

Original Research Article

Microbial etiology and antibiogram profile of surgical site infections in orthopaedic open reduction and internal fixation surgeries from a tertiary care hospital

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ABSTRACT

Background: Surgical site infections (SSIs) are the most common hospital-acquired infections, constituting around 20% of all healthcare-associated infections. In India, surveillance of SSI, particularly after discharge, is limited; therefore, the true burden and microbiological patterns of these infections may be underestimated. The objective was to describe the microbiological profile and antimicrobial susceptibility patterns in patients who developed SSI after open reduction and internal fixation (ORIF) for closed fractures.

Methods: A retrospective study was conducted, and data were collected from patients diagnosed with SSI following ORIF for closed fractures over a period of one year from January 2025 to December 2025. SSI surveillance forms were completed for all diagnosed SSI cases according to CDC/NHSN SSI criteria. Pus aspirate and tissue biopsy were collected for microbiological analysis, and antimicrobial susceptibility testing was performed.

Results: Of 1,290 patients reviewed, 21 developed SSI, yielding an SSI rate of 1.62%. The mean age was 39.6 years with marked male predominance. Comorbidities included diabetes mellitus and immunocompromised status (19% each), with 96% being emergency surgeries. The mean time to SSI detection was 18.2 days. Of 21 samples, 15 (71.4%) yielded bacterial isolates. Enterobacter species were most frequent (46.6%), followed by *Klebsiella pneumoniae* (20%) and MRSA (20%). Enterobacteriaceae showed high resistance to ciprofloxacin (100%), piperacillin-tazobactam (80%), and amikacin (77.8%). MRSA was resistant to erythromycin (100%) and clindamycin (66.7%). Most cases were managed with debridement, antibiotic and implant retention; implant removal was required in 9.5% of cases.

Conclusions: SSIs following ORIF for closed fractures occurred at a rate of 1.62%, with Gram-negative pathogens, particularly Enterobacter species, emerging as the predominant organisms. High resistance to ciprofloxacin, amikacin, and piperacillin-tazobactam underscores the need for local microbiological data for empirical therapy for established infections. Strengthening SSI surveillance, infection control practices, and antimicrobial stewardship is essential to reduce SSI burden in orthopaedic trauma patients.

Keywords: Surgical site infection, Open reduction and internal fixation, Antimicrobial resistance, Implant

INTRODUCTION

Surgical site infections (SSIs) are the most common hospital-acquired infections, constituting around 20% of all healthcare-associated infections. They cause high

morbidity and mortality, increased hospital stays, and treatment costs, along with psychosocial consequences for patients and their families.¹ Open reduction and internal fixation (ORIF) is one of the most commonly performed procedures in orthopaedic trauma surgery for fracture

management. According to the 2011 World Health Organization report on the global burden of healthcare-associated infections in low- and middle-income countries, there is a pooled incidence of 11.8 SSI episodes per 100 surgical procedures.² In a multicentric study conducted by the Indian Council of Medical Research, including three major hospitals-AIIMS New Delhi, KMC Manipal, and TMC Mumbai-the overall incidence of SSI was 5.2%.³ In orthopaedic surgeries, implants and fixation devices facilitate bacterial adherence and biofilm formation, making infections difficult to eradicate and adversely affecting fracture healing and implant retention.⁴

In India, surveillance of surgical site infections, particularly after discharge, is limited; therefore, the true burden and microbiological patterns of these infections may be underestimated.⁵ Local microbiological data are important because they help guide empirical antibiotic therapy, support antimicrobial stewardship, and improve infection control in orthopaedic units. In this context, our study was undertaken to describe the microbiological profile and antimicrobial susceptibility patterns in patients who developed SSI after open reduction and internal fixation of closed fractures at a tertiary care center in East Delhi.

METHODS

Study design and setting

A retrospective study was conducted from January 2025 to December 2025 by collecting data from hospital records and SSI surveillance forms of patients who underwent ORIF for closed fractures in a tertiary care hospital in East Delhi.

Study population and case definition

The study population included all patients who underwent ORIF for closed fractures and were subsequently diagnosed with a surgical site infection according to Centers for Disease Control and Prevention/National Healthcare Safety Network (CDC/NHSN). Patients were included if the date of infection occurred within 30 days or 90 days (with implant) after the NHSN operative procedure involving superficial incisional, deep incisional, or organ/space sites. Diagnosis required at least one of: purulent drainage from the surgical site; organism identified by culture or non-culture-based testing from aseptically obtained specimen; or clinical diagnosis by surgeon based on localized pain, swelling, erythema, warmth, wound dehiscence, or fever ($>38^{\circ}\text{C}$).⁶ Of 1,290 patients reviewed, 21 developed SSI and were included in the study.

