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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.

hospital stay by ≥1 day on average than BT fractures (p = .002). The pilon group also had significantly more open fractures than the BT group (Table 1).

Mortality and Adverse Events

No significant differences were found between the BT and pilon fractures regarding mortality rates (OR 0.24; 95% CI 0.03-1.80; p = .16), which represented <1% of cases in both groups. Also, no significant difference was found for most adverse events between the 2 injuries. The composite of all adverse events was <5% for both types of injuries (3.3% for BT versus 3.9% for pilon; OR 1.2; 95% CI 0.85-1.66; p = .30).

Adverse events related to cardiac, respiratory, central nervous system, and venous thromboembolism did not show any significant difference between the 2 fracture types (Table 2). A significantly increased risk of wound complications was found in patients with pilon fractures compared with those with BT fractures (OR 1.76; 95% CI 1.00-3.10; p = .048; Table 2). Open BT fractures and open pilon fractures had a 3.8% and 6.8% wound complication rate, respectively; however, this difference was not significant (OR 1.83; 95% CI 0.45-7.38; p = .41).

The readmission rate was also analyzed as adverse event and showed that 2.2 % of BT cases and 2.6% of pilon cases were readmitted for causes related to the injury (OR 1.21; 95% CI 0.76-1.90). No statistically significant differences were found between the 2 types of injuries (p = .42).

In our analysis of adverse events, the numbers were too small to elicit any potential risk factors; thus, the statistics were purely descriptive.

Discussion

The present study compared the baseline characteristics of patients treated operatively for BT fractures and pilon fractures and the adverse events in these patients. In our study, patients with pilon fractures were more likely to be younger and male and less likely to be obese than those with BT fractures. More than 50% of pilon fractures have also been previously reported to be in young male patients (14).

The pilon fracture group had a lower percentage of patients with diabetes, hypertension, and an American Society of Anesthesiologists class >3, and a high creatinine level compared with the BT group. This might have resulted from the younger and less obese population in the pilon fracture group.

The pilon fracture patients also required a longer average operative time and hospital stay than the BT fracture patients. The operative time was usually longer for pilon fractures than for BT fractures because of the complex nature of the procedure for the pilon injury.

Table 2
Adverse events

Adverse Event	BT (n = 6005)	Pilon (n = 1122)	BT versus Pilon OR	95% CI	p Value
Mortality	22 (0.37)	1 (0.09)	0.24	0.03-1.80	.16
Cardiac	13 (0.22)	3 (0.27)	1.24	0.35-4.34	.73
Respiratory	50 (0.83)	5 (0.45)	0.53	0.21-1.34	.17
CNS*	2 (0.05)	1 (0.13)	2.66	0.24-29.37	.40
Wound	49 (0.82)	16 (1.43)	1.76	1.00-3.10	.048
VTE	41 (0.68)	10 (0.89)	1.31	0.65-2.62	.45
Related readmission†	103 (2.19)	23 (2.64)	1.21	0.76-1.90	.42
Any, with related readmission‡	199 (3.31)	44 (3.92)	1.20	0.85-1.66	.30

Abbreviations: BT, bimalleolar/trimalleolar; CI, confidence interval; CNS, central nervous system; OR, odds ratio; VTE, venous thromboembolism.
Data presented as n (%).
* Number of missing outcomes was 2198 (30.4% of 7230).
† Number of missing outcomes was 1588 (22% of 7230).
‡ Based on first readmission.

The measured postoperative adverse events showed low rates of mortality, morbidity, and readmission for both types of fractures. No significant difference was noted between these groups for cardiac, respiratory, and neurologic adverse events or for thromboembolism.

The rate of adverse events, including readmission related to the procedure, was <4% in both groups, well below the range of 5% to 40% reported in the published data for ankle fractures in general, especially considering that our analysis only included high-energy BT and pilon fractures (3). This might have resulted from the short-term follow-up postoperatively recorded in the database.

