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Original Research

Comparison of Early Adverse Events After Operative Treatment of Bimalleolar and Trimalleolar Fractures Versus Pilon Fractures

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ABSTRACT

Ankle fractures requiring open reduction and internal fixation vary in severity from unimalleolar fractures to bimalleolar/trimalleolar (BT) fractures to pilon fractures. Consequently, the postoperative outcomes with these surgeries can vary. Most previous studies of these injuries had small sample sizes, studied a single risk factor or adverse event, or did not compare different injuries by severity. The purpose of the present study was to describe and compare the patient characteristics and postoperative outcomes of 2 high-energy ankle fractures: BT and pilon fractures. The relevant patients were identified from the American College of Surgeons National Surgical Quality Improvement Program database using the Current Procedural Terminology codes for BT and pilon fractures. Patient demographics, characteristics, comorbidities, and 30-day mortality and adverse events were recorded and compared between the 2 types of ankle fractures. More than 45% of patients with these fracture types were aged 40 to 65 years. Pilon fractures occurred more frequently in younger patients, were more likely to occur in men, required a longer hospital stay and operative time, were less likely to occur in patients with a body mass index of >30 kg/m^2, and conferred a greater risk of wound complications (odds ratio 1.76; $p = .048$) compared with BT fractures. The findings from the present study help us understand the differences in patient characteristics and potential early adverse events after open reduction and internal fixation of BT fractures versus pilon fractures.

Ankle fractures are common, accounting for approximately 9% of all fractures (1,2). These injuries are treated operatively with open reduction and internal fixation (ORIF) when significant displacement, incongruity, or instability is present.

Most of the published data on the outcomes after ORIF of ankle fractures include studies that grouped different types of injuries together (3–5). However, these ankle injuries vary in severity according to their type and can be classified as unimalleolar, bimalleolar, trimalleolar, or pilon fractures. Bimalleolar/trimalleolar (BT) fractures are typically high-energy injuries (6). Although rare, pilon fractures are complex, high-energy injuries resulting in severe soft tissue damage and an increased risk of wound complications and infections (7,8). Thus, the postoperative outcomes of these injuries could be different.

The published data on ankle fractures include studies reporting the long-term radiographic and clinical outcomes of specific injuries (6,9). Some studies included small sample sizes with an analysis of a single risk factor or adverse event or combined different types of ankle fractures (3–5,10–12). One published study analyzed the short-term adverse events in ankle fractures from a large database; however, it did not consider pilon fractures or the difference in severity

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between pilon fractures and unimalleolar or BT fractures with the potential influence on adverse events (13). A comparative study of different high-energy ankle injuries from a large patient database is needed to appropriately counsel patients treated operatively regarding the potential adverse events.

The purpose of the present retrospective cohort study was to compare the baseline characteristics and adverse events of patients who had undergone ORIF of BT fractures versus pilon fractures using the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database.

Materials and Methods

Study Design

The present study was a retrospective cohort study using data from the ACS-NSQIP database. The database includes >240 variables collected on surgical patients from various centers worldwide and has information on 30-day morbidity and mortality and other various demographic variables. Specially trained personnel at every collaborating institution collect de-identified medical information and log it into the databank. In accordance with our institutional guidelines (which follow the U.S. Code of Federal Regulations for the Protection of Human Subjects), institutional review board approval was not needed or sought for our analysis because the data had been de-identified and collected as part of a quality assurance activity.

Patient Selection and Outcomes

For the present study, data from 2008 through 2014, including 3,359,900 patients, were used to identify patients who met the inclusion criteria. The inclusion criteria for the present study were age ≥18 years and operative fixation of ankle fractures. The current procedural terminology codes were used to search for patient data within the database. Ankle injuries were divided into 2 categories: BT fractures and pilon fractures. The Current Procedural Terminology codes used were 27814, 27822, and 27823 for BT fractures and 27827 and 27828 for pilon fractures. The exclusion criterion was any concomitant procedure performed on the lower extremities or pelvis.

The patient demographics, comorbidities, and selected laboratory values were obtained from the ACS-NSQIP database as baseline characteristics. These included age, gender, American Anesthesiologists Association class, total operative time, duration of hospital stay, functional status, body mass index, tobacco use, diabetes mellitus, hypertension, steroid use, congestive heart failure, chronic obstructive pulmonary disease, renal disease, malignancy, anesthesia type, prothrombin time, international normalized ratio, platelet count, albumin, white blood cell count, and serum sodium levels.

Thirty-day mortality and morbidity, including cardiac, respiratory, central nervous system, wound, venous thromboembolism, and readmission related to the procedure, were recorded as adverse events. Other variables with >50% of patients with missing data were removed from the analysis.