SSI surveillance

Postoperative surveillance data for surgical site infection were extracted from follow-up documentation during the hospital stay and after discharge through outpatient

follow-up and telephone contact at 30, 60, and 90 days (in patients with implants) after surgery. Data from patients who were clinically suspected of SSI were retrieved using a structured surveillance proforma. The surveillance proforma included demographic, clinical, operative, and administrative variables, including age, gender, admission and surgery dates, diagnosis, procedure performed, comorbidities, smoking status, immunocompromised state, malnutrition, steroid use, obesity, infection at another body site, infection at the surgical site, operative category, trauma status, surgical site, anaesthesia type, wound class, duration of surgery, drain use and duration, preoperative and postoperative antibiotic exposure. SSI management was recorded, specifically the type of intervention (debridement with implant retention versus removal). Additionally, the final status of the implant, whether retained, removed, or removed after fracture union, was documented at the last follow-up.

Microbiological evaluation

For each clinically suspected case, records of all microbiological samples obtained from the surgical site, including pus aspirates from superficial and deep wounds and tissue biopsies, were extracted. For each specimen, Gram staining was performed, and cultures were inoculated onto blood agar and MacConkey agar according to standard laboratory protocols. Organisms were identified using conventional biochemical methods. Antimicrobial susceptibility testing was performed by the Kirby-Bauer disc diffusion method in accordance with Clinical and Laboratory Standards Institute (CLSI) guidelines. The antibiotic panel comprised agents commonly used in our setting; however, certain antimicrobial discs were unavailable at the time of testing, and this limitation was taken into account when interpreting the antibiogram.

Statistical analysis

Statistical analysis was performed using SPSS version 25. Categorical variables were expressed as frequencies and percentages. Continuous variables were summarized as mean $\pm$ standard deviation or median (range), as appropriate.

RESULTS

A total of 1,290 patients who underwent ORIF for closed fractures were reviewed during the study period. Of these, 21 patients developed SSI, with an SSI rate of 1.62%. The monthly distribution of SSI demonstrated variability across the study period, with the highest incidence observed in June (3.19%) and the least in October (0%). Figure 1 illustrates the monthly variation in SSI rates.

The mean age of the study population was 39.6 years, with the majority of patients in the 20-40-year age group (38%), with a marked male predominance. In contrast, female predominance was observed in the older age groups,

particularly in the 40-60 years (19%) and >60 years (14.3%) groups. Figure 2 shows the age and gender distribution among the 21 SSI cases.

Comorbid conditions such as type 2 diabetes mellitus and immunocompromised status were present in 19% of patients. Obesity and malnutrition were seen in 4.8% of patients, whereas no history of nicotine or steroid use was observed in any case. A history of trauma was present in 66% of patients, and the majority of cases were operated on as emergencies (96%). All patients received surgical

antimicrobial prophylaxis with ceftriaxone and amikacin. Regarding anaesthesia, spinal anaesthesia was administered to 14 patients, general anaesthesia to 2, supraclavicular and axillary blocks to 2, and combined epidural and spinal anaesthesia to 3. Surgery exceeded 2 hours in 9.5% of cases, while the remaining procedures were completed within 2 hours. Drains were used in 7 patients; in 6 of these, the drain was retained for 2 days, while in 1 patient it remained in place for 9 days (Table 1).

Table 1: Perioperative comorbidities and perioperative characteristics among SSI cases.

Characteristics	Category	Frequency	%
Comorbid characteristics			
Comorbidities	Type 2 diabetes mellitus	4	19
	Immunocompromised	4	19
	Obesity	1	4.8
	Malnutrition	1	4.8
	Nicotine use	0	0
	Steroid use	0	0
History of trauma	Yes	14	66.7
Perioperative characteristics			
Operation category	Emergency	20	95.2
	Elective	1	4.8
Anaesthesia type	Spinal anaesthesia	14	66.7
	General anaesthesia	2	9.5
	Regional block (Supraclavicular/axillary)	2	9.5
	Combined (epidural + spinal)	3	14.3
Duration of surgery	≤2 hours	19	90.5
	>2 hours	2	9.5
Drain placement	Yes, and retained ≤2 days)	6	28.5
	Yes, and Drain retained >2 days	1	4.8

