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Prolonged operative time increases infection rate in tibial plateau fractures

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ABSTRACT

Background: Fractures of the tibial plateau present a treatment challenge and are susceptible to both prolonged operative times and high postoperative infection rates. For those fractures treated with open plating, we sought to identify the relationship between surgical site infection and prolonged operative time as well as to identify other surgical risk factors.

Methods: We performed a retrospective controlled analysis of 309 consecutive unicondylar and bicondylar tibial plateau fractures treated with open plate osteosynthesis at our institution's level I trauma centre during a recent 5-year period. We recorded operative times, injury characteristics, surgical treatment, and need for operative debridement due to infection. Operative times of infected cases were compared to uncomplicated surgical cases. Multivariable logistic regression analysis was performed to identify independent risk factors for postoperative infection.

Results: Mean operative time in the infection group was 2.8 h vs. 2.2 h in the non-infected group ($p = 0.005$). 15 fractures (4.9%) underwent four compartment fasciotomies as part of their treatment, with a significantly higher infection rate than those not undergoing fasciotomy (26.7% vs. 6.8%, $p = 0.01$). Open fracture grade was also significantly related to infection rate (closed fractures: 5.3%, grade 1: 14.3%, grade 2: 40%, grade 3: 50%, $p < 0.0001$). In the bicolumnar fracture group, use of dual-incision medial and lateral plating as compared to single incision lateral locked plating had statistically similar infection rates (13.9% vs. 8.7%, $p = 0.36$). Multivariable logistic regression analysis of the entire study group identified longer operative times (OR 1.78, $p = 0.013$) and open fractures (OR 7.02, $p < 0.001$) as independent predictors of surgical site infection.

Conclusions: Operative times approaching 3 h and open fractures are related to an increased overall risk for surgical site infection after open plating of the tibial plateau. Dual incision approaches with bicolumnar plating do not appear to expose the patient to increased risk compared to single incision approaches.

Introduction

The optimal treatment paradigm for displaced fracture of the tibial plateau is open reduction internal fixation. Preservation of a healthy soft-tissue envelope, restoration of the mechanical axis and meticulous joint reduction are the primary tenets of care.[1–3] The operative care of a high-energy plateau fracture requires advanced fracture-reduction skills and meticulous soft-tissue handling. As such, operative times can be extended.

In the pre-modern era, deep infection rates following open plating of the proximal tibia as high as 80% were reported.[1,4] Modern techniques such as delay of definitive surgery, the use of temporary spanning external fixation, a dual-incision approach for bicolumnar fractures and meticulous soft-tissue handling have improved the results of open plating,[5–7] yet complication rates from wound necrosis and infection are still reported in the range of 10–14%.[8] A recent study even identified fracture of the proximal tibia as an independent risk factor for surgical site infection (SSI).[9] One variable that may affect the rate of infection and remains poorly investigated is operative time. Specifically, it is unknown how the prolonged operative times necessary to achieve the goals of fracture care affect the incidence of postoperative SSI. We hypothesise that in open plate osteosynthesis of tibial plateau fractures, the prolonged operative times sometimes required for restoration of mechanical axis and joint surface integrity may increase the rate of SSI. In addition, we sought to identify other

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surgeon-controlled variables that might affect the rate of postoperative SSI.

Methods

Study design

We performed a retrospective controlled analysis of 309 consecutive tibial plateau fractures treated with open plate osteosynthesis at our institution's level I trauma centre during the 5-year period from 2005 to 2010. The minimum follow-up period from the index procedure was 1 year. Exclusion criteria included extra-articular fractures, those fractures treated with alternative methods of fracture stabilisation other than open plate osteosynthesis and any patient who had received surgical care at an outside institution. We recorded patient characteristics and co-morbidities, injury characteristics and treatment profiles including operative time (Table 1). Lower-energy fractures with Schatzker grades I–IV ($N = 158$) were grouped together in a category labelled 'unicondylar', and higher-energy fractures with Schatzker grades V and VI ($N = 151$) were grouped together in a category labelled 'bicondylar' in order to facilitate statistical analysis along a binary system based on fracture energy. The major outcome measure in this study, SSI, was defined by postoperative development of deep infection requiring operative debridement as defined by tissue culture or infectious disease consulting opinion. Operative times and other surgeon-controlled variables of infected cases were compared to uncomplicated surgical cases.

