Original Article

Factors Associated with the Outcome of Open Tibial Fractures

Nazri Mohd Yusof[1], Kamarul Ariffin Khalid[1], Ahmad Hafiz Zulkifly[1], Zamzuri Zakaria[1], Mohammad Azril Mohammad Amin[1], Muhammad Shukimi Awang[1], Aminudin Che Ahmad[1], Sheikh Farid Uddin Akter[2]

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[1] *Department of Orthopaedics, Traumatology and Rehabilitation, Kulliyyah of Medicine, International Islamic University Malaysia, Jalan Hospital, 25150 Kuantan, Pahang, Malaysia*

[2] *Department of Community Medicine, Kulliyyah of Medicine, International Islamic University Malaysia, Jalan Sultan Ahmad Shah, Bandar Indera Mahkota, 25200 Kuantan, Pahang, Malaysia*

Abstract

Background: **Although open tibial fractures are common in Malaysia, the outcomes for these patients have not been evaluated in the literature. This retrospective study was conducted to examine the factors associated with infection and non-union in open tibial fractures managed at Hospital Tengku Ampuan Afzan (HTAA), Kuantan, in 2009.**

Methods: **From 1 January until 31 December 2009, the Department of Orthopaedics of HTAA managed 58 patients with open tibial fracture who had a minimum of a one year follow-up period. The median age was 24.5 years (range: 4 to 72 years). The open tibial fractures were graded using the Gustilo open fracture classification as follows: 4 grade I, 21 grade II, 24 grade IIIA and 9 grade IIIB. All open fractures were subjected to a standard treatment protocol at HTAA, which includes the use of prophylactic antibiotics, emergency debridement, fracture stabilisation, wound coverage, and bone reconstruction when required. The mean time from injury to the initial debridement was 29.7 hours (range: 13 to 216 hours).**

Results: **Seventeen (29%) cases were complicated by infection, and 10 patients (17%) developed non-union. The grade of the open fracture was significantly associated with infection, and age and the time interval between the injury and the initial wound debridement were significantly associated with non-union.**

Conclusions: **The high rates of infection and non-union, particularly in severe open fractures, indicate that there is a need to improve the management of open tibial fractures treated at HTAA. The time to initial debridement is an important factor that can be readily amended to improve the outcome. Further studies with larger sample sizes are likely needed to replicate and confirm our findings.**

Keywords: *assessment, case management, fractures, open, patient outcome, tibia*

Introduction

The occurrence of open tibial fractures in Malaysia has been described in many scientific articles. These studies have primarily focused on demographics, the bacteriological pattern, case reports, and audits on waiting time (1–4). However, no studies published in scientific journals have evaluated the outcomes of open tibial fractures in Malaysia. The outcomes of open fractures vary by institution (5,6). The main outcome criteria for assessing open fractures in the literature include infection, non-union, and amputation. The outcome of open fractures is also a good indicator of the quality of care (7).

The aim of this study was to examine the factors associated with infection and non-union in patients treated for open tibial fractures in the Department of Orthopaedics, Hospital Tengku Ampuan Afzan (HTAA) in Kuantan. The factors that were analysed included age, gender, fracture location, fracture severity based on the Gustilo open fracture classification (8), injury severity score (ISS), (9) the time interval between injury and the time of first debridement, the method of initial fracture stabilisation and the surgeons

who performed the initial debridement.

Materials and Methods

This was a follow-up study based on retrospective data for all cases of open tibial fracture managed by the HTAA Department of Orthopaedics over a one year period from 1 January to 31 December 2009. The data were obtained from available patient records and radiographs. Only patients who were directly admitted to and completed their follow up at HTAA were included in the study. Patients initially managed in other facilities or who continued their treatment and/or follow up in other hospitals were excluded. This study was approved by the International Islamic University (IIUM) research ethics committee.

All open fractures were subjected to a standard treatment protocol at HTAA, which includes prophylactic antibiotics for at least three days, emergency debridement, skeletal stabilisation, and no primary wound closure. Intravenous cefuroxime (1.5 g bolus and 750 mg every 8 hours) was administered for grade I and II open fractures. Intravenous gentamycin (80 mg every 8 hours) and intravenous metronidazole (500 mg every 8 hours) were administered for grade III A and IIIB open fractures.

The injury severity score (ISS) was calculated based on the records available for each patient. The initial stabilisation methods used for this series of patients included external fixation in 46 cases, skeletal traction in three cases, casts in three cases, percutaneous screws and casts in two cases, and K wires and casts in another four cases. Only one local flap and two split- thickness skin grafts were performed for wound management. All other wounds were healed by secondary intention.