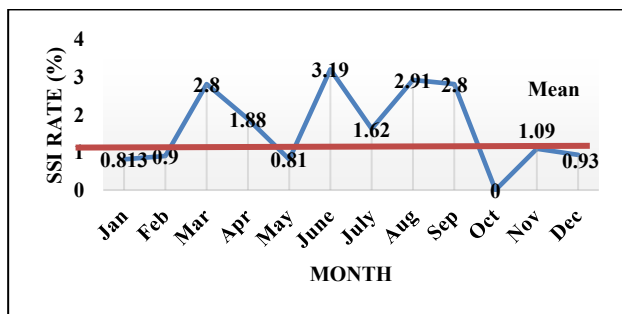


Figure 1: Monthly distribution of SSI rate.

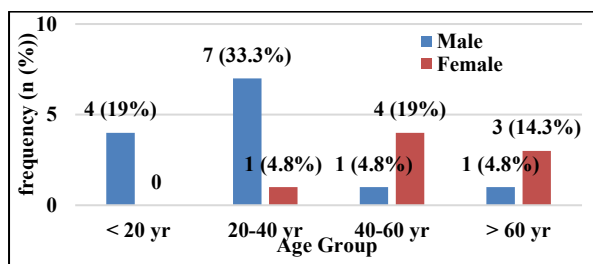


Figure 2: Age and gender distribution among SSI cases.

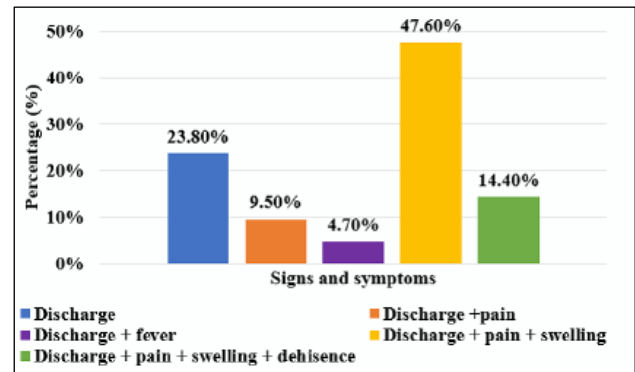


Figure 3: Clinical presentation of surgical site infections.

The mean time to development of SSI was 18.2 days (range, 5-70 days). Most patients presented during follow-up outpatient visits with wound discharge associated with pain and swelling (47.6%), while 14.4% also had wound dehiscence. Figure 3 displays the clinical presentation patterns among SSI cases.

The lower extremity was the most common site of infection, with closed femoral fractures accounting for the majority of SSIs ($n=12$, 57.1%), followed by the tibia ($n=2$, 9.5%), knee ($n=1$, 4.8%), and heel ($n=1$, 4.8%). Among upper-extremity cases, the humerus accounted for 3 infections (14.3%), while the elbow and wrist accounted for 1 case each (4.8% each). All documented wounds were classified as clean-contaminated.

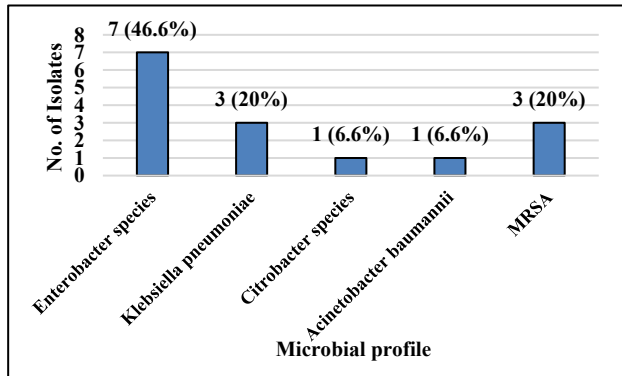


Figure 4: Distribution of bacterial isolates from SSI cultures.

