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Increased Rates of Readmission, Reoperation, and Mortality Following Open Reduction and Internal Fixation of Ankle Fractures Are Associated With Diabetes Mellitus

Jennifer W. Liu, BS[1], Junho Ahn, BS[1], Katherine M. Raspovic, DPM, FACFAS[1], George T. Liu, DPM, FACFAS[1], Paul A. Nakonezny, PhD[2], Lawrence A. Lavery, DPM, MPH, FACFAS[3], Dane K. Wukich, MD[1]

[1] *Department of Orthopaedic Surgery, University of Texas Southwestern Medical Center, Dallas, TX*
[2] *Department of Clinical Sciences, Division of Biostatistics, University of Texas Southwestern Medical Center, Dallas, TX*
[3] *Department of Plastic Surgery, University of Texas Southwestern Medical Center, Dallas, TX*

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ABSTRACT

The purpose of this study was to compare the rates of readmission, reoperation, and mortality in patients with and without diabetes mellitus during the 30-day postoperative period after ankle fracture surgery. Patients who underwent operative management for ankle fractures between 2006 and 2015 were identified in the American College of Surgeons National Surgical Quality Improvement Program® database by using Current Procedural Terminology codes for ankle fracture surgery. A total of 17,464 patients undergoing ankle fracture surgery were identified. Of these patients, 2044 (11.7%) had diabetes and 15,420 (88.3%) did not have diabetes. We excluded patients older than 90 years or with inadequate perioperative data. Patients with diabetes had significantly higher rates of readmission (2.84% vs 1.05%, $p < .0001$), significantly higher rates of unplanned reoperation (2.3% vs 0.74%, $p < .0001$), and significantly higher rates of mortality (0.7% vs 0.2%, $p < .0001$) compared with patients without diabetes. Additionally, patients with diabetes had significantly greater age-adjusted odds ratios (ORs) of unplanned readmission (OR 2.40, 95% confidence interval [CI] 1.74 to 3.31, $p < .0001$), unplanned reoperation (OR 2.56, 95% CI 1.44 to 3.27, $p < .0001$), and mortality (OR 2.01, 95% CI 1.08 to 3.62, $p = .0432$) than did patients without diabetes after ankle surgery. In this large-scale retrospective study, we demonstrated that the presence of diabetes significantly increases the risk of unplanned readmission, unplanned reoperation, and mortality during the 30-day postoperative period after ankle fracture surgery.

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Ankle fractures compose 9% of all fractures seen in adults, with an annual incidence of 187 per 100,000 people in the United States (1,2). These injuries may result in extended time for recovery and residual functional impairment (3). The economic burden to patients often involves the direct costs of hospital-related charges and the indirect costs of temporary loss of work and permanent disability (4,5).

Diabetes mellitus (DM) is a growing health epidemic that affects 30.3 million people in the United States (6–8). Ankle fractures in patients with DM are related to higher rates of complications, including infection, malunion, and impaired wound healing after surgical management compared with patients without DM (9–14). These diabetes-related complications in operativelymanaged ankle fractures increase hospital costs ranging from length of stay to nonroutine discharges (15–17).

Although several studies have reported the association of DM with postoperative complications after open reduction internal fixation (ORIF) for ankle fractures (10,14,18,19), to our knowledge, there has not been a large-scale recent nationwide study evaluating the rates of readmission, reoperation, and mortality associated with DM. Several database studies during the past 13 years have reviewed the outcomes of patients undergoing ankle fracture repair. As a part of their statistical analysis, the studies found that patients with DM experienced high rates of adverse outcomes (13,17,20,21).

The purpose of this study was to expand on these previous studies, incorporating data from the most recently reported information. Our outcome measures were the rates of readmission, reoperation, and

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Address correspondence to: Dane K. Wukich, MD, Department of Orthopaedic Surgery, University of Texas Southwestern Medical Center, 1801 Inwood Road, Dallas, TX 75390.

E-mail address: Dane.Wukich@utsouthwestern.edu (D.K. Wukich).

