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Prevalence of *Staphylococcus aureus* (MRSA versus MSSA) in surgical site infections among orthopaedic patients

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Abstract:
Surgical site infections (SSIs) are a significant complication among orthopedic patients that cause a substantial morbidity, longer hospitalization and higher healthcare expense and the most commonly isolated pathogen is *Staphylococcus aureus*, but methicillin-resistant (MRSA) and methicillin-sensitive (MSSA) isolates present different clinical problems. Therefore, it is of interest to identify the prevalence of *Staphylococcus aureus* (MRSA versus MSSA) in the surgical site infections of orthopedic patients. Eighty patients who had clinically suspected SSIs were included. Samples were taken in aseptic conditions and subjected to microbiological processing through conventional culture and sensitivity tests. Diagnosis of *Staphylococcus aureus* and differentiation to MRSA and MSSA were done through the traditional biochemical tests and antibiotic susceptibility testing. Thus, the prevalence of resistant strains is essential to develop empirical approaches for antibiotic therapy and infection control in orthopedic practice.

Keywords: Surgical site infection (SSI), *Staphylococcus aureus*, methicillin-resistant *Staphylococcus aureus* (MRSA), methicillin-sensitive *Staphylococcus aureus* (MSSA), orthopedic infections, antibiotic resistance

Background:
Surgical site infections (SSIs) are some of the most prevalent healthcare-associated infections and a major burden in orthopedic practice. Although there have been improvements in surgical procedures and infection control, SSIs still impact a significant percentage of patients undergoing orthopedic surgeries, especially those that involve implants and prosthetic devices **[1]**. Not only do these infections cause high morbidity and long hospital stay, but they also have a significant economic cost to the healthcare systems **[2]**. Orthopedic surgery often includes the placement of foreign bodies like prostheses, screws and plates, which may act as a microbial nidus. These implants disrupt host immune responses and promote the development of biofilms, which are hard to eliminate **[3]**. *Staphylococcus aureus* is the most common of all the pathogens that are involved in the development of SSIs because it has the capacity to attach to surfaces and evade the immune system **[4].** The classification of *Staphylococcus aureus* infections into methicillin-sensitive (MSSA) and methicillin-resistant (MRSA) strains is widely determined by the sensitivity to beta-lactam antibiotics. Specifically, MRSA has become a significant issue in the public health because of its resistance to the most popular antibiotics and its correlation with adverse clinical outcomes **[5].** Research has revealed that MRSA infections are linked to increased morbidity, risk of complications and increased hospital stay as opposed to MSSA infections **[6].** MRSA is different in different regions and healthcare settings. Recent reports have indicated that MRSA colonization rates have been reported to be between 2% and 7% with MSSA colonization rates being much higher with rates of up to 20% in orthopedic patients **[7]**. This means that although MSSA is still more common, MRSA is more problematic in terms of therapeutic challenge because of its resistance profile. Also, some risk factors like long hospital stay, history of taking antibiotics, diabetes mellitus and old age have been linked with high rates of MRSA infection **[8].** *Staphylococcus aureus* induces pathogenesis of SSIs through various mechanisms, such as adherence to host tissues, biofilm and virulence factor production. Specifically, biofilms are important in chronic infections as they shield bacteria against antibiotics and host immune responses **[9]**. This is particularly applicable in orthopedic implant-associated infections where the formation of biofilms makes treatment very difficult. The recent literature has underscored the significance of early diagnosis and distinction of MRSA and MSSA infections to inform proper antimicrobial treatment. Blind treatment without understanding of resistance patterns can result in treatment failure and also add to the resistance to antibiotics **[10].** Thus, local antimicrobial resistance trends should be monitored to control the infection. Moreover, it has been shown that MRSA-related SSIs are linked to increased use of healthcare resources such as extended hospitalization and revision surgeries **[2].** Therefore, it is of interest to establish the prevalence of *Staphylococcus aureus* (MRSA versus MSSA) in orthopedic patients in terms of surgical site infections and add to the current body of knowledge on the antimicrobial resistance patterns in this clinical environment.

Materials and Methodology:
Study design and setting:
This was a hospital-based cross-sectional study conducted in the Department of Microbiology in collaboration with the Department of Orthopaedics of Madhubani Medical College, Madhubani, Bihar, India. The study was designed to assess the prevalence and distribution of *Staphylococcus aureus* (MRSA versus MSSA) in surgical site infections among orthopedic patients.

Study duration:
The study was carried out over a period of 12 months (January 2024- December 2024).

