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Risk factors for infection after operative fixation of Tibial plateau fractures

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ABSTRACT

Introduction: Tibial plateau fractures are challenging to treat due to the high incidence of postoperative infections. Treating physicians should be aware of risk factors for postoperative infection in patients who undergo operative fixation.
Patients and methods: A retrospective review was undertaken to identify all patients with tibial plateau fractures over a 10 year period (2003–2012) who underwent open reduction internal fixation. A total of 532 patients were identified who met the inclusion criteria. Several patient and clinical characteristics were recorded, and those variables with a significant association ($p < 0.05$) with postoperative infection after a univariate analysis were further analyzed using a multivariate analysis.
Results: Fifty-nine (11.1%) of the 532 patients developed a deep infection. The average length of follow-up for patients was 19.5 months. Methicillin-resistant *Staphylococcus aureus* was the most common species, and it was isolated in 26 (44.1%) patients. Open fractures, the presence of compartment syndrome, and a Schatzker type IV–VI were found to be independent risk factors for deep infection.
Conclusions: The rate of deep infection remains high after operative fixation of tibial plateau fractures. Patients with risk factors for infection should be counseled on the possibility of reoperation, and surgeons should consider MRSA prophylaxis in those patients who are at higher risk.

Introduction

Historically, tibial plateau fractures were complicated with wound complication rates as high as 88% [1]. Over the last decade, a change in clinical practice focusing on preservation of the soft tissue envelope has resulted in a decrease in wound complications and associated postoperative infections. Egol et al. [2] demonstrated a 5% incidence of deep infection following a damage control approach for high-energy tibial plateau fractures. Similarly, Barei et al. [3] demonstrated a 6% incidence of infection when utilizing two incisions for fragment-specific fixation of tibial plateau fractures.

Larger clinical series employing modern, damage control techniques, however, have deep infection rates up to 14% [4]. Risk factors previously shown to be associated with postoperative infections in high-energy tibial plateau fractures include: open fractures, smoking, compartment syndrome, prolonged operative time, and fractures requiring two incisions and two plates [1,3,5–8]. Postoperative infections are often associated with prolonged intravenous antibiotics, multiple operations, loss of function, loss of limb, and pose an economic burden on the healthcare system.

The purpose of this study was to identify injury, patient, and surgical risk factors for deep infection in patients with tibial plateau fractures undergoing operative fixation. Our hypotheses were that certain patient factors (tobacco use and diabetes) and injury characteristics (concomitant compartment syndrome, Schatzker types IV–VI fractures, and open fractures) would be associated with infection. We further hypothesized that increased operative time and number of personnel scrubbed would be risk factors for infection.

Patients and methods

Following institutional review board approval, all AO/OTA 41 tibial plateau fractures from a single high volume level I academic trauma center were collected over a 10 year period from

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2003 to 2012 using current procedural terminology (CPT) codes. Each chart was then reviewed for inclusion or exclusion. Inclusion criteria were: articular fracture (AO/OTA B/C) and age >19 years. Patients were excluded if they were: pregnant, had insufficient documentation for review, or transferred following any surgery other than damage control orthopaedic procedures.

Patient-related factors (gender, race, age, body mass index (BMI), diabetes, tobacco use, and intravenous (IV) drug use) and injury-related factors (Schatzker type, open versus closed fracture, presence of compartment syndrome, and vascular injury) were recorded. Potential treatment risk factors for infection including time to surgery (both to external fixation and definitive fixation), operative time, number of incisions, number of plates, tourniquet use, and the number of healthcare staff scrubbed in the definitive operation were evaluated. In addition, the variables were stratified by timing of infection. Early infections were defined as those presenting earlier than 6 weeks while late infections were those presenting after 6 weeks. All patients were treated by fellowship trained orthopedic trauma surgeons, and fixation schema was at the discretion of the treating surgeon.

