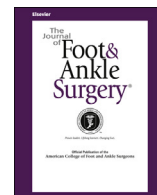




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Original Research

Factors Associated With Wound- and Implant-Related Complications After Surgical Treatment of Ankle Fractures

Diederik P. J. Smeeing, MD ^{1,2}, Jan P. Briet, MD ³, Charlotte S. van Kessel, MD, PhD, MsC ⁴, Michiel M. Segers, MD ⁵, Egbert J. Verleisdonk, MD, PhD ⁶, Luke P. H. Leenen, MD, PhD ⁷, Roderick M. Houwert, MD, PhD ^{8,9}, Falco Hietbrink, MD, PhD ¹⁰

¹Surgical Resident, Traumacenter Utrecht, Utrecht, The Netherlands

²Surgical Resident, Department of Surgery, University Medical Center Utrecht, Utrecht, The Netherlands

³Surgical Resident, Department of Surgery, Diaconessenhuis Utrecht, Utrecht, The Netherlands

⁴Surgical Resident, Department of Surgery, St Antonius Hospital, Nieuwegein, The Netherlands

⁵Trauma Surgeon, Department of Surgery, St Antonius Hospital, Nieuwegein, The Netherlands

⁶Trauma Surgeon, Department of Surgery, Diaconessenhuis Utrecht, Utrecht, The Netherlands

⁷Professor in Trauma Surgery, Department of Surgery, University Medical Center Utrecht, Utrecht, The Netherlands

⁸Trauma Surgeon, Traumacenter Utrecht, Utrecht, The Netherlands

⁹Trauma Surgeon, Department of Surgery, St Antonius Hospital, Nieuwegein, The Netherlands

¹⁰Trauma Surgeon, Department of Surgery, University Medical Center Utrecht, Utrecht, The Netherlands

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ABSTRACT

We have described the epidemiology of complications after surgical treatment of ankle fractures and assessed which factors are associated with the most frequent complications. We conducted a retrospective cohort study at 2 level 2 and 1 level 1 trauma center in a single trauma region in the Netherlands. The study variables were collected from the electronic medical patient records; all ankle fractures were classified using the Lauge-Hansen classification, and the complications were recorded. A total of 989 patients were included from 3 hospitals, with 173 complications in 156 patients (15.8%). The most frequent complication was wound related, occurring in 101 patients (10.2%). Implant-related complications occurred in 44 patients (4.4%). Other complications, such as cast pressure spots, posttraumatic dystrophy, nonunion, impingement, and pneumonia occurred in 28 patients (2.8%). The 2 most important complications were further analyzed for risk factors. Multivariate analysis showed the risk factors for wound-related complications were advanced age, increased American Society of Anesthesiologists classification, smoking, right side symptomatic, open fracture, and initial external fixation. Most implant-related complications were caused by malreduction ($n = 22$) or untreated syndesmotic injury ($n = 19$). Malreduction was associated with supination eversion fractures ($p = .059$), and untreated syndesmotic injury occurred more often with pronation external rotation fractures ($p < .001$). The most frequent complications after ankle fracture surgery were wound- and implant-related complications. Postoperative wound-related complications were multifactorial and dependent on a combination of trauma-, patient-, and treatment-related factors. In contrast, implant-related complications resulted from the interaction between the fracture type and subsequent surgical treatment.

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Ankle fractures are among the most common type of fractures worldwide (1). More than one half of the ankle fractures occur in young men during sports activities and in older women (2,3). The diverse trauma mechanisms cause different types of ankle fractures, which

can be classified using several fracture classification systems (4,5). Over the years, many systems have been developed to classify ankle fractures. The 3 systems most used in clinical practice and research are the Lauge-Hansen classification, Danis-Weber classification, and AO classification (4-6). The AO and Danis-Weber systems only describe the bone-specific injuries of an ankle fracture. The Lauge-Hansen classification is more complex but also describes the extent of ligamentous injury and, thereby, ankle stability (4-6). In general, stable ankle fractures can be treated nonoperatively. When incongruity of the ankle mortise is present or the stability of the ankle joint is compromised,

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Address correspondence to: Diederik P.J. Smeeing, MD, Department of Surgery, University Medical Center Utrecht, P.O. Box 85500, Utrecht 3508 GA, The Netherlands.

E-mail address: diederiksmeeing@hotmail.com (D.P.J. Smeeing).

surgical treatment should be performed (7). After surgery, an accelerated functional recovery is crucial for an early return to daily activities, work, and sports. However, certain complications can occur after surgical treatment, resulting in delayed functional recovery or long-term disability and considerable associated costs (8–11). Several studies have assessed the complication rates after surgical treatment of ankle fractures and showed that wound-related complications are the most frequently occurring complications (12–17). Wound-related complications have been related to patient factors (i.e., age, diabetes). However, the generalizability of these studies has been limited because only selected groups of patients were included in small numbers or only a few variables were assessed. The epidemiology of complications after ankle surgery is still unclear and can be influenced by trauma-, patient-, and treatment-related factors. The interaction among the variables has been scarcely explored. By identifying “high-risk” patients, measures can be taken to reduce or even prevent complications in these patients. The aims of the present study were to describe the epidemiology of complications after surgical treatment of ankle fractures and to assess which factors and their interactions are associated with the most frequent complications.

