Original Article

Injury Characteristics and Microbial Resistance Patterns in Infections of Open Tibia Fractures

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Abstract

Background: *Tibial fractures are the most frequent open fractures and frequently accompanied by other injuries, which were high vigor injuries.* ***Materials and Methods:*** *A hospital-based cross-sectional study was done among 608 patients to assess the injury characteristics and resistance patterns of microorganisms involved in the infection of open fracture tibia at the National Institute of Traumatology and Orthopedic Rehabilitation (NITOR), Dhaka.* ***Results:*** *The mean age of the patient's was 36.2±15.5 years. Gustilo III was higher injury (72.1%) and Gustilo subtype IIIB was the predominant (37.5%). Gustilo type II infection was higher injury (31.3%). Positive surveillance culture was found among the 38.2% patients at admission. The contamination rate decreased to 26.2% after debridement and 12.0% of patients became contamination free. The infection rate from the ward samples again elevated to 44.4% from post debridement contamination of 26.2% which indicates hospital acquired infection. Gram-negative organisms were common with multidrug resistance. Pseudomonas and Klebsiella species are only sensitive to Imipenem and Meropenem only around 49-70%. Cotrimoxazole and Chloramphenicol also showed good sensitivity against both Staphylococcus aureus (90.9%) and E. coli (69-75%).* ***Conclusion:*** *Regrettably, hospital-acquired infections are frequent in orthopaedics admitted patients where Gram-negative organisms were predominant and the antibiograms indicated concerning patterns of treatment resistance. Surgical debridement is useful in decreasing contamination from the open fracture wound.*

Keywords: Injury characteristics, Resistance patterns, Microorganisms involved, Fracture tibia.
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Introduction

The most frequent open fractures involve the tibia and are often associated with multiple injuries. Most of them were primary closure in traumatic amputations, significant soft tissue injuries, and segmental fractures[1]. The fracture location was classified based on whether it occurred in the proximal, middle, or distal third of the tibial shaft. Tibial diaphyseal fractures are the most common type of fracture in the lower limb. Managing these fractures is often challenging due to the tibial shaft's limited soft tissue coverage and blood supply. The prognosis is affected by factors like the extent of soft tissue damage, the degree of comminution, and the amount of bone displacement. Achieving successful bone and soft tissue healing typically requires advanced bone repair techniques and soft tissue coverage. As a result, open tibial fractures are often linked to complications such as infection, non-union, and limb loss, all of which significantly contribute to patient morbidity. Infectious complications include osteomyelitis, implant-related infections, and soft tissue infections[2]. Moreover, tibial shaft fractures in working-age individuals have been found to impose a substantial financial burden through lost productivity and direct medical costs[3].

Open fracture has a significant risk for infection and other microbe-related complications at the wound site[4]. As is often observed, many infections involving open fractures are often nosocomial[5]. The mechanism of the initial trauma has a significant impact on the microbial pattern at the wound site[6]. It is also noteworthy that many infections in open fractures often originate from nosocomial sources. When the causal microorganisms in ward sample cultures on numerous occasions are different from the initial surveillance cultures at admission[7,8].

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Thus, infection rates can also be positively altered by debridement, instrumentation, fracture stabilization, irrigation at ward[9-11].

Adult tibial shaft fractures compensate 44.4% of all open long-bone fractures and account for 2% of all fractures[12,13]. Due to the specific anatomical features of the tibia (limited soft coverage) more than 15% of its' fractures are classified as open and have made most infectionprone bone of the body[12]. The Gustilo classification system is commonly used to assess the grading of open fractures. The infection rate of open fractures varies with the fracture characteristic which is progressively increase[13]. Treatment of open fractures is based on the principles that include assessment of the patient, classification of the damage, antimicrobial medication, debridement and wound care, fracture stabilization, early bone grafting, and additional therapies to achieve healing[10,14,15].

The most important stage in the treatment of open lower limb fractures is surgical debridement. A commonly acknowledged standard of therapy is to prevent infection by doing surgical irrigation and debridement within 6 hours of the injury[16,17]. While it is logical for open fractures to receive prompt treatment, current medical research does not support a fixed time window as the optimal standard for intervention.