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Table 1
Patient characteristics and fracture characteristics (N = 17,464 patients)

	Patients With DM (n = 2,044)	Patients Without DM (n = 15,420)	*p* Value
Patient factors			
Age, y, median (IQR)	63 (55 to 72)	48 (33 to 61)	< .0001
Obesity, n (%)	1361 (66.6)	7265 (47.1)	< .0001
Smoking, n (%)	361 (17.6)	2304 (26.4)	< .0001
Steroid use, n (%)	67 (3.3)	213 (1.4)	< .0001
Female, n (%)	1314 (64.1)	12,036 (61.1)	.0126
Comorbidities, n (%)			
Hypertension	1617 (79.2)	3970 (25.8)	< .0001
COPD	179 (8.8)	392 (2.5%)	< .0001
ESRD	74 (3.6)	41 (0.3)	< .0001
Functional status, n (%)			
Independent	1779 (87.0)	14,697 (95.3)	< .0001
Partially dependent	219 (10.7)	554 (3.6)	< .0001
Totally dependent	19 (0.9)	32 (0.2)	< .0001
Laboratory values, median (IQR)			
Creatinine, mg/dL	0.92 (0.74 to 1.22)	0.8 (0.70 to 0.99)	< .0001
BUN, mg/dL	18 (13 to 25)	14 (11 to 17)	< .0001
WBCs, $\times 10^3/\mu$L	8.6 (7 to 10.7)	8.5 (6.9 to 10.5)	.1316
Fracture type, n (%)			
Unimalleolar	468 (22.9)	3932 (25.5)	.0137
Bimalleolar	1023 (50.0)	8265 (53.6)	.0029
Trimalleolar	407 (19.9)	2328 (15.1)	< .0001

Abbreviations: BUN, blood urea nitrogen; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; ESRD, end-stage renal disease; IQR, interquartile range; WBC, white blood cell.

mortality after operative treatment of ankle fractures in patients with DM. A secondary aim was to compare the outcomes of patients with and without DM regarding these complications during the 30-day perioperative period after ORIF.

Patients and Methods

Study Population

The American College of Surgeons National Surgical Quality Improvement Program® (ACS-NSQIP®, Chicago, IL) database is a validated and risk-adjusted database of 30-day perioperative outcomes from a national sample of more than 600 participating hospitals in the United States (22). Patients who underwent ORIF for ankle fractures between 2006 and 2015 were identified in the ACS-NSQIP® database by using Current Procedural Terminology (CPT) codes: 27766, 27769, 27786, 27792, 27808, 27814, 27816, 27822, 27823, 27826, 27827, 27828, and 27829. Patients were excluded if they were older than 90 years or did not have adequate perioperative data. A total of 17,464 patients were identified and included in the current study.

Diabetes Mellitus

The main independent variable of this study was a cohort of NSQIP patients with DM vs patients without DM who underwent ORIF for ankle fractures. Patients with DM who routinely take antidiabetic agents (insulin and/or noninsulin agents) at the time of admission were included in the DM cohort. Patients without DM, or patients whose DM was controlled by diet alone, were included in the non-DM cohort according to the ACS-NSQIP® database.

Outcome Variables

The primary outcomes for this study were 30-day postoperative readmission, reoperation, mortality, and length of stay after ankle ORIF. "Readmission" was defined as unplanned readmission to the same or another hospital that was related to the original ankle fracture procedure. "Reoperation" was defined as an unplanned return to the operating room for surgery that was related to the original ankle fracture procedure. "Mortality" was defined as patient death within 30 days of the ankle fracture surgery. Cause-specific mortality is not reported in the ACS-NSQIP® database. "Length of stay" was defined as number of days spent at the hospital after surgery, and based on the admission date and the discharge date. Readmission, reoperation, and mortality were operationalized as binary outcomes for statistical modeling.

Before 2012, reporting in the ACS-NSQIP® database did not distinguish between readmissions/reoperations that were related to the index procedure vs nonrelated causes. Thus, analyses for readmission and reoperation were performed only on patients from 2012 to 2015. Analyses for length of stay and mortality were performed on patients from 2006 to 2015, as these variables were available in the ACS-NSQIP® database from the beginning.