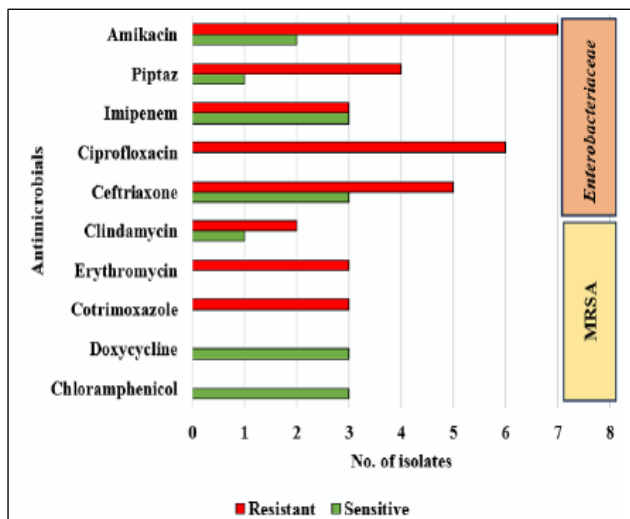


Figure 5: Antimicrobial susceptibility profile of the Isolated organisms from surgical site infection.

A total of 21 samples from SSI cases were analyzed, of which 15 (71.4%) yielded bacterial isolates, while 6 (28.6%) showed no growth. Among the isolates, Enterobacter species were the most frequently identified ($n=7$, 46.6%), followed by *Klebsiella pneumoniae* ($n=3$, 20%) and methicillin-resistant *Staphylococcus aureus* (MRSA) ($n=3$, 20%). Figure 4 shows the distribution of bacterial isolates. Antimicrobial susceptibility analysis of the Enterobacteriaceae family, including Enterobacter species, *K. pneumoniae*, and Citrobacter species, revealed high levels of resistance to ciprofloxacin (6/6, 100%), piperacillin-tazobactam (4/5, 80%), and amikacin (7/9, 77.8%). The isolates showed comparatively lower resistance to imipenem and ceftriaxone, with resistance

observed in 50% (3/6) and 62.5% (5/8) of isolates, respectively, suggesting relatively preserved susceptibility to carbapenems and selected cephalosporins. Methicillin-resistant *S. aureus* (MRSA, $n=3$) was also isolated and demonstrated susceptibility to doxycycline and chloramphenicol, while resistance was noted to clindamycin in 66.7% of isolates and to erythromycin in 100%. Figure 5 presents the complete antibiogram showing resistance patterns across all tested antibiotics for both Gram-negative and Gram-positive isolates.

Post-operatively, the most frequently administered regimen was a dual therapy with ceftriaxone and amikacin, given in 38.1% ($n=8$) of patients. To expand coverage particularly against suspected MRSA, this regimen was escalated to triple drug combinations, including ceftriaxone, amikacin and vancomycin ($n=3$, 14.3%), or linezolid ($n=2$, 9.5%). In Late SSI cases, broader-spectrum combinations were employed, such as meropenem, amikacin, cefoperazone/sulbactam and linezolid ($n=1$), as well as ceftriaxone, amikacin and teicoplanin ($n=1$). The majority of SSI cases were managed with surgical debridement, antibiotics, and retention of stable implants; implant removal was necessary in 9.5% of cases, typically in the setting of unstable fixation, persistent deep infection, or failure of initial debridement and antibiotic therapy.

DISCUSSION

In this study of 1,290 patients undergoing ORIF for closed fractures, the SSI rate was 1.62%, which is lower than rates reported by Das et al (7.9% overall and 8.5% in ORIF), Koyagura et al (6.47%), and Mathur et al (5.5%).^{5,7,8} The lower incidence might be due to a difference in study population, local infection control practices, perioperative prophylaxis, and follow-up methods. The month-to-month variation, with the highest incidence in June and the lowest in October, suggests that factors such as seasonal changes, trauma load, and environmental contamination may have influenced infection risk.

The mean age of SSI cases in this study was 39.6 years, with male predominance among younger adults and female predominance in older age groups. This is similar to findings by Yang et al.⁹ This distribution reflects the trauma profile in orthopaedic practice, where younger men are more frequently exposed to trauma, while older women increasingly sustain fractures due to reduced bone density caused by reduced estrogen levels after menopause.¹⁰ Several risk factors were identified, including diabetes mellitus or immunocompromised status (19%), obesity (4.8%), surgery lasting >2 hours (9.5%), and trauma-related surgeries (66%). These findings are consistent with previous studies. Sun et al identified prolonged operative time (>130 min) as a significant risk factor, while Purva et al reported obesity, surgery lasting >2 hours, and clean-contaminated wounds as independent predictors of SSI.^{5,11} Similarly, Ma et al found higher BMI, prolonged surgery (>138 min), and smoking to be significant risk factors.¹² Lee et al, Kimmatkar et al, and Patel et al also identified

diabetes as an important risk factor for SSI.¹³⁻¹⁵ Diabetes may predispose to infection through impaired immune function, delayed wound healing, and increased bacterial colonisation due to elevated tissue glucose levels.¹⁶ The predominance of emergency surgeries (96%) in this study, which were mostly due to orthopaedic trauma, may have further increased SSI risk. Although drains were used infrequently, prolonged retention for 9 days in one patient is noteworthy, as extended drain duration has been associated with increased infection risk due to bacterial colonisation and biofilm formation.¹⁷

