A comprehensive analysis of patients with malreduced ankle fractures undergoing re-operation

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Abstract

Purpose The present study aimed to determine the most common surgical errors resulting in early re-operation following ankle fracture surgery.

Methods We performed a chart review to determine the most common types of malreductions that led to early re-operation following ankle fracture surgery. From 2002 to 2011, we identified 5,123 consecutive ankle fracture operations in 5,071 patients. Seventy-nine patients (1.6 %) which underwent re-operation due to malreduction detected in postoperative radiographs. These patients were compared with an equal number of age- and sex-matched controls which did not need further surgery.

Results The most common indication for re-operation was syndesmotic malreduction (47 of 79 patients, 59 %). Four main types of errors related to syndesmotic reduction or fixation were identified, with the most common being fibular malpositioning within the tibiofibular incisura. Other indications for re-operation were fibular shortening and malreduction of the medial malleolus. Fracture dislocation, fracture type, posterior malleolar fracture, associated medial malleolar fracture, duration of index surgery, and fixation of an associated medial malleolar fracture with other than two parallel screws were also associated with re-operation. Correction of the malreduction was successfully achieved in the majority (84 %) of cases needing further surgery.

Conclusion Early re-operation after ankle fracture surgery was most commonly caused by errors related to syndesmotic reduction or failure to restore fibular length. In the majority of cases, postoperative malreduction was successfully corrected in the acute setting.

Keywords Ankle fracture · Malreduction · Fibular length · Re-operation

Introduction

Ankle fractures, varying in severity from stable lateral malleolus fractures to open fracture dislocations with comminution, are among the most common fractures requiring surgical treatment. It was recently shown that the incidence of more complex fracture patterns is increasing [1]. The overall aim of surgical treatment of an ankle fracture is to restore the anatomical congruity of the ankle mortise. Failure to reproduce the anatomic relationship of the distal tibia and fibula leads to altered loading of the tibiotalar joint [2–4] and subsequent post-traumatic arthritis [5–8] with poor functional outcomes [9–13].

For many reasons, anatomic fracture reduction may not be achieved. Fracture comminution, poor bone quality, and technical errors may predispose a patient to residual displacement following ankle fracture surgery [14, 15]. Although there is a large body of literature about ankle fractures, no studies have examined the true frequency or the most common types of postoperative malreduction necessitating early re-operation.

The present study aimed to identify the most common technical errors resulting in early re-operation following ankle fracture surgery at a level-I trauma centre. We hypothesized that more complex fracture patterns such as trimalleolar or Weber type C fractures would be associated with postoperative malreduction, and that syndesmotic malreduction would be the predominant indication for re-operation.

Materials and methods

We performed a chart review of all ankle fractures that were surgically treated at a level-I trauma centre from January 2002

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through December 2011. All patients who had undergone an ankle fracture were identified by querying the hospital surgical procedure database for diagnoses coded using the International Classification of Diseases, Tenth Revision (ICD-10) as fibular fracture (S82.4), medial malleolar fracture (S82.5), lateral malleolar fracture (S82.6), bimalleolar or trimalleolar fracture (S82.8), and with the procedure code for internal fixation of ankle fractures. Approval from our institutional review board was obtained prior to the beginning of the study. Eligible operations were restricted to those performed primarily at our institution, and in patients 18 years of age or older. We identified 5,123 ankle fracture operations in 5,071 patients, performed by 151 treating surgeons, including residents and specialists. Surgeries were performed based on AO principles, with tourniquet application depending on the personal preferences of the treating surgeon.

Fluoroscopic images were obtained in the operating room before wound closure. Postoperatively, a cast was applied to all patients. On day one, radiographs (AP, mortise, and lateral view) were obtained before weight bearing was allowed. We identified 79 patients (1.6 %) from our hospital surgical procedure database who underwent further surgery due to a fracture malreduction observed in postoperative radiographs. At our institution the criteria for early re-operation are a residual fracture displacement of more than 2 mm and/or an incongruent ankle mortise. As controls, from the same cohort we randomly selected 79 age- and sex-matched patients who did not undergo re-operation.