Materials and Methods

Study design and settings: This was a hospital-based cross-sectional study conducted to assess the injury characteristics and resistance patterns of microorganisms involved in the infection of open fracture tibia at a tertiary care teaching hospital named National Institute of Traumatology and Orthopedic Rehabilitation (NITOR), Dhaka, Bangladesh. ***Sample selection:*** Participants were purposefully selected, 608 patients with open fracture tibia (all Gustilo types) within 24 hours of injury and admitted in the hospital from January 2018 to October 2019. Patients with closed tibia fracture, open fracture tibia presented already with infection at admission, those required amputation of lower extremity at emergency theater and open fracture tibia along with open fracture elsewhere in the body were excluded from this study. ***Data collection procedures:*** During the initial resuscitation at emergency room, surveillance culture sample (from wound before prophylactic antibiotic) was collected and sent. Prophylactic antibiotics (intravenous flucloxacillin and third-generation cephalosporin) were given. Patients were then taken to the emergency operation room for wound debridement, fracture stabilization, and soft tissue treatment. Debridement was done following current practice at NITOR using Chlorhexidine (Hexi scrub), normal saline, Hydrogen peroxide and Povidone-iodine solution. A second post debridement culture (last saline wash from the wound at emergency theater) was sent. From the theater after initial fracture stabilization, stable patients were sent to post-operative ward followed by to general ward. A third infection culture sample after admission in the ward after 7-10 days and was sent for culture sensitivity and identification of organism. A pretested semi-structured questionnaire was filled up by the investigator containing information regarding demographic variables, mechanism and time of injury, time of wound debridement (time elapsed since injury in hours), Gustilo types and subtypes of fracture characteristic along with the results of three successive culture sensitivity tests. ***Statistical analysis:*** The data were reviewed and analyzed using IBM SPSS v23. Quantitative parameters were summarized as a means with standard deviation and percentages. Inferential statistics were applied to evaluate the significance of associations between two nominal variables, with a p-value of <0.05 at a 95% confidence interval considered statistically significant. The results were presented in tables and charts. ***Ethical approval:*** Informed written consent was obtained from all participants. Data confidentiality was maintained, and unauthorized access was strictly prohibited. The Institutional Review Board of NITOR, Dhaka, Bangladesh provided ethical approval for the study. (Reference: NITOR/Academy/2018/172/KA).

Results

The mean age of the patient's was 36.2±15.5 years. Figure-1 portray that the majority of the patients came from the age group 21-40 years followed by 13.9% from the age group <20 years and only 7.5% from the age group >60 years. Table-I depicts that Gustilo-III was predominant injury (72.1%) followed by type-II (23.8%) and type-I (4.1%). In the Gustilo subtypes, subtype-IIIB was predominant (37.5%), followed by subtype-IIIA (29.7%) and subtype-II (23.8%). Table-II demonstrates among type-II fracture infection was predominant injury (31.3%), followed by Gustilo subtype-IIIA was 26.8% and Gustilo subtype-IIIB was 24.2%.

Table-III shows a positive surveillance culture among 38.2% of patients at admission. The contamination rate fell to 26.2% after debridement. After debridement, 12% of patients were contamination-free. Figure-2 shows that the infection rate from the ward samples again elevated to 44.4% from post debridement contamination of 26.2% which indicates hospital acquired infection. Table-IV describes several species discovered in three subsequent cultures. The percentage of organisms dropped in the second culture following debridement but increased in the third culture (ward sample). This is a hospital-acquired infection.

Gram-negative organisms were prevalent in all cultures.

Table-V demonstrates resistance patterns of gram-positive and gram-negative organisms found in this study. Gram-negative organisms were predominant with multidrug resistance. *Pseudomonas* and *Klebsiella* species are only sensitive to intravenous Imipenem and Meropenem only around 49-70%, which is the highest sensitivity of all used drugs in this study. Less commonly used antibiotics, Cotrimoxazole and Chloramphenicol shows good sensitivity against *Staphylococcus aureus* both 90.9% and *E. coli* around 69-75%. But they are not effective against the *Pseudomonas* and *Klebsiella* species.