Those fractures too swollen for acute definitive fixation were either splinted or placed in an external fixator for a planned staged procedure, which is standard practice for this institution since 2003. Deep infections were defined as requiring both operative irrigation and debridement and IV antibiotics. The incidence of wound complications were recorded in addition to the pathogen isolated.

For closed fractures, weight-based dosing of cefazolin was given within 1 h prior to incision. If the patient reported an allergy that would preclude cefazolin, clindamycin was given. The same antibiotic was continued for 1 day postoperatively. All open fractures underwent urgent debridement and irrigation. These patients received IV antibiotics (piperacillin/tazobactam) upon hospital presentation, and antibiotics were continued until 48 h status post-definitive coverage.

Statistics were calculated using Statistical Analysis System 9.3 (Cary, NC, USA). A *t*-test was used to compare continuous variables and a chi-square test was used to compare categorical variables. Univariate logistic regression was used to assess the risk of deep infection for each of the covariates. Any covariates that were statistically significant ($p < 0.05$) were then included in a multivariate logistic regression.

Results

Following a retrospective chart review, 657 patients were identified by CPT code 27535 (tibial plateau ORIF). One hundred-fifteen patients had incomplete records or failed to meet inclusion criteria, and 10 patients were lost to follow up and excluded from the study. Of the remaining 532 patients, 59 (11.1%) developed a deep infection. The average follow up for these patients was 19.5 months.

Three hundred and forty (64%) patients were male. The average age was 47.8 years (range, 20–89). Sixty-four percent of patients were Caucasian. One hundred ninety-four patients were obese (BMI > 30), and 38 patients were morbidly obese (BMI > 40). Obesity (BMI 30–40) and morbid obesity (BMI > 40) did not correlate significantly with infection. Sixty-nine patients (13%) had diabetes; two hundred and forty patients (45.2%) endorsed tobacco use. The presence of diabetes or tobacco use trended toward deep infection. These demographics are summarized in Table 1.

Table 1
Comparison of demographic, injury, and clinical characteristics between patients with tibial plateau fracture who did and did not have deep infection following fixation.

	Total (N = 532)	No deep infection (N = 473)	Deep infection (N = 59)	p-value*
DEMOGRAPHIC				
Male (%)	341 (64.1)	295 (62.4)	46 (78.0)	0.0208
Race/Ethnicity (%)				
Black	178 (33.5)	153 (32.4)	25 (42.4)	0.2736
Other	11 (2.1)	10 (2.1)	1 (1.7)	
White	343 (64.6)	310 (65.7)	33 (55.9)	
Age (yrs)	47.76 ± 15.2	47.83 ± 15.36	47.37 ± 13.53	0.8239
BMI (%)				
<30	335 (63.3)	305 (64.9)	30 (50.8)	0.0903
30–40	156 (29.5)	132 (28.1)	24 (40.7)	
>40	38 (7.2)	33 (7.0)	5 (8.5)	
Tobacco use (%)	240 (45.3)	207 (43.9)	33 (55.9)	0.0959
Diabetes (%)	69 (13.0)	57 (12.1)	12 (20.3)	0.0975
INJURY				
Open fracture (%)	84 (15.8)	65 (13.7)	19 (32.2)	0.0009
Gustillo Anderson category (%)				
Not open	448 (85.5)	408 (87.2)	40 (71.4)	0.0026
I	16 (3.1)	15 (3.2)	1 (1.8)	
II	17 (3.2)	14 (3.0)	3 (5.4)	
III	43 (8.2)	31 (6.6)	12 (21.4)	
Schatzker classification (%)				
1–3	170 (32.1)	163 (34.6)	7 (11.9)	0.0003
4–6	360 (67.9)	308 (65.4)	52 (88.1)	
Vascular injury (%)	15 (2.8)	12 (2.5)	3 (5.1)	0.2257
Compartment syndrome (%)	44 (8.3)	31 (6.6)	13 (22.0)	0.0004
CLINICAL				
Mean days to ORIF	7.44 ± 6.30	7.33 ± 6.30	8.28 ± 6.28	0.2825
Mean number scrubbed	5.39 ± 1.85	5.38 ± 1.87	5.47 ± 1.67	0.7303
External fixator (%)	180 (33.8)	147 (31.1)	33 (55.9)	0.0002
Single incision (%)	390 (73.6)	351 (74.5)	39 (66.1)	0.2093
Single plate (%)	403 (76.9)	363 (77.7)	40 (70.2)	0.2428
Bone graft (%)	145 (27.3)	134 (28.4)	11 (18.6)	0.1233
IVDU (%)	23 (4.3)	21 (4.5)	2 (3.4)	1.0000