For descriptive purposes, readmission was subcategorized based on the following reasons for readmission: fracture complication, surgical site infection (SSI), pulmonary embolism, wound dehiscence, and other. Reoperation was subcategorized based on reason for reoperation: unplanned ankle fracture revision, unplanned removal of fixation device, irrigation and debridement, amputation, and other surgical procedures.

Covariates

Patient factors such as age, sex, smoking history, body mass index (BMI), level of preoperative functional dependence, and length of hospital stay—in addition to patient comorbidities such as hypertension (HTN), chronic obstructive pulmonary disease (COPD), end-stage renal disease (ESRD), and chronic steroid use—were included in the analyses. "HTN" was defined as a positive history for blood pressure elevation severe enough to require antihypertensive medication. "Obesity" was defined as a BMI > 30 kg/m^2. "ESRD" was defined as chronic renal failure requiring dialysis. Patient functional status was recorded as independent, partially dependent, or totally dependent. Preoperative laboratory values included serum creatinine, blood urea nitrogen (BUN), and white blood cell count (WBC).

Statistical Analysis

Demographic and clinical characteristics were described by using median and 25th to 75th interquartile range (IQR) for continuous variables and by using the frequency and percentage for categorical variables. Statistical tests used to compare differences between patients with DM and nonpatients with DM were Mann-Whitney *U* test for nonparametric continuous variables and χ^2 test of homogeneity for categorical variables. Separate multiple logistic regression models were implemented to estimate the odds of readmission, reoperation, and mortality after ORIF of ankle fractures in patients with DM compared with patients without DM, while controlling for age and, separately, controlling for age and comorbidities. Adjusted odds ratios (ORs) along with 95% confidence intervals (CIs) were reported. Statistical analyses were performed by using IBM SPSS Statistics, version 23 (IBM, Armonk, NY). The level of statistical significance was set at $\alpha = .05$ (2-tailed), and the Benjamini-Hochberg method of false discovery rate *p*-value adjustment of multiple tests was performed (23).

Results

Participant Characteristics

From 2006 to 2015, a total of 17,464 patients undergoing ankle ORIF were identified. Of these patients, 2044 (11.7%) had DM and 15,420 (88.3%) did not have DM. Patient factors, comorbidities, functional status, and preoperative laboratory values are summarized in Table 1. Patients with DM were significantly older ($p < .0001$), more likely to be female ($p < .0126$), more likely to be functionally dependent ($p <$

Table 2
Postoperative length of stay, readmission, reoperation, and mortality (N = 17,464 patients)

	Patients With DM	Patients Without DM	*p* Value
Readmission,* n (%)	58 (3.70)	162 (1.33)	<.0001
Surgical site infection	26 (1.65)	66 (0.54)	<.0001
Fracture complication	14 (0.89)	54 (0.44)	.0232
Venous thromboembolism	5 (0.32)	16 (0.13)	.0860
Wound dehiscence	5 (0.32)	9 (0.07)	.0063
Reoperation,* n (%)	48 (3.06)	114 (0.93)	<.0001
Fracture repair revision	19 (1.21)	56 (0.46)	.0003
Irrigation and debridement	11 (0.70)	40 (0.32)	.0308
Unplanned removal of fixation device	7 (0.44)	10 (0.08)	<.0001
Amputation	3 (0.19)	1 (0.01)	<.0001
Mortality,† n (%)	15 (0.7)	32 (0.2)	<.0001
Length of stay,† days, median (IQR)	2 (1 to 3)	1 (0 to 2)	<.0001

Abbreviations: DM, diabetes mellitus; IQR, interquartile range.
* Readmission and reoperation data were available only from 2012 through 2015 (n = 13,766). Reasons for readmission and reoperation are listed in order of decreasing frequency.
† Mortality and length of stay analysis was done for all patients from 2006 through 2015 (N = 17,464).

