Elevated Risks of Ankle Fracture Surgery in Patients With Diabetes

Nelson F. SooHoo, MD, Lucie Krenek, MD, Michael Eagan, MD, and David S. Zingmond, MD, PhD

Ankle fractures are one of the most common types of injuries treated by orthopedic surgeons. For the majority of patients, results are satisfactory, and most are able to return to their pre-injury level of functioning. However, for a minority, a seemingly straightforward ankle fracture can be devastating, resulting in wound complications, multiple reoperations, and, for some, amputation.

Previous studies have shown that certain patients are more likely to suffer from these complications, particularly those with impaired wound healing. Patients predisposed to impaired wound healing may include, among others, those with diabetes or peripheral vascular disease and those taking steroid medications. In today's aging population, diabetes is common and on the rise, making it vital that treatment teams be aware of potential pitfalls in their treatment.

The purposes of this study were to determine the rates of wound infection, reoperation, and amputation after surgical treatment of ankle fractures in patients with diabetes and to quantify the increased risk of these complications in a large, diverse patient population. Clarifying the magnitude of risk and the rates of these complications will assist orthopedic surgeons and medical consultants in the treatment and the counseling of patients with these conditions. The strength of this study lies in the large, diverse patient sample, in which multiple races, ages, comorbidities, and provider characteristics are represented.

We hypothesized that the risk of wound infection, revision surgery, and amputation after surgical treatment of ankle fractures would be higher in patients with diabetes compared to patients without these conditions. In addition, we hypothesized that patients with complicated diabetes would have a higher risk of these complications compared to both patients without diabetes and those with uncomplicated diabetes.

Study Methods

Data source

Data for all hospital discharges in California in the years 1995–2005 were obtained from California's Office of Statewide Health Planning and Development (OSHPD) through the patient discharge database. This database is compiled annually by OSHPD and includes discharge abstracts from all non-federal hospitals in California.

Each discharge abstract includes codes for up to 20 inpatient procedures and 24 diagnoses per hospitalization. All procedures and diagnoses are coded using the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM). Also included are patient demographic information (race, Hispanic ethnicity, sex, expected source of payment, age, and zip code of residence), outcomes (in-hospital mortality), and site of hospitalization (unique hospital identifier and zip code).

The study protocol was reviewed and approved by the University of California–Los Angeles institutional review board. Because of the nature of these secondary data analyses, waiver of patient consent was granted.

Inclusion and exclusion criteria

The sample consisted of patients undergoing open reduction and internal fixation of a lateral malleolar, bimalleolar, or trimalleolar ankle fracture during the study period. ICD-9-CM procedure codes were used to identify the cohort sample. Patients with non-California zip codes were excluded because these patients are more likely to be readmitted outside of the state during the observation period. The unit of analysis was hospital discharge for each patient.

Outcomes studied (dependent variables)

The outcomes identified as dependent variables included short-term readmission rates for specific complications. The short-term outcomes of readmission for infection or wound complication, reoperation for revision surgery, and below-knee amputation were reported for the first 90 days after the primary procedure.

Predictors (independent variables)

The predictive variables of interest included patient and provider characteristics, which were used in the regression models as covariates to

adjust for their effect. These independent variables included patient demographic characteristics such as age, sex, race/ethnicity, and insurance type.

Comorbid disease was assessed using the Charlson score, as well as the separate inclusion of the presence of either complicated or uncomplicated diabetes as covariates. Complicated diabetes was identified using the Charlson system of coding and includes patients with end-organ damage, whereas uncomplicated diabetes includes patients without end-organ damage.[1,2] The Charlson comorbidity index assesses 17 comorbid conditions and has been validated for use in administrative database studies.[1,2]

Race and ethnicity were reported by hospitals based on patient self-report, and insurance type was also reported by hospitals for each patient. Patients were categorized into three age-groups: < 50 years, 50–75 years, and > 75 years of age.

