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Risk Factors for Short-Term Complication After Open Reduction and Internal Fixation of Ankle Fractures: Analysis of a Large Insurance Claims Database

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A R T I C L E I N F O

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A B S T R A C T

Although fractures of the ankle are common injuries treated by surgical podiatrists and orthopaedic surgeons specializing in foot and ankle surgery, postoperative complications can occur, often imposing an economic burden on the patient. As health care in the United States moves toward value-based care, cost reduction has primarily focused on reducing complications and unplanned episodes of care. We used a large modern database of insurance claims to examine patterns of complications after open reduction internal fixation of ankle fractures, identifying diabetes mellitus and history of myocardial infarction as risk factors for postoperative infection within 30 days of surgery. Lateral malleolar repair was less likely to lead to infection, or need for repeated surgery, than was medial malleolar fracture repair. Diabetes mellitus, neuropathy, and chronic obstructive pulmonary disease were associated with development of postoperative cellulitis. Patients with a history of cerebrovascular accident were more likely to return to the emergency department or to have a pulmonary embolism. Male sex, presence of lupus, and increased age were associated with repeat surgery.

An estimated 100 million visits are made to emergency departments (EDs) each year in the United States (1,2), with 14.6% of those visits relating to lower extremity injury (1). Sprains and strains accounted for 36% of injuries of the lower extremity; however, ankle fractures occur with the highest incidence (206 of 100,000) (3). The ankle is also the most common lower extremity location for fracture, accounting for 19.2% of such injuries (3,4). Specifically among foot and ankle fractures, >50% involve the ankle (4). More than 50% of ankle fractures in patients presenting to major trauma centers involve the medial malleolus (4,5), and often such injuries require open reduction internal fixation (ORIF) (6). Surgical repair is also indicated in open fractures, which comprise 18.5% of all fractures of the foot and ankle in the major trauma institutions (4).

Both short- and long-term complications after surgical repair of ankle fractures can lead to significant morbidity. Long-term complications may include arthritis, malunion, nonunion, avascular necrosis, instability, and chronic pain, whereas short-term complications include soft tissue infections, wound-healing complications, and thrombotic events, such as deep vein thrombosis (DVT) and/or pulmonary embolism (PE). In general, surgical site infection after ankle fracture surgery is rare (7−14), unless the fracture is open. When infection occurs, *Staphylococcus aureus* is the most common pathogen (15,16). Postoperative infection rates are variable, ranging from 1.3% to 14% (9,10). The rates of DVT and PE in both elective and nonelective foot and ankle surgery are generally low. In an early study, Mizel et al (17) noted DVT and nonfatal PE rates of 0.22% and 0.15%. Similar DVT and nonfatal PE rates of 0.4% and 0.3% were observed by Wukich et al (18) in a more recent study. Finally, reoperation occurs for a variety of reasons, such as nonclosing wound, malreduction, and infection after ankle ORIF, and rates are widely variable (10−12,19,20).

Understanding the risk factors associated with complications following ankle fracture surgery is important, because complications affect a large portion of foot and ankle surgical issues in the United States. Such information could also affect each surgeon's clinical

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Table 1
Current Procedural Terminology codes for procedures included in the study

CPT Code	Procedure
27766	ORIF of the medial malleolus
27792	ORIF of the lateral malleolus
27814	ORIF of a bimalleolar fracture
27822	ORIF of a trimalleolar fracture without fixation of the posterior malleolus
27823	ORIF of a trimalleolar fracture with posterior fracture fixation
27829	ORIF of distal tibiofibular joint with internal fixation

Abbreviations: CPT, Current Procedural Terminology; ORIF, open reduction internal fixation.

decision-making and would be useful in health services research and policy making. Of particular interest in this regard is whether different types of professional training relate to outcomes. An estimated 25% of patients who undergo foot and ankle surgery return to the ED within 30 days of the operation (21,22). Anecdotal references to risk factors may be subject to selection or recall bias of how ankle fracture is managed in this country and in an individual's practice.

There are a limited number of large population studies evaluating risk factors for both short-term and mid-term complications after ORIF of ankle fractures, while considering interactions of fracture patterns and patient demographics, characteristics, and comorbidities (23). Our goals were to assess the incidence of complications after ORIF of ankle fractures, identify risk factors associated with those complications, and identify risk factors associated with return to ED within 30 days of this procedure. Further, as a secondary analysis, we assessed whether outcomes differed between podiatric and orthopedic surgeons.