Twenty-two secondary bone procedures were performed to promote union, including intramedullary nailing in 12 patients, plating in five patients, bone grafting in three patients, ring external fixation in one patient and hybrid external fixation in one patient. All patients were followed up for a minimum period of 12 months.

The statistical analysis was conducted using SPSS version 12 software (SPSS Inc, Chicago, IL). The differences in age, time interval from injury to first debridement and ISS between patients with infection and non-union were compared using student's *t* tests. The factors associated with infection and non-union were determined using Pearson chi-square tests.

Results

There were 79 cases of open tibial fracture in 79 patients treated at HTAA, Kuantan, from 1 January to 31 December 2009. Three records were lost, and 76 records were available for review. Three patients died due to their injuries, three patients were transferred to another hospital, two refused hospital treatment, and 10 did not complete their follow up at HTAA, leaving a total of 58 patients who were included in the analysis.

The median age of the patients was 24.5 years (range: 4 to 72 years). There were 52 males (89.6%) and six females. 52 cases (89.6%) were the result of motor vehicle accidents, three resulted from falls from height, two from lawn mower injuries and one from an industrial accident. 31 cases involved the right leg, and 27 involved the left leg. 13 involved the proximal tibia, 20 involved the midshaft, and 25 involved the distal tibia. According to the modified Gustilo-Anderson open fracture classification, 4 were grade I, 21 were grade II, 24 were grade IIIA and 9 were grade IIIB.

The time from injury to the initial operation ranged from 13 to 216 hours, with a mean time of 29.7 hours. No patients were operated on within 6 hours, and only 13 of the patients (22%) were operated on within 24 hours. In 54 of the cases (93%), the initial debridement was performed by the registrar, and in the other four the debridements were performed by the orthopaedic surgeon.

Seventeen cases (29%) were complicated by infection, and 10 cases (17%) resulted in non-union (Table 1). No amputations were performed. The most common organisms isolated were *Pseudomonas aeruginosa* and *Staphylococcus aureus*. *Enterobacter aeruginosa,* Methicillin-resistant coagulase-negative staphylococcus and *Acinetobacter baumannii* were also isolated from the infected fractures. These patients received therapeutic antibiotics according to the culture and sensitivity results (Table 2). Cloxacillin and fusidic acid were given to patients whose cultures did not grow any microorganisms and to those for whom no specimens were sent for microbiological investigation. These patients presented with cellulitis and thus, had no pus or discharge to be sent for bacteriological investigation.

Age, time between injury and initial debridement, and the ISS were not related to infection in this series of patients (Table 3a). However, the occurrence of infection was significantly related to fracture severity (Table

3b) ($P < 0.005$), and age and the time interval between the injury and the initial wound debridement were significantly related to non-union (Table 4a) ($P < 0.05$). Other factors such as gender, where the fracture is located on the tibia, severity of the open fracture, and level of training of the surgeon performing the initial debridement was found to have little effect on the occurrence of the non-union (Table 4b).

Discussion

The number of open tibial fractures managed at HTAA was higher than that reported for other patient series from developed and developing countries (5,6). This difference could be due to the high number of motorcycles involved in motor vehicle accidents in Malaysia, as nearly 90% of open tibial fractures resulted from a motor

Table 1: The severity of the open tibial fractures according to the modified Gustilo-Anderson open fracture classification

Gustilo Anderson classification	*n* (%)	Non-union *n* (%)	Infection *n* (%)	Union time Mean (SD)
Grade I	4 (6.9)	0 (0.0)	0 (0.0)	3.3 (0.96)
Grade II	21 (36.2)	3 (30.0)	3 (17.6)	6.1 (3.6)
Grade IIIA	24 (41.4)	4 (40.0)	7 (41.2)	7.3 (4.7)
Grade IIIB	9 (15.5)	3 (30.0)	7 (41.2)	8.5 (3.1)
Total	**58 (100.0)**	**10 (100.0)**	**17 (100.0)**	**6.7 (4.0)**

Union time is in months.