Operative protocols

Our cohort was cared for by a heterogeneous population of five to six attending surgeons whose protocols can be generalised in several ways. All 309 cases presented initially to our institution for definitive care without outside surgical intervention. After initial trauma survey and radiographic and clinical evaluation, each patient was medically optimised for operative intervention. For patients with excessive swelling who displayed clinical signs of acute compartment syndrome, urgent operative four-compartment fasciotomy with external fixation was used for the preservation of the soft tissues and for obtaining tissue equilibrium until definitive fracture stabilisation. The diagnosis of compartment syndrome was in nearly all cases a clinical one and compartment measurements were inconsistently available. For those who did not have acute compartment syndrome, immediate external fixation or splinting is used depending on soft-tissue traumatisation, swelling, injury energy and mechanism, neurologic and circulatory exam and knee joint congruity. Definitive open plating was performed at the discretion of the attending surgeon when the swelling decreased and soft-tissue equilibrium was achieved. The goals of each surgeon in this series were to use meticulous soft-tissue handling using full-thickness fascio-cutaneous flaps and to perform anatomic restoration of the mechanical axis, joint line and condylar width. Fracture reduction was accomplished using standard *Arbeitsgemeinschaft für Osteosynthesefragen* techniques for split patterns (Schatzker I and IV). For depression-type fractures (Schatker II and III) we typically use an 'open book' or corticotomy technique to visualise the depressed fragments prior to elevating them into an anatomic position followed by bone grafting as necessary. For higher-energy variants (Schatker V and VI) we typically use a combination of the above techniques as dictated by fracture personality. Open plating was performed with a variety of implants but the overwhelming majority consisted of modern proximal tibia periarticular plating systems. Minimally invasive plating techniques were rarely used. For bicondylar variants, lateral locking vs. dual-column, dual-incision plating techniques were used at the attending surgeon's discretion. Care was taken to identify posteromedial fragments, which were stabilised with posteromedial plating. In all cases, preoperative antibiotics were administered just prior to skin incision, were re-dosed if the operative duration was longer than 4 h, and for closed fractures were discontinued within 24 h postoperatively in accordance with our institution's participation in the Surgical Care Improvement Project. All attending surgeons typically close wounds over a drain, except for those wounds that have fasciotomy incisions, where a vacuum-assisted closure (VAC) (Kinetics Concepts, Inc., San Antonia, TX, USA) dressing is applied until delayed closure or skin grafting.

Statistical analysis

In order to examine differences between patients who developed SSI and those who did not, bivariate analysis was performed for all variables using the two-tailed Student's *t*-test and non-parametric tests for continuous data and two-tailed Chi-squared tests for categorical data. Using those variables where we detected a statistically significant difference between infected and

Table 1
Results of univariate analysis of risk factors for surgical site infection following open plating. Unless otherwise specified, statistical analysis comprised of Chi-squared test or Student's *t*-test.

Risk factor	$N = 24$ Infected group	$N = 285$ Non-infected group	*p* value
Age (mean in years)	47.9	47.8	0.97
Sex (male incidence)	79.2%	58.9%	0.05
Diabetes mellitus (incidence)	20.8%	9.5%	0.08
Tobacco use (incidence)	45.8%	30.5%	0.12
Presence of compartment syndrome and four-compartment fasciotomies (incidence)	16.70%	3.90%	0.01
Schatzker grade (bicondylar incidence)	62.50%	47.70%	0.16
Open fracture grade			<0.0001*
Closed	62.5%	94.4%	
1	4.2%	2.1%	
2	16.7%	2.1%	
3	16.7%	1.4%	
Time from injury to definitive plating (days)	5.0	4.1	0.15**
Use of external fixation	79.2%	54.4%	0.02
Time from external fixation to definitive plating (days; external fixator group only, $N = 174$)	6.4	7.3	0.46
Operative time (h)	2.8	2.2	0.005**
Incidence of dual incision approach (bicondylar group only, $N = 151$)	33.3%	22.8%	0.36

* Linear by linear correlation.
** Non-parametric test.