (range 2.6 to 7.6). Time interval for implant removal (IR) in those 10 patients showed a range from 2 to 12 months, in five cases no IR was performed at the end of follow up. In conclusion Standard radiographic views are not reliable for intraoperative diagnosis of articular hardware protrusion at the fibular notch. Therefore computer tomography seems to be the only logical, albeit expensive alternative, to exclude intra-articular hardware protrusion.
Keywords: ankle fracture, x-ray, screw protrusion, accuracy, fibular notch

INTRODUCTION

Ankle fractures are among the most common injuries to the lower limb and the most common operatively treated skeletal injuries[1-6]. Posterior malleolar fractures may occur with trimalleolar ankle fractures or alone, accompanying 14% to 44% of all ankle fractures[7].

Generally, posterior malleolar fragments are either fixed with percutaneous anterior to posterior screws or through a posterolateral approach using screws and / or a buttress plate[3,8-12]. Fixation with A to P screws relies on reduction of the posterior malleolus through ligamentotaxis of the posterior inferior tibio-fibular ligament with reduction of the fibula[10].The importance of anatomic reduction and rigid internal fixation in displaced ankle fractures has been emphasized in order to achieve rapid return of normal function and to reduce complications[9,13].

However, intra-articular hardware penetration and cartilage damage are potential disadvantages related to screw fixation in proximity to joint surfaces, reducing the chances of successful outcome[9,13]. When it comes to intraoperative radiographic evaluations mandatory to assess correct fracture reposition and hardware placement, controversial opinions exist[9,14-21].Anterior, lateral and Mortise radiographs were long be recommended as gold standard, but recent publications question the benefit and necessity, or radiographs et all. [9, 22-25]. Intraoperative recognition of misplaced screws may be difficult due to the challenge of adequate interpretation of specific radiographic views[9].

In 1984, Morrissey discussed radiographic hardware placement and concluded that should the hardware appear intra-articular in any view then it is indeed intra-articular[26,27]. Romiti *et al.;* published a paper investigating hardware placement in the medial malleolus[27]. They concluded, that when hardware is placed close to a concave surface, if any image shows the hardware to be extra-articular then it is extra-articular[27]. In the 21st century, a statement like this cannot be estimated as evidence based or at least as satisfactory. After searching the current literature, the

findings regarding this topic were disappointing. We therefore conducted the present study to investigate the accuracy of intraoperative radiographic images when it comes to hardware placement in ankle fractures with a posterior wedge.

MATERIAL AND METHODS

Data for the present double blind study were collected prospectively and evaluated retrospectively. Our study was performed by the standards of International Conference of Harmonization (ICH) and Good Clinical Practice (GCP) after permission of the internal revision board. During a study period of 18 months, a total of 29 patients with 29 ankle fractures were included. All patients were admitted to our emergency room (ER) with a diagnosed ankle fracture (OTA 44A, 44B, and 44C) in accordance with the Orthopedic Trauma Association (OTA) classification[28].Fractures caused by motor vehicle accidents, falls, and direct impact were included, pathologic fractures were not included into the present study. All data were collected from electronically patients records due to clinical treatment and no study only procedures were performed. (Table1).

In all patients, surgery was performed for fracture stabilization. The posterior wedge was stabilized with a screw or more from an anterior to posterior direction. Radiographs were taken in Mortise and lateral view[24,29,30].Intraoperative x-rays were judged by the attending, performing the surgical procedure. At grand rounds on the following day the same x-rays were evaluated by the chief in command for the trauma team on call for the next 24 hours. Independent from their judgment, a CT scan was performed and evaluated by an attending from the Department of Radiology on duty. An independent member from the trauma team, not involved in the patients treatment also evaluated the x-rays and CT scan not knowing the previous results. We also evaluated the overall outcome, pain and range of motion in the ankle joint. For final evaluation all results and patient data were collected in a data bank to enable statistical calculations. For statistical analyses we used the SPSS software package, version 14 (SPSS, Chicago, Ill., USA). Discrete variables were presented as counts and percentages, continuous variables as median and range unless otherwise stated.