Table 2: The bacteria isolated and the antibiotic used for patients with infection following open fracture of tibia

Bacteria isolated	Number of patients	Antibiotic used based on sensitivity results
Pseudomonas aeruginosa	5	Ceftazidime and gentamycin
Methicillin Resistant *Staphylococcus aureus* (MRSA)	3	Vancomycin, Fucidic acid and Rifampicin
Enterobacter aeruginosa	3	Ceftazidime and gentamycin
Staphylococcus aureus	2	Cloxacillin
Methicilline Resistant Coagulase Negative *Staphylococcus* (MRCONS)	1	Vancomycin
Acinetobacter baumanii	1	Gentamycin and Trimethoprim and co-trimoxazole
No growth	2	

Table 3a: Factors related with infection following open tibial fractures

Factors	Infection, *n* = 17 (29.3%)	Infection, *n* = 41 (70.7%)	*P* value
Age (years)	34.2 (16.4)	27.8 (17.0)	0.193
Time between injury and first debridement (h)	64.1 (47.6)	56.8 (44.4)	0.580
Injury severity score (ISS)	10.2 (2.77)	10.6 (3.18)	0.670

Data are expressed in mean (SD). Age, $t_{(56)} = 0.09$; Time between injury and first debridement, $t_{(56)} = 0.53$; ISS, $t_{(56)} = 0.51$.

Table 3b: Factors related with infection following tibial open fractures

Factors		Infection *n* (%)	No infection *n* (%)	*P* value
Gender	Male	17 (32.7)	35 (67.3)	0.090
	Female	0 (0.0)	6 (100.0)	
Fracture location	Proximal	5 (38.5)	8 (61.5)	0.647
	Midshaft	6 (30.0)	14 (70.0)	
	Distal	6 (24.0)	19 (76.0)	
Severity of fracture according to Gustilo Anderson classification	Grade I	0 (0.0)	4 (100.0)	0.003**
	Grade II	3 (14.3)	18 (85.7)	
	Grade IIIA	7 (29.2)	17 (70.8)	
	Grade IIIB	7 (77.8)	2 (22.2)	
Surgeon performing the first debridement	Registrar	15 (27.8)	39 (72.2)	0.340
	Specialist	2 (50.0)	2 (50.0)	

Gender $\chi^2_{(1)} = 2.78$; Fracture location $\chi^2_{(2)} = 0.87$; Fracture grade, $\chi^2_{(3)} = 14.15$; Surgeon performing first debridement, $\chi^2_{(1)} = 0.89$.

Table 4a: Factors related with non-union following tibial open fractures

Factors	Union *n* = 48 (82.8%)	Non union *n* = 10 (17.2%)	*P* value
Age (years)	27.5 (14.2)	40.5 (24.8)	0.03**
Time between injury and first debridement. (hours)	52.8 (35.6)	88.4 (71.3)	0.02 **
Injury severity score (ISS)	10.35 (2.95)	10.9 (3.6)	0.600

Data are expressed in mean (SD). Age, $t_{(56)} = 11.06$; Time between injury and first debridement, $t_{(56)} = 12.46$; ISS $t_{(56)} = 0.53$.

Table 4b: Factors related with non-union following tibial open fractures

Factors		Infection *n* (%)	No infection *n* (%)	*P* value
Gender	Male	43 (82.7)	9 (17.3)	0.900
	Female	5 (83.3)	1 (16.7)	
Fracture location	Proximal	12 (92.3)	1 (7.7)	0.590
	Midshaft	16 (80.0)	4 (20.0)	
	Distal	20 (80.0)	5 (20.0)	
Severity of fracture according to Gustilo Anderson classification	Grade I	4 (100.0)	0 (0.0)	0.460
	Grade II	18 (85.7)	3 (14.3)	
	Grade IIIA	20 (54.1)	17 (45.9)	
	Grade IIIB	6 (66.7)	3 (33.3)	
Surgeon performing the first debridement	Registrar	44 (81.5)	10 (18.5)	0.340
	Specialist	4 (100.0)	0 (0.0)	

Gender, $\chi^2_{(1)} = 0.002$; Fracture location $\chi^2_{(2)} = 1.07$; Fracture grade $\chi^2_{(3)} = 14.15$; Surgeon performing first debridement, $\chi^2_{(1)} = 0.9$.

vehicle accident. Traffic accidents are the third most common cause of hospital admission and the fifth leading cause of death in Malaysia (9). Court-Brown et al. reported that road traffic accidents contributed to only 58% of open tibial fractures in Edinburgh, Scotland, (5) whereas Ikem et al. noted that 71% of their cases in Nigeria were due to traffic accidents (6). In this series of patients, the open tibial fractures commonly occur in males between 11–20 years of age and are mostly caused by traffic accidents. This finding is similar to that of Imran and Vishvanathan, who reviewed similar fractures at a University Hospital in northern Malaysia (1). Open tibial fractures seem to involve the younger age group in Malaysia than in other reported series.

Our results showed a slightly higher percentage (89.6%) of males among patients with open tibial fractures than that reported in the Malaysian trauma database (84.6%) (9). In developed countries, males only account for 66% of open tibial fractures, whereas in Nigeria, males account for 69% of cases (5,6).