Hospital surgical volume was also included as a covariate. Surgical volume was defined as the average number of open reduction and internal fixation procedures performed yearly during the study period. Hospitals were categorized as low-volume if they were in the lowest 40th percentile by annual volume among hospitals where ankle fracture open reduction and internal fixation procedures were performed. Intermediate-volume hospitals were defined as the next 40th percentile, and high-volume hospitals were defined as the highest 20th percentile.

Additional hospital characteristics included were hospital size, rural location, and teaching status, all of which were reported by hospitals in the OSHPD database.

Injury severity was included as a covariate using two methods. First, fractures were classified by severity into the three categories of lateral malleolar fractures, bimalleolar fractures, and trimalleolar fractures. Second, open fractures were identified, and the presence of an open injury was included as a covariate. An ICD-9-CM coding algorithm was used to identify fracture type and the presence of an open injury.

Table 1. Incidence of Ankle Fractures Requiring Open Reduction and Internal Fixation in California, 1995–2005 (n = 57,183)

Year	Lateral Malleolar Fractures	Bimalleolar Fractures	Trimalleolar Fractures
1995	873	2,184	2,110
1996	859	2,110	2,006
1997	769	2,152	1,944
1998	797	2,309	2,174
1999	815	2,294	2,014
2000	856	2,327	2,104
2001	846	2,400	2,076
2002	845	2,398	2,083
2003	860	2,549	1,996
2004	810	2,564	1,989
2005	779	2,352	1,939
Total	9,109	25,639	22,435

Statistical analysis

All statistical analyses were performed using Stata/SE 8.0 (StataCorp, College Station, Tex.). We used multivariate regression techniques to identify the independent effect of the predictor patient and provider variables on the risk of complications. Multivariate logistic regression models were used to estimate the impact of diabetes on the outcomes of wound infection/complication, revision surgery, and below-knee amputation, while controlling for patient demographics (age, sex, race/ethnicity, and insurance type), comorbidities (Charlson comorbidity index), and provider characteristics (hospital volume, teaching status, rural location, and hospital size).

The strength of association between the risk of short-term complications and each of the provider and patient covariates was expressed as odds ratios (ORs) for a complication with respect to a reference group. The 95% CIs and P values are reported as well.

Study Results

Patient sample

A total of 57,183 patients underwent open reduction and internal fixation of an ankle fracture during the 11-year study period. Table 1 shows the annual incidence of each procedure.

Table 2 lists demographic information for the patients undergoing surgery. The mean age of the patient population was 51 years, and 63% of the patients were female.

There were a total of 9,109 lateral malleolar fractures, 25,639 bimalleolar fractures, and 22,435 trimalleolar fractures. A total of 3,940 fractures

Table 2. Demographics of Patient Sample (*n* = 57,183)	
Age	51 years (range 18–103)
Sex	Male 37.0% (21,130) Female 63.0% (36,053)
Race/ethnicity	White 69.90% (39,971) Hispanic 17.70% (10,125) Black 6.63% (3,789) Asian-Pacific Islander 2.89% (1,651) Other 2.88% (1,647)
Insurance type	Private 45.34% (25,927) Medicare 25.75% (14,728) Medicaid 9.56% (5,464) Other 19.35% (11,064)
Open fracture	6.89% (3,940)
Charlson comorbidity	0.43 ± 0.99 (mean ± SD)
Uncomplicated diabetes	8.24% (4,710)
Complicated diabetes	2.13% (1,219)

Table 3. Incidence of Complications After Ankle Fracture Open Reduction and Internal Fixation by Patient Comorbidity

	Overall Rate	Uncomplicated Diabetes	Complicated Diabetes
Complication at 90 days	***n* = 57,183**	***n* = 4,710**	***n* = 1,219**
Pulmonary embolism	0.34% (193)	0.38% (18)	0.33% (4)
Wound infection	1.44% (826)	3.55% (167)	7.71% (94)
Revision surgery	0.82% (468)	1.40% (66)	4.43% (54)
Below-knee amputation	0.16% (94)	0.51% (24)	3.86% (47)
Mortality	1.07% (609)	2.53% (119)	4.27% (52)

(6.89%) were associated with an open injury.

