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Infection after operative fixation of tibia plateau fractures. A risk factor analysis

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ABSTRACT

Introduction: Surgical fixation of tibial plateau fractures has been shown to improve long-term functional outcomes, but a major complication is that of postoperative infection which can be deleterious to long-term outcomes. This study aims to assess the impact of common comorbidities on the risk of postoperative infection.

Method: A retrospective study of 210 consecutive operatively treated patients, treated at two Level 1 Trauma Centres over a 27-month period was performed. Records were analysed to assess the presence of the study factors; smoking, alcohol intake >13 units/week, diabetes, and BMI $\geq$ 30. The impact of these factors on infection was assessed with univariate and multivariate analyses.

Results: 175 patients were included in the study, 56.6% male with a mean age of 46.9 years ($\pm$ 18.2 years). Excessive alcohol consumption of >13 units/week was the only significant risk factor for postoperative infection ($p = 0.05$) on multivariate analysis.

Conclusion: This study has identified excessive alcohol consumption as the only independent risk factor for postoperative infection in patients with all types of tibial plateau fracture treated with operative fixation. No relationship between smoking, diabetes nor obesity was found for postoperative infection.

Introduction

Surgical treatment of tibial plateau fractures has been shown to improve patient reported outcomes [1,2]. However as with any orthopaedic operation, infection is one of the greatest postoperative concerns for any surgeon. Historic postoperative infection rates for tibial plateau fixation were as high as 80% [3,4]. Modern surgical approaches through careful soft tissue handling and greater use of minimally invasive techniques have reduced rates of post-operative infection to approximately 10% [5]. Incidents of infection increase not only patient morbidity and mortality, but associated healthcare costs [6]. With increasing demands on global healthcare systems, reducing such occurrences is of paramount importance.

Lifestyle choices such as smoking deleteriously affect wound healing [7] through the reduction in tissue oxygenation [8], with smoking being one of the greatest predictors of wound infection after elective orthopaedic procedures [9–13]. Pre-operative alcohol consumption increases general postoperative morbidity and surgical site infections across a wide spectrum of surgical specialities [12,14] thought to be through the acute immunosuppressive effect of ethanol [15].

The current global obesity epidemic will drive an exponential rise in the prevalence of diabetes mellitus [16], with hyperglycaemic states and its associated reactive end products inhibiting the normal wound-healing process [15]. Obesity itself is an independent risk factor for postoperative infection in elective orthopaedic operations [10,11].

Previous studies have demonstrated overuse of alcohol and obesity (body mass index (BMI) $\geq$ 30) as independent risk factors for surgical site infections in patients with ankle fractures treated with open reduction internal fixation [17]. This multi-centre study is the first that aims to correlate the use of alcohol and smoking, in addition to obesity and diabetes mellitus to the occurrence of post-operative infections in patients undergoing open reduction and internal fixation for all types [1] of tibial plateau fractures.

Patients & methods

A retrospective analysis of 210 consecutive patients surgically treated for tibial plateau fractures at two Level 1 trauma centres

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(Major Trauma Centres) between January 2015 and April 2017 was performed. Inclusion criteria for the study were; patients over 18 years of age, operative treatment with open reduction internal fixation and a minimum of 6-months follow-up. Patients under 18 years of age and those treated with circular frames, intramedullary fixation or percutaneous screw fixation were excluded from this study.

Operative fixation was performed or supervised by experienced trauma surgeons using either Stryker AxSOS 3 Ti Proximal Tibial plates (Michigan, United States of America) or DePuy Synthes VA-LCP Proximal Tibial plates (Massachusetts, United States of America). Direct medial/posteromedial and lateral/anterolateral approaches were used to preserve the vascularity of the tibia [18], with careful soft tissue handling observed throughout all procedures. All fractures were fixed with a combination of buttress plate techniques and compression of the articular block, with or without additional locked constructs for support of the depressed articular surface.

All study patients' medical records were reviewed to collect demographic, injury, past medical history, lifestyle and operative data. Alcohol overuse was considered to be $\geq$ 14 units per week, and any tobacco use irrespective of amount was considered as smoking. An elevated BMI was considered to be $\geq$ 30 kg/m^2. Follow-up records were analysed to detect the occurrence of infections (deep or superficial) and any subsequent intervention required; antibiotics and/or reoperation.

