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Review

Incidence and risk factors for surgical site infection after open reduction and internal fixation of tibial plateau fracture: A systematic review and meta-analysis

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HIGHLIGHTS

- The article is the first study to quantitatively summarize the risk factors for the surgical site infection after open reduction internal fixation of tibial plateau fractures.
- It can help to develop effective management strategies for prevention of surgical site infection following open reduction internal fixation of tibial plateau fractures.
- The article explains the reasons of risk factors clearly.

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ABSTRACT

Background: This study aimed to quantitatively summarize the risk factors associated with surgical site infection after open reduction and internal fixation of tibial plateau fracture.
Methods: Medline, Embase, CNKI, Wanfang database and Cochrane central database were searched for relevant original studies from database inception to October 2016. Eligible studies had to meet quality assessment criteria according to the Newcastle-Ottawa Scale, and had to evaluate the risk factors for surgical site infection after open reduction and internal fixation of tibial plateau fracture. Stata 11.0 software was used for this meta-analysis.
Results: Eight studies involving 2214 cases of tibial plateau fracture treated by open reduction and internal fixation and 219 cases of surgical site infection were included in this meta-analysis. The following parameters were identified as significant risk factors for surgical site infection after open reduction and internal fixation of tibial plateau fracture ($p < 0.05$): open fracture (OR 3.78; 95% CI 2.71–5.27), compartment syndrome (OR 3.53; 95% CI 2.13–5.86), operative time (OR 2.15; 95% CI 1.53–3.02), tobacco use (OR 2.13; 95% CI 1.13–3.99), and external fixation (OR 2.07; 95% CI 1.05–4.09). Other factors, including male sex, were not identified as risk factors for surgical site infection.
Conclusion: Patients with the abovementioned medical conditions are at risk of surgical site infection after open reduction and internal fixation of tibial plateau fracture. Surgeons should be cognizant of these risks and give relevant preoperative advice.

1. Introduction

Tibial plateau fracture (TPF) is a common intra-articular fracture that accounts for 1.66% of all fractures in adults [1]. Surgical treatment of TPF aims to restore the articular surface, correct the mechanical axis, and stabilize the joint [2–6]. Open reduction and internal fixation (ORIF) is highly successful for displaced TPF.

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However, this treatment reportedly results in a relatively high incidence of complications, including surgical site infection (SSI) [7]. SSI is a common complication that is associated with serious poor postoperative outcomes [8]; postoperative SSI prolongs hospital stay by about 2 weeks per patient, and increases the additional costs by more than 300% [9], causing a large financial burden to the healthcare system. Therefore, it is important to identify the risk factors related with SSI after ORIF of TPF.

Many risk factors have been investigated as potential risk factors for SSI after ORIF of TPF, including open fracture [7,10–13], compartment syndrome [7,10–13], operative time [10,13], tobacco use [12,13], and external fixation [7,10,12,13]. However, previous research has had limitations such as small sample size and inclusion of a single criterion; moreover, some of the results obtained from individual studies are conflicting, such as the effect of external fixation on SSI [7,10,12,13].

For a reliable conclusion, the current meta-analysis was performed using data obtained from previous studies to conclusively identify the risk factors of SSI after ORIF of TPF. To our knowledge, this is the first study to quantitatively summarize the risk factors for SSI after ORIF of TPF.

2. Methods

2.1. Literature search

A computerized search was performed in Medline, Embase, CNKI and Cochrane central database from database inception until October 2016 for studies exploring the risk factors for SSI after ORIF of TPF. The main keywords were: "factor" or "predictor" or "risk" AND "infection" AND "tibial plateau fractures" or "tibial plateau" or "proximal tibia". In addition, a manual search of the bibliographies of the identified articles was performed to elucidate potentially relevant studies.

2.2. Inclusion criteria

Two authors independently evaluated the titles and abstracts of the identified articles. Only full-text articles without language restriction were included in this meta-analysis. The inclusion criteria were: (1) observational or cohort studies or randomized controlled trials; (2) cases and controls were defined according to the presence or absence of SSI after ORIF of TPF; and (3) sufficient data presented to estimate the odds ratios (ORs) with 95% confidence intervals (CIs).

