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Rates and timing of short-term complications following operative treatment of tibial shaft fractures

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Abstract

Introduction: Tibial shaft fractures are a relatively common injury in orthopaedic surgery, with management options including intramedullary nail (IMN) fixation or open reduction internal fixation (ORIF) with plate osteosynthesis. Using a large national database, we sought to compare the prevalence and timing of short-term complications following either IMN or ORIF for tibial shaft fractures.

Methods: The American College of Surgeons National Surgical Quality Improvement Program was used to identify patients undergoing IMN or ORIF for the treatment of tibial shaft fracture between 2012 and 2018. Multivariate Poisson hurdle regression models were utilized to determine predictors of postoperative complications as well as the timing of postoperative complications.

Results: A total of 4963 tibial shaft fracture were identified, with 3601 patients undergoing IMN (72.6%) and 1362 undergoing ORIF (27.4%). Patients undergoing IMN had a lower mean age of 48.8 compared with 53.9 for plate osteosynthesis ($P < .001$). IMN patients were also more likely to be male (53.5%) compared with ORIF patients (44.2%, $P < .001$). In multivariate analysis, ORIF patients were significantly more likely to experience surgical site complications, including dehiscence, superficial, and deep infections (OR 2.04, $P = .003$). There was no difference in probability of VTE between constructs; however, patients who underwent ORIF were diagnosed with VTE earlier than those who underwent IMN (relative rate 0.50, $P < .001$). There was no difference between ORIF and IMN with regard to probability or timing of subsequent blood transfusion, major complications, or return to the operating room. Many patient factors, such as higher American Society of Anesthesiologists score, congestive heart failure, and hypertension, were independently associated with an increased risk of postoperative complications.

Conclusions: Postoperative complications within 30 days are common after the surgical treatment of tibial shaft fractures. The risk of developing specific complications and the timing of these complications vary depending on numerous factors, including potentially modifiable risk factors such as the method of fixation or operative time, as well as nonmodifiable risk factors such as medical comorbidities.

Keywords: orthopaedic trauma, postoperative complications, surgical outcomes, tibial shaft fractures

1. Introduction

Tibial shaft fractures are one of the most common long bone fractures, with an annual incidence between 17 and 22 per 100,000 patient years.[1–4] Operative management has become the mainstay of treatment due to the morbidity associated with nonoperative treatment modalities. Management options for tibial shaft fractures include intramedullary nailing (IMN) and open reduction internal fixation (ORIF) with plate osteosynthesis. IMN fixation has become the mainstay of surgical treatment for diaphyseal tibial fractures[5,6] due to preservation of the periosteum and minimal soft tissue stripping at the fracture site, as well as the potential for early weightbearing.[7] Prior studies have found high rates of union, early time to weight bearing, and low rates of infection with IMN.[8–11] However, IMN fixation is not without its own unique complication profile including higher rates of anterior knee pain ranging from 11% to 23% based on recent prospective studies and metanalyses.[12–17]

Despite the relative advantages of IMN, treatment of tibial shaft fractures with plating remains a common treatment option, particularly for fractures of the metaphysis or metaphyseal–diaphyseal junction. Malalignment after IMN for fractures of these regions is common due to the lack of endosteal fit at the fracture site, with several studies showing higher rates of malunion after IMN compared with ORIF with plating.[18–22] While some studies have found increased rates of postoperative infection and wound complications after ORIF with plating compared with IMN,[23,24] other studies have found similar infection rates between the 2 methods of fixation.[18–20]

In this study, a large, nationwide database was used to identify risk factors for and timing of short-term complications following

treatment of tibial shaft fractures with IMN and ORIF. We hypothesized that—after controlling for age and medical comorbidities—patients undergoing ORIF would have higher rates of surgical site infections and reoperation while having no difference in other complications. Furthermore, we hypothesized that patients undergoing ORIF would have surgical site complications diagnosed earlier than those undergoing IMN.