Patients and Methods

A retrospective cohort study was conducted at 2 level 2 trauma centers (Diakonessenhuis Utrecht, Utrecht and St Antonius Hospital, Nieuwegein) and 1 level 1 trauma center (University Medical Center Utrecht, Utrecht) in the Netherlands. Using the hospitals' surgical registration database, all the patients with a surgically treated ankle fracture from January 2008 to January 2013 were identified using International Classification of Diseases codes. Patients aged ≥ 18 years with both pre- and postoperative radiographs (preoperative radiographs were taken before cast placement) of the injured ankle available were considered for inclusion. All patients who returned for postoperative outpatient department visits were included in the present study. Data were extracted from the electronic medical patient records. To assess fracture classification, mortise- and lateral-view radiographs from admission in the emergency room were used. Two of us (D.S., J.B.) classified all the fractures. In the case of a dispute, consensus was reached by 2 senior investigators (R.H., F.H.). In addition, all fractures with implant failure were discussed in a consensus meeting to classify the type of failure. Ankle fractures were assessed as uni-, bi-, or trimalleolar, complex or simple, and using the Lauge-Hansen, AO, and Weber classifications (4–6).

Study Variables

The patient demographic data collected included gender, age, body mass index, American Society of Anesthesiologists (ASA) classification, preoperative mobility, diabetes, immunologic compromise by medication or infection, peripheral arterial disease, smoking, and psychiatric disease present during hospital admission. The collected trauma and fracture variables included trauma mechanism, symptomatic side, open fracture, ankle luxation fracture, fracture classification using the Lauge-Hansen, Weber, and AO classification systems, and whether the fracture was unimalleolar, bimalleolar, or trimalleolar and complex or simple. The surgical variables collected included the interval between the trauma and surgery in days, whether surgery was performing during

the day or night, and the use of open reduction and internal fixation or initial external fixation. The collected postoperative variables included the postoperative treatment protocol (cast immobilization and weightbearing regimen). Finally, all complications that occurred were recorded. The postoperative treatment protocol was classified as weightbearing if weightbearing started within 3 weeks after surgery. Preoperative mobility was assessed as immobile if the patient had been using a wheelchair or crutches before the occurrence of the fracture. Smoking was defined as a dichotomous outcome: yes or no (patients who had quit smoking were considered nonsmokers). A fracture was classified as complex if it consisted of >2 parts.

If variables were not noted in the electronic medical patient file, we assumed that what was not recorded was absent for that patient. Thus, peripheral arterial disease was presumed absent if not mentioned in the file and the patient was not under the supervision of a vascular surgeon nor used any medication for peripheral arterial disease. All variables were established before data extraction was performed.

Outcome Variables

All complications were recorded. The outcome variables and their definitions are described in Table 1. Wound-related complications included all wound healing disorders and superficial and deep wound infections. Implant-related complications that required revision surgery were categorized as malreduction, inadequate fixation, implant breakage, untreated syndesmotom injury, or primary failure of external fixation. All these outcomes were defined before data extraction was performed. The interaction was analyzed for patient-, trauma-, and treatment-related (surgical and postoperative) factors. All complications were analyzed for an interaction between the Lauge-Hansen classification and an additional factor.

Statistical Analysis

Continuous parametric data are presented as the mean \pm standard deviation and dichotomous data as frequencies and percentages. Uni- and multivariate analyses were performed using univariate and multivariate logistic regression analysis to identify independent predictors for the occurrence of postoperative wound-related complications. Univariate analyses were performed between wound-related outcomes and each covariate. Variables showing a $p < .15$ on univariate analysis were included in the multivariate analysis. Multivariate logistic regression with simultaneous entry was performed. After the multivariate analyses, interaction analyses were performed. Because no other variables were significantly different between those with and without implant failure, we did not perform multivariate regression analysis. To compare the patient characteristics between those with and without implant failure, the independent samples Student t test was used for continuous data and the Pearson χ^2 test for dichotomous and categorical data. To test the interaction between the Lauge-Hansen classification and the type of implant-related complication, we used the Fisher-Freeman-Halton test. Missing data were excluded from the analyses. A p value $< .05$ was considered statistically significant. All statistical analyses were performed using SPSS Statistics for Windows, version 20.0, released 2011 (IBM Corp., Armonk, NY).

Study Approval

In accordance with the legal departments of the participating hospitals and their local ethics commission, individual patient approval was not required owing to the full anonymity of the included patients and the retrospective study design.

Table 1
Outcome variables and definitions used

Outcome Variable	Definition
Wound-related complications	
Wound healing disorders	Any deviation in postoperative course but without additional pharmacologic or surgical intervention required
Superficial wound infection	Clinical suspicion of wound infection based on redness and pus and/or fever combined with necessity of antibiotic treatment
Deep wound infection	All characteristics of a superficial wound infection with additional surgical debridement
Other complications	
Deep venous thrombosis	Demonstrated using ultrasonography (which was only performed for clinical signs of deep venous thrombosis) and treated with an anticoagulant
Pulmonary embolism	Proved by radiologic imaging and treated with an anticoagulant
Implant-related complications	Revision surgery after primary surgical intervention due to an unsatisfactory result, loss of reduction, or broken implant (implant failure); broken cortical screws were considered implant failure if the fracture had not healed and/or the ankle mortise was incongruent
Malreduction	Misalignment of medial or lateral malleolus, regardless of accompanying syndesmotom injuries
Inadequate fixation	Malpositioned implant
Implant breakage	Broken implant material or implant bent to such an extent, it affected the congruence of the ankle mortise
Untreated syndesmotom injury	Lack of syndesmotom screw placement resulting in an incongruent ankle mortise

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