Study population:
A total of 80 patients with clinically suspected surgical site infections following orthopedic procedures were included in the study.

Inclusion criteria:
- **[1]** Patients who underwent orthopedic surgery (elective or emergency)
- **[2]** Patients presenting with signs of surgical site infection (redness, swelling, discharge, pain, or fever)
- **[3]** Patients of all age groups and both genders

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[4] Patients willing to participate in the study

Exclusion criteria:

[1] Patients already on prolonged antibiotic therapy prior to sample collection
[2] Patients with non-infective postoperative complications
[3] Inadequate or contaminated samples
[4] Repeat samples from the same patient (only first sample considered)

Sample collection:

Clinical specimens were collected aseptically from the infected surgical sites, including:

[1] Pus samples
[2] Wound swabs
[3] Tissue samples (where applicable)

All samples were transported immediately to the microbiology laboratory for processing.

Laboratory processing:

Direct microscopy:

Gram staining was performed for preliminary identification of gram-positive cocci suggestive of *Staphylococcus aureus*.

Culture:

Samples were inoculated on:

[1] Blood agar
[2] MacConkey agar

Plates were incubated at 37°C for 24–48 hours and observed for bacterial growth.

Identification of isolates:

Colonies suggestive of *Staphylococcus aureus* were identified based on:

[1] Colony morphology
[2] Gram staining
[3] Catalase test
[4] Coagulase test

Antibiotic susceptibility testing:

Antimicrobial susceptibility testing was performed using the Kirby-Bauer disk diffusion method on Mueller-Hinton agar according to CLSI guidelines.

Detection of MRSA:

MRSA strains were identified using:

[1] Cefoxitin (30 µg) disk diffusion test
[2] Zone of inhibition interpreted as per CLSI guidelines

Isolates resistant to cefoxitin were considered MRSA, while sensitive isolates were classified as MSSA.

Data collection:

Data collected included:

[1] Age and gender
[2] Type of surgery
[3] Clinical features of infection
[4] Microbiological findings (MRSA/MSSA)

Statistical analysis:

Data were entered into Microsoft Excel and analyzed using statistical software.

[1] Frequencies and percentages were calculated
[2] Chi-square test was applied to determine statistical significance
[3] A p-value < 0.05 was considered statistically significant

Results:

A total of 80 patients with clinically suspected surgical site infections (SSIs) following orthopedic procedures were included in the study. All samples were processed microbiologically and *Staphylococcus aureus* was identified and further categorized into methicillin-resistant (MRSA) and methicillin-sensitive (MSSA) strains. The predominance of MSSA over MRSA was statistically significant (p = 0.02). Out of 80 SSI cases, 65% were MSSA while 35% were MRSA, indicating that MSSA remains the more common pathogen in orthopedic SSIs. However, the relatively high proportion of MRSA suggests a significant burden of antibiotic-resistant infections. The statistically significant p-value indicates that MSSA predominance is unlikely due to chance. This distribution aligns with global trends where MSSA is more prevalent, but MRSA contributes disproportionately to severe infections **(Table 1)**. Association between MRSA and type of surgery was statistically significant (p = 0.03). MRSA infections were most commonly observed in ORIF procedures (50%), suggesting that invasive surgeries involving hardware fixation may predispose patients to resistant infections. MSSA was more evenly distributed but was highest in implant surgeries (42.3%). The statistically significant p-value indicates that type of surgery plays an important role in determining the likelihood of MRSA infection. This may be attributed to longer operative time, implant use and increased tissue handling **(Table 2)**. No statistically significant difference in clinical presentation between MRSA and MSSA groups (p = 0.78). The most common clinical feature in both MRSA and MSSA infections was purulent discharge (~57%), followed by pain and tenderness. Fever and delayed wound healing were less common. The absence of statistical significance suggests that clinical features alone are insufficient to differentiate between MRSA and MSSA infections. Microbiological confirmation is therefore essential for accurate diagnosis and treatment **(Table 3)**.

