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*Retrospective Cohort Study*

**Identification of risk factors for surgical site infection after type II and type III tibial pilon fracture surgery**

**Abstract**

**BACKGROUND**

High-energy tibial pilon fractures are complex and severe fractures that are associated with a high risk of infection following open reduction and internal fixation. Infection can negatively impact patient outcomes.

**AIM**

To compare risk factors for postoperative infection after open reduction and internal fixation for a pilon fracture.

**METHODS**

Among the 137 patients included, 67 developed a surgical site infection. Demographic, clinical, and surgical factors were compared between the two groups. A binary logistic regression analysis was used to determine the odds ratio (OR) and corresponding 95%CI for significant risk factors for postoperative infection.

**RESULTS**

The distribution of pathogenic bacteria among the 67 patients who developed a surgical site infection was as follows: Gram-positive, 58.2% ( $n = 39$ ); Gram-negative, 38.8% ( $n = 26$ ); and fungal, 2.9% ( $n = 2$ ). The following factors were associated with postoperative

infection ( $P < 0.05$ ): a Ruedi-Allgower pilon fracture type III (OR = 2.034; 95%CI: 1.109–3.738); a type III surgical incision (OR = 1.840; 95%CI: 1.177–2.877); wound contamination (OR = 2.280; 95%CI: 1.378–3.772); and diabetes as a comorbidity (OR = 3.196; 95%CI: 1.209–8.450).

## CONCLUSION

Infection prevention for patients with a Ruedi-Allgower fracture type III, surgical incision type III, wound contamination, and diabetes lowers the postoperative infection risk after surgical management of tibial pilon fractures.

**Key Words:** High-energy trauma; Pilon fracture; Surgical site infection; Ruedi-Allgower; Risk factors

## INTRODUCTION

High-energy tibial pilon fractures are a complex and severe fracture type<sup>[1,2]</sup>. Traditionally, these fractures have been treated by early open reduction and internal fixation. However, there is a risk for delayed union or even non-healing due to incomplete cleaning of the fracture site and/or early infection of the internal fixation device<sup>[3]</sup>. To reduce the risk of delayed union, stepwise delayed surgery has been used for the treatment of tibial pilon fractures, with satisfactory results reported<sup>[4]</sup>. These fractures, however, are generally associated with severe soft tissue injury. As there is shallow coverage of tibial osteoarticular cartilage tissue and a lack of muscle tissue in this area, subcutaneous tissue, mainly composed of tendons and ligaments, is often exposed after fracture. Therefore, internal fixation, in combination with the trauma caused by surgery, increases the risk of surgical site infection, which negatively impacts patient prognosis and the recovery of tibial nerve and motor function after surgery<sup>[5,6]</sup>. There is a need in practice to identify the risk factors for non-union of these fractures to

formulate and implement appropriate prevention and treatment measures during the perioperative period to reduce the likelihood of postoperative infection. Our aim in this study was to compare the risk factors associated with postoperative infection after open reduction and internal fixation for a pilon fracture to provide a theoretical basis for prevention strategies to lower the risk of postoperative infection for these fractures.

## **MATERIALS AND METHODS**

### ***Study cohort***

This was a retrospective cohort study, with the methods approved by our institutional Medical Ethics Committee. The study cohort comprised 137 patients who underwent surgical treatment for a pilon fracture between February 2016 and May 2019. Of these, 67 patients developed a surgical site infection; the 70 patients who did not develop a surgical site infection formed the control group. The inclusion criteria were as follows: negative history of trauma resulting in a unilateral tibial pilon fracture confirmed by clinical examination, radiographs, and computed tomography (CT); a Ruedi-Allgower classification fracture type II or III; and age  $\geq 19$  years. Patients with a history of infectious diseases, such as lower limb skin ulcers, were excluded. Patients with missing data were also excluded.

The diagnostic criteria for surgical site infection, based on the Diagnostic Criteria for Hospital Infection Trial<sup>(7-9)</sup>, were as follows: signs of infection at the surgical site, such as swelling, heat, pain; purulent discharge from the incision; and identification of pathogenic bacteria in wound tissue or secretion culture.

The infection group included 38 men and 29 women, with a mean age of  $52.3 \pm 8.0$  (range, 21 to 76) years. These patients were treated with early open reduction and internal fixation. The control group included 45 men and 25 women, with a mean age of  $51.5 \pm 7.3$  (range, 24 to 73) years. Patients in the control group were treated with delayed open reduction and internal fixation, after confirmation of decreased swelling of local soft tissues.