* Estimated from Fischer's exact and t-test for categorical and continuous variables, respectively

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Table 2
Crude and adjusted odds ratios* (ORs) and associated confidence intervals (95% CI) for the association between deep infection and characteristics of interest, stratified by timing of infection.

	Crude OR (95% CI)	Adjusted† OR (95% CI)	Adjusted p-value
ANY INFECTION			
Male gender	2.13 (1.12–4.06)	1.67 (0.85–3.28)	0.1345
Gustilo-Anderson category			
Not open	Ref	Ref	
I	0.68 (0.09–5.28)	0.65 (0.08–5.11)	0.0065
II	2.19 (0.60–7.93)	2.34 (0.61–8.91)	
III	3.95 (1.88–8.29)	3.64 (1.70–7.81)	
Schatzker classification			
1-3	Ref	Ref	
4-6	3.93 (1.75–8.85)	2.93 (1.27–6.76)	0.0116
Compartment syndrome	4.03 (1.97–8.24)	3.10 (1.45–6.65)	0.0036
EARLY INFECTION			
Male gender	6.83 (1.59–29.31)	5.35 (1.21–23.54)	0.0267
Gustilo-Anderson category			
Not open	Ref	Ref	
II	1.69 (0.21–13.52)	1.79 (0.21–15.46)	0.0259
III	4.38 (1.62–11.86)	4.17 (1.48–11.75)	
Schatzker classification			
1-3	Ref	Ref	
4-6	5.73 (1.34–24.60)	3.79 (0.86–16.78)	0.0794
Compartment syndrome	3.90 (1.47–10.34)	3.35 (1.20–9.37)	0.0207
LATE INFECTION			
Male gender	1.18 (0.56–2.48)	0.96 (0.45–2.07)	0.9249
Gustilo-Anderson category			
Not open	Ref	Ref	
I	1.18 (0.15–9.29)	1.14 (0.14–9.12)	0.2076
II	2.36 (0.51–10.90)	2.27 (0.50–11.17)	
III	2.87 (1.10–7.45)	2.62 (0.99–6.90)	
Schatzker classification			
1-3	Ref	Ref	
4-6	2.89 (1.10–7.60)	2.42 (0.90–6.53)	0.0801
Compartment syndrome	3.23 (1.32–7.92)	2.38 (0.90–6.29)	0.0817

* Estimated from logistic regression
† Adjusted for other variables in table

Three hundred and sixty patients (68%) sustained high energy fractures defined as a Schatzker type IV, V, or VI. These patients had a statistically significant increased likelihood of deep infection ($p = 0.011$). Eighty-four patients (15.8%) sustained open injuries; forty-four patients (8.3%) had concomitant compartment syndrome. Both open fractures and the presence of compartment syndrome were predictors of deep infection.

One hundred eighty patients (33.9%) underwent initial external fixation followed by definitive fixation. Thirty-three (18.3%) of these patients developed a postoperative deep infection following definitive fixation. Days to external fixation and days to definitive ORIF were not predictive of deep infection. A total of 121 (22.8%) patients were treated with bicondylar plating. More than one incision was used in 141 (26.6%) patients. A tourniquet was used in 208 (39.1%) patients. The mean tourniquet time was 96.7 min. The number of plates, incisions, bone graft choice, number scrubbed, tourniquet use, and operative time were not predictive of infection.