RESULTS

We enrolled 29 patients with a mean age of 50 years (range 23 to 88). 72% were females, and 28% were male. Follow up was 9.4 months (range 1 to 28 months). Type of fracture distribution according to OTA classification was as following: 44A.3 (n=3), 44B.2 (n=2), 44B.3 (n=16), 44C.1 (n=1), 44C.2 (n=5) and 44C.3 (n=2).

Radiographs performed in the operation theatre showed a correct placement on the lateral and Mortise view, a judgement all involved observers agreed to. When it comes to the results of the CT scan, the finding was surprising. There was a poor level of agreement between x-rays and CT scans.CT scans of the ankle joint revealed 10 (34.48%) out of 29 patients with intra-articular hardware protrusion at the tibia-fibular notch ($p<0.05$). Mean protrusion of the screw was 4.36 mm (range 2.6 to 7.6). Time interval for implant removal (IR) in those 10 patients showed a range from 2 to 12 months, in 5 cases no IR was performed at the end of follow up, and range of motion (ROM) for the ankle joint was between 0-0-45 and 30-0-40. Pain in the intra-articular sub-group as reported by the patients at the last follow up visit was graded non-in 6 cases, mild in 3 cases and severe in one case. (Table 1 and 2, Figure 1 and 2). In the extra-articular group, time interval for IR showed a range from 0 to 22 months; in 9 cases no IR was performed. ROM was between 5-0-40 and 30-0-60, and pain was described as non in 15 patients, and mild in 4 cases.

Fig-1

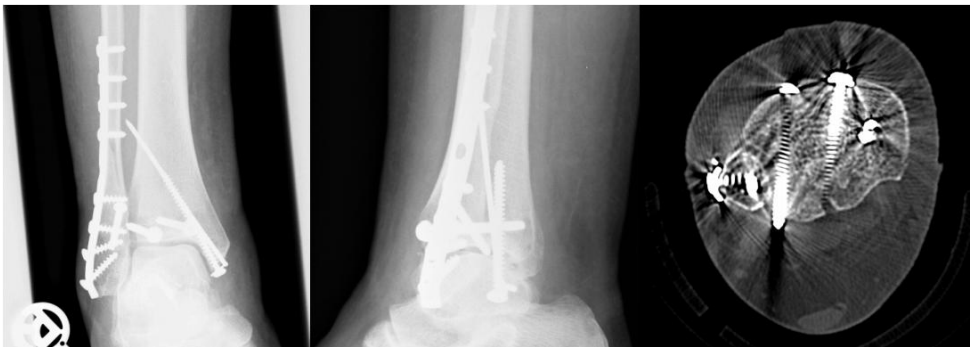

Fig-2

Table-1: General patients characteristics

	n	%
Total patients	29	100
Gender		
Male	8	28
Female	21	72
Age	50	23-88ǂ
Follow up*	9.4	1-28
Type of fracture		
44A.3	3	10.34
44B.2	2	6.89
44B.3	16	55.17
44C.1	1	1.1
44C.2	5	17.24
44C.3	2	6.89
CT findings		
Extraarticular	19	65.51
Extraarticular	10	34.48
Pain		
Extraarticular		
Non	15	51.72
Mild	4	13.79
Severe	0	
Intraarticular		
Non	6	20.68
Mild	3	10.34
Severe	1	3.44

ǂResults are range in years
*in months
**IR=implant removal in months after surgery

Table-2: Intraarticular screw position

Study subject	Fracture*	Position	Protrusion**	IR intervall***	Pain	ROM	FU‡
#1	44B.3	fibular notch	4.9	non	non	30-0-30	1
#2	44C.1	fibular notch	4.1	12	non	10-0-30	13
#3	44B.3	fibular notch	3.4	non	mild	5-0-20	7
#4	44B.3	fibular notch	7.6	8	severe	0-0-45	19
#5	44B.3	fibular notch	3.9	non	mild	20-0-20	4
#6	44B.3	fibular notch	4.4	2	non	20-0-40	4
#7	44C.1	fibular notch	4.4	non	mild	20-0-20	1
#8	44B.3	fibular notch	2.6	2	non	30-0-40	8
#9	44B.3	fibular notch	4.6	non	non	10-0-20	5
#10	44C.3	fibular notch	3.7	7	non	30-0-40	7