Patients and Methods

Institutional review board approval for this study was granted by The University of Texas Medical Branch. We used the Optum Database, a commercially available database of private insurance claims data from all 50 states. The database contains >1 billion claims ranging from 2008 to 2015. We identified patients from the database who had outpatient ankle fracture repair performed by podiatric and orthopaedic foot and ankle surgeons between January 1, 2009, and June 30, 2015, by using the Current Procedure Terminology (CPT) codes listed in Table 1. Pilon fractures were excluded, as were patients <18 or >64 years old. Furthermore, we included patients who had continuous enrollment with the insurance carrier for at least 1 year before and 3 months after the procedure. This allowed us to ensure that patients had no prior ORIF within 1 year of the index surgery and had at least 3 months of follow-up after surgery. We excluded cases in which the emergency medicine physician was listed as the primary provider, working under the assumption that in cases where emergent medical services were required, foot and ankle trauma may have been a secondary concern.

Table 3
Complications

Complication	ICD-9 Code
Infection	136.9, 682.9, 996.0, 996.1, 996.2, 996.3, 996.4 996.5, 998.59
Wound dehiscence	958.3, 998.31, 998.32, 998.33, 12020, 12021
DVT	410.9, 411.81, 434.1, 444.9, 452, 453.3, 453.40, 453.41, 453.42, 453.6, 453.81, 453.81, 453.82, 453.83, 453.84, 453.85, 453.86, 453.87, 453.89, 453.9, 557
PE	415.11, 415.12, 415.13, 415.19, 673.8, 958.1
Wound care	998.51, 97605, 97606
Cellulitis	681.00, 681.02, 681.10, 681.11, 681.9, 682.0, 682.1, 682.2, 682.3, 682.4, 682.5, 682.6, 682.7, 682.8, 682.9

Abbreviations: ICD-9, *International Classification of Diseases, 9th Revision*; DVT, deep vein thrombosis; PE, pulmonary embolism.

We recorded age at time of surgery, sex, and the presence of the following comorbidities: chronic obstructive pulmonary disease (COPD), lupus, obesity, neuropathy, diabetes mellitus (DM), retinopathy, chronic and nonchronic renal disease, nephropathy, myocardial infarction (MI), and cerebrovascular accident. Comorbidities must have been coded within the year before surgery and to have been coded as at least 1 inpatient bill or 2 outpatient bills at least 30 days apart. The *International Classification of Diseases, Ninth Revision* (ICD-9) codes used to identify comorbidities are provided in Table 2.

We examined short-term complications with DVT, PE, infection, or wound dehiscence within 30 days of the index surgery. As a sensitivity analysis, we also selected those cases where these complications occurred within 30 days and were the primary ICD-9 diagnostic code for the visit during which they were recorded. We also evaluated for the presence of extremity cellulitis as the primary diagnostic code, within 90 days of the index surgery. Cellulitis was examined at 90 days to capture infection caused by less virulent organisms, as such infection may often manifest beyond 30 days after surgery. Finally, we looked for return to the ED and repeat ORIF (same codes as the index surgery) within 30 days of the index surgery. The ICD-9 codes for the various complications are listed in Table 3.

Statistical Analyses

All variables were summarized using means and standard deviations, or frequencies and percentages, for continuous and discrete variables, respectively. Separately for each complication, we examined the association of each variable with the occurrence of that complication, using Student's *t* tests or χ^2/Fisher's exact tests, for continuous and discrete variables, respectively. Those variables whose associations with an outcome were at a *p* value of $\leq .2$ were included in a multivariate logistic regression for that outcome.

Results

Subjects and Univariate Analyses

A total of 10,602 patients were included in this analysis. The average age was 43.3 years (standard deviation 13.57 years, range 18 to 64 years),

Table 2
Comorbidities

Comorbidity	ICD-9 Code
COPD	490, 491, 492, 494, 496
Hyperparathyroidism	252.00, 252.08, 252.01, 252.8, 259.3, 588.81
Lupus	017.0, 135, 286.53, 289.81, 289.82, 373.34, 695.4, 710.0, 795.79, 972.6
Rheumatoid arthritis	714.0, 714.1, 714.2, 714.30 (juvenile), 714.31, 714.32, 713.33, 714.89, 720.0
Obesity	278.0X
Neuropathy	032.89, 045.1, 053.13, 072.72, 135, 145.0, 199.1, 242.9 249.6, 250.6, 251.2, 265.0, 265.2, 266.1, 266.2, 266.9, 269.1, 269.2, 269.8, 269.9, 274.89, 277.1, 277.39, 291.1, 335.21, 337.00, 337.1, 337.1, 337.9, 344.9, 344.9, 352.6, 354.0, 354.1, 354.2, 354.3, 354.4, 354.5, 354.8, 354.9,, 355.1, 355.2, 355.3, 355.4, 355.5, 355.6, 355.71, 355.79, 355.8, 355.8, 355.9, 356.0, 356.1, 356.2, 356.3, 356.4, 356.8, 356.9, 357.0, 357.2, 357.4, 357.5, 357.6, 357.7, 357.81, 357.82, 357.89, 446, 585.9, 710.0, 710.1, 710.9, 714.0, 729.2, 977.0, 985.0
Diabetes	250.xx
Retinopathy	362.0x, 362.1x, 362.2x, 362.3x, 362.4x, 362.5x, 362.6x, 362.7x, 362.8x, 362.9,
Renal disease, nonchronic	249.4, 250.4, 274.1, 403.9, 403.90, 403.91,, 404.12, 404.13, 404.02, 404.03, 446.21, 580.xx, 583.xx, 584.xx, 593.9, 753.1,
Chronic renal disease	582.xx, 585.xx, 587, 588.xx
Nephropathy	282.6, 581.xx, 584.5, 584.7, 588.89, 593.89, 593.9
Renal infarct	593.81
Atherosclerosis	249.7, 250.7, 440.0, 440.1, 440.20, 440.21, 440.22, 440.23, 440.24, 440.29, 440.30, 440.31, 440.32, 440.4, 440.8, 440.9, 443.81, 443.9, 459.9,
Myocardial infraction	410.00, 410.01, 410.02, 410.10, 410.11, 410.12, 410.20, 410.21, 410.22, 410.30, 410.31, 410.32, 410.40, 410.41, 410.42, 410.50, 410.51, 410.52, 410.60, 410.61, 410.62, 410.70, 410.71, 410.72, 410.80, 410.81, 410.82, 410.90, 410.91, 410.92
CVA	431, 434.01, 434.11, 434.91, 435.9, 997.02