The incidence of uncomplicated diabetes was 8.24%, whereas diabetes complicated by end-organ damage was found in 2.13% of patients. Table 3 shows the incidence of complications by patient comorbidity.

Complication rates

Odds ratios (ORs) of short-term complications are shown in Table 4. Low rates of readmission within 90 days were seen for infection (1.44%), revision open reduction and internal fixation (0.82%), and below-knee amputation (0.16%) in the entire patient population. The rates were significantly higher for patients with diabetes. The rates of amputation (3.86%), infection (7.71%), and revision surgery (4.43%) were notably high in patients with complicated diabetes, with ORs of 27.6 (95% CI 13.5–56.5, $P < 0.001$) for amputation, 3.85 (95% CI 2.92–5.07, $P < 0.001$) for infection, and 5.09 for revision surgery (95% CI 3.41–7.61, $P < 0.001$) in this group compared to patients without diabetes.

The presence of uncomplicated diabetes also resulted in higher rates of complications. The rate of below-knee amputation was 0.51% with an OR of 6.41 (95% CI 3.27–12.6, $P < 0.001$), revision surgery was 1.40% with an OR of 1.84 (95% CI 1.37–2.47, $P < 0.001$), and the wound infection rate was 3.55% with an OR of 2.46 (95% CI 2.05–2.95, $P < 0.001$).

Discussion

Ankle fractures are one of the most common operative injuries treated by orthopedic surgeons today, surpassed only by hip fractures in the elderly.[3] Ankle fractures have varied presentations, being common in young, healthy individuals, in multi-injury trauma patients, and in older patients with multiple medical comorbidities. Each of these patient groups has a different set of potential complications and may have significant variation in outcomes. Younger, healthy individuals tend to have better outcomes with good return of function.[4] However, the treatment of diabetic patients is more complex, given their poor healing potential and greater propensity for complications.

Diabetes has long been known to be a risk factor for multiple postoperative complications. The reasons for this are multifactorial. Peripheral neuropathy may play a role in that these patients have impaired proprioception and nociception, predisposing them to further injury and loss of fracture reduction. Studies have also revealed that diabetic patients have longer healing times, both in insulin-dependent patients and in those using oral hypoglycemic agents.[5] Multiple physiological factors are known to contribute to wound-healing deficiencies in diabetic patients. These factors include impaired growth factor production, angiogenic response, macrophage function, quantity of granulation tissue, bone healing, and fibroblast

Table 4. ORs of Short-Term Complications by Patient Comorbidity

Short-Term Complication (at 90 days)	Complicated Diabetes [OR (95% CI, *P* value)]	Uncomplicated Diabetes [OR (95% CI, *P* value)]
Pulmonary embolism	0.37 (0.13–1.05, $P = 0.06$)	0.69 (0.42–1.12, $P = 0.13$)
Wound infection*	3.85 (2.92–5.07, $P < 0.001$)	2.46 (2.05–2.95, $P < 0.001$)
Revision surgery*	5.09 (3.41–7.61, $P < 0.001$)	1.84 (1.37–2.47, $P < 0.001$)
Below-knee amputation*	27.63 (13.5–56.5, $P < 0.001$)	6.41 (3.27–12.59, $P < 0.001$)
Mortality	1.08 (0.78–1.50, $P = 0.63$)	1.08 (0.87–1.34, $P = 0.51$)

*$P < 0.05$.

migration and proliferation.[6] Bone healing is impaired as well, which further places diabetic patients at risk for malunions and need for subsequent surgery.[5–7]

In this study, we attempted to quantify the increased risk of various complications incurred by diabetic patients. Specifically, we focused on the risk of amputation, revision surgery, and wound complications and infections in these patients and how the rates of these complications compare to those in the entire patient sample. To better understand the impact of diabetes, patients were further divided into those with complicated diabetes involving end-organ damage and those with uncomplicated diabetes.

