Incidence and Microbiological Profile of Surgical Site Infections in Closed Fractures Treated by Internal Fixation in a Tertiary Care Hospital

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KEYWORDS
Surgical Site Infections (SSIs), Orthopedic Surgery, Internal Fixation, Biofilm Formation, Staphylococcus aureus, Nosocomial Infections, Infection Control, Hospital Stay.

ABSTRACT
Objective: To determine the incidence and microbiological profile of surgical site infections (SSI) in closed fractures treated by internal fixation with intramedullary interlocking nails. **Methods:** A prospective, observational study was conducted involving 141 patients with closed femur and tibia fractures treated by internal fixation over two years. SSIs were classified and monitored based on CDC guidelines, with regular post-operative follow-ups for infection assessment. **Results:** The incidence of SSIs was 5%, with Staphylococcus aureus identified as the predominant causative organism. Diabetes emerged as the most common comorbidity. Patients who developed SSIs experienced significantly longer hospital stays, highlighting the burden on healthcare resources. **Conclusion:** While the incidence of SSIs in orthopedic closed fractures is manageable with stringent protocols, extended hospital stays for infected patients notably increase healthcare costs and impact patient quality of life, underscoring the need for targeted preventive measures. .

1. Introduction

Healthcare-Associated Infections (HAIs), also called nosocomial infections, are infections that patients acquire during their hospital stay, often becoming apparent 48 hours or more after admission. These infections affect patient safety and healthcare quality, particularly in Intensive Care Units (ICUs), where patients face higher risks due to invasive procedures and weakened immune responses. Among HAIs, Surgical Site Infections (SSIs) stand out, as they can lead to significant complications in surgical patients, accounting for approximately 38% of infections in this group. Orthopedic surgeries, which frequently involve implants like screws, plates, or prostheses, are especially susceptible to SSIs. These implants can attract bacterial biofilms—a layer of bacteria that adhere to surfaces and become resistant to antibiotics, complicating treatment and often requiring prolonged hospital stays, additional surgeries, or implant removal. In India, SSI rates in orthopedic surgeries are estimated to be between 4.1 and 11 per 100 surgeries, which reflects the challenges of infection control and the need for

extended post-discharge monitoring, as infections can develop long after patients leave the hospital. This high incidence not only impacts patient health, recovery time, and quality of life but also creates a considerable financial strain on both patients and healthcare systems due to the increased need for medical resources and interventions. Reducing SSI rates in orthopedic surgeries is essential for improving patient outcomes, minimizing economic burdens, and advancing healthcare quality overall.

Objectives

1. To establish the incidence of SSIs in orthopedic surgeries.
2. To identify the causative microorganisms of SSIs in closed fractures treated by internal fixation.

2. Review of Literature

2.1 Historical Perspective

The understanding and prevention of Surgical Site Infections (SSIs) have a deep-rooted history. The early concept of "hospital diseases," first noted by Malgaigne in 1841, highlighted the risk of infections originating within healthcare settings (Guthrie, 1958). This early recognition of hospital-acquired infections paved the way for critical advancements in antiseptic techniques and surgical hygiene. Joseph Lister, often regarded as the father of modern antiseptics, introduced the use of antiseptics in the late 19th century, revolutionizing surgical practice and significantly reducing post-operative infections (Pitt & Aubin, 2012). The discovery of antibiotics by Alexander Fleming in 1928 further transformed the management of SSIs, providing an effective treatment approach that allowed for greater surgical success and patient safety (Whitehouse et al., 2002). Despite these milestones, SSIs remain a prevalent issue in modern healthcare, particularly in complex surgical fields like orthopedics, where infection control is challenging due to the presence of implants.