2. Materials and methods

We utilized the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database to identify patients with tibial shaft fractures undergoing ORIF with plates and screws or IMN between January 1, 2012 and December 31, 2018. Current Procedural Terminology codes were used to identify patients undergoing tibial shaft fixation with IMN (27,759) or ORIF with plates and screws (27,758). The NSQIP includes data from over 700 hospitals, and is assembled by hospital-appointed, specially trained staff members. The NSQIP database includes data regarding baseline patient demographics, surgical details, and 30-day postoperative outcomes. The data collection process is overseen by a surgeon champion, and independent review found overall data reliability to be excellent.[25]

Patient characteristics collected from the registry included patient age, sex, height, weight, smoking history (within 1 year), American Society of Anesthesiologists (ASA) class, operative time (in minutes), and medical comorbidities including diabetes, chronic obstructive pulmonary disease (COPD), liver disease with ascites, congestive heart failure (CHF), hypertension, sepsis within 48 hours of surgery, bleeding disorders, chronic steroid use for medical condition, disseminated cancer, and dialysis-dependent kidney disease. Body mass index (BMI) was calculated from each patient's height and weight. Functional status was defined as the patient's ability to perform the activities of daily living in 3 categories. These categories included activities of daily living performed independently, in a partially dependent manner, or a completely dependent manner within the 30 days prior to admission.

Data on postoperative medical complications within 30 days were collected. Primary outcomes of the study were mortality, major complications, venous thromboembolism (pulmonary embolism (PE), or deep vein thrombosis (DVT), wound complications (including deep infection, wound infection, superficial infection, or dehiscence), postoperative blood transfusion and discharge destination (facility vs home). Major complications were defined as the occurrence of any of the following: death, on ventilator more than 48 hours, unplanned intubation, stroke/cerebrovascular accident, DVT, PE, cardiac arrest, myocardial infarction, acute renal failure requiring dialysis, sepsis, septic shock, return to OR, wound dehiscence, superficial infection, wound infection, deep surgical organ/space infection.

Baseline characteristics of patients sustaining tibial shaft fractures were summarized using descriptive statistics. Multivariate Poisson hurdle regression models were utilized to determine predictors of postoperative complications as well as the timing of postoperative complications, where applicable. Interaction terms were used to determine whether the effect of construct varied with age. Standardized odds ratio (OR), rate ratios (RR), 95% confidence intervals, interquartile ranges (IQR), and P values were computed. When days to event were analyzed, a Poisson distribution was assumed. Patients with missing covariates were excluded from multivariate analysis. Statistical significance was defined as $P < .05$. Statistical analyses were performed using R 3.6.0 (R Foundation for Statistical Computing, Vienna, Austria).

3. Results

A total of 4963 tibial shaft fractures were identified, with 3601 patients treated with IMN (72.6%) and 1362 patients treated with ORIF with plate osteosynthesis (27.4%). Patients treated with IMN were younger (mean age = 48.8 vs 53.9, $P < .001$) than those treated with ORIF. A greater percentage of patients treated with IMN were aged 50-years-old or younger compared with patients treated with ORIF (51.9% vs 39.3%, $P < .001$). Patients treated with IMN were more likely to be male compared with patients treated with ORIF (53.5% vs 44.2%, $P < .001$). Mean OR time was not significantly different for IMN compared with ORIF (102 minutes vs 105 minutes, $P = 0.05$) (Table 1).

3.1. Prevalence of complications

On unadjusted analysis, patients who underwent ORIF with plating had a higher rate of complications compared with patients who underwent IMN (13.7 vs 11.1%, $P = .03$) (Table 2).

Table 1

Baseline characteristics of patients sustaining tibial shaft fractures treated with IMN vs plating

		IMN (n = 3601)	Plate (n = 1362)	P value
Sex, female		46.5% (1675)	55.8% (760)	<.001
Age				
	0–50	51.9% (1870)	39.3% (535)	<.001
	50–65	27.1% (976)	30.1% (410)	
	65–80	15.2% (549)	21.5% (293)	
	80+	5.7% (206)	9.1% (124)	
Race				
	White	58.0% (2090)	62.1% (846)	.06
	Hispanic	10.2% (366)	8.1% (110)	
	Black	9.7% (348)	9.5% (130)	
	Asian	2.3% (84)	2.0% (27)	
	Other	19.8% (713)	18.3% (249)	
BMI				
	Mean	28.5	29.7	<.001
ASA				
	1	19.1% (686)	15.7% (213)	.003
	2	44.4% (1596)	43.2% (588)	
	3	31.7% (1140)	36.7% (499)	
	4	4.9% (175)	4.4% (60)	
Functional status				
	Independent	93.5% (3327)	84.8% (2331)	.26
	Partially dependent	5.7% (202)	6.7% (91)	
	Totally dependent	0.8% (28)	1.0% (14)	
Medical comorbidities				
	Smoker	28.8% (1037)	24% (327)	<.001
	Diabetes	13% (469)	16.5% (225)	.002
	HTN	31% (1117)	38% (518)	<.001
	COPD	4% (143)	4.9% (67)	.16
	CHF	0.9% (31)	1.1% (15)	.54
	Dialysis	1.4% (51)	1.3% (18)	.91
	Steroids	3% (109)	3% (41)	1
	Systemic infection	7.3% (262)	5.9% (81)	.11
	Bleeding disorder	5% (179)	5.5% (75)	.48
	Metastatic Cancer	0.7% (25)	0.6% (8)	.82
OR time				
	Mean	102.2	105.4	.05
Wound				
	Clean	88.3% (3181)	89.5% (1219)	.02
	Clean/contaminated	3.7% (133)	4.7% (64)	
	Contaminated	5.2% (187)	4.1% (56)	
	Dirty/infected	2.8% (100)	1.7% (23)	