The results of the study demonstrated that diabetic patients are at increased risk for multiple postsurgical complications. The rate of wound infection in patients with diabetes was significantly increased compared to those without diabetes. Infection rates were particularly high, at 7.71%, in those with complicated diabetes compared to 1.44% in the overall patient sample, leading to a statistically significant OR of 3.85. Even in those with uncomplicated diabetes, the rate of infection was higher, at 3.55%, resulting in an OR of 2.46.

These results clarify previous investigators' findings of high rates of wound complications and infections, ranging from 10% to 60% in diabetic ankle fractures treated operatively.[8–11] The results of our study, in combination with previous findings, underscore the importance of meticulous preoperative planning and postoperative wound care in any patient with diabetes.

Patients with diabetes were also found to be at a greater risk of requiring revision surgery. Those with complicated diabetes were found to have a greatly increased risk of revision surgery, with an OR of 5.09. Uncomplicated diabetes resulted in an increased risk as well, with an OR of 1.84. As previously noted, diabetic patients are at a greater risk for fracture displacement given impaired proprioception and nociception. In addition, fracture healing in general is impaired, further placing these patients at risk. For these reasons, it has been suggested that diabetic patients require longer postoperative immobilization than their nondiabetic counterparts.[9] In addition, diabetic patients require closer follow-up to detect any fracture displacement or wound problem earlier.

Although the rates of wound infection and revision are high in diabetic patients, these are relatively minor complications in comparison to amputation. Unfortunately, the risk of below-knee amputation in diabetic patients was found to be extremely high in this study. There was a striking increase in the rate of amputation for patients with complicated diabetes—3.86% compared to 0.16% in the overall sample—resulting in an OR of 27.6. Those with uncomplicated diabetes were found to be at significantly increased risk as well, with an OR of 6.41.

This is particularly unsettling given that patients with uncomplicated diabetes are generally considered a healthier population. Previous smaller studies have found varying rates of amputation resulting from operatively treated ankle fractures in diabetic patients, with McCormack and Leith[11] reporting a rate of 11% and Costigan et al.[8] a rate of 1%. This is very alarming given estimates that > 20 million people in the United States suffer from diabetes, with rates as high as 18.5% in patients aged 65–74 years and on the rise among youths.[12]

One major weakness of this study is the limited types of data available in administrative databases. The A1C levels of patients were not available, and risk stratification was not available for this important prognostic variable. There was no available report on functional outcomes, which would be helpful in clarifying long-term prognosis. In addition, ankle fracture procedures performed on an outpatient basis were not captured in the databases analyzed. Similarly, rates of complications not requiring readmission, such as superficial infections and

minor procedures, were not available for analysis. Despite these limitations, we have provided useful data with comparison among different patient populations on several important short-term complications after operative treatment of ankle fractures in patients with diabetes.

The results of this study confirm and clarify the increased risk of complications in diabetic patients, supporting the results of previous smaller studies. Some of the results of this study, particularly the increased risk of amputation in patients with complicated diabetes, are strikingly high, and both surgeons and patients need to be aware of this increased risk.

Patients with these comorbidities, and specifically those with complicated diabetes, require extensive preoperative counseling regarding their risks of wound complications, the need for further surgery, and amputation. In addition, these patients require meticulous postoperative wound care, close follow-up, and prolonged immobilization to help prevent and identify these potential complications.

One of the most striking findings of this study was the high rate of amputation among diabetic patients, which reinforces the need for vigilance by providers caring for patients with diabetes during the perioperative period.

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Nelson F. SooHoo, MD, is an associate professor; Lucie Krenek, MD, and Michael Eagan, MD, are residents; and David S. Zingmond, MD, PhD, is an assistant professor at the University of California–Los Angeles School of Medicine.