Medical, operative, and radiological records were reviewed of all 158 patients (79 cases and 79 controls) to identify potential patient-, surgeon-, and surgery-related factors for re-operation. The charts and radiographs of each patient were scrutinized, and records from other medical specialties were also assessed. We collected demographic data and information about the possible co-morbidities of the patients (diabetes, systemic vascular disease, alcohol abuse or tobacco use), the presence of a fracture-dislocation or an open fracture, and the fracture type (Danis-Weber classification, uni-, bi-, or trimalleolar fracture). We recorded the numbers of patients with multiple (two or more) comorbidities, and the number with a posterior malleolar fracture, an associated medial malleolar fracture, or a Chaput-Tillaux fragment. The time of day of surgery (08–16, 16–24, or 00–08 hours), duration of surgery, and surgeon experience (resident operating without supervision of a specialist, resident together with specialist, or specialist) were collected, and the fixation method of each malleolus and syndesmotomic screw application was noted.

All radiographs of the re-operated and control patients were analysed independently by two orthopaedic surgeons to categorize the surgical errors; discrepancies were resolved by consensus. Postoperative radiographs of both groups were assessed for ankle joint congruency (talar shift or talar tilt), possible fracture malreduction of each malleolus (in mm), fibular shortening [16], medial clear space widening (> 4 mm in mortise

view) [17], tibiofibular clear space (TFCS; the distance between the medial border of the fibula and the floor of the tibiofibular incisura on the AP view at 10 mm above the ankle joint level) [18], and syndesmotomic screw positioning. Computed tomography (CT) images were analyzed if available, with attention paid to the fibular positioning in the tibiofibular incisura at 10 mm above the joint line in the axial CT scan. A postoperative CT scan was available for 40 of 79 (51 %) patients.

Surgical errors were classified according to the anatomical site of malreduction: fibula, medial malleolus, posterior malleolus, Chaput-Tillaux fragment, and syndesmosis. A residual fracture displacement of more than 2 mm was considered malreduction. Problems related to syndesmotomic reduction or fixation were further divided into four categories: malpositioning of the fibula in the tibiofibular incisura with a syndesmotomic screw, tibiofibular widening (TFCS > 6 mm) [19], positioning of a syndesmotomic screw posterior to the posterior margin of the tibia (missed), and syndesmotomic transfixation in the presence of a stable syndesmosis. A syndesmotomic screw was considered unnecessary if lateral and external rotation stress tests were negative after proper reduction and fixation of the fracture at the time of reoperation [20]. The radiological outcome of the revision surgery was recorded, and any persistent malreduction was noted.

The data were statistically analysed by an independent biostatistician, and SAS statistical software version 9.2 (SAS Institute INC, Cary, NC, USA) was used in the analysis. The differences in fracture and surgical characteristics between reoperated and control patients were tested with McNemar's test (dichotomous variables), the test of marginal homogeneity (polytomous variables), and the Wilcoxon signed-rank test (continuous variables). A logistic regression model with generalized estimating equations was used to compare associated medial malleolar fixation with other than two screws and syndesmotomic reduction techniques between re-operated and control patients. P values of < 0.05 were considered statistically significant.

Results

Seventy-nine of 5,071 (1.6 %) patients underwent revision surgery on within the first postoperative week due to malreduction. The incidence of re-operation was 1.5 % and 1.6 % during the time period of 2002–2006 and 2007–2011, respectively. The mean age of these patients was 44 years (range, 18–80), and 49 % were women. The right ankle was affected in 53 % of the cases. In four patients, a locking plate was used. There were no differences between the groups regarding diabetes, tobacco use, peripheral vascular disease, or alcohol abuse. Multiple comorbidities were present in eight of 79 (10 %) re-operated patients and 11 of 79 (14 %) control patients. Table 1 presents fracture characteristics, and Table 2 presents surgical characteristics.

Table 1 Fracture characteristics of the reoperated patients and controls

Characteristics	Number of patients (%) with reoperation (n=79)	Number of controls (%) (n=79)	p value
Fracture-dislocation	42 (53)	27 (34)	0.011
Open fracture	6 (8)	1 (1)	0.059
Fracture type			0.001
Unimalleolar	12 (15)	32 (41)	
Bimalleolar	22 (28)	18 (23)	
Trimalleolar	45 (57)	29 (37)	
Weber classification			0.157
A	2 (3)	2 (3)	
B	42 (55)	52 (69)	
C	32 (42)	21 (28)	
Posterior malleolar fracture	58 (73)	41 (52)	0.005
Associated medial malleolar fracture	55 (70)	35 (44)	0.001
Chaput-Tillaux fragment	4 (5)	1 (1)	0.180

The indications for re-operation were classified according to the anatomic sites of malreduction (Table 3 and Fig. 1). Thirty-six of the 79 (46 %) reoperated patients had a combination of at least two different malreductions, most commonly of both the fibula and syndesmosis (16 of 79 patients, 20 %). Among the patients with an isolated surgical error, syndesmotic malreduction was predominant, occurring in 19 of 43 (44 %) patients. In 54 of 79 (68 %) patients, the ankle joint was not congruent.