Table 2

Unadjusted 30-day complication rates by construct

	IMN (n = 3601)	Plate (n = 1362)	P value
Any complication	11.08% (399)	13.66% (186)	.03
Major complication	3.78% (136)	5.58% (76)	.009
Unplanned re-admit	3.58% (129)	5.14% (70)	.021
Return to OR	1.22% (44)	3.01% (41)	<.001
Reintubation	0.44% (16)	0.07% (1)	.086
On vent >48 h	0.44% (16)	0.15% (2)	.198
Death	0.56% (20)	0.59% (8)	1
Cardiac arrest	0.22% (8)	0.07% (1)	.469
MI	0.19% (7)	0.29% (4)	.746
CVA	0.08% (3)	0.07% (1)	1
Dialysis	0.17% (6)	0.15% (2)	1
Sepsis	0.39% (14)	0.73% (10)	.184
Septic shock	0.17% (6)	0.07% (1)	.722
PNA	1.42% (51)	1.17% (16)	.609
AKI	0.08% (3)	0.07% (1)	1
UTI	1.08% (39)	1.32% (18)	.585
VTE	0.81% (29)	0.59% (8)	.546
PE	0.33% (12)	0.29% (4)	1
DVT	0.56% (20)	0.29% (4)	.341
Wound complications	1.22% (44)	2.86% (39)	<.001
Dehiscence	0.03% (1)	0.44% (6)	.002
Infection, superficial	0.81% (29)	1.17% (16)	.296
Infection, wound	0.28% (10)	0.73% (10)	0.045
Infection, deep	0.14% (5)	0.73% (10)	0.002
Blood transfusion	4.17% (150)	5.51% (75)	0.064

Compared with IMN, ORIF with plating was associated with a higher rate of major complications (5.6% vs 3.8%, *P* = 0.009), specifically return to OR (3.0% vs 1.2%, *P* < .001), and wound complications (2.9% vs 1.2%, *P* < .001), such as wound dehiscence, wound infection, and deep surgical site infection.

There were no differences in rates of postoperative blood transfusion or VTE (PE or DVT).
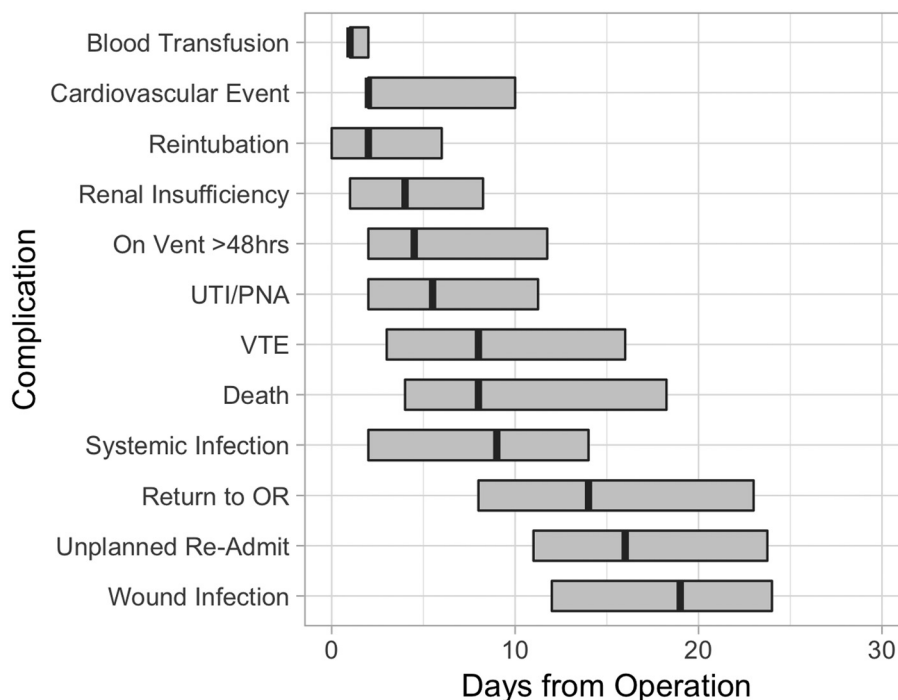
3.2. Time to complications