*according to OTA classification
** in milimeter
***IR=implant removal in months after surgery
‡follow up in month

DISCUSSION

The study concept aimed to investigate the diagnostic precision of standardized radiographic ankle views to determine the accuracy of diagnosis for intra-articular hardware placement in ankle fractures. The therapeutic decision in ankle fractures is based primarily on simple and well-defined radiographic evaluations, which include AP, Mortise and lateral views[9].The concept that plain radiographic evaluation may not consistently reveal articular malreduction is not new to orthopedic trauma surgeons[24]. However little has been said about intraoperative evaluation in these situations, either in relation to the quality of the reduction or in relation to the intra-articular penetration of the implants used to fix these fractures[9,25]. The available literature mostly used retrospective designs, reduced number of cases, lack of characterization in the evaluation of the images and the absence of statistical analysis[9,19,31]. Several studies investigated the accuracy of x-rays for evaluation of intra-articular hardware material to fix medial malleolar fractures, but for screw fixation of the posterior wedge no data were found [9, 19, 31].

Based on the finding by Gourineni *et al.;* published in 1999, the Mortise view can be seen as superior to the AP view to evaluate a possible hardware penetration into the fibular notch[19, 22].When hardware protrusion is eminent, the position of the outer tip, if it is in the subchondral cortical bone or cartilage may affect the appearance on the x-ray[27]. Giordano concluded in his study that a low level of intra and interobserver agreement with relation to the diagnosis of articular penetration by screw used to fix the medial malleolar fractures, both in terms of the AP and mortise views[9]. In an observer reliability study in ankle fractures, a substantial portion of measurement on the radiographs without fracture fell outside the range of normal parameters, raising the question concerning the validity of x-rays for normal ankle anatomy[14]. This is in contrast to our results were all observers agreed to the correct screw placement on the x-rays. Surprisingly the results of the CT scans showed a quite clear protrusion of hardware at the fibular notch. Due to the fact of a double blind study design, we do not think that our results can only be related to the observer reliability. In our opinion, the interpretation of a plain x-ray´s, even for experienced surgeons, has its limits, a fact that is supported by findings in the literature [9, 14, 22, 23]. This is in contrast to a published study by Musgrave, stating that a fracture reduction and fixation can be assessed adequately with mortise and lateral views[25].

In the present study, we observed a low level of accuracy with relation to the diagnosis of articular penetration at the fibula notch for screw fixation of the posterior wedge in ankle fractures using Mortise and lateral views. The evaluation of 29 patients allows us to suggest that standard radiographic views are not reliable for intraoperative diagnosis of articular protrusion at the fibular notch. Therefore we recommend to spare the danger zone, the lateral third of the distal tibia, for screw fixation of the posterior wedge. When the invasion of the medial aspect of the tibia (fibular notch) is suspected, the best to do is to replace the screw. CT scans after screw fixation of the posterior wedge are the only reliable diagnosis to exclude intra-articular hardware protrusion.

There are several limitations of the current study we have to mention in relation to our results. The first and most gravid is the small number of cases. Our study population represents a wide range of age and heterogenity in cause of injury and fracture type. Several surgeons, performing surgeries and reviewing the x-rays might also influence our results. With our study concept we tried to keep a possible observer influence to a minimum. The generalizability of our results beyond level I trauma centre is uncertain. Finally the results are based on out-comes during the first months after injury, a period in which patients have not

yet completely recovered. Despite those limitations and the lack of data related to this topic, we believe that the results justify our conclusion, even if further prospective clinical trials have to be conducted to approve our findings.

CONCLUSION

Standard radiographic views are not reliable for intraoperative diagnosis of articular hardware protrusion at the fibular notch. Therefore computer tomography seems to be the only logical, albeit expensive alternative, to exclude intra-articular hardware protrusion.

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