



Wound complications after open reduction and internal fixation of tibial plateau fractures in the elderly: a multicentre study

Christopher L. Gaunder¹ · Zibin Zhao² · Corey Henderson³ · Brandon R. McKinney¹ · Philip F. Stahel³ · Boris A. Zelle²

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Abstract

Purpose The incidence of wound complications after open reduction with internal fixation (ORIF) of tibial plateau fractures in young patients has been reported to range from approximately 5 to 15%. Reports on wound complication rates in the elderly patients are limited. This study investigates the incidence of post-operative wound complications in elderly patients undergoing ORIF of their tibial plateau fractures.

Methods A retrospective study was performed within three accredited level 1 trauma centres. Patients > 60 years of age undergoing open reduction and internal fixation of their tibial plateau fractures were included. The primary outcome measure was wound complications of the surgical site. These were divided into superficial infections versus deep infections.

Results One hundred two patients matched the inclusion criteria. Of these, 16 patients (15.7%) developed a post-operative wound infection. The analysis of underlying co-morbidities and risk factors revealed that patients with American Society of Anaesthesiologists (ASA) classes 3 and 4 were at significantly increased risk of sustaining a wound complications as compared to ASA classes 1 and 2 (23.7 versus 5.1%, $p = 0.015$).

Conclusions The overall infection rates in elderly patients undergoing ORIF for tibial plateau fractures is in a similar range to published data on younger patient populations. In particular, elderly patients without significant co-morbidities seem to be appropriate candidates for ORIF of their tibial plateau fractures. However, elderly patients with significant co-morbidities must be considered as high risk and alternative treatment options, such as nonoperative treatment or less invasive surgical options, should be explored in these patients.

Keywords Tibial plateau · Fracture · Elderly · Complication · Surgical site infection

Introduction

The operative indications for tibial plateau fractures include displaced bicondylar tibial plateau fracture, displaced medial condyle fracture, knee instability, lateral condyle fractures with valgus malalignment greater than 5°, articular step-off in excess of 3 mm, or condylar widening greater than 5 mm

[1]. Appropriate management of tibial plateau fractures is not only dictated by the osseous injury pattern but also by the associated trauma to the soft tissue envelope. In particular, the risk of surgical site infection remains a concern when treating tibial plateau fractures with open reduction and internal fixation. Recent studies have reported that with staged treatment and appropriate soft tissue management, open reduction and internal fixation remains a relatively safe procedure with infection rates ranging between approximately 5 and 15% [2–6]. However, most of the treatment guidelines for tibial plateau fractures refer to young patients with high-energy injuries. It can be expected that with increasing life expectancies, the treatment of elderly patients with tibial plateau fractures will gain importance. Previous investigations have reported higher complication rates in elderly patients undergoing open reduction and internal fixation as compared to younger patient populations [7, 8]. In particular, post-operative wound complications remain an ongoing concern in

✉ Boris A. Zelle
zelle@uthscsa.edu

¹ Department of Orthopaedics and Rehabilitation, San Antonio Military Medical Center, 3551 Roger Brooke Drive, Fort Sam Houston, San Antonio, TX 78234, USA

² Department of Orthopaedic Surgery, UT Health San Antonio, 7703 Floyd Curl Dr, MC-7774, San Antonio, TX 78229, USA

³ Rocky Vista University, 8401 S. Chambers Road, Parker, CO 80134, USA

elderly patients with tibial plateau fractures [2–6]. However, safety data from the literature on elderly patients undergoing surgical treatment of their tibial plateau fracture remain limited and are mostly based on smaller case series and single-centre experiences.

Given the overall sparse literature on the treatment of elderly patients with tibial plateau fractures, further study seems warranted to establish the safety and efficacy of open reduction and internal fixation in this specific patient population. The rationale of our investigation is to confirm previous studies that have suggested open reduction and internal fixation of tibial plateau fractures in the elderly patient as a safe procedure.

The goal of this study is to evaluate the risk of wound complications in elderly patients undergoing open reduction and internal fixation of their tibial plateau fracture. We hypothesise that the risk of wound complications in elderly patients will be within the range of 5 to 15% as it has been reported in the literature for mostly younger patient populations.