Distribution of the number of days to different complications can be seen in Figure 1. Blood transfusions occurred earliest, at a mean of 1.5 days postoperatively (median 1 day, IQR 1-2 days). VTE was diagnosed at a mean of 11.0 days postoperatively (median 8, IQR 3-16), while return to the operating room occurred at a mean of 15.2 days postoperatively (median 14, IQR 8-23). Finally, wound complications were diagnosed at a mean of 17.9 days postoperatively (median 19, IQR 12-24).

Complication by construct type is illustrated in Figure 2. On univariate analysis, return to the operating room occurred earlier for those who underwent IMN (mean 13.6 vs 17.0 days, *P* < .001). VTE was diagnosed earlier in patients who underwent ORIF (mean 5.5 vs 12.5 days, *P* < .001). Cardiovascular complications (myocardial infarction, CVA, cardiac arrest) occurred earlier in ORIF patients (mean 4.2 vs 12.0 days, *P* < .001).

3.3. Multivariate regression analysis

In multivariate hurdle regression models, there was no difference in the rates of major complications after ORIF compared with IMN (OR 1.2, *P* = .38) (Table 3). Male sex, ASA of 3 or 4, OR time greater than 120 minutes, nonindependent functional status, wound contamination, hypertension, and CHF were independently associated with higher rates of major complications. In patients greater than 65 years old, major complications tended to occur later after ORIF compared with IMN (RR 1.31, *P* = .002, Table 4). BMI over 30 and smoking were also independently associated with a later occurrence of major complications (Table 4).

Figure 1. Box plot of days to complications recorded after surgical fixation of tibial shaft fractures. Bar represents median, gray box represents IQR. Cardiovascular event includes MI, CVA, and cardiac arrest. Wound infection includes categories of surgical site complication described previously.
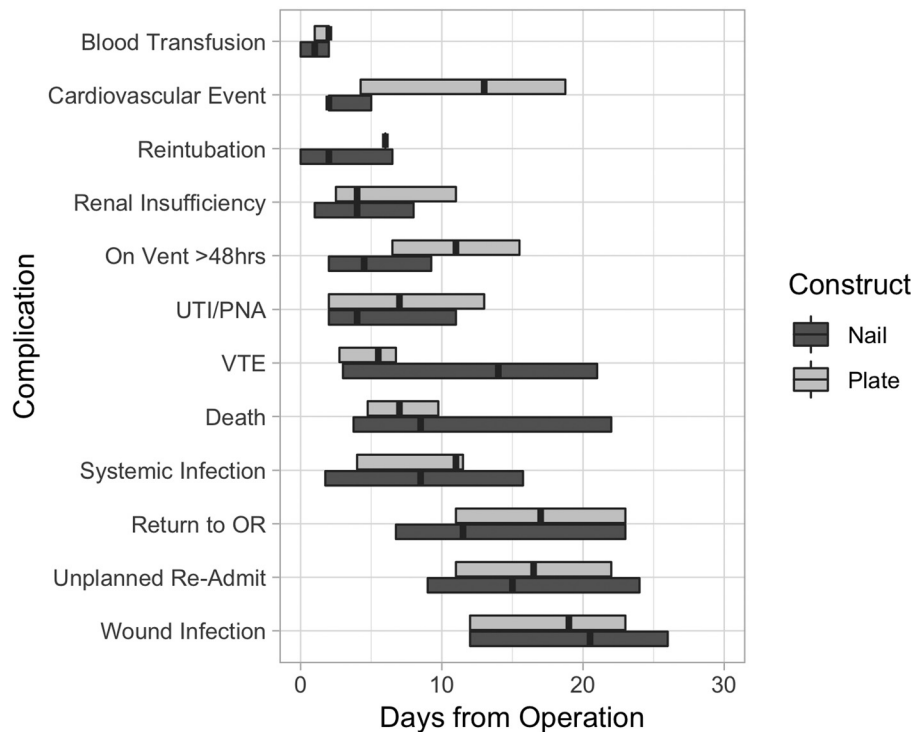
Figure 2. Box plot of days to complications recorded after surgical fixation of tibial shaft fractures by construct. Bar represents median, gray box represents IQR. Cardiovascular event includes MI, CVA, and cardiac arrest. Wound infection includes categories of surgical site complication described previously.