### *Surgical treatment*

For both groups, open reduction and internal fixation was performed under general anesthesia. An incision of 10–12 cm was made on the lateral aspect of the tibia, and the skin, subcutaneous tissue, muscle, and deep fascia were separated, layer by layer, to expose the fracture site. The bone fragments at the fracture site were cleaned and cauterization was used to completely stop the bleeding. Subsequently, manual reduction of the fracture was performed, with internal fixation performed using steel plates. After intra-operative radiography to confirm alignment at the fracture site, the incision was closed.

For patients treated with delayed open reduction and internal fixation (the control group), calcaneal traction was applied after emergency treatment (7–8 kg fixed to the calcaneal nodule). The status of local soft tissue swelling was evaluated by CT imaging. We proceeded with open reduction and internal fixation once the local swelling had been effectively managed. The surgical procedure was the same as used for the early intervention group.

### *Measured outcomes*

The following data were compared between the two groups: age, sex, delay between fracture and surgery, Ruedi–Allgower fracture classification, wound contamination, early or delayed fracture treatment, type of surgical incision, antibiotic use during the perioperative period, and comorbidities.

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### *Statistical analysis*

Continuous data were reported as mean  $\pm$  SD, with categorical variables reported as count and percentage. Between-group differences were evaluated using  $\chi^2$  test for categorical variables and statistical test for continuous variables. A multivariate logistic regression analysis was used to identify significant risk factors ( $P < 0.05$ ) with postoperative infection as the independent variable. All analyses were performed using SPSS software (version 21.0).

## **RESULTS**

### ***Between-group comparison of baseline values***

The distribution of baseline variables between the patients with and without postoperative infection is reported in Table 1. There were significant between-group differences in the Ruedi-Allgower fracture type, wound contamination, surgical incision type, and presence of diabetes mellitus as a comorbidity ( $P < 0.05$ ). There were no between-group differences with respect to age, sex, surgical method, antibiotic use, and presence of hypertension as a comorbidity.

### ***Risk factors for surgical site infection***

Multivariate logistic regression found Ruedi-Allgower classification type III fracture, type III surgical incision, wound contamination, and diabetes as a comorbidity as risk factors for surgical site infection ( $P < 0.05$ ; Table 2).

## **DISCUSSION**

Tibial pilon fractures, involving the distal one-third of the tibia, are caused by high-energy external forces, such as falling from a height and motor vehicle accidents. Owing to the high energy forces causing the trauma, these fractures are accompanied by massive loss of tibial cartilage tissue, destruction of blood supply to the bone, and loss of anatomical integrity and function of the distal tibial articular surface. These fractures require reduction and internal fixation, and the trauma of surgery increases the risk for postoperative infection. In this study, we identified Ruedi-Allgower type III fracture, wound contamination, type III (compared to type I-II) surgical incision, and diabetes mellitus as significant risk factors for postoperative infection ( $P < 0.05$ ). Therefore, although delayed treatment has been proposed to reduce the risk of postoperative infection, this clinical recommendation was not supported by our findings.

The benefits of delayed compared to those of early treatment of a tibial pilon fracture are deemed to include a clean and stable fracture environment for reduction, control of

soft tissue swelling and local hematoma, and ensuring adequate microcirculation of the middle and lower segments of the tibia to support fracture healing and recovery of local soft tissues, including function of the tibial nerve<sup>[10]</sup>. Previous studies have reported a shorter time to fracture healing and full weight-bearing, as well as a reduced risk of fracture non-union, with delayed compared to early fracture reduction and internal fixation<sup>[11,12]</sup>. Our findings indicate that factors other than the time of surgery, namely the fracture type, the presence/absence of wound contamination, type of incision used, and health comorbidities influence the risk postoperative infection.