Statistical Analysis

Statistical analyses were performed using the Statistical Analysis System, version 9.1 (SAS Institute, Cary, NC). Categorical variables are presented as numbers and percentages and continuous variables as the mean ± standard deviation. Continuous variables were compared using the independent *t* test and categorical variables using the chi-square test. Odds ratios (ORs) for mortality and morbidities were calculated using logistic regression with 95% confidence intervals (CIs). Patient characteristics and adverse events were compared between the 2 types of injuries. The level of significance was set at $p < .05$.

Results

A total of 7127 patients met the inclusion criteria and their data analyzed. Of the 7127 patients, 6005 (84.3%) had BT fractures and 1122 (15.7%) had pilon fractures.

Baseline Characteristics

A comparison of the baseline characteristics between the 2 groups is presented in Table 1. Patients with pilon fractures varied significantly from those with BT fractures in several demographic and comorbid parameters. Pilon fractures were more likely to occur in males (51.2% of pilon patients versus 31.8% of BT patients; $p < .0001$). The age group distribution was also significantly different between the BT and pilon groups. The largest age group for both of these injuries was 40 to 64 years at 46.7% and 50.4% in the BT and pilon groups, respectively. BT fractures had an almost equal distribution of patients aged <40 years and >64 years, equaling approximately one fourth of all BT patients for both. In contrast, the patients with pilon fractures were 2 times more likely to be <40 years than aged 65 to 85 years at 31.5% and 15.9%, respectively. The greater percentage of older age patients would explain why patients with BT fractures were more likely than those with pilon fractures to have hypertension requiring medication (37.8% for BT versus 317 for pilon; $p < .0001$). In addition, the pilon group had a significantly lower proportion of patients with a body mass index >30 kg/m^2 (39.4% for pilon fractures and 45.8% for BT fractures; $p = .0002$) but a significantly greater percentage of patients who had used tobacco previously (24.6% of BT patients versus 39.4% of pilon patients; $p < .0001$).

Pilon fractures also required a significantly longer mean total operative time than BT fractures, with a mean difference of approximately 40 minutes ($p < .0001$) and required a significantly longer

Table 1
Baseline characteristics

Characteristic	BT (n = 6005)	Pilon (n = 1122)	*p* Value
Age (yr)			< .0001
<40	1471 (24.5)	354 (31.5)	
40-64	2805 (46.7)	565 (50.4)	
65-85	1547 (25.8)	178 (15.9)	
>85	182 (3.0)	25 (2.2)	
Male gender	1907 (31.8)	574 (51.2)	< .0001
ASA class			.0003
I-II	4104 (68.4)	833 (74.4)	
III	1710 (28.5)	264 (23.6)	
IV-V	184 (3.1)	23 (2.0)	
Total operation time (min)	81.59 ± 43.88	123.04 ± 69.16	< .0001
Duration of hospital stay (days)	2.42 ± 4.44	3.53 ± 12.05	.002
BMI ≥30 kg/m^2	2534 (45.8)	404 (39.4)	.0002
Tobacco use in past year	1479 (24.6)	343 (30.6)	< .0001
Diabetes on oral drugs or insulin	818 (13.6)	121 (10.8)	.01
HTN requiring medication	2267 (37.8)	317 (28.2)	< .0001
Steroid use for chronic condition	112 (1.9)	14 (1.2)	.15
Cardiac history			
CHF	44 (0.7)	4 (0.4)	.16
Severe COPD	236 (3.9)	38 (3.4)	.38
Renal history			
Acute renal failure	18 (0.3)	1 (0.1)	.34
Currently receiving dialysis	43 (0.7)	8 (0.7)	.99
Creatinine >1.2 mg/dL	475 (11.2)	70 (8.2)	.01
Malignancy history			
>10% loss of body	5 (0.1)	2 (0.2)	.30
Disseminated cancer	13 (0.22)	3 (0.27)	.73
Anesthesia technique			
General or MAC/IV sedation	5180 (86.3)	998 (89.0)	.04
Regional or spinal	804 (13.4)	121 (10.8)	
Other	21 (0.3)	2 (0.2)	
PTT	28.62 ± 6.57	28.43 ± 5.31	.52
INR >1.4	93 (3.6)	13 (2.2)	.08
Platelet count <150 K/μL	291 (6.6)	61 (7.0)	.65
Serum albumin	3.82 ± 0.55	3.81 ± 0.58	.75
WBC count >11,000/μL	940 (21.2)	187 (21.5)	.85
Sodium <135 mEq/L	343 (8.0)	73 (8.7)	.51
Sodium >145 mEq/L	51 (1.2)	7 (0.8)	.37
Functional status before surgery, dependent	375 (6.3)	61 (5.4)	.27
Type of fracture			
Open	182 (3.5)	44 (13.4)	< .0001
Closed	5011 (96.5)	284 (86.6)	< .0001

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index; BT, bimalleolar/trimalleolar; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; HTN, hypertension; INR, international normalized ratio; IV, intravenous; MAC, monitored anesthesia care; PTT, partial thromboplastin time; WBC, white blood cell.
Data presented as n (%) or mean ± standard deviation.