Fractures were classified based on Schatzker and McBroom's classification [1] using standard anteroposterior and lateral radiographs and computerised tomography (CT) images.

Statistical analysis was performed using IBM (New York, United States of American) SPSS v23.0. Significance was set at $\leq$ 0.05. Pearson's Chi-square was used for monovariant analysis and direct logistic regression was conducted for the multivariant model of the study.

Results

175 patients (91 from hospital 1 and 84 from hospital 2) were included in this study, with a mean age of 46.95 years ($\pm$ 18.2 years). The majority of patients were male (56.6%), and the most common injury pattern identified was a Schatzker II type fracture (53.3%). A lateral plate was the most commonly used device for operative fixation (65.1%) (Table 1).

20% of study patients were over users of alcohol and 30% were smokers. The mean body mass index (BMI) for the study was 26.1 ($\pm$ 4.8). 45% of patients were American Society of Anesthesiologists (ASA) grade II or above (Table 2).

The incidence of deep infection was 0.6% (n = 1). This patient required two further operative interventions with surgical washout and long-term intravenous antibiotics. An additional 6.8% (n = 12) developed superficial infections during their follow-up period, all of whom were successfully treated with oral antibiotics alone. The overall incidence of infections during the study period for operatively treated tibial plateau fractures was 7.4%.

Univariant analysis of fracture pattern in relation to the occurrence of postoperative infection demonstrated a significant increase in the incidence of infection (p = 0.026) with increasing fracture severity (Schatzker I - II vs Schatzker IV – VI). Patients treated with two or more plates had a higher incidence of infection (p = 0.05). Age, gender, BMI and ASA grade did not significantly impact the risk of infection.

Patients with alcohol overuse had a significantly higher rate of infection (p = 0.006) compared to those without. There was no significant association between infection and the presence of diabetes and smoking.

Multivariant analysis demonstrated that alcohol was the only risk factor associated with infection (p = 0.05), with patients having a five-fold increase in infection if they consumed 14 or more units of alcohol a week (Table 3). This analysis has a positive predictive value of 24% and negative predictive value of 95%.

Discussion

Our multicentre study of 175 sequential patients undergoing operative fixation of tibial plateau fractures at Level 1 Trauma Centres over a 27-month period demonstrated an overall infection rate of 7.4% consistent with the published literature [5]. Excess alcohol use of $\geq$ 14 units per week was the only risk factor identified on multivariant analysis for infection after operative fixation of tibial plateau fractures. Other factors such as smoking, and medical conditions such as diabetes mellitus, obesity and ASA grade had no impact on postoperative infection.

Previous studies have identified alcohol overuse as a significant risk factor in infection post ankle fracture operative fixation on univariant analysis, however this significance was not maintained through multivariant analysis [17]. Alcohol overuse has also previously been associated with the increased infection risks in patients undergoing elective spinal procedures [11]. Increased alcohol consumption has been associated with increased perioperative bleeding [12], and subsequent relative immunosuppression in the postoperative period [12,15]. The combination of increased perioperative bleeding in those patients with excessive alcohol

Table 1
Demographics of study population and frequency of injury pattern presentation and operative modalities used.

	Frequencies (N)	Percentage (%)
Hospital		
Hospital 1	91	52.0
Hospital 2	84	48.0
Gender		
Male	76	43.4
Female	99	56.6
Fracture Type		
Schatzker I	7	4.0
Schatzker II	95	54.3
Schatzker III	3	1.7
Schatzker IV	29	16.6
Schatzker V	11	6.3
Schatzker VI	30	17.1
Fixation Type		
Lateral plate	114	65.1
Lateral & Medial plate	32	18.3
Medial plate	26	14.9
Three plates	3	1.7

Table 2
ASA grades for all patients undergoing operative treatment, and frequencies of assessed risk factors.