2.2 Pathogenesis

The pathogenesis of SSIs is complex, particularly due to the behavior of bacteria in forming biofilms. “Biofilms are structured communities of bacteria encased in a protective matrix that adheres to surfaces, including surgical implants. This matrix shields bacteria from antibiotics and immune responses, making infections persistent and difficult to eradicate once established (Fey & Olson, 2010). Bacteria in biofilms can exist in two states: planktonic (free-floating) and colonized (attached to a surface). The transition from planktonic to colonized bacteria typically occurs in the presence of necrotic tissue or foreign material, creating an ideal environment for biofilm formation (Dankert, 1986). Once a biofilm is established on an implant, treating the infection requires prolonged antibiotic courses and, in severe cases, may necessitate removal of the implant. This biofilm-related persistence of infection is especially problematic in orthopedic surgeries, where the presence of foreign materials increases the risk of bacterial colonization.

2.3 Classification and Incidence of SSI

The Centers for Disease Control and Prevention (CDC) categorizes SSIs into three types based on the depth of the infection: superficial, deep, and organ-space infections. Superficial SSIs affect only the skin and subcutaneous tissue, while deep SSIs extend into muscle and fascia, and organ-space SSIs involve infection of organs or spaces manipulated during surgery (CDC, 2014).” The incidence of SSIs varies widely, with studies reporting rates ranging from 3.1% in clean surgical procedures to over 20% in certain orthopedic settings where implants are

involved (Culver et al., 1991; Liang et al., 2019). This variability highlights the influence of surgery type, patient factors, and surgical technique on SSI rates, particularly in orthopedic surgeries where implants provide a surface for bacterial adherence and biofilm formation, thus increasing the infection risk.

2.4 Microbiology

Among the pathogens responsible for SSIs, *Staphylococcus aureus* remains the most common causative agent. The prevalence of methicillin-resistant *Staphylococcus aureus* (MRSA) strains has increased over recent decades, adding complexity to infection control and treatment (Jernigan, 2004). MRSA poses a higher risk for SSIs due to its resistance to commonly used antibiotics, complicating treatment options and leading to prolonged infections. In orthopedic surgeries, where infections are often associated with biofilm formation on implants, *S. aureus* can persist and evade standard antibiotic treatments, requiring advanced infection management strategies to control and prevent further complications (Verderosa et al., 2019).

2.5 Risk Factors and Prevention

Risk factors for SSIs can be divided into patient-related and procedure-related factors. Patient-related factors include age, diabetes, smoking, and overall health status, all of which contribute to an individual's susceptibility to infection (Mundhada & Tenpe, 2015). Procedure-related factors, such as the surgical technique used, preoperative skin preparation, and duration of surgery, also play a crucial role in SSI risk. The World Health Organization (WHO) has outlined preventive measures aimed at reducing SSI incidence, including preoperative decolonization of nasal carriers of *S. aureus*, strict glycemic control in diabetic patients, and optimal surgical site skin preparation (WHO, 2018). These guidelines underscore the importance of both patient management and procedural protocols in minimizing infection risk, particularly in high-risk surgeries like orthopedics, where implant-associated infections can have severe consequences.

3. Methodology

3.1 Study Design

This study employed a prospective, follow-up design conducted in a tertiary care hospital. The study population consisted of 141 patients who underwent internal fixation procedures for closed fractures of the femur and tibia. Each patient was monitored post-operatively for signs of infection, with data collected over a defined follow-up period to assess the incidence and characteristics of Surgical Site Infections (SSIs).

3.2 Inclusion and Exclusion Criteria

The study included patients based on specific criteria to maintain a focused and relevant sample:

- **Inclusion Criteria:** Patients aged 18 years and above who presented with closed fractures of the femur or tibia and were treated through internal fixation.
- **Exclusion Criteria:** Patients younger than 18 years, those classified with American Society of Anesthesiologists (ASA) Grade 5 (indicating moribund status), or those undergoing revision surgeries were excluded to ensure the study focused on a specific population of adult patients receiving primary orthopedic fixation.

3.3 Data Collection

Data collection was systematic and aligned with the CDC guidelines for SSI surveillance. SSIs were classified into superficial, deep, and organ-space infections based on depth and location. Post-operative and follow-up assessments were conducted on days 2, 5, and 11 to observe and

record any signs of infection, including fever, redness, swelling, warmth, or purulent drainage. In cases where SSI was suspected, samples from the surgical site were collected using sterile swabs and sent for microbiological analysis to identify causative organisms. This process ensured that SSIs were accurately detected, categorized, and documented based on CDC standards.