Abbreviations: ICD-9, *International Classification of Diseases, 9th Revision*; COPD, chronic obstructive pulmonary disease; CVA, cerebrovascular accident.

with 46.93% male and 53.07% female. Because the population was relatively young, the burden of comorbid diseases was low, with only COPD (2.27%), DM (7.70%), neuropathy (4.63%), and obesity (4.60%) appearing in >2% of the population.

The complication rates were also low, with only 1.13%, 1.41%, 0.41%, and 0.43% having DVT, infection, PE, or wound dehiscence within 30 days of surgery. Cellulitis occurred in 2.6% of the sample, and 4.39% returned to the ED within 30 days. Finally, 1.15% had a repeat ORIF within 30 days. Demographic details are shown in Table 4.

Bivariate Analyses

Very few factors predisposed to DVT: only lupus (odds ratio 5.73, 95% confidence interval 2.28 to 14.4) and nonchronic renal disease (3.56, 1.11 to 11.44) affected the occurrence of DVT. Similarly, DM (2.73, 1.26 to 5.9) and nonchronic renal disease (7, 2.13 to 22.95) predisposed to PE, and those who had PE were older than those who did not. Age was the only factor associated with wound dehiscence: those with the complication were older (49.39, 12.19 versus 43.28, 13.57). Infection was associated with a greater number of risk factors: atherosclerosis, cerebrovascular accident (CVA), chronic renal disease, DM, MI, neuropathy, obesity, nonchronic renal disease, and age predisposed to infection. Notably, infections occurred in 3.28% of those with DM and only 1.26% of those without DM and in 3.05% of those with neuropathy but only 1.34% of those without neuropathy. Cellulitis was associated with a similar array of comorbidities: atherosclerosis, COPD, chronic renal disease, DM, MI, nephropathy, neuropathy, obesity, nonchronic renal disease, retinopathy, and age. Females were more likely to have an unplanned return to the ED than were males (4.87% versus 3.84%, $p = .01$), and those with COPD were almost twice as likely to have unplanned return to the ED as those without COPD (8.3% versus 4.29%, $p = .003$). The presence of CVA, chronic renal disease, DM, lupus, MI, neuropathy, nephropathy, obesity, and nonchronic renal disease also confer risk of return to the ED; 12.17% of patients with nonchronic renal disease returned to the ED. Finally, only DM, lupus, retinopathy, and increasing age contributed to the risk of repeated ORIF. Details of bivariate analysis are shown in Table 5.

Table 4
Patient demographics (N = 5625 females and 4975 males)

Variable	n	%
Female	5625	53.07
Male	4975	46.93
Atherosclerosis	79	0.75
COPD	241	2.27
CVA	45	0.42
Chronic renal disease	87	0.82
Diabetes	824	7.77
Lupus	84	0.79
Myocardial Infarction	19	0.18
Nephropathy	76	0.72
Neuropathy	491	4.63
Obesity	488	4.6
Nonchronic renal disease	115	1.08
Retinopathy	78	0.74
DVT	120	1.13
Primary DVT	98	0.92
Infection	150	1.41
Primary infection	121	1.14
PE	43	0.41
Primary PE	36	0.34
Wound dehiscence	45	0.43
Primary wound dehiscence	34	0.32
Cellulitis	276	2.6
Primary cellulitis	211	1.99
Return to ED	465	4.39
Repeat ORIF	122	1.15

Abbreviations: COPD, chronic obstructive pulmonary disease; CVA, cerebrovascular accident; DVT, deep vein thrombosis; PE, pulmonary embolism; ED, emergency department; ORIF, open reduction internal fixation.