Table 3
Multiple logistic regression results for the effect of diabetes mellitus on readmission, reoperation, and mortality (N = 17,464 patients)

	Odds Ratio (95% CI)	*p* Value
Age adjusted		
Readmission	2.40 (1.74 to 3.31)	<.0001
Reoperation	2.56 (1.76 to 3.73)	<.0001
Mortality	2.01 (1.08 to 3.62)	.0432
Age/comorbidity adjusted		
Readmission	1.70 (1.21 to 2.40)	<.0001
Reoperation	2.17 (1.44 to 3.27)	<.0001
Mortality	1.07 (0.55 to 2.08)	.8570

Abbreviation: CI, confidence interval.
Age-adjusted odds ratios controlled for differences in age between the diabetes mellitus (DM) and non-DM cohort. Age/comorbidity-adjusted odds ratios controlled for both age and other comorbidities (obesity, steroid use, hypertension, chronic obstructive pulmonary disease, end-stage renal disease, and functional dependence).
* Readmission and reoperation data were available only from 2012 through 2015 (n = 13,766). Reasons for readmission and reoperation are listed in order of decreasing frequency.
† Mortality and length of stay analysis was done for all patients from 2006 through 2015 (N = 17,464).

.0001), less likely to have a smoking history ($p < .0001$), more likely to be obese ($p < .0001$), and more likely to use steroids ($p < .0001$) compared with patients without DM (Table 1). Comorbidities such as HTN ($p < .0001$), ESRD ($p < .0001$), and COPD ($p < .0001$) were significantly more prevalent in patients with DM (Table 1). Patients with DM had significantly higher preoperative BUN ($p < .0001$) and creatinine levels ($p < .0001$), but no significant differences in preoperative WBC levels ($p = .1215$) were appreciated.

Types of Ankle Fractures

The distribution of the types of ankle fractures seen in patients with DM and without DM is shown in Table 1. Bimalleolar fractures were most common (n = 9288, 53.2%) followed by unimalleolar (n = 4400, 25.2%) and trimalleolar fractures (n = 2375, 15.7%). The DM cohort had significantly higher rates of trimalleolar fractures ($p < .0001$) and lower rates of unimalleolar ($p = .0137$) and bimalleolar ($p = .0029$) fractures compared with the non-DM cohort (Table 1).

Outcome Variables: Readmission, Reoperation, Mortality, and Length of Stay

From 2012 to 2015, there were 220 total unplanned readmissions of 13,766 patients analyzed for unplanned readmission. Unplanned readmission was most commonly owed to SSI (n = 92, 41.8%) followed by fracture complication (n = 68, 30.9%). Patients with DM had significantly higher rates of readmission (Table 2) within the 30-day perioperative period compared with patients without DM (3.70% vs 1.32%, $p < .0001$). Additionally, patients with DM had higher rates for readmission owed to SSI (1.65% vs 0.54%, $p < .0001$), fracture complications (0.89% vs 0.44%, $p = .0232$), and wound dehiscence (0.32% vs 0.07%, $p = .0063$) as shown in Table 2.

Of the 13,766 patients analyzed for unplanned reoperation from 2012 to 2015, there were 162 unplanned reoperations. Of these unplanned reoperations, 75 (46.3%) were documented as ankle fracture revision surgery, 51 (31.5%) as irrigation and debridement procedures, and 17 (10.5%) as unplanned removal of fixation devices. Patients with DM had significantly higher rates of unplanned reoperation (Table 2) compared with patients without DM (3.06% vs 0.93%, $p < .0001$). Patients with DM were also significantly more likely to require fracture repair revision procedures (1.21% vs 0.46%, $p = .0003$) and skin debridement procedures (0.70% vs 0.32%, $p = .0308$), as shown in Table 2. Although prevalence of perioperative lower-extremity amputation was very low (n = 4, 0.02%), patients with DM were significantly more likely to require amputation than were patients without DM (0.2% vs 0.01%).

Of 17,464 patients analyzed from 2006 to 2015, 52 patients died during the 30-day perioperative period after ankle ORIF. Patients with DM had a significantly higher perioperative mortality (Table 2) than did patients without DM (0.7% vs 0.2%, $p < .0001$).

Patients with DM had a significantly longer median postoperative length of stay (2 days) compared with patients without DM, who had a median postoperative length of stay of 1 day ($p < .0001$; Table 2).