3.4 Statistical Analysis

The collected data encompassed patient demographics (such as age and gender), duration of surgery, "and length of hospital stay. Statistical analyses were performed using SPSS software to identify any significant correlations between these factors and the incidence of SSIs. Chi-square tests, t-tests, and correlation analyses were applied as appropriate to explore the relationship between patient and surgical variables with SSI outcomes. A p-value of less than 0.05 was considered statistically significant, indicating meaningful associations between variables and SSI risk. This analytical approach provided insights into potential predictors of SSI, aiding in the identification of high-risk patient profiles and surgical factors associated with infection.

4. Results

4.1 Demographics and Surgery Details

Table 1: Demographics and Surgery Details"

Characteristic	Value
Average Age	65-75 years
Gender Distribution	Slight female predominance
Most Common Surgery Duration	1-1.5 hours

The study included 141 patients who underwent internal fixation for closed femur and tibia fractures. The average age of participants ranged from 65 to 75 years, with a slight female predominance among the sample. Most surgeries were completed within 1 to 1.5 hours, aligning with standard procedural times for closed fracture fixation. These demographics provided a baseline context for understanding the patient population's risk profile in relation to Surgical Site Infections (SSIs).

4.2 Incidence of SSI

Table 2: Incidence of Surgical Site Infections (SSI)

Type of Infection	Percentage of Cases	Number of Cases
Superficial SSI	2%	3
Deep SSI	3%	4
Total SSI Incidence	**5%**	**7**

The overall incidence of SSIs in this cohort was observed to be 5%, a rate comparable to reported incidences in similar surgical contexts. Among the 7 cases of SSI, 2% were classified as superficial infections involving the skin and subcutaneous tissue, while 3% were classified as deep infections, extending to muscle or fascial layers. This breakdown reflects the distribution of SSI types within this study's orthopedic surgery population and underscores the significant risk of deeper, more severe infections in implant-associated surgeries.

4.3 Microorganisms

Table 3: Microorganisms Identified in SSI Cases

Organism	Frequency in SSI Cases	Percentage of SSI Cases
Staphylococcus aureus	3	42.8%
Escherichia coli	2	28.6%
Other/No Growth	2	28.6%

Microbiological analysis identified *Staphylococcus aureus* as the predominant pathogen, responsible for 3 out of the 7 cases of SSI (42.8%). This organism, well-documented in SSI cases due to its ability to form biofilms on implant surfaces, represents a critical target for infection control in orthopedic procedures. *Escherichia coli* was also isolated in some cases, indicating the presence of gram-negative organisms that may contribute to infection in these surgical settings. These findings highlight the importance of both gram-positive and gram-negative bacteria in SSI incidence and emphasize the need for broad-spectrum preventative measures in orthopedic surgery.

4.4 Hospital Stay

Table 4: Hospital Stay Duration by SSI Type

Patient Group	Mean Hospital Stay (days)
Non-infected Patients	6.78
Patients with Superficial SSI	15.33
Patients with Deep SSI	26.7

The presence of an SSI was associated with significantly extended hospital stays, underscoring the additional healthcare burden and impact on patient recovery. For patients with superficial SSIs, the mean hospital stay was 15.33 days, while those with deep SSIs had a mean stay of 26.7 days. This is in stark contrast to the 6.78 days observed for non-infected patients, illustrating the profound impact of SSIs on healthcare resources and patient outcomes. The extended duration not only increases healthcare costs but also reflects the additional medical interventions, monitoring, and support required for managing infections in surgical patients.