At the end of the one year follow up, 10 patients exhibited non-union. Templeman et al. recommended early bone procedures to promote bone healing for severe open fractures (11). In their series, the mean union time for grade IIIA was 38 weeks in cases requiring secondary bone procedures and 18 weeks in cases that did not require secondary bone procedures. Based on this observation, they suggested that bone grafting should be performed when bone healing is not evident after 20 weeks. We performed 22 secondary bone procedures to promote healing. The union rate at one year may be improved if secondary bone procedures are performed earlier for patients with severe open fracture.

We found that age and the time from injury to the initial debridement were significantly associated with non-union. Fracture healing has been found to be delayed in older age groups in both animal and clinical studies, (12,13) and this result was also reflected in our study.

The infection rate for grade IIIB open fractures has been reported to be between 8.5% and 52% (8,11,15–18). Our infection rate was higher (78%) than that reported in other studies. This difference may be due to the delay in the initial debridement, as only 22% of the cases were operated on within 24 hours of injury. The reason for this delay was primarily the unavailability of the operation theatre as the orthopaedic emergency operation theatre was also used for surgical and obstetric emergencies during the study period. Zainiyah et al. also noted a similar result in their series of open fracture cases in other Malaysian public hospitals (4). This study did not show that delayed initial debridement was a significant risk factor for infection. In Ikem's series, the wound infection rate was 51%, although the mean time to initial debridement was 13.7 hours (6). In their analysis of the management of open fractures, Okike and Bhattacharyya reported that time is most likely not as important a risk factor for infection as the adequacy of debridement (14). Recent studies from larger series of patients in the United Kingdom and Singapore clearly showed that performing the initial debridement within 6 hours of injury does not confer any benefit in open tibial fractures and does not decrease the risk of infection for grade III open tibial fractures (15,16).

Additionally, in our study, 93% of the initial debridement procedures were not performed by an experienced surgeon. There is no significant difference (P = 0.34) between procedures performed by registrars and those performed by orthopaedic surgeons in this series. However, other studies have shown that the outcome of open fractures was greatly improved when surgeries were performed in the trauma centre by a trauma surgeon and a plastic surgeon (17–19). Wurtz et al. also showed that the infection rate was higher for new surgeons than for experienced surgeons and that the infection rate decreased with the level of training (20). The severity of the open fracture was the only factor that was significantly associated with infection in this series ($P < 0.05$).

The infection rate for grade IIIB open tibial fractures was higher than that in other studies. All grade IIIB open tibial fractures were initially treated with a dressing of wet gauze soaked with saline in an attempt to promote granulation tissue. This traditional method is ineffective in preventing infection. Negative pressure wound dressing has been used successfully as a temporary wound dressing for severe open fractures before definitive wound closure (21). The infection rate was significantly lower than that for a standard fine mesh gauze dressing or synthetic membrane (Epigard®, Biovision GmbH, Ilmenau, Germany) (22,23).

Only one local flap was performed seven weeks after injury for a grade IIIB open fracture, and two split-thickness skin grafts were performed in other patients. The small

number of soft tissue procedures is due to the lack of time for elective operations because the operating theatre is shared with the other orthopaedic subspecialties, such as spine surgery, arthroplasty, hand and microsurgery, sports medicine, oncology, foot and ankle surgery, limb reconstruction, paediatric orthopaedics and other fracture cases. Early plastic surgery intervention and wound coverage have been shown to significantly reduce wound infection in severe open fractures in many other series (17,18,24).

Conclusion

The infection and non-union rates for open tibial fractures at HTAA in Kuantan were high. Delay of the initial debridement was a significant contributing factor for non-union. This study provides a reference for future intervention and the improvement of the quality of care for the management of open tibial fractures in Malaysia. However, this is a small study, and larger studies are needed to replicate and confirm our findings.

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Conflict of Interest

None.

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Authors' Contribution

Conception and design, analysis and interpretation of the data and statistical expertise: SFUA
Provision of study materials or patient: AHZ, MAMA, MSA, ACA, ZZ, NMY
Drafting of the article, critical revision of the article for the important intellectual content, final approval of the article, obtaining of funding, administrative, technical or logistic support and collection and assembly of data: NMY, KAK

Correspondence

Dr Nazri Mohd Yusof
MMed (USM)
Department of Orthopaedic, Traumatology and Rehabilitation
International Islamic University of Malaysia
Jalan Hospital
25150 Kuantan, Pahang, Malaysia
Tel: +6019-998 4086
Fax: +609-514 4451
Email: nazrimy2000@yahoo.com

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