ORs for Readmission, Reoperation, and Mortality

The prevalences of perioperative unplanned readmission, unplanned reoperation, and mortality in the DM and non-DM groups are described in Table 2. Patients with DM had significantly greater age-adjusted odds of unplanned readmission (OR 2.40, 95% CI 1.76 to 3.73, $p < .0001$), unplanned reoperation (OR 2.56, 95% CI 1.44 to 3.27, $p < .0001$), and mortality (OR 2.01, 95% CI 1.08 to 3.62, $p = .0432$) than did patients without DM after ankle ORIF (Table 3).

Even with adjustment for comorbidities, patients with DM had a significantly greater odds of unplanned readmission (OR 1.70, 95% CI 1.21 to 2.40, $p < .0001$) and reoperation (OR 2.17, 95% CI 1.44 to 3.27, $p < .0001$) than did patients without DM (Table 3); however, the difference in perioperative mortality was not significant (OR 1.07, 95% CI 0.55 to 2.08, $p = .8570$).

Discussion

The ACS-NSQIP database prospectively collects a large volume of data from hundreds of participating hospitals across the United States. Improvement in quality metrics, based on initiatives derived from ACS-NSQIP® data, has been reported in Veterans Administration hospitals, military hospitals, and the private sector (24–27). As we transition from volume-based to value-based reimbursement, reducing the rates of readmission, reoperation, and mortality becomes paramount. The ACS-NSQIP® provides us with validated perioperative risk factors that identify areas of quality improvement, potentially reducing costs and improve outcomes. While participation in ACS-NSQIP® is voluntary, participating surgeons and healthcare systems have access to these data.

In reviewing the data on ankle fracture repair from 2006 through 2015, we found several important findings, particularly in patients with DM. When adjusting for age, DM was identified as an independent risk

factor for unplanned readmission, reoperation, and mortality during the 30-day perioperative period after ORIF ankle fracture surgery. We are not the first to report on the complication rate observed when extracting data from large databases. In 2005, Ganesh et al (17) analyzed data from the Nationwide Inpatient Sample for 1988 through 2000. They found that patients with DM (N = 9174) who underwent surgical treatment of ankle fractures had higher rates of mortality and complications and longer hospital stays than did patients without DM. SooHoo et al (13) reported on data obtained from California hospital discharges from 1995 to 2005, identifying nearly 6000 patients with DM who were treated for ankle fractures. Their study found that patients with complications of DM (neuropathy, peripheral artery disease, renal disease) were at risk for the development of postoperative complications. Basques et al (20) reported on 4412 patients with DM and found that insulin-dependent DM was associated with higher rates of adverse effects after ankle fracture repair. Finally, Belmont et al (21) reported on 3328 patients and found that DM was significantly associated with longer hospital stays.

Thirty-day readmission has been a primary performance-based metric used by the Centers for Medicare and Medicaid Services to evaluate quality of patient care and to guide reimbursement rates to both hospital systems and providers, aimed at reducing costly readmissions (28). In 2004, the cost of unplanned readmission for all surgical specialties was estimated to be $17.4 million (29). The 30-day readmission rate for orthopedic surgery was approximately 5.4% and was associated with increased age, length of hospital stay, elevated body mass index, and American Society of Anesthesiologists (ASA) classification of 4 or higher, and discharge to a skilled nursing facility (15). Approximately half of the orthopedic readmissions were due to wound complications from SSIs. Basques et al (20) examined 30-day readmission rates from the ACS-NSQIP® database for ankle fractures after ORIF. Using a multivariate analysis, Basques et al (20) found that significant predictors of any adverse event included insulin-dependent DM, age of 60 or older, ASA classification of 3or higher, bimalleolar fractures, hypertension, and dependent functional status. The authors reported a 3.17% readmission rate associated with an ASA classification of 3 or higher (OR 2.01, 95% CI 1.13 to 3.57). In this study, we also found an increased OR for 30-day readmission in patients with DM compared with patients without DM (OR 2.40, 95% CI 1.74 to 3.31).