Methods

The study was performed at three different certified level 1 trauma centres. The data was obtained through a retrospective chart review including the electronic medical records and existing radiographs. This study was approved by the respective Institutional Review Boards.

The existing databases at the participating trauma centres were searched for male and female patients, 60 years of age and older, who underwent open reduction and internal fixation of their unicondylar (CPT code, 27535) or bicondylar (CPT code, 27536) tibial plateau fractures between July 2005 and December 2015 at two institutions and July 2011 to December 2015 at the third institution. Fractures from neoplastic disease and nonunion surgeries were excluded from this study. Potential subjects were then verified through the electronic medical records to have undergone open reduction and internal fixation and have at least three months of documented clinical follow-up after surgery.

The main outcome measure was wound complications of the surgical site. These were divided into superficial infections, defined as treated with oral antibiotics and local wound care, versus deep infections, defined as required surgical debridement. In addition, subject demographics including age at the time of injury, sex, body mass index (BMI), and current tobacco use (yes/no) were noted. BMI was further coded as normal weight ($BMI \leq 24.9$) or overweight/obese ($BMI \geq 25$). Mechanism of injury was described as either low energy (fall from standing) or high energy (e.g., fall from height, motor vehicle collision). Co-morbidities were recorded using the American Society of Anesthesiologists' Physical Status

Classification (ASA) [9]. The ASA was coded as low risk (ASA 1 or 2) or high risk (ASA 3 or 4). Fractures were noted to be either open or close. The AO/OTA fracture classification was applied to classify the fractures [10]. Treatment variables were largely binomial to indicate the use of provisional external fixation, intra operative use of a bone void filler. Continuous treatment variables included time in days from injury. Incisions used for the ORIF were categorised as single incision versus dual incision.

Statistical analysis

The primary outcome of infection was defined as any superficial or deep (soft tissue or bone) infection that required additional medical or surgical treatment. Overall infection rate was defined as the number of diagnosed infections divided by the number of fractures studied. Fisher's exact tests and Chi-square tests were used to determine if the proportion of diagnosed infections were different between each of the separate binomial and other categorical variables. Non-parametric Mann-Whitney *U* tests were used to compare the continuous variables age, tourniquet time, and BMI. Statistical analysis was completed using Stata/IC 14.2 (College Station, TX).

Results

One hundred and fifty-one tibial plateau fractures were identified during the study period across three level 1 trauma centers. Of these, 46 fractures were excluded due to lack of documented follow-up of at least one month post-operatively. Three fractures were excluded due to incomplete medical records and coding errors. The remaining 102 acute tibial plateau fractures treated with open reduction and internal fixation were included in the analysis.

Sixteen fractures (15.7%) were diagnosed with infection following operative treatment. Infection frequencies were not different between the three participating sites ($p = 0.448$). Four superficial and 12 deep infections occurred. Treatment for superficial infection was oral antibiotics and local wound care. All four superficial infections resolved with oral antibiotics alone. Treatment for deep infections included surgical irrigation and debridement followed by intravenous antibiotics. Five of the 12 deep infections were successfully treated with surgical debridement and subsequent intravenous antibiotics while the surgical hardware was retained. In seven patients, a hardware removal was performed in conjunction with the surgical debridement followed by intravenous antibiotics. Three of these patients remained unable to clear the infection despite repeat surgical debridements. This resulted in an above-knee amputation in two patients, and the third patient died in the hospital of subsequent sepsis and cardiac arrest.

Table 1 shows the results comparing demographic and clinical data between patients with and without surgical site infection. In our series, sex, mechanism of injury, BMI, prevalence of diabetes, and tobacco use were not significantly different in patients with a surgical site infection ($p < 0.05$). In addition, there was no significant age difference between patients who developed an infection (69.25 ± 7.22 years old) versus patients who did not develop an infection (66.81 ± 7.6 years old; $p = 0.134$). Subjects with a higher ASA classification (3 or 4) were more likely to develop an infection as compared to those of ASA classification 1 or 2 ($p = 0.015$).

Table 2 shows the results comparing fracture and treatment characteristics between patients with and without infection. Fracture type, use of provisional external fixation, number of incisions, and use of a bone void filler was not significantly different between patients with and without infection ($p < 0.05$). Of note, a significant difference in infection rates was found for the timing of fracture fixation. Patients who developed infections waited significantly longer to undergo fixation after injury (10.87 ± 7.59 days) than patients who did not develop infections (6.69 ± 5.63 days; $p = 0.038$).