5. Discussion

The incidence of Surgical Site Infections (SSIs) observed in this study aligns with previous findings from similar orthopedic surgery settings, with an overall rate of 5%, which is consistent with global and regional reports of SSI rates in developing healthcare contexts. This rate highlights the persistent challenge of infection control in orthopedic surgeries, especially given the presence of implants that increase susceptibility to infection. Similar studies have documented lower SSI rates in high-resource settings, often between 1.2% and 5.2% (Culver et al., 1991; Liang et al., 2019), suggesting that robust infection control practices and advanced preventive strategies can significantly reduce these rates. However, the constraints in resource-limited settings—such as lack of advanced infection control infrastructure, challenges in maintaining sterility, and limited post-operative monitoring—underscore the need for practical, affordable, and feasible infection prevention measures to manage SSIs in such healthcare environments.

A significant factor contributing to SSIs in orthopedic procedures is the predominance of *Staphylococcus aureus* as the leading causative organism, particularly methicillin-resistant strains (MRSA). *S. aureus* is highly adept at forming biofilms on implant surfaces, which

complicates eradication due to its resistance to immune defenses and antibiotic treatment (Jernigan, 2004; Verderosa et al., 2019). The presence of other organisms, such as *Escherichia coli*, further emphasizes the role of both gram-positive and gram-negative bacteria in these infections, requiring a multifaceted approach to prevention and treatment. Preventive strategies, including the WHO-recommended preoperative nasal decolonization for *S. aureus* carriers, perioperative glycemic control, and optimal skin antisepsis, have been shown to reduce SSI risk (WHO, 2018). These measures are particularly critical in orthopedic surgeries due to the presence of implants, which heighten the risk of persistent infections and complicate treatment options, as seen in the prolonged hospital stays of affected patients in this study.

The extended hospital stays for patients with SSIs—averaging 15.33 days for superficial infections and 26.7 days for deep infections—highlight the considerable economic and social impact of these infections. These longer durations not only increase healthcare costs but also pose a substantial burden on patients and healthcare systems due to the additional resources needed for treatment, monitoring, and infection management. Patients with comorbidities such as diabetes, which was prevalent in 27.7% of cases, are at even greater risk, as diabetes impairs immune function and delays wound healing, although statistical significance was not observed in this study. Enhanced infection control protocols, comprehensive perioperative care, and improved patient education on infection risk and follow-up care could help mitigate these impacts, reduce SSIs, and improve outcomes in orthopedic surgeries.

6. Conclusion

This study highlights that the incidence of Surgical Site Infections (SSIs) in closed fractures treated by internal fixation is manageable with proper infection control practices, with an observed rate of 5% in a tertiary care setting. *Staphylococcus aureus* was identified as the predominant causative organism, reflecting its role as a common pathogen in orthopedic surgeries and its capacity to form biofilms on implant surfaces, which complicates treatment. The presence of SSIs, particularly deep infections, led to significantly prolonged hospital stays, increasing both healthcare costs and the social burden on patients and systems alike. This study underscores the importance of adhering to stringent protocols for infection prevention, including preoperative nasal decolonization, glycemic control in diabetic patients, and meticulous perioperative antisepsis, which align with WHO recommendations and have proven effective in reducing infection rates. Furthermore, patient comorbidities, such as diabetes, were prevalent among SSI cases, reinforcing the need for targeted risk assessments and tailored interventions to support at-risk groups. Moving forward, a focus on enhancing infection control measures, especially in resource-limited settings, is crucial. This includes optimizing surgical techniques, implementing regular follow-up care, and educating patients on post-operative infection risks to improve overall patient outcomes, reduce SSIs, and mitigate their long-term health and economic impacts.

Author Contribution:

Dr. Vivian Roshan D Almeida: Conceptualization, Methodology, Investigation.
Dr. George Joseph: Methodology, Patient follow-up, Statistics, Manuscript Writing.
Dr. Kotedadi Ramprasad Rai: Reviewing and Supervision, Manuscript Writing.
Dr. Ashwin Kamath: Reviewing and Supervision, Manuscript Writing.
Dr. Manjunatha R: Conceptualization, Methodology, Manuscript Writing.
All authors read and approved the final version of the manuscript.

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