Multivariate Analyses

Multivariate logistic regression greatly reduced the number of factors impacting complications (Table 6). Risk of DVT was only increased by lupus (4.25, 1.61 to 11.24) and age (1.02, 1.00 to 1.03). History of CVA greatly impacted the risk of PE (6.87, 1.47 to 32.06). Dehiscence was associated only with increased age (1.03, 1.01 to 1.06). Both DM (1.72, 1.04 to 2.84) and MI (5.12, 1.10 to 23.87) increased the risk of infection, whereas lateral malleolus repair was less likely to experience infection compared with medial malleolus fracture repair (0.52, 0.27 to 0.99). Cellulitis risk was increased by DM (2.41, 1.71 to 3.41), neuropathy (1.88, 1.24 to 2.84), and COPD (1.87, 1.10 to 3.17). Returns to the ED were less frequent in males (0.82, 0.67 to 1.00), and increased in those patients with CVA (2.55, 1.08 to 6.03). Finally, 3 factors increased the likelihood of repeated ORIF: male sex (1.48, 1.01 to 2.17), lupus (5.89, 2.45 to 14.18), and increased age (1.02, 1.00 to 1.03). However, lateral malleolus fracture repairs were less likely to need repeated ORIF compared with medial malleolus fracture repairs (0.50, 0.25 to 0.98).

Discussion

This study analyzed rates and risk factors for complications in a US population of patients who underwent ankle fracture surgery. Rather than examining complications in isolation, we took a more epidemiological view, trying to understand the totality of the range of complications in which we were interested and considering short-term complications.

The short-term complication rates reported in our study are comparable to those in the literature, with infection, dehiscence, and cellulitis occurring in 1.41%, 0.43%, and 1.99% of our cohort, respectively. Reported rates of infection are widely variable, from 1.3% by Macera et al (10) to 14% by Thangarajah et al (9), most likely because of differing definitions of clinically relevant infection and depending on whether fractures are open or closed. Diabetes and MI increased the likelihood of infection. Aklthough the presence of MI had a greater association with postoperative infection, the rates of MI in our population are low, making this finding less conclusive. Interestingly, other systemic issues, such as kidney disease and obesity, did not have an impact on infection. The question of obesity and its impact on wound complications and infection is one that is widely studied, although results are not conclusive (24–28). Diabetes is a well-known risk factor that affects infection rates and the occurrence of cellulitis (29). Neuropathy and COPD are also associated with cellulitis. Neuropathy has been associated with bone- and wound-healing complications in foot and ankle surgery. Although this has mostly been studied in patients with diabetes, the current study shows that this relationship may affect the general population as well (30–32).

Lateral malleolar fracture repairs were less likely to have postoperative infection compared with medial malleolar fracture repairs. This is most likely confounded by severity of ankle fracture, such as bimalleolar or trimalleolar ankle fracture, where the associated soft tissue envelope may be compromised and the likelihood of surgical wound-healing complications is greater. Further, medial malleolar fractures may be coded as a unimalleolar fracture, rather than bimalleolar or trimalleolar fractures, when only ligamentous rupture is seen laterally. Although the same holds true for lateral malleolar fractures, isolated lateral malleolar fracture is more common than isolated medial malleolar fracture.

Our infection rates are comparable to those in the literature, but the rates of DVT and PE may be slightly lower than those reported elsewhere in foot and ankle trauma. The difference is likely largely the result of each study's follow-up period, rate at which they track postoperative complications, type of included procedures (soft tissue versus

Table 5
Bivariate analysis of complications and risk factors (N = 5655 females and 4975 males)