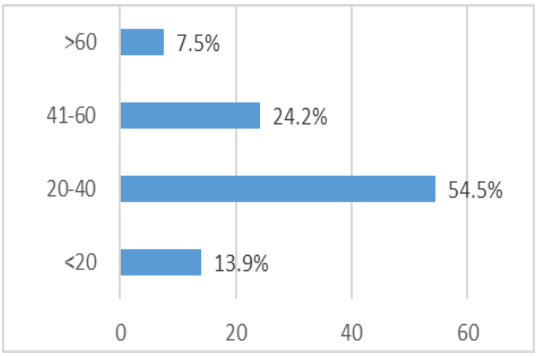

Figure-1: Age group of patients (years)

Table-I: Injury characteristics as per Gustilo classification (n=608)

Injury characteristics	Frequency	Percentage
Type		
Gustilo I	24	4.1
Gustilo II	145	23.8
Gustilo III	438	72.1
Sub type		
Gustilo I	24	4.1
Gustilo II	145	23.8
Gustilo IIIA	181	29.7
Gustilo IIIB	228	37.5
Gustilo IIIC	29	4.9

Table-II: Infection rate as per Gustilo classification (n=608)

Gustilo subtype	Frequency	Percentage
Gustilo I	86	14.1
Gustilo II	190	31.3
Gustilo IIIA	163	26.8
Gustilo IIIB	147	24.2
Gustilo IIIC	22	3.6

Table-III: Contamination presence on admission (surveillance culture positive) and after debridement (post-debridement culture positive) (n=608)

Organism	On admission (Surveillance culture)		After debridement (Post debridement culture)		Third (infection) Culture (From the wards)	
	Frequency	%	Frequency	%	Frequency	%
Present	232	38.2	449	73.8	535	88.0
Absent	376	61.8	159	26.2	73	12.0

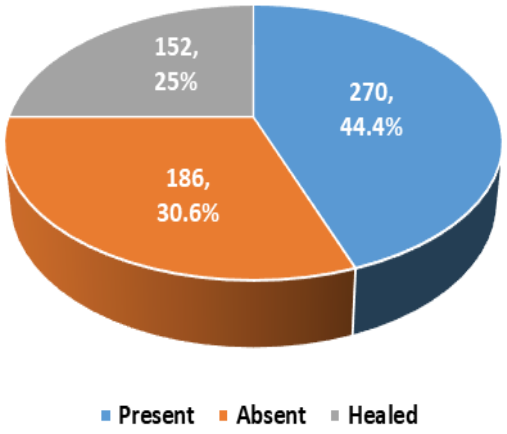

Figure-2: Presence of infection in admitted cases (Ward sample culture positive) (n=608)

Table-IV: Common organisms in three cultures (n=608)

Bacteria	1st Culture		2nd Culture		3rd Culture	
	Frequency	%	Frequency	%	Frequency	%
Staphylococcus aureus	32	10.2	10	4.5	5	1.5
Streptococcus sp.	9	2.9	7	3.2	8	2.4
Escherichia coli	56	17.8	34	15.4	23	6.8
Pseudomonas sp.	59	18.7	53	24.0	172	51.2
Kliebsiella sp.	55	17.5	45	20.4	81	24.1
Citrobacter freundii	9	2.9	6	2.7	0	0
Proteus sp.	11	3.5	13	5.9	17	5.1
Acineto bacter	51	16.2	29	13.1	18	5.4
Serratia sp.	2	0.6	1	0.5	0	0
Providencia alcalifaciens	3	1.0	2	0.9	5	1.5
Enterobacter sp.	26	8.3	17	7.7	5	1.5
Flavobacterium	2	0.6	0	0	0	0
Plesiomonas sp.	0	0	2	0.9	0	0
Aeromonas	0	0	2	0.9	0	0
Morganella morganii	0	0	0	0	2	0.6

Table-V: Resistance pattern of common organisms found in this study (n=608)