We found no difference in rates of VTE after ORIF compared with IMN (OR 0.72, $P = .42$) (Table 3). Hypertension was the only factor associated with an increased risk of postoperative VTE (OR 1.65, $P = .008$). Of the patients who were diagnosed with VTE postoperatively, those who underwent ORIF were diagnosed earlier compared with those who underwent IMN (RR 0.5, $P < .001$). Similarly, VTE was diagnosed earlier in patients greater than 65 years old (RR 0.64, $P = .014$) or with an ASA of 3 or 4 (RR 0.68, $P = .015$). In contrast, VTE was diagnosed later in patients with contaminated wounds (RR 1.51, $P = .02$) or diabetes (RR 2.02, $P < .001$) (Table 4).

There was no difference in rates of or time to postoperative blood transfusions between patients treated with ORIF compared with IMN (Table 3). Patients greater than 65 years old were more likely to receive a blood transfusion (OR 2.39, $P < .001$), and likely to receive one earlier (RR 0.72, $P = .004$) than those under the age of 65 (Table 4). Other risk factors for postoperative blood transfusion include female sex, BMI of 30 or less, ASA of 3 or 4, OR time greater than 120 minutes, contaminated wounds, diabetes, and COPD (Table 3). Of the patients who received a blood transfusion postoperatively, transfusions were administered earlier for patients who were non-White or smokers (Table 4).

Patients treated with ORIF had higher rates of wound complications compared with those treated with IMN (OR 2.04, $P = .003$) (Table 3). OR time greater than 120 minutes (OR 2.03, $P = .003$) and a contaminated wound (OR 3.73, $P < .001$) were also independently associated with an increased risk of wound complications (Table 3). There was no difference in the time to development of a wound complication for patients treated with ORIF compared with those treated with IMN (RR 0.95, $P = .427$, Table 4). Of the patients who were diagnosed with a

wound complication, the time to diagnosis was later in patients who were female, with an ASA of 3 or 4, or with CHF.

There was no difference in reoperation rates or time to reoperation between patients treated with ORIF compared with IMN (Table 3). Factors associated with reoperation include female sex and independent functional status. Of those patients who required a reoperation, the time to reoperation was later in patients with increased BMI, diabetes, hypertension, and COPD (Table 4).

4. Discussion

Tibial shaft fractures are common injuries that are typically treated with IMN or ORIF with plating. While the mainstay of care for midshaft fractures has been intramedullary fixation, plate osteosynthesis remains a viable treatment modality. Orthopaedic surgeons must consider various factors when choosing a method of surgical fixation, including the fracture pattern, degree of soft tissue injury, and complication profile associated with each method of fixation. Using a large, nationwide database, this is the largest study to date specifically evaluating complications after the surgical treatment of tibial shaft fractures. Our study found a moderate rate of short-term complications within 30 days after both ORIF and IMN, with unadjusted rates of any complication of 13.7% vs 11.1%, major complication of 5.6% vs 3.8%, and wound complications of 2.9% vs 1.2% for ORIF and IMN. After adjusting for potential confounders, overall 30-day complication rates were largely similar regardless of the method of fixation, with the exception of wound complications.

