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Original Research Article

Microbial Trends and Risk Analysis of Surgical Site Infections in Various Post-operative Orthopedic Surgeries in a Tertiary Care Teaching Hospital: A Non-interventional Study

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Abstract:

Introduction: Surgical site infections (SSIs) pose a major challenge in orthopedic surgeries in India, with infection rates varying across hospitals. High infection rates in certain settings emphasize the need for effective surveillance and infection control measures. The presence of multidrug-resistant strains further complicates treatment, making continuous monitoring and antibiotic stewardship essential. This study aimed to determine the bacteriological profile, SSI rates, antibiotic susceptibility, and associated risk factors to improve infection prevention and management strategies in orthopedic surgeries.

Material and Methods: This study was conducted as an active surveillance program in a tertiary care hospital to monitor surgical site infections (SSI) in orthopedic patients. Patients were systematically assessed post-operatively, and suspected SSIs were identified based on clinical symptoms. Data collection included demographic details, surgical and anesthesia type, risk factors, and wound classification. Standard preoperative protocols, antibiotic prophylaxis, and microbiological analysis were followed for infection detection. Statistical analysis using SPSS software assessed SSI incidence and associated risk factors, with $p < 0.05$ considered significant.

Results: Our study found an SSI incidence of 5.5% among 180 orthopedic patients, with the highest infection rate observed in patients aged 0-25 (8.82%). Staphylococcus aureus (60%), was the most frequently isolated pathogen, followed by Pseudomonas aeruginoa (30%) and Acinetobactor spp. (10%), indicating the need for targeted infection control strategies. Among surgical procedures, Plate/K-wire fixation had the highest SSI rate (9.45%), followed by implant removal (5.26%). The SSI rate was significantly associated with prolonged hospital stay (>6 days: 13.8%), emergency surgeries (66.6%), general anesthesia (25%), dirty wounds (75%), and prolonged surgical duration (>2 hours: 50%) ($p < 0.0001$). While diabetes (50%) showed an increased risk, their association was not statistically significant ($p = 0.4003$).

Conclusion: Effective infection control strategies, risk assessment, and optimized surgical protocols are essential to reduce SSIs in orthopedic patients, particularly in high-risk cases such as emergency surgeries, prolonged hospital stays, and contaminated wounds.

Keywords: Surgical Site Infection, Orthopedic Surgery, Risk Factors, Infection Control

Introduction

In India, surgical site infections (SSIs) remain a significant challenge in orthopedic procedures, with infection rates varying across the hospitals and patient populations. [1] According to the Indian Council of Medical Research (ICMR), the overall surgical site infection rate for orthopedic surgeries is 54.2% in some settings, highlighting the urgent need for effective surveillance and infection control measures. [2] The infection rate in prosthetic knee surgeries ranges from 0.8% to 1.9%, while for total hip prostheses, it is between 0.3% and 1.7%. [3] Addressing microbial resistance patterns and associated risk factors is essential for improving patient outcomes and guiding antibiotic stewardship programs in India. The microbial profile of SSIs in orthopedic patients varies across hospital settings and geographical regions, with common pathogens including Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa, and Klebsiella spp. [4] The emergence of multidrug-resistant organisms further complicates the management of these infections, necessitating continuous surveillance and antibiotic stewardship programs. [5] Identifying risk factors such as prolonged operative time, type of wound, comorbid conditions, and perioperative antibiotic use plays a major role in reducing SSI incidence and improving patient outcomes. [6] This study aims to determine the rate of surgical site infections in orthopedic patients, analyze the microbial profile, and assess antimicrobial susceptibility patterns. Additionally, it seeks to identify associated risk factors and recommend appropriate antimicrobial agents for effective treatment.