2.3. Quality assessment

The quality of the included studies was evaluated by the Newcastle-Ottawa Scale (NOS) [14] based on the three main options: selection of the study groups (0–4 points), comparability of the groups (0–2 points), and determination of either the exposure or the outcome of interest (0–3 points), with a maximum score of 9. Studies with an NOS score $\geq$6 were considered to be of high quality.

2.4. Data extraction

All data were carefully obtained from all eligible studies independently by two authors (Shao and Chang). The following variables were obtained from each study: the first author's name, publication year, country, risk factors, numbers of cases and controls, and infection ratio. Any disagreement was settled by discussion.

Lin et al. [7] defined SSIs using the standard definitions from the Centers for Disease Control [15,16]: deep SSIs included deep fascia and muscle that had been infected within 1 year after the initial operation, while superficial SSI was defined as an infection including only skin or subcutaneous tissue surrounding the surgical site that began within 30 days postoperatively. In contrast, other studies defined deep infection as an unexpected return to the operating room for irrigation and debridement, with positive surgical cultures taken from below the deep fascia and muscle, requiring antibiotic treatment [10,11,13].

2.5. Statistical analyses

When possible, adjusted ORs (from multivariate analysis models) and 95% CIs were extracted from the original studies for each risk factor. When adjusted ORs were not provided, crude ORs were used. ORs and corresponding 95% CIs were estimated and pooled across studies to assess the differences between different variables and the risk of SSI, with $p < 0.05$ indicating significance. Heterogeneity between studies was tested by the Q-test, with significance set at $p < 0.10$ [17]. The I^2 statistic was used as a quantitative measure of heterogeneity, with $I^2 > 50\%$ indicating significant inconsistency. A random effects model was used to calculate pooled ORs in the case of significant heterogeneity ($p < 0.10$ or $I^2 > 50\%$); otherwise, a fixed effects model was used. The outcome of meta-analysis for variables was summarized by forest plots. Publication bias was not assessed due to the small number of included studies. For any variable presenting with large heterogeneity, a sensitive analysis excluding outlier studies was conducted to investigate the potential sources of heterogeneity. All analyses were performed using Stata 11.0 software (Stata Corporation, College Station, TX). To better elucidate the associations between the identified risk factors and SSI, we considered the parameter as a strong risk factor when the OR $\geq$ 2, a moderate risk factor when 1 < OR < 2, and a protective risk factor when OR < 1 [18–20].

3. Results

A total of 195 full-text studies were retrieved; of these, eight studies were eligible for inclusion in this meta-analysis (Fig. 1). Five studies were published in English and three studies were published in Chinese. All studies were published between 2013 and 2016. These eight studies included a total of 2214 cases of TPF treated by ORIF, and 219 cases of SSI, suggesting a cumulative incidence of 9.9%. Detailed information about these included studies is shown in Table 1. Regarding the NOS quality assessment, two studies scored 8 [10,11], three studies scored 7 [7,12,13], and three studies scored 6 [21–23].

The main results of the meta-analysis are summarized in Table 2. Combined ORs ranged from 1.31 to 3.78. Significant heterogeneity was observed between studies regarding external fixation. On the basis of the combined ORs and corresponding 95% CIs, the following risk factors were found to be significantly associated with SSI after ORIF of TPF ($p < 0.05$): open fracture (OR 3.78; 95% CI 2.71–5.27), compartment syndrome (OR 3.53; 95% CI 2.13–5.86), operative time (OR 2.15; 95% CI 1.53–3.02), and tobacco use (OR 2.13; 95% CI 1.13–3.99). The outcomes of variables identified as significant risk factors have been presented using forest plots (Fig. 2–7). The following variables were not found to be significantly associated with risk of SSI after ORIF of TPF ($p > 0.05$): male sex and external fixation.

A sensitivity analysis was performed for risk factors with significant heterogeneity (external fixation) by excluding outlier studies of low quality or with larger CIs for some ORs. When the study by Lin et al. [7] was excluded, the I^2 value decreased to 0% (p for heterogeneity was 0.771) and external fixation was found to be significantly associated with SSI after ORIF of TPF ($p = 0.035$).