	Frequencies (N)	Valid Percentage (%)
ASA grade		
ASA I	89	55.3
ASA II	59	36.6
ASA III	12	7.5
ASA IV	1	0.6
Smoking		
Yes	43	29.9
No	101	60.1
Alcohol		
Yes	30	20
No	120	80
Diabetes (type I and II)		
Yes	14	9
No	142	91

Table 3
Multivariant analysis of risk factors to infection after operative fixation of tibial plateau fractures.

	p	*Odds Ratio*	*95% C.I.*	
			Lower	*Upper*
BMI $\geq$ 30	.75	1.03	.88	1.19
Smoking	.43	.51	.10	2.71
Alcohol[a]	.05	.20	.04	.97
ASA grade	.59	.66	.15	2.99
Diabetes	.64	.55	.05	6.56
Gender	.76	.76	.13	4.38
Age	.55	1.01	.97	1.07
Fracture Type	.11	.29	.07	1.33

[a] Clinically significant reduction in infections in those patients consuming under 14 units of alcohol per week.

consumption, in conjunction with the rich extraosseous vascularity of the proximal tibia metaphysis [19]. May provide basis the increased risk of postoperative infection, due to postoperative haematoma formation.

Patients undergoing surgical fixation of bicondylar tibial plateau fractures (Schatzker V & VI) with a preoperative history of smoking have significantly increased risks of infection [20]. However, our study analysing all types of tibial plateau fracture did not demonstrate a similar association. This may be due to the majority of patients having two incision operations in that study whereas only 18.3% of our study's patients underwent dual plating operations. Previous studies have demonstrated much higher rates of infection (circa 18.0%) [21,22] in patients undergoing dual incision, dual plating operations for tibial plateau fractures [23]. The significance of dual plating was not carried through from the initial univariant analysis into the multivariant analysis. It may therefore be the predominance of unicondylar tibial plateau injuries in this study that has negated the impact of smoking on infection risk in this study.

Previous studies have demonstrated obesity (BMI > 30) and diabetes as being risk factors for infection after operative fixation of ankle fractures [17]. Our study treated BMI as a continuous variable and didn't demonstrate such relationships. We were unable to differentiate between type I and II diabetes mellitus, so are unable to comment or make further analysis as to the independent impact of type I or II on the occurrence of postoperative infections in surgically treated tibial plateau fractures. The relative proportion of patients with a BMI $\geq$ 30 (18.2%) is comparable to Olsen et. al.'s publication on risk factors for infection post ankle fracture fixation; 17.3% [17]. The lack of any significant relationship between BMI and infection cannot therefore be attributed to a smaller proportion of this study being overweight.

The demographic composition of this study is different compared to other published outcome studies [2,20,24,25]; namely our study had a greater proportion of female patients to male patients. However, we are not aware of any study that has established a link between gender and outcomes of operatively treated tibial plateau fractures and this is supported by our multivariate analysis including gender. Schatzker II tibial plateau fractures were the most commonly encountered injury in this study, consistent with previous epidemiological studies on the frequencies of tibial plateau fractures [26]. The retrospective nature of this study is its principle limitation, thereby limiting our ability to adjust for confounding variables such as the soft tissue state of patients on their presentation. We have attempted to control as many confounding variables that we were able to access reliable data for in our multivariate analysis. This study is however strengthened by its multicentre nature; combining 2 Level 1 trauma centres covering a geographically and socially diverse population in the United Kingdom. Our study size of 175 patients also represents one of the largest samples in any study assessing functional or operative outcomes of operatively treated tibial plateau fractures [5].

Previous studies have assessed risk factors for infection in patients sustaining higher energy [1,18] bicondylar tibial plateau fractures [20] but no study to the authors' knowledge has assessed risk factors for infection across all types of tibial plateau fractures. Our study has demonstrated that alcohol consumption in excess of 13 units per week, is a significant risk factor for postoperative infection following operative treatment of all types of tibial plateau fractures. This may indicate additional care being paid to prophylactic antibiotic selection and monitoring for early signs of postoperative infection, in those patients with excessive alcohol consumption.

Conclusion

This study has demonstrated that alcohol consumption in excess of 13 units per week is a risk factor that significantly increases the risk of postoperative infection in surgically treated tibial plateau fractures. Surprisingly our study did not demonstrate any relationship between smoking nor diabetes on the risk of postoperative infection. Further prospective studies would help to consolidate the knowledge base on risk factors for infection after surgical fixation of tibial plateau fractures.

Declaration of Competing Interest

All authors have no conflicts of interests to declare with regards to the submitted manuscript.

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