Univariate logistic regression demonstrated that open fracture, compartment syndrome, external fixation, Schatzker type IV–VI, and male gender were all statistically significant predictors of deep infection. When entered in a multivariate regression, however, only open fracture, compartment syndrome, and Schatzker type IV–VI remained statistically significant. Further analysis was completed to look at those patients who presented with early versus late infection. Twenty-five patients (42.3%) sustained early infections while 34 (57.6%) were diagnosed with late infections. Independent risk factors for early infection were male gender, open fracture, and compartment syndrome. None of these variables remained independent risk factors for late infection. However, there was a trend toward infection with Schatzker IV–VI and compartment syndrome (Table 2).

A subset analysis of high-energy tibial plateau fractures compared those patients above and below age 65 years. Three hundred and ten patients younger than 65 years of age sustained a Schatzker IV–VI fracture. Forty-six of these patients went on to develop a deep infection. Only six of the fifty-one patients older than 65 years of age who sustained a Schatzker IV-VI fracture developed a deep infection ($p = 0.25$). Schatzker type IV, V, or VI were not a predictor of infection in patients older than 65 years.

Methicillin-resistant *Staphylococcus aureus* (MRSA) was cultured in 26 (44.8%) of the deep infections. Other common organisms included methicillin-sensitive *S. aureus* (18.9%), *Enterobacter cloacae* (8.6%), and *Enterobacter faecalis* (8.6%).

Discussion

To our knowledge, this is the largest series in the literature in which risk factors for deep infection are studied for tibial plateau fractures treated with open reduction internal fixation. Data here demonstrates that open fractures, the presence of compartment syndrome, and a Schatzker types of IV–VI were all statistically significant risk factors for deep infection.

There have been few previously published studies analyzing the rate of infection after tibial plateau fractures. Recently, Morris et al. [4] reported on a series of 302 patients with bicondylar tibial plateau fractures and found that 43 (14%) developed a deep infection. In a study by Barei et al. [3], a two incision technique was employed to treat bicondylar tibial plateau fractures. Out of 83 patients, seven (8.4%) developed a deep wound infection. Egol et al. reported on the infection rate of all high-energy proximal tibia fractures. A standardized protocol was used including an immediate spanning knee external fixation followed by definitive fixation once soft tissues allowed. A total of 67 high energy proximal tibia fractures were included, and a 5% rate of overall infection was reported [2]. Colman et al. [5] reported an overall postoperative surgical site infection rate of 7.8% in all types of tibial plateau fractures. In our study, we report a 10.9% rate of deep infection overall in operatively treated tibial plateau fractures. With regard to bicondylar tibial plateau fractures, the rate of deep infection was 15.0%. These numbers are comparable to previously published studies.

With high-energy tibial plateau fractures, there is often destruction and compromise of the surrounding soft tissue envelope. Such a high-energy mechanism can result in an open fracture. Our study showed that open fractures were 3.38 times more likely to develop a deep infection. These results are in line with those published by Morris et al. [4] and Lin et al. [6] in which open fractures were found to be associated with a higher risk of infection.

Also, we found that Schatzker types IV–VI fractures were more likely to develop a deep infection. These types of fractures are usually representative of more severe trauma, with increased swelling and a greater destruction to the surrounding soft tissues. Most previous studies have limited their studies to tibial plateau fractures characterized by higher energy mechanisms [4,6]. In the current study, all tibial plateau fractures were studied. Furthermore, a subset analysis was performed, and we found that those patients over the age of 65 years with Schatzker IV–VI tibial plateau fractures did not show an increased risk for infection, while those under the age of 65 years did show an increased risk. A Schatzker IV–VI type fracture sustained by an older patient generally occurs in the setting of a lower energy mechanism combined with poor, osteoporotic bone quality. Thus, the Schatzker type may not accurately reflect the true severity of injury in older patients compared with younger patients.