A significantly higher rate of wound complications and infections within 30 days of surgical fixation occurred with

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Table 3

Probability of complications from logistic regression portion of hurdle model

	Variable	Major complication OR	P	VTE OR	P	Transfusion OR	P	Wound complication OR	P	Return to OR OR	P
Construct	Plate vs IMN	1.2 (0.8, 1.82)	.377	0.72 (0.33, 1.59)	.417	1.14 (0.83, 1.56)	.429	2.04 (1.27, 3.3)	.003	0.93 (0.59, 1.46)	.758
Age	>65 vs <65	1.06 (0.68, 1.63)	.806	0.63 (0.27, 1.47)	.290	2.39 (1.68, 3.39)	<.001	1.44 (0.79, 2.65)	.234	1.58 (0.93, 2.7)	.093
Interaction	Plate + age > 65	1.51 (0.81, 2.81)	.198	–	–	–	–	–	–	–	–
Sex	Female vs male	0.65 (0.48, 0.88)	.006	0.58 (0.29, 1.15)	.117	1.88 (1.36, 2.61)	<.001	0.79 (0.49, 1.29)	.348	0.63 (0.42, 0.95)	.029
BMI	> 30 vs <=30	1.06 (0.78, 1.45)	.702	0.67 (0.32, 1.39)	.280	0.51 (0.36, 0.7)	<.001	1.07 (0.65, 1.76)	.799	1.26 (0.83, 1.91)	.280
ASA	3–4 vs 1–2	1.91 (1.31, 2.8)	.001	1.66 (0.73, 3.8)	.227	4.35 (2.79, 6.78)	<.001	1.44 (0.8, 2.59)	.221	1.29 (0.73, 2.28)	.377
OR time	>120 min	1.49 (1.09, 2.03)	.011	1.22 (0.61, 2.46)	.575	2.47 (1.81, 3.37)	<.001	2.03 (1.27, 3.27)	.003	0.97 (0.63, 1.51)	.896
Race	Non-White vs White	1.16 (0.84, 1.59)	.375	0.95 (0.48, 1.9)	.889	1.31 (0.93, 1.86)	.121	0.96 (0.58, 1.58)	.868	1.1 (0.71, 1.72)	.663
Function	Independent vs any dependence	0.49 (0.32, 0.73)	.001	1.24 (0.36, 4.28)	.836	0.67 (0.45, 0.99)	.045	0.8 (0.36, 1.77)	.582	0.61 (0.4, 0.94)	.025
Wound	Contaminated vs clean	1.98 (1.36, 2.87)	<.001	1.11 (0.42, 2.89)	.729	2.25 (1.54, 3.28)	<.001	3.73 (2.24, 6.2)	<.001	1.43 (0.61, 3.36)	.406
Medical History	Smoker	1.01 (0.71, 1.45)	.938	0.72 (0.33, 1.59)	.420	0.71 (0.47, 1.07)	.099	1.26 (0.73, 2.16)	.411	1.44 (0.85, 2.43)	.172
	Diabetes	1.43 (0.99, 2.05)	.054	0.79 (0.32, 1.94)	.604	2.04 (1.44, 2.88)	<.001	0.86 (0.43, 1.72)	.661	1.33 (0.84, 2.08)	.221
	HTN	1.65 (1.14, 2.39)	.008	3.08 (1.36, 7.01)	.007	1.29 (0.89, 1.86)	.184	1.03 (0.56, 1.88)	.936	1.14 (0.73, 1.79)	.558
	COPD	1.23 (0.73, 2.06)	.444	1.79 (0.58, 5.51)	.311	2.25 (1.44, 3.53)	<.001	1.25 (0.5, 3.13)	.634	1.67 (0.98, 2.88)	.062
	CHF	3.79 (1.85, 7.76)	<.001	1.51 (0.19, 11.77)	.692	1.62 (0.69, 3.78)	.265	3.33 (0.94, 11.85)	.063	0.34 (0.08, 1.4)	.135

95% confidence intervals in parentheses.

plating compared with IMN. This difference was observed in both univariate and multivariate analysis after adjusting for potential confounders. The increased rate of wound complications may be secondary to the limited amount of subcutaneous tissue overlying the tibia in conjunction with the soft tissue dissection implicit with ORIF with plating. Recent prospective studies have found no differences in the rates of wound complications and infections after ORIF with plating vs IMN.[18,20,26] However, these studies are limited by small sample sizes and may be underpowered to detect differences in infection rates. More recent methods of tibia shaft fracture plate osteosynthesis have gained popularity, such as minimally invasive plate osteosynthesis utilizing percutaneous screw placement, which reduce soft tissue trauma and can lower the higher rates of wound complications found in this study.[27]