Materials and Methods

The present observation study was conducted as an active surveillance study as part of an infection control program at a tertiary care teaching hospital, Civil Hospital, Ahmedabad. The study included 180 orthopedic patients who underwent various surgical procedures from July 2017 to August 2018. All patients were systematically monitored post-operatively for surgical site infections (SSI). A suspected SSI was identified based on clinical symptoms such as purulent discharge, localized inflammation (redness, swelling, tenderness, raised local temperature), fever (>38°C), wound dehiscence, or any other signs of infection. Patients were followed up until discharge and educated on SSI symptoms during discharge for further follow-up.

The study included various orthopedic surgery patients of any age and gender who developed symptoms of SSI post-operatively during their hospital stay. Patients with pre-existing infections before surgery or those with non-surgical wound infections were excluded. Data collection followed a structured proforma, each document mentioned demographic details, type of surgery (elective/emergency), anesthesia type, anesthesia risk score, wound classification, associated risk factors, surgical duration, and laboratory investigations.

Preoperative institutional protocols included routine blood investigations (CBC, hemoglobin, HIV, HBsAg, blood grouping, RBS, RFT, LFT), urine routine microscopy, chest radiogram, and ECG based on patient condition. Patients scheduled for elective surgery were admitted one to two days prior, kept nil per mouth from the evening before surgery, and received bowel preparation with enemas. Antibiotic prophylaxis was administered at 8:00 AM before surgery. Emergency surgeries followed similar protocols, with urgent investigations conducted upon admission. The operation was performed in a separate emergency OT, with preoperative shaving and antibiotic prophylaxis before shifting the patient.

Sample collection for suspected SSIs was performed under strict aseptic conditions using sterile swabs for gram staining and culture. Samples were immediately transported to the Microbiology Department for bacterial identification and antimicrobial susceptibility testing using the Kirby-Bauer disk diffusion method following CLSI guidelines. Culture samples were inoculated onto MacConkey agar and blood agar, incubated at 37°C for 24-48 hours, and examined for colony morphology, gram staining, and biochemical characteristics.

Data were recorded and analyzed using SPSS software version 22.0. Descriptive statistics were applied to calculate infection rates by dividing the number of SSIs per month by the total number of surgeries performed and multiplying by 100. Chi-square tests and Fisher's exact tests were used to assess the association between SSI incidence and risk factors such as type of surgery, duration of surgery, wound classification, and patient comorbidities. A p-value < 0.05 was considered statistically significant.

Results

Among the 180 orthopedic patients of the study, 10 cases were identified as bacteriologically proven surgical site infections (SSI). This indicates that the incidence of SSI in orthopedic surgeries was 5.5%.

The mean age ± standard deviation (SD) of orthopedic SSI patients in this study is: 37 ± 12 years. This table highlights that the highest SSI rate (8.82%) is observed in patients aged 0-25 years, followed by those aged ≥51 5.08% of SSI rate, while the lowest rate (4.59%) is in the 26-50 years group.

The findings suggest that older age is a risk factor for SSIs in orthopedic surgeries. (Table 1) Among them, 40 were females with 1 infection (2.5%), while 140 were males with 9 infections (6.42%).

Table 1: Age Distribution of Orthopedic SSI Patients

Age Group	Total Ortho Cases	Infected Ortho Cases	SSI Rate (%)
0-25	34	3	8.82
26-50	87	4	4.59
≥51	59	3	5.08
Total	180	10	5.5

The microbial analysis of 10 orthopedic SSI cases revealed that Staphylococcus aureus (60%), was the most common pathogen, followed by Pseudomonas aeruginosa (30%), and Acinetobacter spp. (10%), highlighting the need for targeted infection control strategies. (Figure 1)