Unplanned reoperation secondary to serious adverse events and/or complications is a potential indicator of quality of treatment and risk management. The mean cost of reoperation within 30 days in general surgery was estimated to be $82,300 for each patient compared with $17,700 for patients without reoperation. Barksfield et al (30) reported on the epidemiology of reoperation rates in patients with orthopedic trauma. They found that the 28-day unplanned reoperation rate after ORIF of ankle fractures was 1.86%, which increased to 8% during the follow-up period. In addition, the authors noted that the reoperation rate for ankle fractures was higher than that rate for any other anatomic region (ankle > hand > shoulder > wrist > knee = tibia > elbow > forearm) except for the hip/proximal femur. Our overall 30-day reoperation rate was 1.18% (162 of 13,766 patients), which is lower than the rate of 1.86% reported by Barksfield et al. However, patients with DM were 2.5 times more likely to require readmission than were patients without DM (OR 2.56, 95% CI 1.76 to 3.73).

Mortality has been used by the CMS as a metric to evaluate treatment quality for acute myocardial infarction, heart failure, and pneumonia. Soohoo et al (13) identified an increased mortality rate after ORIF of ankle fractures in patients with DM with comorbidities (4.27%) compared with patients with DM without comorbidities (2.53%). In our study, we also found greater age-adjusted odds of 30-day mortality in patients with DM compared with patients without DM after operative ankle fracture fixation (OR 2.01, 95% CI 1.08 to 3.62, $p = .0432$).

Many factors contribute to the increased rates of complications, subsequent readmissions, and reoperations in patients with DM after ankle fracture repair surgery. Delayed fracture healing in patients with DM has been attributed to a combination of metabolic alterations, neuropathy, and angiopathy. DM-related metabolic alternations include decreased synthesis of collagen and growth factors, impaired osteoblast functionality, impaired callus formation, and increased levels of advanced glycation end-products (31,32). Furthermore, it has been shown that there is an increased risk for SSIs in patients with DM (33,34), which has been linked to impaired chemotactic and phagocytic function of macrophages and granulocytes (35).

The primary limitation of this study was that it was a retrospective database study. Readers should recognize that participation in ACS-NSQIP® is voluntary, and potential selection bias is present because there is a preponderance of tertiary care and academic institutions in the ACS-NSQIP® database. Nonetheless, recent studies have found that there is no difference in improvement in postoperative outcomes when comparing participating with nonparticipating hospitals (36,37). Additionally, the ACS-NSQIP® database followed patients only for 30 days postoperative. Thus, our results may underestimate the true rate of complications, readmissions, reoperations, and mortality seen in patients undergoing ankle fracture surgery. The database does not record the method of fracture fixation, surgeon experience, hospital volume, or results from procedures performed at independent ambulatory surgical centers. Furthermore, the ACS-NSQIP® database did not include some important parameters for assessing diabetes such as type of DM (type 1 vs type 2), duration of DM, perioperative glucose measurements, glycated hemoglobin, peripheral neuropathy, and peripheral vascular disease. Another source of bias arises from the way diabetes is classified by the ACS-NSQIP® database. The criterion to define diabetes in the registry is based on data that are collected at the time of hospital admission, and the primary criterion to define diabetes is the use of medications for diabetes. Consequently, this may underestimate the number of patients in the DM group because patients who are diagnosed during hospital admission and patients who are diet controlled are included in the "nondiabetic group." Patients with "diet"-controlled DM may also represent a segment of the diabetic population with a lower risk of diabetes-related complications. However, despite these limitations, the current study contributes significantly to the growing body of literature on the epidemiology of diabetes-related foot complications.

The strength of this study is that we reported on the results of > 17,000 patients who underwent ankle fracture surgery, of whom > 2000 patients had DM. This is the largest study to date using the ACS-NSQIP® database to evaluate the outcomes of patients with and without DM after ankle fracture surgery. The outcomes reported represent real-world treatment of ankle fractures and is not subject to the inherent bias of the experience of a single surgeon or single institution.

In this large-scale retrospective study of a national database, we demonstrated that the presence of DM significantly increases the risk of unplanned readmission, unplanned reoperation, and mortality within 30 days after ankle fracture ORIF. Thus, patients with DM who require ankle ORIF surgery should be informed of their increased risk of complications and additional precautions should be taken to minimize risk. Further research in optimization of perioperative care for diabetic patients is crucial to reducing rates of complication. Ideally, future large clinical databases such as ACS-NSQIP® should endeavor to record more patient-related variables to facilitate these studies.