Discussion

The rate and risk factors of surgical site infections following operative treatment of tibial plateau fractures in the elderly is something that all surgeons address when counseling patients on treatment options. To our knowledge, this is one of the largest multicentred studies to evaluate this issue. The purpose of this research was to define the infection frequency following open treatment of tibial plateau fractures in patients over the age of 60 and evaluate for associations between

infection development and a variety of patient, injury, and treatment characteristics. One hundred two patients over the age of 60 were included in this study. Sixteen patients (15.7%) developed an infection post-operatively, which is in the upper range of infection rates reported for the younger patient population of approximately 5–15% [11–13]. Interestingly, our data demonstrated that the infection rates in elderly patients without significant problems (ASA 1 and 2) are relatively low with 5.1% even when compared to younger patient populations from the literature. However, in elderly patients with significant medical co-morbidities (ASA 3 and 4), the infection rates are unacceptably high with 23.7% suggesting that almost one out of four patients will be at risk for experiencing a wound infection. Moreover, our series also suggests that wound complications in this patient population may have devastating outcomes, such as amputations or death, as was observed in our study. Of note, another significant finding in our database was that a longer time interval between injury and surgery increases the risk of infection. It is our opinion that the increased time interval is not the cause for increased infections, but rather reflects the results of a patient population with significant soft tissue compromise that required a staged treatment with delayed ORIF as part of the soft tissue management. Thus, we caution against early fixation when the soft tissue injury precludes patients from placement of formal surgical incisions.

Our study has both strengths and limitations. One limitation is the retrospective design of our study and we acknowledge that further prospective investigations are required to further address this issue. We also encountered a significant number of patients with incomplete follow-up, which we assume was due to the retrospective study design as well as the patient population studied. Similarly, for some variables, we

Table 1 Demographic and clinical variables in patients with infected versus non-infected fractures

		Infection (<i>n</i> = 16) (%)	No infection (<i>n</i> = 86) (%)	<i>p</i> value
Sex	Male	11 (18.3)	49 (81.7)	0.422
	Female	5 (11.9)	37 (88.1)	
Mechanism of injury	Low energy	4 (20.0)	16 (80.0)	0.734
	High energy	12 (15.2)	67 (84.8)	
ASA classification	1 or 2	2 (5.1)	37 (94.9)	0.015*
	3 or 4	14 (23.7)	45 (76.3)	
Body mass index	Normal weight	3 (13.6)	19 (86.4)	1.000
	Overweight or obese	13 (17.3)	62 (82.7)	
Diabetes	Yes	3 (11.1)	24 (88.9)	0.547
	No	13 (17.8)	60 (82.2)	
Tobacco use	Yes	5 (16.7)	25 (83.3)	1.000
	No	11 (15.5)	60 (84.5)	

Chi-square and Fisher's exact tests, as appropriate

ASA American Society of Anesthesiologists

**p* value significant at 0.05 level

Data not available for all 102 subjects

Table 2 Fracture and treatment characteristics of infected versus non-infected fractures

		Infection (<i>n</i> = 16) (%)	No infection (<i>n</i> = 86) (%)	<i>p</i> value
AO/OTA classification	41-B	6 (14.3)	36 (85.7)	0.718
	41-C	10 (16.9)	49 (83.1)	
Open fracture	Open	1 (11.1)	8 (88.9)	1.000
	Closed	15 (16.1)	78 (83.9)	
Provisional external Fixation	Yes	9 (22.0)	32 (78.0)	0.154
	No	7 (11.5)	54 (88.5)	
Incision	Single	10 (13.0)	67 (87.0)	0.138
	Dual	5 (29.4)	12 (70.6)	
Bone void filler	Yes	5 (20.8)	19 (79.2)	0.521
	No	11 (14.1)	67 (85.9)	

Data not available for all 102 subjects

had a few missing data points in our database, which was attributed to the multicentre design and the retrospective data collection from the electronic patient charts. Given the relatively low incidence of tibial plateau fractures in the elderly, we decided to combine the results from three academic trauma centers. However, this also created another limitation as the patients enrolled in this study were treated by multiple surgeons with varying surgeons' preferences. In addition, we do not have a comparison group and the infection rates recorded in this study can only be compared to infection rates reported in the literature. In contrast to other studies, we did not see an increased risk of infection for patients with some potential risk factors, such as BMI, diabetes, and tobacco use. We acknowledge that, despite the relatively high number of patients enrolled, our study may still be underpowered to detect subtle differences in infection rates between these groups.