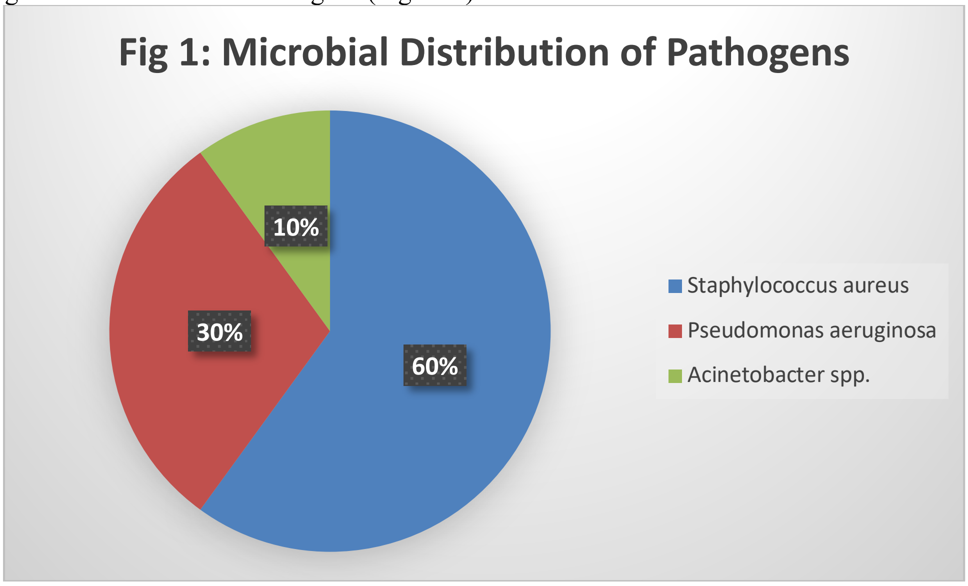

Figure 1: Microbial Distribution of Pathogens

Table 2: Distribution of SSI in Orthopedic Surgeries

No.	Surgery	Total No.	Infected	SSI (%)
1	Plate/K-wire	74	7	9.4
2	Implant Removal	38	2	5.2
3	Spondylitis	36	1	2.7
4	Total Knee Replacement (TKR)	21	0	0.00
5	Total Hip Replacement (THR)	11	0	0.00

Table 3: Distribution of SSI Cases in Orthopedic Patients Based on various risk Factors

Factors	Category	Total Cases	Infected Cases	SSI Rate (%)
Post-operative Hospital Stay	0-5 days	108	0	0.0
	6-10 days	69	7	10.14
	>10 days	3	3	100
Duration of OT	0-1 hour	52	0	0.0
	1-2 hours	126	8	6.34
	>2 hours	2	2	50
Risk Index	Risk index 0	157	0	0.0
	Risk index 1	11	1	9.09
	Risk index 2	3	1	33.3
	Risk index 3	8	7	87.5
	Risk index 4	1	1	50
Type of OT	Elective	174	6	3.44
	Emergency	6	4	66.6
Type of anesthesia	Spinal	176	9	5.11
	General	4	1	25
Wound type	Clean	5	0	0.0
	Clean Contaminated	159	1	0.62
	Contaminated	12	6	50
	Dirty	4	3	75
Risk factors	Diabetes Mellitus	8	4	50

The study found that prolonged hospital stays, emergency surgeries, general anesthesia, contaminated wounds, and longer surgical duration were significantly associated with higher SSI rates in orthopedic patients ($p < 0.0001$). Patients with a hospital stay >6 days (13.8%), emergency surgeries (66%), and surgeries lasting >2 hours (50%) had the highest infection rates. Patients with diabetes