Complications																					
Risk Factor	DVT			PE			Wound Dehiscence			Infection			Cellulitis			ED			ORIF		
	No	Yes	p	No	Yes	p	No	Yes	p	No	Yes	p	No	Yes	p	No	Yes	p	No	Yes	p
Female	5588 (98.81)	67 (1.19)	.541	5598 (99.52)	27 (0.48)	.2	5601 (99.57)	24 (0.43)	.903	5544 (98.56	81 (1.44)	.817	5469 (97.23)	156 (2.77)	.244	5351 (95.13)	274 (4.87)	.01	5568 (98.99)	57 (1.01)	.158
Male	4922 (98.93)	53 (1.07)		4959 (99.68)	16 (0.32)		4953 (99.56)	22 (0.44)		4906 (98.61)	69 (1.39)		4855 (97.59)	120 (2.41)		4784 (96.16)	191 (3.84)		4910 (98.61)	65 (1.31)	
Atherosclerosis																					
No	x	x	.25	x	x	.276	x	x	.292	x	x	.005	x	x	<.001	x	x	.161	x	x	.601
Yes	x	x		x	x		x	x		x	x	OR: 4.84 (1.93-12.14)	x	x	OR: 5.59 (2.85-10.97)	x	x	OR: 1.08 (0.78-4.16)	x	x	
COPD																					
No	x	x	1	x	x	1	x	x	.281	x	x	.586	10106 (97.54)	255 (2.46)	<.001	9916 (95.71)	445 (4.29)	.003	x	x	.532
Yes	x	x		x	x		x	x		x	x		220 (91.29)	21 (8.71)		221 (91.7)	20 (8.3)		x	x	
CVA																					
No	x	x	.092	x	x	.14	x	x	1	x	x	.026	x	x	.112	x	x	.003	x	x	.407
Yes	x	x	OR: 4.11 (0.99 to 17.18)	x	x	OR: 11.93 (2.8 to 50.89)	x	x		x	x	OR: 5.06 (1.55 to 16.5)	x	x	OR: 2.69 (0.83 to 8.73)	x	x	OR: 4.06 (1.8 to 9.15)	x	x	
Chronic renal disease																					
No	x	x	1	x	x	.3	x	x	.316	x	x	<.001	10252 (97.5)	263 (2.5)	<.001	x	x	.014	x	x	.079
Yes	x	x		x	x		x	x		x	x	OR: 7.4 (3.51 to 15.6)	74 (85.06)	13 (14.94)		x	x	OR: 2.55 (1.27 to 5.11)	x	x	OR: 3.12 (0.97 to 10.01)
Diabetes																					
No	9669 (98.89)	109 (1.11)	.566	x	x	.016	x	x	.087	9655 (98.74)	123 (1.23)	<.001	9567 (97.84)	211 (2.16)	<.001	9369 (95.82)	409 (4.18)	<.001	9673 (98.93)	105 (1.07)	.011
Yes	813 (98.67)	11 (1.33)		x	x	OR: 2.73 (1.26 to 5.9)	x	x	OR: 2.14 (0.95 to 4.8)	797 (96.72)	27 (3.28)		759 (92.11)	65 (7.89)		768 (93.2)	56 (6.8)		807 (97.94)	17 (2.06)	
Lupus																					
No	x	x	.003	x	x	.29	x	x	.307	x)	x	.116	x	x	.175	x	x	.011	x	x	<.001
Yes	x	x	OR: 5.73 (2.28 to 14.4)	x	x		x	x		x	x	OR: 2.61 (0.82 to 8.37)	x	x	OR: 1.88 (0.69 to 5.18)	x	x	OR: 2.65 (1.32 to 5.32)	x	x	OR: 6.9 (2.9 to 16.14)
Myocardial infarction																					
No	x	x	1	x	x	1	x	x	1	x	x	.029	x	x	.012	x	x	.048	x	x	.2
Yes	x	x		x	x		x	x		x	x	OR: 8.29 (1.9 to 36.23)	x	x	OR: 7.08 (2.05 to 24.44)	x	x	OR: 4.11 (1.19 to 14.15)	x	x	OR: 4.8 (0.64 to 36.27)
Nephropathy																					
No	x	x	.58	x	x	.267	x	x	1	x	x	.093	x	x	<.001	x	x	.049	x	x	.586
Yes	x	x		x	x		x	x		x	x	OR: 2.9 (0.9 to 9.31)	x	x	OR: 4.5 (2.14 to 9.46)	x	x	OR: 2.23 (1.02 to 4.88)	x	x	
Neuropathy																					
No	x	x	.529	x	x	.137	x	x	.163	9976 (98.66)	135 (1.34)	.02	9875 (97.67)	236 (2.33)	<.001	9683 (95.77)	428 (4.23)	<.001	x	x	.309
Yes	x	x		x	x	OR: 2.12 (0.75 to 5.96)	x	x	OR: 1.97 (0.7 to 5.51)	476 (96.95)	15 (3.05)		451 (91.85)	40 (0.15)		454 (92.46)	37 (0.754)		x	x	
Obesity																					
No	x	x	.835	x	x	.722	x	x	.059	9977 (98.65)	137 (1.35)	.017	98.66 (97.55)	248 (2.45)	<.001	9684 (95.75)	430 (4.25)	.002	x	x	.3
Yes	x	x		x	x		x	x	OR: 2.54 (1 to 6.46)	475 (97.34)	13 (2.66)		460 (94.26)	28 (5.74)		453 (92.83)	35 (7.17)		x	x	
Nonchronic renal disease																					
No	x	x	.041	x	x	.112	x	x	.395	x	x	<.001	10231 (97.560)	256 (2.44)	<.001	10036 (95.7)	451 (4.3)	<.001	x	x	.383
Yes	x	x	OR: 3.22 (1.17 to 8.880	x	x	OR: 7 (2.13 to 22.95)	x	x		x	x	OR: 5.45 (2.61 to 11.38)	95 (82.61)	20 (17.39)		101 (87.83)	14 (12.17)		x	x	
Retinopathy																					
No	x	x	.058	x	x	.04	x	x	.289	x	x	.098	x	x	<.001	x	x	.084	x	x	.012
Yes	x	x	OR: 3.56 (1.11 to 11.44)	x	x	OR: 6.73 (1.6 to 28.32)	x	x	0.645	x	x	OR: 2.82 (0.88 to 9.06)	x	x	OR: 4.37 (2.08 to 9.18)	x	x	OR: 2.17 (0.99 to 4.74)	x	x	OR: 4.77 (1.71 to 13.25)