We identified four main types of errors related to syndesmotic reduction or fixation, with malpositioning of the fibula in the tibiofibular incisura being the most common

Table 3 Indications for reoperation (n=79)

Anatomic site of malreduction	n (%)
Syndesmosis	47 (59)
Fibula ^a	30 (38)
Medial malleolus ^b	30 (38)
Posterior malleolus	12 (15)
Chaput-Tillaux fragment	4 (5)

^a Two patients with articular screw penetration

^b Four patients with articular screw penetration and two patients with a missed fracture

error (Table 4). Of the 24 patients with fibular malpositioning in the tibiofibular incisura, a CT scan was available for further analysis for 14 patients. A posterior malpositioning was observed in nine (64 %) of these patients. Of the 30 patients with fibular malreduction, 20 (67 %) presented shortening, and in 17 of these 20 (85 %) patients, fibular shortening was associated with malreduction at another anatomic site. Conversely, malreduction of the medial malleolus often presented as an isolated indication for reoperation (16 of all 30 patients with medial malleolus malreduction, 53 %). In all four patients with a Chaput-Tillaux fragment, re-operation was due to a primarily missed fracture. Correction of the malreduction was achieved in the majority of re-operated cases (66 of 79 patients, 84 %). The rate of deep infection did not significantly differ between re-operated patients and controls (6 % vs. 3 %; $p=0.257$).

In 13 of the 79 patients for whom malreduction could not be corrected, a trimalleolar fracture was the most common type (69 %). None of these patients had a unimalleolar fracture. The most common persistent malreduction was related to the medial malleolus (seven of 13 patients). Ten of the 13 patients with

Table 2 Surgical characteristics of the reoperated patients and controls

Characteristics	Number of patients (%) with reoperation (n=79)	Number of controls (%) (n=79)	p value
Surgeon at the index surgery			0.376
Resident	57 (72)	52 (66)	
Specialist	20 (25)	24 (30)	
Resident and specialist	2 (3)	3 (4)	
The time of day when index surgery was performed			0.362
08:00–16:00 (daytime)	36 (46)	43 (54)	
16:00–24:00 (evening)	36 (46)	29 (37)	
24:00–08:00 (night)	7 (9)	7 (9)	
Duration of index surgery (minutes) ^a	82 (19–288)	61 (14–229)	0.001
Associated medial malleolar fracture fixation with other than two parallel screws ^b	18/55 (33)	5/35 (14)	0.045
Use of syndesmotic screw	41 (52)	32 (41)	0.170
Syndesmotic reduction technique			0.974
Clamp	33/41 (80)	26/32 (81)	
Direct visualisation	8/41 (20)	6/32 (19)	

^a Values given as mean (range)

^b Single screw, K-wire(s), cerclage, suture

Fig. 1 Three of the most common errors in reoperated patients. **a** Posterior positioning of the fibula in the tibiofibular incisura. **b** Fibular shortening associated with syndesmotic malreduction. **c** Malreduction of medial malleolus

unsuccessful correction showed posttraumatic talocrural osteoarthritis in the last available follow-up radiographs.

Discussion

Data on failed fracture surgery is limited and often underreported. To our knowledge, the present study is the first to focus on determining the most common surgical errors resulting in early re-operation after ankle fracture surgery. Our results showed that problems related to syndesmotic reduction were the most important indications for early re-operation, and that more severe fracture patterns were associated with postoperative malreduction. Furthermore, we found that fibular shortening can initiate an insidious cascade of events leading to a combination of surgical errors. In the majority of re-operations, the malreduction was corrected and the incidence of deep infection was not increased.