Venous thromboembolic events are known complications after lower extremity trauma which can result in significant morbidity and mortality.[28] There was no difference in rates of VTE after ORIF with plating vs IMN in this study. Hypertension was the only independent factor associated with increased risk of VTE, consistent with the existing literature.[28] While other comorbidities such as smoking, diabetes, and obesity have been previously shown to be associated with an increased risk of VTE, these factors were not associated with an increased risk here.[29] Although the rates of VTE were similar after ORIF with plating and IMN, of the patients who were diagnosed with VTE, those who underwent IMN were diagnosed a mean of 7 days later than those who

underwent ORIF with plating. Patients undergoing IMN are often able to begin early weightbearing and may mobilize quicker than patients after ORIF with plating, which could lower physicians' index of suspicion for VTE. For example, physicians may be less likely to suspect the presence of a DVT and fail to order diagnostic testing in the setting of mild leg pain or swelling in a patient who is mobilizing well after IMN compared with a patient who is mobilizing slower after ORIF with plating. Given that delays in diagnosis and treatment of DVT and PE can result in a worse prognosis, physicians should maintain a low threshold to obtain further diagnostic testing particularly in patients treated with IMN to ensure timely diagnosis and treatment.[30–32]

Complications after the surgical treatment of tibial shaft fractures can lead to significantly higher healthcare costs in addition to increased patient morbidity and disability.[33–35] Prior studies have found infection to be the highest driver of increased healthcare costs, with a 6.5-fold increase in healthcare costs for patients with an infection.[34] These studies have focused primarily on the impact of the method of fixation on complication rates.[36] In addition, no studies have specifically evaluated the timing of postoperative complications after surgical management of tibial shaft fractures. Understanding the risk factors for and timing of various complications after operative management of tibial shaft fractures can help inform future strategies to prevent these complications.

Patient factors and medical comorbidities were associated with an increased risk of complications in this patient cohort. Much of

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Table 4

Days to complications from Poisson regression portion of hurdle model

	Variable	Major complication		VTE		Transfusion		Wound complication		Return to OR	
		RR	P	RR	P	RR	P	RR	P	RR	P
Construct	Plate vs IMN	1.02 (0.91, 1.15)	.744	0.72 (0.33, 1.59)	.417	1.14 (0.92, 1.41)	.224	0.95 (0.85, 1.07)	.427	1.12 (0.99, 1.26)	.070
Age	>65 vs <65	0.92 (0.81, 1.03)	.152	0.63 (0.27, 1.47)	.290	0.72 (0.58, 0.9)	.004	0.93 (0.79, 1.1)	.385	0.95 (0.83, 1.09)	.442
Interaction	Plate + age > 65	1.31 (1.11, 1.56)	.002	–	–	–	–	–	–	–	–
Sex	Female vs male	1.05 (0.96, 1.14)	.285	0.58 (0.29, 1.15)	.117	1.02 (0.8, 1.3)	.868	1.14 (1.02, 1.28)	.025	1.00 (0.9, 1.12)	.935
BMI	> 30 vs <=30	1.15 (1.05, 1.26)	.002	0.67 (0.32, 1.39)	.280	0.95 (0.76, 1.2)	.694	1.08 (0.96, 1.21)	.206	1.17 (1.05, 1.31)	.004
ASA	3–4 vs 1–2	1.09 (0.98, 1.21)	.116	1.66 (0.73, 3.8)	.227	1.06 (0.78, 1.45)	.701	1.17 (1.02, 1.33)	.023	1.08 (0.93, 1.26)	.308
OR time	>120 min	1.08 (0.99, 1.17)	.094	1.22 (0.61, 2.46)	.575	1.16 (0.93, 1.44)	.178	1.05 (0.93, 1.18)	.416	0.96 (0.85, 1.08)	.459
Race	Non-White vs White	0.99 (0.91, 1.09)	.899	0.95 (0.48, 1.9)	.889	0.77 (0.61, 0.96)	.020	0.93 (0.82, 1.05)	.238	1.23 (1.08, 1.39)	.001
Function	Independent vs any dependence	0.96 (0.86, 1.07)	.456	1.24 (0.36, 4.28)	.729	1.09 (0.84, 1.42)	.509	1.02 (0.84, 1.24)	.836	1.03 (0.92, 1.16)	.588
Wound	Contaminated vs clean	1.07 (0.98, 1.18)	.147	1.11 (0.42, 2.89)	.836	0.9 (0.69, 1.16)	.399	0.95 (0.84, 1.07)	.394	1.03 (0.79, 1.33)	.841
Medical history	Smoker	1.14 (1.03, 1.26)	.010	0.72 (0.33, 1.59)	.420	0.58 (0.41, 0.82)	.002	1.14 (0.99, 1.3)	.064	1.03 (0.89, 1.18)	.721
	Diabetes	0.91 (0.82, 1.01)	.083	0.79 (0.32, 1.94)	.604	0.85 (0.67, 1.09)	.202	1.08 (0.92, 1.27)	.332	1.19 (1.05, 1.35)	.005
	HTN	0.95 (0.86, 1.05)	.303	3.08 (1.36, 7.01)	.007	1.12 (0.87, 1.44)	.373	1.05 (0.91, 1.2)	.496	1.41 (1.23, 1.61)	<.001
	COPD	1.04 (0.9, 1.19)	.629	1.79 (0.58, 5.51)	.311	0.97 (0.72, 1.32)	.845	1.1 (0.9, 1.35)	.352	0.86 (0.74, 0.99)	.041
	CHF	0.98 (0.82, 1.17)	.843	1.51 (0.19, 11.77)	.692	0.7 (0.34, 1.43)	.328	1.42 (1.1, 1.84)	.007	1.16 (0.81, 1.68)	.418