(*continued on next page*)

Table 5. (*Continued*)

Complications																					
Risk Factor	DVT			PE			Wound Dehiscence			Infection			Cellulitis			ED			ORIF		
	No	Yes	*p*	No	Yes	*p*	No	Yes	*p*	No	Yes	*p*	No	Yes	*p*	No	Yes	*p*	No	Yes	*p*
Procedure																					
27766	x	x	.262	x	x	.925	x	x		x	x	.004	780 (97.74)	18 (2.26)	.219	767 (96.12)	31 (3.88)	.098	x	x	.001
27792	x	x		x	x		x	x		x	x		3948 (97.77)	90 (2.23)		3885 (96.21)	153 (3.79)		x	x	
27814	x	x		x	x		x	x		x	x		2511 (96.95)	79 (3.05)		2472 (95.44)	118 (4.56)		x	x	
27822	x	x		x	x		x	x		x	x		1311 (97.04)	40 (2.96)		1284 (95.04)	67 (4.96)		x	x	
27823	x	x		x	x		x	x		x	x		311 (96.28)	12 (3.72)		303 (93.81)	20 (6.19)		x	x	
27829													1465 (97.54)	37 (2.46)		1426 (94.94)	76 (5.06)		x	x	
Age	43.27 (13.58)	46.48 (12)	.004	43.28 (13.57)	48.53 (11.86)	.012	43.28 (13.57)	49.39 (12.19)	.001	43.26 (13.57)	46.43 (13.34)	.004	43.23 (13.57)	46.19 (13.05)	<.001	43.3 (13.57)	43.34 (13.42)	.951	43.27 (13.57)	46.15 (12.97)	.016

Abbreviations: DVT, deep vein thrombosis; PE, pulmonary embolism; ED, emergency department; ORIF, open reduction internal fixation; COPD, chronic obstructive pulmonary disease; CVA, cerebrovascular accident.

Table 6
Multivariate analysis of complications and risk factors (N = 5655 females and 4975 males)

Complications														
Risk Factor	DVT	*p*	PE	*p*	Wound Dehiscence	*p*	Infection	*p*	Cellulitis	*p*	ED	*p*	ORIF	*p*
Sex (male vs female)											0.82 (0.67 to 1.00)	.0486	1.48 (1.01 to 2.17)	.042
Atherosclerosis							2.05 (0.74 to 5.64)	.166	1.87 (0.88 to 4.01)	.105	1.01 (0.41 to 2.47)	.979		
COPD									1.87 (1.10 to 3.17)	.02	1.43 (0.87 to 2.35)	.163		
CVA	2.15 (0.46 to 10.01)	.328	6.87 (1.47 to 32.06)	.014			2.54 (0.72 to 8.97)	.15	1.04 (0.28 to 3.80)	.954	2.55 (1.08 to 6.03)	.032		
Chronic renal disease							3.00 (0.95 to 9.51)	.062	1.05 (0.43 to 2.59)	.909	0.96 (0.37 to 2.46)	.926	1.42 (0.41 to 4.90)	.579
Diabetes			1.52 (0.62 to 3.79)	.356	1.35 (0.57 to 3.20)	.498	1.72 (1.04 to 2.84)	.033	2.41 (1.71 to 3.41)	<.001	1.27 (0.92 to 1.76)	.145	1.3 (0.74 to 2.36)	.341
Lupus	4.25 (1.61 to 11.24)	.003					1.46 (0.43 to 4.92)	.539	0.93 (0.31 to 2.75)	.89	1.79 (0.86 to 3.72)	.117	5.89 (2.45 to 14.18)	<.001
Myocardial infarction							5.12 (1.10 to 23.87)	.038	3.14 (0.80 to 12.25)	.1	2.71 (0.74 to 9.94)	.133	3.31 (0.42 to 25.96)	.25
Nephropathy							0.61 (−0.15 to 2.47)	.489	0.81 (0.31 to 2.12)	.664	1.06 (0.42 to 2.68)	.905		
Neuropathy			0.94 (0.28 to 3.16)	.92	1.28 (0.44 to 3.74)	.651	1.17 (0.62 to 2.22)	.624	1.88 (1.24 to 2.84)	.003	1.30 (0.88 to 1.91)	.191		
Obesity					1.96 (0.75 to 5.16)	.173	1.24 (0.66 to 2.32)	.5	1.34 (0.86 to 2.10)	.196	1.33 (0.91 to 1.95)	.139		
Nonchronic renal disease	2.00 (0.68 to 5.91)	.208	3.29 (0.79 to 13.66)	.102			1.46 (0.45 to 4.79)	.529	2.69 (1.26 to 5.74)	.011	1.74 (0.78 to 3.90)	.176		
Retinopathy	2.20 (0.63 to 7.61)	.215	2.55 (0.51 to 12.84)	.256			0.99 (0.28 to 3.51)	.99	1.30 (0.56 to 2.99)	.54	1.39 (0.60 to 3.20)	.441	2.91 (0.97 to 8.77)	.058
Procedure														
27792							0.52 (0.27 to 0.99)	.047			0.97 (0.5 to 1.44)	.869	0.50 (0.25 to 0.98)	.042
27814							0.97 (0.52 to 1.83)	.929			1.13 (0.75 to 1.69)	.565	0.70 (0.35 to 1.40)	.317
27822							0.91 (0.45 to 1.84)	.803			1.21 (0.78 to 1.87)	.404	1.17 (0.57 to 2.38)	.671
27823							1.07 (0.40 to 2.88)	.895			1.53 (0.85 to 2.74)	.152	0.63 (0.17 to 2.25)	.47
27829							1.40 (0.73 to 2.69)	.317			1.34 (0.87 to 2.06)	.179	1.13 (0.56 to 2.27)	.733
Age	1.02 (1.00 to 1.03)	.032	1.02 (1.00 to 1.05)	.066	1.03 (1.01 to 1.06)	.009	1.01 (1.00 to 1.02)	.093	1 (0.99 to 1.01)	.471			1.02 (1.00 to 1.03)	.04