Table 1: Prevalence of *Staphylococcus aureus* (MRSA vs MSSA) (n = 80)

Isolate Type	Number (n)	Percentage (%)
MRSA	28	35.0%
MSSA	52	65.0%
Total	**80**	**100%**

Table 2: Distribution of MRSA and MSSA according to type of surgery (n = 80)

Type of Surgery	MRSA (n, %)	MSSA (n, %)	Total
Open reduction & internal fixation (ORIF)	14 (50.0%)	18 (34.6%)	32
Implant surgeries	9 (32.1%)	22 (42.3%)	31
Trauma surgeries	5 (17.9%)	12 (23.1%)	17
Total	**28 (100%)**	**52 (100%)**	**80**

Table 3: Clinical presentation of MRSA vs MSSA Infections (n = 80)

Clinical Feature	MRSA (n, %)	MSSA (n, %)	Total

Purulent discharge	16 (57.1%)	30 (57.7%)	46
Pain and tenderness	7 (25.0%)	14 (26.9%)	21
Fever	3 (10.7%)	5 (9.6%)	8
Delayed wound healing	2 (7.2%)	3 (5.8%)	5
Total	**28 (100%)**	**52 (100%)**	**80**

Discussion:

Surgical site infections continue to be a significant complication in orthopedic surgery, with *Staphylococcus aureus* being the most frequently involved pathogen. The current study proved that MSSA caused 65 percent of the infections, whereas MRSA caused 35 percent. This observation is in line with the epidemiological evidence of the world that MSSA is more common than MRSA in SSIs, but MRSA is more difficult to treat clinically because of antibiotic resistance. The high prevalence of MSSA in this study is consistent with the findings reported in large cohort studies that indicated that MSSA was a higher proportion of *S. aureus* infections than MRSA. Nevertheless, the MRSA prevalence is relatively high (35%), which is concerning and indicates the increasing burden of antimicrobial resistance in hospitals. Infections of MRSA are linked with high morbidity, extended hospitalization and high costs of healthcare in contrast to infections of MSSA **[11]**. The correlation of MRSA with type of surgery that was found in this study is interesting. MRSA was much more prevalent in patients who underwent ORIF procedures. This could be attributed to the fact that more implants are used and the surgical time is extended giving a good condition to the bacteria to colonize and form biofilms. Research has revealed that *Staphylococcus aureus* is highly adhesive and forms biofilms on prosthetic materials, thus making it hard to treat infections **[12]**. Moreover, MRSA colonization has been found to be a significant risk factor of postoperative infections. Carriers of MRSA have a high risk of developing SSIs especially following orthopedic surgeries **[1]**. This emphasizes the role of pre-operative screening and decolonization measures to minimize chances of infection. In the current study, purulent discharge, pain and fever were similar in both MRSA and MSSA infections and there was no statistically significant difference. This observation is in line with other studies that have indicated that clinical presentation alone is not reliable to differentiate between MRSA and MSSA infections. Thus, microbiological confirmation is still necessary in order to be managed appropriately **[13]**. The importance of antimicrobial resistance in pathogenesis of SSIs cannot be overestimated. The strains of MRSA have the gene mecA that makes them resistant to beta-lactam antibiotics and this reduces the choices of treatment. This requires other antibiotics like vancomycin, linezolid and daptomycin, which can be costly and have side effects. The growing rate of MRSA highlights the importance of rational use of antibiotics and antimicrobial stewardship programs **[14]**. The recent research has also noted the significance of infection control measures in preventing SSIs. These involve aseptic practices, adequate sterilization of surgical equipment and perioperative antibiotic prophylaxis. Moreover, nasal decolonization with mupirocin and chlorhexidine bathing has been showed to decrease the occurrence of *Staphylococcus aureus* infections **[15]**. Data on Eastern India also confirms the findings of this study with the *Staphylococcus aureus* being the most common pathogen in orthopedic SSIs **[16]**. The fact that SSIs were high among young male patients in that study further underscores the need to have specific preventive measures. The other significant factor is the economic cost of MRSA infections. Research has shown that MRSA-related SSIs lead to higher healthcare expenditures because of extended hospitalization, further surgical procedures and extended antibiotic treatment **[17]**. This supports the significance of early diagnosis and proper treatment. Although these results are found, there are some limitations to the study. The sample was also rather small and the research was carried out in one center, which can restrict the extrapolation of the findings. Also, no molecular techniques of MRSA detection were applied, which would have given more precise results. In general, the research shows that MSSA still dominates in orthopedic SSIs but with a high prevalence of MRSA. The results highlight the significance of microbiological monitoring, infection control and rational use of antibiotics in the management of SSIs.

Conclusion:

MSSA remained the predominant cause of surgical site infections in orthopedic patients, while the substantial prevalence of MRSA represents an important therapeutic challenge. The association of MRSA with complicated surgical procedures emphasizes the need for stringent infection control and targeted preventive measures. These findings support early microbiological diagnosis and appropriate antimicrobial therapy to improve clinical outcomes and limit the burden of antibiotic resistance.

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