References

1. Court-Brown CM, Caesar B. Epidemiology of adult fractures: a review. Injury 2006;37:691–697.
2. Ovaska MT, Madanat R, Honkamaa M, Mäkinen TJ. Contemporary demographics and complications of patients treated for open ankle fractures. Injury 2015;46:1650–1655.

3. Beckenkamp PR, Lin C-WC, Chagpar S, Herbert RD, van der Ploeg HP, Moseley AM. Prognosis of physical function following ankle fracture: a systematic review with meta-analysis. J Orthop Sport Phys Ther 2014;44:841–851.
4. Stull JD, Bhat SB, Kane JM, Raikin SM. Economic burden of inpatient admission of ankle fractures. Foot Ankle Int 2017 Jun 17. https://doi.org/10.1177/1071100717709576. [Epub ahead of print].
5. Belatti DA, Phisitkul P. Economic burden of foot and ankle surgery in the US Medicare population. Foot Ankle Int 2014;35:334–340.
6. American Diabetes Association. Diagnosis and classification of diabetes mellitus. Diabetes Care 2009;32(suppl 1):S62–S67.
7. Deshpande AD, Harris-Hayes M, Schootman M. Epidemiology of diabetes and diabetes-related complications. Phys Ther 2008;88:1254–1264.
8. National Diabetes Statistics Report. *Estimates of Diabetes and Its Burden in the United States*.. US Department of Health and Human Services, Centers for Disease Control and Prevention, Atlanta, GA. 2017;2009–2012.
9. McCormack RG, Leith JM. Ankle fractures in diabetics. Complications of surgical management. J Bone Joint Surg Br 1998;80:689–692.
10. Blotter RH, Connolly E, Wasan A, Chapman MW. Acute complications in the operative treatment of isolated ankle fractures in patients with diabetes mellitus. Foot Ankle Int 1999;20:687–694.
11. Jones KB. Ankle fractures in patients with diabetes mellitus. J Bone Joint Surg Br 2005;87:489–495.
12. Costigan W, Thordarson DB, Debnath UK. Operative management of ankle fractures in patients with diabetes mellitus. Foot Ankle Int 2007;28:32–37.
13. SooHoo NF, Krenek L, Eagan MJ, Gurbani B, Ko CY, Zingmond DS. Complication rates following open reduction and internal fixation of ankle fractures. J Bone Joint Surg Am 2009;91:1042–1049.
14. Wukich DK, Joseph A, Ryan M, Ramirez C, Irrgang JJ. Outcomes of ankle fractures in patients with uncomplicated versus complicated diabetes. Foot Ankle Int 2011;32:120–130.
15. Bernatz JT, Tueting JL, Anderson PA. Thirty-day readmission rates in orthopedics: a systematic review and meta-analysis. PLoS One 2015;10:1–20.
16. Menendez ME, Neuhaus V, Bot AGJ, Ring D, Johnson AH. The impact of metabolic syndrome on inpatient outcomes after isolated ankle fractures. Foot Ankle Int 2014;35:463–470.
17. Ganesh SP, Pietrobon R, Cecílio WC, Pan D, Lightdale N, Nunley J. The impact of diabetes on patient outcomes after ankle fracture. J Bone Joint Surg Am 2005;87:1712–1718.
18. Guo JJ, Yang H, Xu Y, Wang G, Huang L, Tang T. Results after immediate operations of closed ankle fractures in patients with preoperatively neglected type 2 diabetes. Injury 2009;40:894–896.
19. Prisk VR, Wukich DK. Ankle fractures in diabetics. Foot Ankle Clin 2006;11:849–863.
20. Basques BA, CP Miller, Golinvaux NS, Bohl DD, Grauer JN. Morbidity and readmission after open reduction and internal fixation of ankle fractures are associated with preoperative patient characteristics. Clin Orthop Relat Res 2015;473:1133–1139.
21. Belmont PJ, Davey S, Rensing N, Bader JO, Waterman BR, Orr JD. Patient-based and surgical risk factors for 30-day postoperative complications and mortality after ankle fracture fixation. J Orthop Trauma 2015;29:e476–e482.