The only adverse effect that reached statistical significance was postoperative wound complications, with pilon fractures having an incidence of 1.43% compared with 0.83% for BT fractures. Both these rates were quite low compared with those reported in the published data, with rates of wound complications in ankle fractures, in general, reported as 1.4% to 18% and ≤7.9% in pilon fractures (3,15,16). The overall low rate of all morbidities, and of wound complications in particular, in the present study made it difficult to provide any stratified analysis of adverse events. This might have resulted from the 30-day window for follow-up in the ACS-NSQIP database, which is considered short for some complications. However, wound complications after ORIF for ankle fractures become apparent within the first few days to 2 to 3 weeks. Only occasionally will they occur several months after surgery.

The patient population aged >65 years with BT fractures versus pilon fractures did not confer a greater adverse event rate with this type of injury. The published data showed evidence to suggest that the increase in adverse events was not statistically significant in elderly patients undergoing ankle fracture surgery (4,10). Other studies found that age was a patient-based risk factor for adverse events (3,17). However, in 2 studies of geriatric populations, patients who underwent surgery for ankle fracture were usually healthier than those who did not (18), which could explain the discrepancy between these studies.

In our study, the proportion of obese patients was greater in both groups, with a significantly greater proportion in the patients with BT fractures. Studies have shown that these patients are at an increased risk of short-term adverse events, in particular, superficial surgical site infections (9,18). The numbers in our study, however, were too small to stratify patients according to body mass index. Nevertheless, patients with pilon fractures had a greater risk of wound complications than did those with BT fractures. Similarly, the greater percentage of diabetic and hypertensive patients in those with a BT fracture versus a pilon fracture did not result in the expected increase in the complication rate between the groups, with a paradoxical increase in the wound complication rate in the pilon fracture group. The low number of patients in both groups precluded our ability to perform a stratified analysis, limiting these findings.

In contrast, previous tobacco use in the pilon fracture patients was associated with the well-known effects of tobacco use on wound healing. In addition, open fractures might predispose patients to wound complications. Our pilon group had a greater percentage of open fractures compared with the BT group; however, the adjusted OR for open versus closed fractures was not able to accurately reflect the effect of this factor on the development of wound complications because the number of patients with wound complications and open fractures was low. This increase in wound complications in the pilon fracture group could also be explained by the significantly longer mean operative time (approximately 40 minutes longer, on average) in the pilon group versus the BT fracture group (Table 1). Ovaska et al (12) found that an operative time >90 minutes was an independent risk factor for deep surgical site infections. The longer mean operative time for the patients who underwent surgery for pilon fractures might explain the increased risk of wound complications despite the younger age and lower proportion of obese patients. Also, the development of wound complications could lengthen the hospital stay, which was noted for our pilon fracture patients versus those with a BT fracture.

The present study had several potential limitations. The ACS-NSQIP database only reports adverse outcomes for the first 30 days postoperatively, which might underestimate the overall short-term adverse event rates. The ACS-NSQIP database does not report on the use of venous thrombosis prophylaxis, which could vary among different institutions, with the potential effect of under- or over-estimating the rate of venous thromboembolism. The database also does not report on whether the fracture was open or closed. This information would have provided a better understanding of the development of wound complications in this patient population. Another potential limitation of the present study was that we could not control for hospital effects. Variability could have been present in hospital quality or surgical strategy, which could have altered the rate of adverse events. Still further, considerable differences exist between the mechanisms of injury and deforming forces that result in pilon versus BT fractures. However, the strengths of the ACS-NSQIP database are that data collection and the definition of patient characteristics and adverse events are rigid, specially trained personnel perform the data entry, and the data are subject to review. In addition, patients who underwent surgery for associated injuries of the lower extremity were excluded from the analysis, limiting the effect of those procedures on the adverse outcomes.

In conclusion, the present study has shown the characteristics of patients with pilon or BT fractures undergoing surgical management. Younger age, less obese, healthier, and male gender seem to be associated more with pilon fractures than with BT fractures. However, no significant difference in the short-term postoperative outcomes was noted between these types of fractures, except for wound complications. The greater percentage of previous tobacco use and longer operative time might explain the greater rate of wound complications in the pilon fracture patients versus those of BT fractures. This complication might also be the reason for the longer hospital stay noted for the pilon fracture patients. Although further studies are needed, the present study will assist orthopedic trauma surgeons in preoperative counseling of patients with high-energy ankle fractures.

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