The Ruedi-Allgower classification reflects the degree of fracture comminution and the continuity of the articular surface, with type III having a higher degree of comminution and loss of articular surface<sup>[13]</sup>. Previous studies have identified this fracture type as a risk for postoperative infection<sup>[14,15]</sup>, which was consistent with our findings. Previous studies have also shown that wound contamination and diabetes increase the risk of postoperative infection for tibial pilon fractures. Diabetes decreases distal limb perfusion, with the resulting decrease in blood supply to the fracture site impairing fracture healing. The incision used for open reduction and internal fixation has also been previously identified as a risk factor for postoperative infection. We identified use of type III incision as a significant risk factor for postoperative infection. This may likely be due to the larger exposed area with this incision type, which improves the visual field of fracture reduction and internal fixation but also increases exposure to bacteria<sup>[16-19]</sup>.

Based on our findings, the following should be considered in the surgical treatment of tibial pilon fractures, type II and III. First, small surgical incisions, to a possible extent, should be used, to reduce the risk of contamination, particularly for patients with diabetes and possibly other health comorbidities. In this regard, monitoring of blood glucose regulation during the perioperative period is also important. Second, open reduction and internal fixation should be performed, if possible, after soft tissue swelling has subsided. For patients with a severe pilon fracture, namely a Ruedi-Allgower type III fracture, which includes large soft tissue defects, vacuum sealing

drainage can be combined during primary debridement and use of an appropriate flap or autogenous venous flap for transplantation and repair in the second stage, according to the soft tissue defect, could improve outcomes, including a lower risk of infection. Again, regulation of the blood glucose level, including nutritional support, during the perioperative period could also improve outcomes.

Wu *et al*<sup>[20]</sup> evaluated the risk factors for surgical site infection, including age, sex, smoking, diabetes, and operative time, at the surgical site infection after surgical treatment of a tibial pilon fracture. However, other factors, which we included in our study, namely the type of surgical incision, fracture injury classification, antibiotic use after surgery, and wound contamination, were not considered. Therefore, further research is needed to fully confirm our findings.

## **CONCLUSION**

A Ruedi-Allgower classification as type III fracture, a surgical incision type III, presence of wound contamination, and diabetes are significant risk factors for postoperative infection after open reduction and internal fixation of a tibial pilon fracture. Patients with these risk factors should be monitored closely to improve outcomes. As such, our findings provide a basis to develop prevention protocols to lower the risk of postoperative infection and improve the outcomes of patients with tibial pilon fractures.

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**Table 1 Comparison of baseline information between infected and controlled groups, *n* (%)**

Factor	Infected group ( <i>n</i> = 67)	Control group ( <i>n</i> = 70)	<i>t</i> / $\chi^2$ value	<i>P</i> value
Age (yr)	52.3 $\pm$ 8.0	51.5 $\pm$ 7.3	0.612	0.542
Fracture to surgery interval (d)	13.2 $\pm$ 4.1	12.0 $\pm$ 4.8	1.570	0.119
Gender			0.821	0.365
Man	38 (56.72)	45 (64.29)		
Woman	29 (43.28)	25 (35.71)		
Ruedi-Allgower typing			6.295	0.012
Type II	36 (53.73)	52 (74.29)		
Type III	31 (46.27)	18 (25.71)		
Wound contamination			9.260	0.002
Yes	26 (38.81)	11 (15.71)		
No	41 (61.19)	59 (84.29)		
Surgical approach			2.603	0.107
Early open reduction	54 (80.6)	48 (68.57)		
Step delay surgery	13 (19.4)	22 (31.43)		
Surgical incision type			5.952	0.015
I-II	51 (76.12)	64 (91.43)		
III	16 (23.88)	6 (8.57)		
Antibiotics			3.088	0.079

administered				
postoperatively				
Yes	47 (70.15)	58 (82.86)		
No	20 (29.85)	12 (17.14)		
Diabetes			6.518	0.011
Yes	12 (17.91)	3 (4.29)		
No	55 (82.09)	67 (95.71)		
Hypertension			1.476	0.224
Yes	9 (13.43)	5 (7.14)		
No	58 (86.57)	65 (92.86)		

**Table 2 Multivariate analysis**

Parameter		SE	Walds	P value	OR	95%CI
Ruedi-Allgower fracture type	0.711	0.310	5.260	0.038	2.036	1.109-3.738
Wound contamination	0.824	0.257	10.280	0	2.280	1.378-3.772
Surgical incision type	0.610	0.228	7.158	0.006	1.840	1.177-2.877
Diabetes	1.162	0.496	5.488	0.034	3.196	1.209-8.450
Constant term	0.944	0.628	2.260	0.219	2.570	0.751-8.801

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