(50%) showed increased SSI rates, their correlation was not statistically significant (p = 0.4003). Microbiological analysis revealed gram-negative bacteria (40%) and gram-positive bacteria (60%). The predominant pathogen responsible for SSIs was Staphylococcus aureus (n=6) in 60% of cases, followed by Pseudomonas aeruginosa (n=3) in 30% of cases and the least found pathogen was Acinetobacter spp. (n=1) (10%), emphasizing the need for targeted antimicrobial therapy. The Antibiotic susceptibility testing in Staphylococcus aureus (n=6) showed that Penicillin and Ampicillin had the highest resistance rates (50%), followed by Cefoxitin, Cefuroxime, and Ampicillin-Sulbactam (33%), indicating significant resistance to β-lactam antibiotics. Aminoglycosides and fluoroquinolone exhibited moderate resistance (~24%), and tetracyclines exhibited lesser resistance (16.6%), while Erythromycin had the highest resistance among macrolides (66.6%). In contrast, Vancomycin, Teicoplanin, and Linezolid demonstrated 100% sensitivity, confirming their effectiveness against resistant strains. Methicillin-resistant Staphylococcus aureus was found to be approximately 33.3%. Antibiotic resistance for Pseudomonas aeruginosa was highest for β-lactam (100%), while aminoglycosides, fluoroquinolone, aztreonam, and tetracyclines showed (66.6%) however piperacillin-tazobactam and meropenem showed lowest resistance (33%). In contrast, colistin was sensitive (100%). In non-lactose fermenters metallo- β-lactamase produced by one Acinetobacter spp. and one P.aeruginosa.

Discussion

The incidence of surgical site infections (SSI) in orthopedic patients in our study (5.5%) aligns with findings from similar studies but variations due to different regions, factors such as infection control measures, patient demographics, and hospital settings. Feng Y et al. [7] reported an orthopedic SSI rate of 7.6%. That is higher than ours (5.5%), potentially due to differences in preoperative care and post-surgical hygiene practices. In contrast, studies from Malaysia [9] (1.24%) and Ethiopia [10] (2.6%) reported lower SSI rates, possibly reflecting stricter infection prevention strategies and improved surgical protocols. Skender et al. [11] reported an SSI rate of 7.6% in a tertiary care hospital in Madhya Pradesh, India, emphasizing risk factors like prolonged hospital stay and previous antibiotic use.

The mean age of SSI patients in our study (37 ± 12 years) is comparable to reports from Ethiopia [4] (41.90 ± 15.94 years) and China [12] (39.7 ± 14.8 years), indicating that middle-aged adults are commonly affected, likely due to higher surgical intervention rates in this age group. However, some studies report a higher mean age, suggesting that older patients with comorbidities are more susceptible to SSIs due to compromised immunity and prolonged hospital stays. [8,13] These variations in incidence and mean age underscore the importance of hospital-specific surveillance systems, infection control policies, and patient-centered preoperative optimization to minimize SSIs in orthopedic surgeries, as in our study SSI rate was 5.08% in older patients(>51 years). Microbiological analysis revealed gram-negative bacteria (40%) and gram-positive bacteria (60%). The predominant pathogen responsible for SSIs was Staphylococcus aureus (n=6) in 60% of cases, followed by Pseudomonas aeruginosa (n=3) in 30% of cases and the least found pathogen was Acinetobacter spp. (n=1) (10%), emphasizing the need for targeted antimicrobial therapy, and infection control measures. Similar microbial trends were observed in other studies, though with regional variations. Wang et al. [12] found Staphylococcus aureus (37.71%) to be the leading cause of orthopedic infections in a large retrospective study from China, with a significant proportion of methicillin-resistant strains (MRSA), aligning closely with our findings. In contrast, Misha et al. [10] reported E. coli (21.43%) as the dominant pathogen in Ethiopia, and Pseudomonas aeruginosa (19.05%). Similarly, Mundhada et al. [14] in India identified S. aureus (31.58%-55.98%) as the most common pathogen just like our study found Staphylococcus aureus (60%), highlighting geographical differences in pathogen prevalence.

The presence of Gram-positive bacteria (Staphylococcus aureus) as dominant pathogens in our study suggests a possible skin flora contamination, which has also been reported in studies by Feng Y et al.7 and Mundhada et al. [14] in India. The increasing incidence of multidrug-resistant Acinetobacter spp. (9.52%) is particularly concerning, as Wang et al. [12] reported a rising trend in Acinetobacter-related orthopedic infections, often associated with biofilm formation and poor treatment outcomes.