The importance of identifying co-morbidities in surgical patients has long been established. Elderly patients often carry chronic medical conditions in addition to decreased bone quality. Our results demonstrate that subjects with a higher ASA classification of 3 or 4 were more likely to develop an infection compared to those of lower ASA classification of 1 or 2 (23.7 compared to 5.1%). According to the American Society of Anesthesiologists, ASA class 1 is defined as a normal healthy patient who, for example, does not smoke or have systemic illness. Examples which would qualify a patient for class 2 would be current smoker, pregnancy, BMI between 30 and 40, and well-controlled diabetes or hypertension. Class 3 examples include poorly controlled diabetes or hypertension, COPD, BMI > 40, active hepatitis, alcohol dependence, presence of a pacemaker, moderately reduced ejection fraction, end stage renal disease, or history (> 3 months) of myocardial infarction, cerebrovascular accident, transient ischaemic attacks, coronary artery disease, or stents [14]. Higher ASA classifications may play a role in the decision-making and the peri-operative planning. For instance, one key distinction between ASA II and

III is “controlled” vs “uncontrolled” diabetes and hypertension. In non-emergent procedures, this distinction highlights the importance of optimising co-morbidities and systemic medical conditions prior to orthopaedic surgery. This concept is well documented [15–17] and our data extends this concept to post-operative surgical site infections in elderly patients undergoing ORIF of their tibial plateau fracture. We believe that this distinction between ASA classes represented in our dataset highlights the importance of identifying co-morbidities in patients and—when time allows for it—to optimise each patient's medical status prior to surgery.

Tobacco use has been known to increase risk for infection in many types of injuries, including tibial plateau fractures [12, 18, 19]. The negative effect of smoking on blood flow, tissue oxygenation, and healing mechanisms is often referenced when counseling patients preparing for surgery. Similar to other studies [12, 20], our data did not find a statistically significant connection between smoking and surgical site infection of tibial plateau fractures. Regardless, like many institutions, each centre in our study counsels patients against the use of tobacco because of its impact on wound and fracture healing.

Neither fracture type nor number of incisions was linked to the infection rates in our data. Yet, we encountered a remarkable trend of higher infection rates associated with dual incision technique. Momaya et al. (2016) reported an association between fracture-type wound infection rate [11]. Morris et al. (2013) was able to demonstrate increased infection rates with dual incision technique [12]. However, it must be emphasised that there were some notable differences between these patient populations and our dataset. First, we focused almost exclusively on closed injuries where as Momaya and Morris included both open and closed fractures. Additionally, the average age in these studies was 45 and 47 years respectively, which was approximately 20 years younger than the average age of 67.2 years that was recorded in our series.

Conclusions

The purpose of our research was to define the infection frequency following surgical treatment of tibial plateau fractures in elderly patients and to evaluate for associations between surgical site infection and a variety of patient, injury, and treatment characteristics. Of the 102 patients included, 16 subjects developed a surgical site infection for an infection rate of 15.7%. Our investigation demonstrated that an ASA classification of 3 or 4 is associated with a significantly increased infection rate as compared to ASA of 1 or 2, suggesting the importance of optimising patient co-morbidities peri-operatively. An infection rate of 23.7% in higher ASA categories is concerning and should be factored into the decision-making process. Surgeons need to have awareness of this issue, should be counseling patients appropriately about the relatively high risk, and alternative treatment options, such as non-operative treatment or less invasive treatment options should be explored.