22. American College of Surgeons. User Guide for the 2012 Participant Use Data File. American College of Surgeons National Surgical Quality Improvement Program. Available at: http://site.acsnsqip.org/wp-content/uploads/2013/10/ACSNSQIP.PUF_.UserGuide.2012.pdf. Accessed November 10, 2017.
23. Benjamini Y, Hochberg Y. Controlling the false discovery rate: a practical and powerful approach to multiple testing. J Roy Statist Soc Ser B 1995;57:289–300.
24. Montroy J, Breau RH, Cnossen S, Witiuk K, Binette A, Ferrier T, Lavalle LT, Fergusson DA, Schramm D. Change in adverse events after enrollment in the National Surgical Quality Improvement Program: a systematic review and meta-analysis. PLoS One 2016;11:e0146254.
25. Molina CS, Thakore R V, Blumer A, Obremskey WT, Sethi MK. Use of the National Surgical Quality Improvement Program in orthopaedic surgery. Clin Orthop Relat Res 2015;473:1574–1581.
26. Fink AS, Campbell Jr DA, Mentzer Jr RM, Henderson WG, Daley J, Bannister J, Hur K, Khuri SF. The National Surgical Quality Improvement Program in non-veterans administration hospitals: initial demonstration of feasibility. Ann Surg 2002;236:344–353. discussion 353-4.
27. Maturo S, Hughes C, Kallingal G, Silvey S, Johnson AJ, Soderdahl D, Renz E, Brennan J. Improving surgical complications and patient safety at the nation's largest military hospital: an analysis of National Surgical Quality Improvement Program data. Mil Med 2017;182:e1752–e1755.
28. US Department of Health and Human Services, Centers for Medicare & Medicaid Services (CMS). Hospital-level 30-day, all-cause risk-standardized readmission rate (RSRR) following elective primary total hip arthroplasty (THA) and/or total knee arthroplasty (TKA) (NQF #1551). Available at: www.qualityforum.org/WorkArea/linkit.aspx?LinkIdentifier=id&ItemID=72187. Accessed November 10, 2017.
29. Jencks SF, Williams MV, Coleman EA. Rehospitalizations among patients in the Medicare fee-for-service program. N Engl J Med 2009;360:1418–1428.
30. Barksfield RC, Coomber R, Woolf K, Prinja A, Wordsworth D, Lopez D, Burtt S. The epidemiology of reoperations for orthopaedic trauma. Ann R Coll Surg Engl 2015;97:40–45.
31. Van Putte L, De Schrijver S, Moortgat P. The effects of advanced glycation end products (AGEs) on dermal wound healing and scar formation: a systematic review. Scars Burn Heal Dec 16 2016. https://doi.org/10.1177/2059513116676828. [Epub ahead of print].
32. Ahmed N, Thornalley PJ. Advanced glycation endproducts: what is their relevance to diabetic complications? Diabetes Obes Metab 2007;9:233–245.
33. Shilling AM, Raphael J. Diabetes, hyperglycemia, and infections. Best Pract Res Clin Anaesthesiol 2008;22:519–535.
34. Malone DL, Genuit T, Tracy JK, Gannon C, Napolitano LM. Surgical site infections: reanalysis of risk factors. J Surg Res 2002;103:89.
35. Ghiasi MS, Chen J, Vaziri A, Rodriguez EK, Nazarian A. Bone fracture healing in mechanobiological modeling: a review of principles and methods. Bone Rep 2017;6:87–100.
36. Osborne NH, Nicholas LH, Ryan AM, Thumma JR, Dimick JB. Association of hospital participation in a quality reporting program with surgical outcomes and expenditures for Medicare beneficiaries. JAMA 2015;313:496–504.
37. Etzioni DA, Wasif N, Dueck AC, Cima RR, Hohmann SF, Naessens JM, Mathur AK, Habermann AB. Association of hospital participation in a surgical outcomes monitoring program with inpatient complications and mortality. JAMA 2015;313:505–511.