Abbreviations: DVT, deep vein thrombosis; PE, pulmonary embolism; ED, emergency department; ORIF, open reduction internal fixation; COPD, chronic obstructive pulmonary disease; CVA, cerebrovascular accident.

osseous, forefoot versus ankle, elective versus nonelective, etc.), population studied, and whether asymptomatic DVT detected with Doppler were included. Hanslow et al (33) followed their foot and ankle surgery patients, including trauma patients, noting a DVT rate of 4% and a PE rate of 1.3%. Two meta-analyses examined venous thromboembolic disease (VTED) rates in foot and ankle surgery, both noting population level rates < 1% (34,35). Both studies observed higher rates of VTED in trauma patients. In this regard, Lapidus et al (36) noted very high rates of VTED after ankle fracture, up to 20%; however, the clinical relevance is not clear, as many patients were tested with both duplex ultrasound and phlebography, perhaps resulting in overreporting, and rates of PE were not given. Both Lassen et al (37) and Spannagel and Kujath (38) noted that low molecular weight heparin reduced rates of DVT in patients who were immobilized, and across the 2 studies, rates of DVT ranged from 4.8% to 19%. These rates are in stark contrast to the rates of 0.12% DVT and 0.17% PE rates found within 90 days of ankle fracture (39) and the rates of 0.28% DVT and 0.21% PE in our earlier examination of acute incidence of VTED (40) or similarly low rates found by Basques et al (12) and Soohoo et al (41). Finally, a study published in 2018 examined ankle fractures treated with immobilization and ankle fractures treated surgically, with 90-day rates of VTED of 2.2% and 3%, respectively (42). DVT rates in our study were affected by lupus and by age. The relationship between lupus and DVT is understood (43,44), as is that with age (45,46). Other factors known to affect rates of DVT in foot and ankle trauma did not appear here, either because they are not available in the data set or because we did not record them (40). In contradistinction to the analysis in Shibuya et al (40), we did not rule out polytrauma, and this may impact both the rates and the risk factors of DVT. Similarly, in contrast to Shibuya et al (40), CVA was the only risk factor independently associated with PE. In the work of Shibuya et al (40), PE was affected by injury severity score, obesity, and procedure type. It is possible that in other types of foot and ankle trauma, these factors play a greater role; the proportion of ankle fracture among all trauma patients in their study population was not provided.