Aditya et al. [14] highlighted a higher incidence of Pseudomonas aeruginosa (43.3%) and Staphylococcus aureus (41.66%) in orthopedic implant infections, however, our study found Staphylococcus aureus (60%) as the leading pathogen, suggesting variations in microbial trends based on geographic and hospital-specific factors. These variations in microbial patterns highlight the importance of continuous surveillance, local antibiogram studies, and stringent infection control strategies to guide empirical antibiotic therapy and reduce SSI rates in orthopedic surgeries.

Our study found that prolonged hospital stay (>6 days: 13.8%), emergency surgeries (66%), and longer surgical duration (>2 hours: 50%) were significantly associated with higher SSI rates in orthopedic patients (p < 0.0001). These findings align with Misha et al. [10], who also reported longer hospital stays as a key risk factor for SSIs in Ethiopia, emphasizing the role of prolonged hospitalization in nosocomial infections. Similarly, Mundhada et al. [14] in India, Ashraf I et al. [15], and Skender et al. [11] found that emergency procedures significantly increased SSI rates, supporting our observation that urgent surgeries have nearly triple the infection risk compared to elective procedures. The study by Skender et al. [11] corroborates that general anesthesia leads to higher SSI rates, which we also observed in our data (general: 25% vs. spinal: 5.11%), possibly due to prolonged intraoperative exposure and post-surgical respiratory complications. Wound classification also played a critical role, with dirty wounds having the highest SSI rate (75%) in our study, a trend also highlighted in studies by Misha et al. [10] and Wang et al. [12], who reported higher infection risks in contaminated and dirty wounds.

The strong association between surgical duration and SSI risk in our study (>2 hours: 50%) is consistent with findings from Wang et al. [12], who noted that prolonged surgeries lead to increased microbial exposure and immune suppression, significantly raising infection risk. While diabetes (50%) showed an increased SSI rate, the association was not statistically significant ($p = 0.4003$), similar to Mundhada et al. [14], who found these conditions to be potential but non-significant risk factors. These findings emphasize the importance of infection control strategies, optimized surgical timing, and better perioperative management to reduce SSI risks in orthopedic patients.

Our study isolates 33 % of Staphylococcus aureus as MRSA, which is slightly higher than Aditya M, et al. study which reported 10% of Staphylococcus aureus as MRSA due to geographic distribution [14], however, Alelign D et al. [4] reported 57.9% of Staphylococcus aureus as MRSA. Staphylococcus aureus was 100% sensitive to Chloramphenicol, Vancomycin, linezolid, and Teicoplanin. Among aminoglycosides, amikacin (83.3%) is more sensitive than gentamycin (50%) which is similar to the study of Alelign D et al. [4]

Regarding antimicrobial susceptibility patterns organism Pseudomonas aeruginosa isolated from various orthopedics surgeries were sensitive to Piperacillin+ tazobactam, Meropenem 66%, and 100% sensitive to colistin. 33% of Aminoglycosides and Macrolides were sensitive for Pseudomonas aeruginosa. Among cephalosporin, our study found 33% of Pseudomonas aeruginosa were sensitive to Cefipime, in contrast to the study of Aditya M, et al [14] found 51.9% of Pseudomonas aeruginosa were sensitive to Cefipime which support urge of local antibiogram.

Our study found one metallo-beta-lactamase-producing Acinetobacter spp. aligned with the study of Alelign D et al. [4] our study has certain limitations that should be considered. The sample size of 180 orthopedic patients, with only 10 confirmed SSI cases, limits the generalizability of our findings to a broader population. The study was conducted in a single tertiary care hospital, and variations in infection control practices, surgical techniques, and patient demographics across different institutions may influence SSI rates.

Conclusion

Our study emphasizes the need for strict infection control measures and optimized surgical protocols to reduce SSIs in orthopedic patients. Identifying high-risk factors such as prolonged hospital stays, emergency surgeries, and longer operative durations is crucial for targeted prevention. Preoperative risk assessment and proper wound care strategies can significantly lower infection rates. The findings highlight the importance of tailored antimicrobial stewardship and improved perioperative management to enhance patient safety.

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