References

- Honkonen S (1994) Indications for surgical treatment of tibial condyle fractures. *Clin Orthop Relat Res* 302:199–205
- Barei D, Nork S, Mills W, Henley M, Benirschke S (2004) Complications associated with internal fixation of high-energy bicondylar tibial plateau fractures utilizing a two-incision technique. *J Orthop Trauma* 18:649–657. <https://doi.org/10.1097/00005131-200411000-00001>
- Li J, Zhu Y, Liu B, Dong T, Chen W, Zhang Y (2017, 2017) Incidence and risk factors for surgical site infection following open reduction and internal fixation of adult tibial plateau fractures. *Int Orthop*. <https://doi.org/10.1007/s00264-017-3729-2>
- Shah S, Karunakar M (2007) Early wound complications after operative treatment of high energy tibial plateau fractures through two incisions. *Bull Hosp Joint Dis* 65:115–119
- Su E, Westrich G, Rana A, Kapoor K, Helfet D (2004) Operative treatment of tibial plateau fractures in patients older than 55 years. *Clin Orthop Relat Res* 421:240–248. <https://doi.org/10.1097/01.blo.0000119247.60317.bc>
- Hsu C, Chang W, Wong C (2001) Surgical treatment of tibial plateau fracture in elderly patients. *Arch Orthop Trauma Surg* 121:67–70. <https://doi.org/10.1007/s004020000145>
- Ali A, Saleh M, Eastell R, Wigderowitz C, Rigby A, Yang L (2006) Influence of bone quality on the strength of internal and external fixation of tibial plateau fractures. *J Orthop Res* 24:2080–2086. <https://doi.org/10.1002/jor.20270>
- Stevens D, Beharry R, Waddell J, Schemitsch E (1999) Long term functional outcome of operatively treated tibial plateau fractures. *J Orthop Trauma* 13:295–296. <https://doi.org/10.1097/00005131-199905000-00043>
- American Society of Anesthesiologists (1963) New classification of physical status. *Anesthesiology* 24:111
- Marsh JL, Slongo TF, Agel J, Broderick JS, Creevey W, DeCoster TA, Prokuski L, Sirkin MS, Ziran B, Henley B, Audigé L (2007) Fracture and dislocation classification compendium - 2007: orthopaedic trauma association classification, database and outcomes committee. *J Orthop Trauma* 21(10 Suppl):S1–S133
- Momaya AM, Hlavacek J, Etier B, Johannesmeyer D, Oladeji LO, Niemeier TE, Herrera N, Lowe JA (2016) Risk factors for infection after operative fixation of tibial plateau fractures. *Injury* 47:1501–1505. <https://doi.org/10.1016/j.injury.2016.04.011>
- Morris B, Unger R, Archer K, Mathis S, Perdue A, Obremsky W (2013) Risk factors of infection after ORIF of bicondylar tibial plateau fractures. *J Orthop Trauma* 27:e196–e200. <https://doi.org/10.1097/bot.0b013e318284704e>
- Colman M, Wright A, Gruen G, Siska P, Pape H, Tarkin I (2013) Prolonged operative time increases infection rate in tibial plateau fractures. *Injury* 44:249–252. <https://doi.org/10.1016/j.injury.2012.10.032>
- Hurwitz EE, Simon M, Vinta SR, Zehm CF, Shabot SM, Minhajuddin A, Abouleish AE (2017) Adding examples to the ASA-physical status classification improves correct assignment to patients. *Anesthesiology* 126:614–622. <https://doi.org/10.1097/aln.0000000000001541>
- Ng VY, Lustenberger D, Hoang K, Urchek R, Beal M, Callhoun JH, Glassman AH (2013) Preoperative risk stratification and risk reduction for total joint reconstruction. *J Bone Joint Surg Am* 95:e191–e115
- Lee M (2013) Optimizing the safety of surgery, before surgery. *Clin Orthop Relat Res* 472:809–811
- Guss D, Bhattacharyya T (2006) Perioperative management of the obese orthopaedic patient. *J Am Acad Orthop Surg* 14:425–432
- Canale T, Kelly F, Daugherty K (2012) Smoking threatens orthopaedic outcomes. *AAOS Now* 6:1
- Castillo RC, Bosse MJ, MacKenzie EJ, Patterson BM, LEAP Study Group (2005) Impact of smoking on fracture healing and risk of complications in limb-threatening open tibia fractures. *J Orthop Trauma* 19:151–157
- Lin S, Mauffrey C, Hammerberg EM, Stahel PF, Hak DJ (2013) Surgical site infection after open reduction and internal fixation of tibial plateau fractures. *Eur J Orthop Surg Traumatol* 24:797–803. <https://doi.org/10.1007/s00590-013-1252-8>