95% confidence intervals in parentheses.

the existing literature has focused on the effect of the method of fixation on postoperative complications without considering these additional risk factors. For example, increased ASA score, CHF, and hypertension were associated with an increased risk of major complications. In contrast, obesity was not found to be an independent risk factor for complications in multivariate analysis. A large database study of tibial shaft fractures had previously identified obesity as a risk factor for postoperative complications in univariate analysis.[37] This discrepancy could be due to the presence of other confounding medical comorbidities, rather than obesity itself. The findings in this study highlight that the risk of postoperative complications is likely multifactorial and not limited to surgical factors, such as the method of fixation, or isolated patient risk factors.

The findings of this study should be interpreted in the context of several limitations. This study utilizes the ACS-NSQIP database, which includes complication data within the first 30 days postoperatively. Therefore, this study does not include complications occurring beyond this period and there may be differences in delayed complications that are not captured in our study. For example, prior studies have suggested increased rates of symptomatic hardware resulting in secondary procedures for hardware removal after ORIF with plating, while other studies have raised concerns for loss or reduction, malunion, or nonunion requiring reoperation following IMN, particularly for proximal or distal tibial shaft fractures.[18,20,22,38,39] Although this study found no difference in 30-day reoperation rates between ORIF with plating vs IMN, reoperation for these complications is likely not captured within this short postoperative time period. Nevertheless, this study represents one of the largest available analyses of short-term postoperative complications, and future studies are needed to evaluate these long-term complications. Another limitation of this study is the potential for selection bias. Tibial shaft fractures were identified using the Current Procedural Terminology code for surgical treatment of extra-articular tibial fractures, which does not specify whether the fracture involves the proximal, middle, or distal third of the tibia. Therefore, the ORIF with plating cohort may represent a larger proportion of proximal or distal third fractures, given the preference for IMN for middle third fractures by most orthopaedic surgeons.[5,6] This difference in fracture type and surgical approach is likely the cause of increased wound complications in the platting group, rather than plating itself. Lastly, the NSQIP database does not contain relevant clinical or radiographic outcomes, such as union rates or patient-reported outcomes, all of which are important considerations.

5. Conclusion

Postoperative complications are associated with morbidity and a significant increase in healthcare costs and utilization of resources. Identifying the risk factors associated with these complications is an essential step in the development of strategies to reduce these risks and prevent these complications. The results

of this study show that postoperative complications are common after surgical treatment of tibial shaft fractures, with rates of any complication ranging from 11% to 13.6%, return to the OR 3.6% to 5.1%, and wound complications of 1.2% to 2.9% depending on the method of fixation. After adjusting for patient confounders, a higher rate of wound complications was found following ORIF with plating compared with IMN. The risk of developing specific complications and the timing of these complications varies depending on numerous factors, including potentially modifiable risk factors such as the method of fixation or operative time, as well as nonmodifiable risk factors such as medical comorbidities. Orthopaedic surgeons should consider and address these risk factors when deciding on the optimal method of surgical treatment for tibial shaft fractures.

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