The necessity for syndesmotic transfixation does not reliably correlate with the level of the fibular fracture [21, 22]; therefore, intra-operative stress testing is essential for diagnosing syndesmotic instability [20, 23]. It has recently been demonstrated that proper reduction of syndesmosis is technically more demanding than previously thought [11, 24–27], and newer flexible implants have been introduced to syndesmotic transfixation [28]. Although shortening and posterior displacement of the distal fibula can often be seen by

fluoroscopic imaging, lateral translation and rotational malalignment of the fibula at the level of the syndesmosis may go underdetected [29]. This is reflected in our findings, since the majority of re-operated cases were due to syndesmotic malreduction. Furthermore, the most common error was fibular malpositioning in the tibiofibular incisura. This is in line with a previous study cautioning that the syndesmotic screw may be a factor leading to syndesmotic malpositioning [27]. Miller et al. showed that direct visualization of the syndesmosis decreased the rate of malreductions and reductions were further improved with additional posterior malleolar fixation [25]. Interestingly, there is large physiological variation in syndesmosis anatomy regarding the degree of incisura concavity and the position of the fibula within it [11, 24, 26, 30]. In the present study, posterior malpositioning of the fibula in the tibiofibular incisura was more common than anterior displacement.

Studies have shown that anatomic syndesmosis reduction cannot be achieved if the fibula is malreduced [6]. Additionally, a malpositioned syndesmotic screw causes fibular torsional asymmetry [27] and joint incongruence, leading to pathological load distribution [31]. We found that the most commonly combined surgical errors were malreductions of the fibula and syndesmosis. Typically, the fibula was shortened, resulting in erroneous syndesmotic transfixation. Some authors have reported good results with the fixation of more simple fibular fractures with intramedullary implants [32, 33]. However, it is known that malunion of the fibula is the most common and most difficult malunion to reconstruct [34]. Therefore, particular attention must be paid to fibular length assessment in the operative treatment of this common fracture, especially in patients with more complex fracture patterns.

Infection and wound complications are significant concerns when deciding whether to reoperate. Surgical site infection is one of the most common complications following ankle fracture surgery [35, 36], and causes considerable morbidity [37]. Many factors, such as diabetes, smoking, and prolonged operative time predispose a patient to postoperative infection

Table 4 Errors related to syndesmotic reduction or fixation (n=47)

Error	n (%)
Malpositioning of the fibula in the tibiofibular incisura	24 (51)
Tibiofibular widening	13 (28)
Posterior positioning of screw (missed)	6 (13)
Syndesmotic transfixation in the presence of a stable syndesmosis	4 (8)

[38]. There is some evidence that previous ankle surgery increases the risk of infection after reconstructive procedures [39], most likely due to an impaired soft-tissue mantle and compromised circulation. Interestingly, we did not find an increased incidence of infection in patients undergoing revision surgery within the first postoperative week. It is possible that the aforementioned detrimental effects of prior surgery had not yet fully manifested at this early point.

It has been previously shown that an increasing number of anatomic sites showing residual displacement is associated with poor outcome [10]. Furthermore, fracture type [14], associated medial malleolar fracture [15], posterior malleolar fracture [13], or fracture-dislocation [15] are all risk factors for post-traumatic osteoarthritis. Our study seems to clarify this sequence of events, since these same factors were also associated with postoperative malreduction. Since more complex fractures, such as trimalleolar fractures and fracture-dislocations, are more prone to postoperative malreduction, the treatment of these fractures should probably be left to surgeons with greater expertise. Interestingly, we found that the duration of index surgery and an associated medial malleolar fixation with other than two screws were also associated with malreduction.

The study had some limitations. Postoperative CT scans are not routinely obtained in our institution following ankle fracture surgery, and therefore CT scans were not available for all post surgical patients. Hence, we acknowledge that we may have missed some syndesmotic malreductions [40]. Another limitation is that the study design did not enable standardised outcome measurements. It should be noted that the mean age of the re-operated patients was somewhat lower than that previously reported in a recent epidemiological study evaluating ankle fracture incidence [1]. It is possible that some older patients with malreduced fractures were not revised due to their general health condition; however, we found no differences in the prevalence of multiple comorbidities between the reoperated and control patients. Since an age- and sex-matched study design was used we could not assess the effect of these variables on fracture patterns. The strengths of this study include a large number of consecutive patients treated at a single institution. Furthermore, the number of treating surgeons increases the generalizability of the present results. Another strength is that radiographs were evaluated using well-defined criteria, although one could argue that two-dimensional measurements from radiographs may underestimate true three-dimensional displacement. To our knowledge, this is the most comprehensive analysis of early re-operations following ankle fracture surgery.

The present study identified the most common technical errors related to ankle fracture surgery. Restoring fibular length and anatomic syndesmotic positioning are key elements in achieving a congruent ankle joint. Our findings reveal that most of these errors could be successfully corrected

in the acute setting. Recognizing these pitfalls in the operative treatment of this common fracture is essential.

Conflict of interest The authors declare that they have no conflict of interest.

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