Organisms	Antibiotic Sensitivity	Ampicillin	Amoxicillin	Piperacillin	Cephalexin	Ceftriaxone	Ceftazidime	Cefepime	Imipenem	Meropenem	Gentamicin	Amikacin	Netilmicin	Doxycycline	Ciprofloxacin	Levofloxacin	Moxifloxacin	Cotrimoxazole	Chloramphenicol	Azithromycin
Staphylococcus aureus	**S**	36.4	36.4	63.6	63.6	48.5	51.5	18.2	15.2	90.9	84.8	93.9	90.9	100	84.8	60.6	63.6	60.6	90.9	51.5
	I	0.0	0.0	0.0	0.0	12.1	24.2	12.1	0.0	0.0	0.0	0.0	0.0	6.1	6.1	9.1	12.1	0.0	9.1	0.0
	R	63.6	63.6	33.3	36.4	51.5	36.4	72.7	9.1	15.2	6.1	9.1	0.0	9.1	33.3	27.3	27.3	9.1	9.1	48.5
Escherichia coli	**S**	6.9	6.9	29.9	18.4	34.5	35.6	41.4	25.3	78.2	90.8	74.7	73.6	81.6	54.0	56.3	63.2	51.7	69.0	18.4
	I	0.0	11.5	0.0	2.3	3.4	8.1	11.5	6.9	0.0	3.4	0.0	3.4	11.5	2.3	9.2	2.3	0.0	11.5	0.0
	R	93.1	93.1	58.6	60.9	62.1	60.9	63.2	15.0	23.0	2.3	25.3	18.4	42.5	32.2	34.5	39.1	28.7	25.3	70.1
Pseudomonas sp.	**S**	1.6	1.6	19.1	8.5	2.4	18.3	4.1	31.1	57.7	49.2	24.4	45.5	34.6	16.3	38.2	35.0	27.2	19.1	15.0
	I	0.0	37.8	0.0	3.3	3.3	3.3	0.0	4.8	7.3	0.4	4.5	11.4	8.9	2.4	6.1	2.0	0.0	4.1	6.9
	R	98.4	98.4	43.1	91.5	94.3	78.5	95.9	41.9	43.5	75.2	50.0	54.1	74.8	59.3	58.9	70.7	80.9	84.1	78.0
Klebsiella sp.	**S**	0.0	2.8	16.4	16.4	18.6	24.9	16.9	15.8	67.2	70.6	40.1	42.9	38.6	40.7	29.4	58.2	35.0	35.0	8.5
	I	0.0	0.0	0.0	0.0	0.0	0.0	6.0	12.0	22.6	10.5	8.3	5.3	8.1	23.7	6.8	15.3	0.6	2.3	4.5
	R	100	97.2	74.6	83.6	81.4	71.2	76.8	47.4	10.2	19.2	59.8	48.6	53.4	52.4	46.9	35.0	49.7	64.4	87.0

S = Sensitive; I = Intermediate; R = Resistant

Discussion

The mean age of the patient's was 36.2±15.5 years in this study. The majority patients are from the 21-40-year age group, followed by 13.9% from those under 20 years, and only 7.5% from those over 60 years. Similar age distribution was observed in other studies[2,18,19]. Gustilo-III was predominant injury (72.1%) followed by type-II (23.8%) and type-I (4.1%). In the Gustilo subtypes, subtype-IIIB was the predominant (37.5%), followed by subtype-IIIA were 29.7% and subtype-II were 23.8%. Type-II fractures accounted for the highest rate of infection (31.3%), followed by Gustilo subtype-IIIA at 26.8% and subtype-IIIB at 24.2%. A study conducted in Brazil, Gustilo type-III fracture was found in highest (72%) infection rate[19]. In another study, Gustilo type-III fractures also found as highest infection rate in Spain[20].

In our study, the percentage of organisms decreased in the second culture after debridement but increased again in the third culture (ward sample). This suggests a hospital-acquired infection. Gram-negative organisms predominate all cultures. The prevalent pathogens detected in three cultures were worrisome multidrug resistant *Escherichia coli,*

Pseudomonas sp., and Kliebsiella sp. Pseudomonas and Klebsiella species were exclusively susceptible to intravenous Imipenem or Meropenem at a rate of 49-70%, the highest sensitivity of any antibiotic employed in this investigation. A study in Bangladesh discovered *E. coli* (39.8%), followed by *Klebsiella species* (22.7%) and *Pseudomonas species* (14.2%) which was almost similar with this study[21]. A prospective multicenter study on open tibia fractures conducted in Bangladesh identified *Staphylococcus aureus* and *Streptococcus pyogenes* as the major infecting organisms, and these findings differ from our study[18].

Conclusion

This study concluded that Gustilo type-III tibia fractures are predominant injury with the highest infection rate. Surgical debridement is effective in reducing contamination from the open fracture wound, but the hospital-acquired infection is common in the patients at orthopaedics department where Gram-negative pathogens were dominant, and the antibiograms showed alarming pattern of drug resistance.

Conflicts of interest

The authors declared that they have no conflicts of interest.

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