Reoperation occurs for a variety of reasons after ankle ORIF. Lynde et al (11) noted hardware failure in 2.8% of their patients, and that 1.9% needed repeat surgery, both within 90 days of surgery. Macera et al (10) noted a rate of 21.7% return to the operating room for debridement or arthrodesis. Focusing on malreductions, Ovaska et al (20) had 1.6% of the patients in their study return to the operating room for reoperation within a week of initial surgery. Basques et al (12) noted reoperation rates of 1.84% and readmission rates of 3.17%, and Liu et al (19) noted 30-day rates of readmission of 3.7% and 1.3%, and reoperation rates of 3.06% and 0.95%, in diabetic and nondiabetic patients, respectively. Readmissions were for reasons such as surgical site infection, fracture complications, and dehiscence. Reoperations were for debridement and amputation (0.19% and 0.01% in diabetic and nondiabetic patients, respectively). Amputation after ankle ORIF is relatively rare, as seen here, and other studies show similar rates (47). However, rates of amputation may be higher in patients with diabetes (48,49). In our population, we noted that males were less likely to return to the ED but that patients with CVA were more likely to return. Shibuya et al (21) noted that emergent surgery, age, and diabetes were risk factors for return to ED, but sex was not. Their study, however, included both elective and emergent operations, whereas the current study focuses on traumas that are relatively urgent, with some variation in surgical timing depending on severity. The number of patients requiring reoperation in our cohort was low, only 1.15%. Males in our study population were less likely to return to the ED, but they were more likely to have repeat ORIFs. Advanced age also increased likelihood of repeat ORIFs. Lateral malleolar fracture repairs were less likely than medial malleolar fracture repairs to have repeated ORIF (0.50, 0.25 to 0.98).

Ankle fractures are common injuries treated by surgical podiatrists and orthopaedic surgeons who specialize in foot and ankle surgery. Recent publications have compared the results of procedures performed by podiatric and orthopaedic surgeons (50,51). Given this interest, we examined our data to determine whether our results corroborate those of other investigators. In an ankle fracture study, because of restrictions with the use of data, the authors were able to perform only a bivariate analysis (51). This limited the authors' ability to compare cases performed by the 2 specialties, as they were unable to control for factors that might affect outcome and differ between the cases. A study on arthrodesis and total ankle replacement had broader access to data and used propensity score matching to make a comparison between the specialties. They noted no differences in outcome but remarked on increased resource utilization by podiatric foot and ankle surgeons (50). We carried out a similar propensity score analysis, matching on factors we thought might affect outcomes: sex, age, COPD, neuropathy, obesity, and nonchronic renal disease. On bivariate analysis, the rates of DVT, primary DVT, and cellulitis for podiatric foot and ankle surgeons were 1.95%, 1.95%, and 3.6%, whereas for orthopaedic surgeons, these rates were 1.05%, 0.8%, and 2.5%, respectively. Podiatric foot and ankle surgeons treated a higher percentage of patients with chronic renal disease, diabetes, neuropathy, and nonchronic renal disease in their patient populations (Table S1). These differences were all statistically significant in the bivariate analyses that compare specialties. The rates of repeat ORIF for podiatric foot and ankle and orthopaedic surgeons were not significantly different (0.92% and 1.17%, respectively; $p = .488$). On multivariate analysis, podiatric specialty remained significant for DVT and primary DVT but was not significant for cellulitis. On conditional regression after 1:1 propensity score matching, only primary DVT remained statistically significant. We note with interest as well that all DVTs in patients treated by podiatric foot and ankle surgeons were the primary diagnosis, whereas this was not the case with orthopaedic surgeons.

A bivariate analysis comparing the patients treated by podiatric foot and ankle surgeons and those treated by orthopaedic surgeons is given in Table S1. Table S1 also contains a bivariate analysis comparing outcomes between the 2 specialties. Bivariate odds ratios, odds ratios from those multivariate models in which specialty warranted inclusion, and odds ratios from conditional logistic regression models performed on the propensity score–matched data set appear in Table S2.

As with any study of claims data, ours has limitations. Although we attempted to ensure that patients were enrolled continuously in their insurance coverage, there is no way to guarantee that patients did not have other insurance or use clinician services not covered by their policies. Similarly, we are limited to those comorbidities and complications recorded in the data and have no access to patient charts. In addition, we rely on the accuracy of coding and its consistency across institutions and providers. Certain comorbidities and complications of interest appeared in very small numbers. This raises concern for several reasons. First, given the small numbers, statistical analyses can be very sensitive to just a few subjects and thus are difficult to interpret. Second, limitations in the use of data, for the safety of patient privacy, preclude reporting of such small numbers. On the other hand, these small numbers may well be a true representation of the larger, general population; to understand the impacts of and on these variables might require directed studies carried out within specific populations. With these limitations, however, the study is done in a large, representative population, in a data set that have very few missing data.

In conclusion, in this large database study of insurance claims related to ORIF of ankle fractures, short-term complication rates were low and in general corroborate with previously reported rates in the published literature. Of particular interest to podiatric surgeons are factors associated with these complications. Unfortunately, some of the risk factors may not be modifiable before surgery, such as medial malleolar repair predisposing to repeat ORIF and infection or history of CVA predisposing to PE. However, understanding the impact of their occurrence may help improve patient management and efforts at advocacy. Some factors known previously to be associated with complications in diabetic patients are also seen to be important in a more general population. Finally, less intuitive results, such as male sex being associated with lower rates of ED use but higher rates of repeat surgery, warrant further investigation.

Supplementary Materials

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1053/j.jfas.2019.08.003.

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