The mean time to SSI detection in our study was 18.2 days, which is consistent with the findings of Reddy et al in whom 78.6% of infections were detected within 14 days after surgery, highlighting the early postoperative period as the most critical window for close wound surveillance and prompt intervention.¹⁸ In our study, the majority of SSI cases were managed successfully with surgical debridement, targeted antibiotics, and retention of stable implants; implant removal was necessary in only 2 cases (9.5%), typically in the setting of unstable fixation, persistent deep infection, or failure of initial debridement and antibiotic therapy. This is similar to reports with low implant removal rates of 0-10% in some series, although Agarwal et al also noted much higher removal rates of 25-100% in other studies, particularly when infections were deep, persistent, or detected late.¹⁹

The microbiological yield from SSI samples in our study was 71.4%, compared with 93.6% reported by Suranigi et al.²⁰ The slightly lower culture positivity may be explained by prior antibiotic exposure, deep-seated infection, and the presence of anaerobic organisms, all of which can reduce recovery on routine culture. Among the isolates, *Enterobacteriaceae* predominated, with *Enterobacter* species accounting for 46.6% of isolates, followed by *K. pneumoniae* (20%) and MRSA (20%). This pattern indicates a shift in the microbiological spectrum of orthopaedic SSIs toward Gram-negative pathogens and is consistent with recent studies by Deka et al (43%) and Das et al (74.2%).^{7,21} In contrast, older reports had identified *S. aureus* as the predominant organism, highlighting a clear change in pathogen profile over time.^{5,8,14} This evolving pattern may be related to the increasing prevalence of multidrug-resistant Gram-negative organisms in hospital environments, contamination at the time of traumatic injury, perioperative antibiotic exposure, and inadequate infection-control practices and personal hygiene in resource-limited settings.

Antimicrobial susceptibility testing showed high resistance rates among *Enterobacteriaceae* to ciprofloxacin (100%), piperacillin-tazobactam (80%), and amikacin (77.8%). Resistance to ceftriaxone (62.5%) and imipenem (50%) indicates the presence of extended-spectrum β -lactamases and emerging carbapenem resistance in a substantial subset. These findings were similar to a study by Mathur et al which reported resistance to amikacin (68%), ceftazidime (67.8%), ciprofloxacin

and carbapenems (57.8%).⁵ Similarly, Srivastav et al reported high resistance to ceftriaxone (88.2%), ciprofloxacin (61.7%), imipenem (66.7%), and meropenem (70.8%) among 48 *K. pneumoniae* isolates.³ These findings point to a hospital environment under intense selective pressure, which explains why a broader-spectrum perioperative regimen (ceftriaxone plus amikacin) was used at our institution rather than the standard, narrow-spectrum cefazolin recommended by the National Centre for Disease Control.²² However, this empirical escalation of perioperative broad-spectrum antimicrobials can select for organisms with plasmid-mediated ESBLs and aminoglycoside-modifying enzymes, a challenge further compounded by suboptimal infection-control practices. In our study, all *S. aureus* isolates were methicillin-resistant (100% MRSA), whereas Das et al reported 36%, and Koyaguru et al reported MRSA in 48.4% of cases.^{7,8}

CONCLUSION

Our study highlights the emergence of Gram-negative pathogens, particularly *Enterobacter* species, as the predominant cause of orthopaedic SSIs in our setting. Given limited post-discharge SSI surveillance in India, local microbiological data are critical for resistance trends and informing targeted antimicrobial stewardship policies. To reduce overall SSI burden, institutions should prioritize strict adherence to standard narrow-spectrum perioperative prophylaxis. Furthermore, implementing rigorous SSI surveillance, infection control, antimicrobial stewardship, and post-discharge follow-up is essential to reduce SSI burden and improve outcomes in orthopaedic trauma patients undergoing ORIF.

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Ethical approval: Not required

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