The rate of compartment syndrome after bicondylar tibial plateau fracture ranges from 7.3 to 27% [3,4]. In the current study, 44 (8.3%) patients developed compartment syndrome. Multivariate regression analysis showed that compartment syndrome is an independent risk factor for deep infection ($p = 0.012$). Similarly, Morris et al. [4] showed an increased risk of deep infection for those with compartment syndrome. In contrast, Lin et al. [6] found no significant association between compartment syndrome and surgical site infection. Hak et al. [9] reported on 14 patients with compartment syndrome and tibial plateau fractures. There was no increase in the risk for deep infection with compartment syndrome, although the study was limited by sample size.

There has been concern in the literature regarding deep infection after external fixation. Some postulate that external fixator pins placed in the zone of injury may lead to operative site infection through pin site colonization [10–12]. Egol et al. [2] recently reported a low infection rate after staged management with external fixation of high energy proximal tibia fractures. The current study did not show an association between external fixation and deep infection. At our institution, every attempt is made to keep the external fixator pins out of the zone of injury and away from future incisions.

Tobacco use is one of the patient-controlled variables previously shown to increase the risk for infection in multiple types of injuries, including bicondylar tibial plateau fractures and in limb threatening open tibia fractures [4,13]. The mechanism by which smoking is felt to impair wound healing includes its negative effects on tissue oxygenation and the inflammatory healing response [14]. In our study, tobacco use was not shown to be an independent risk factor for deep infection. Similarly, Lin et al. [6] did not find a link to between smoking and surgical site infection in tibial plateau fractures. Nonetheless, at our institution, the risks of tobacco use are acknowledged, and we encourage all patients to abstain from tobacco use to help improve wound healing and fracture union.

Previous studies have commented on the number of incisions and the number of plates used as possible risk factors for infection [3,7]. Dual incisions sometimes entail extensive dissection through the damaged soft tissues, possibly leading to infection. In the current study, a two incision approach was used in 141 (26.6%) cases and two plates were used in 121 (22.8%) cases. Neither the number of incisions nor the number of plates used was shown to be associated with infection. This is in contrast to Morris et al. [4] who showed that fractures requiring the use of two incisions and two plates were at increased risk for infection. A possible explanation for this lack of association is that those fractures requiring two incisions and two plates are generally higher energy fractures already at higher risk for infection, and thus, after accounting for such variables, there is no significant increase in the risk for infection.

With regard to speciation of pathogens responsible for the infections, MRSA was by far the most prevalent organism isolated. Morris et al. [4] reported a MRSA rate of 47% in deep infections, while Lin et al. [6] reported an even higher rate at 75%. With such a high prevalence, MRSA prophylaxis with antibiotics must be considered in those patients who are at high risk for infection.

This study is not without limitations. During the time period studied, there were multiple orthopedic trauma surgeons who performed the cases. Each surgeon used his or her judgment when treating the tibial plateau fractures, and there was not one standardized treatment plan. In addition, plating options have evolved over this time period and may serve as a confounding variable. Also, several patient and clinical characteristics were not recorded, including exact mechanism of injury, nutritional deficiencies, injury severity scores, and the type and dosage of antibiotics received. The study would have been strengthened by evaluating fracture union rates and reoperation rates in the setting of infection.

Conclusions

Tibial plateau fractures are difficult fractures to treat given the high rate of infection. Patients with open fractures, compartment syndrome, and a fracture pattern consistent with a Schatzker type IV–VI should be counseled on the increased risks for infection and reoperation. Surgeons should be cognizant of these risks and consider using prophylactic antibiotics to cover MRSA when appropriate. A better understanding and awareness of the risk factors for infection after operative fixation of tibial plateau fractures will help surgeons improve patient care.

Conflict of interest

The senior investigator of this paper, Dr. Jason Lowe, has potential conflicts of interests as listed below:

- A paid consultant for Accumed.
- Receive research or institutional support as a principal investigator from Stryker and Synthes.

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