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Original Research Article

Antimicrobial Resistance Landscape and MRSA Burden in Postoperative Orthopaedic Surgical Site Infections

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Abstract:
Background: Postoperative orthopaedic surgical site infections are important causes of morbidity, delayed wound healing, prolonged hospitalization and increased treatment cost. Emergence of methicillin-resistant Staphylococcus aureus and multidrug-resistant Gram-negative bacilli has made their management more difficult.
Aim: To detect MRSA among Staphylococcus aureus isolates and to determine the antibiotic susceptibility pattern of bacterial isolates from postoperative orthopaedic wound infections.
Materials and Methods: This bacteriological study included 100 clinically diagnosed postoperative orthopaedic surgical site infection samples. Specimens were collected aseptically using sterile swabs and processed by Gram staining, aerobic culture and standard biochemical tests. Antibiotic susceptibility testing was performed by Kirby–Bauer disc diffusion method. MRSA detection among Staphylococcus aureus isolates was done using oxacillin screen agar.
Results: Of 100 samples, 56 showed aerobic bacterial growth. Gram-positive cocci accounted for 33 isolates (58.92%) and Gram-negative bacilli for 23 isolates (41.07%). Staphylococcus aureus was the predominant isolate, 30 cases (53.57%). Among these, 18 (60%) were MRSA. Gram-positive isolates showed highest resistance to penicillin, while Gram-negative isolates showed highest resistance to ciprofloxacin and ceftriaxone.
Conclusion: Staphylococcus aureus, especially MRSA, was the major pathogen in postoperative orthopaedic wound infections. Routine culture and sensitivity testing is essential for appropriate antibiotic therapy.
Keywords: Postoperative wound infection; Orthopaedic surgical site infection; Staphylococcus aureus; MRSA; Antibiotic susceptibility.
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Introduction

Postoperative wound infection, also termed surgical site infection (SSI), is an infection involving the incision, deep soft tissue or operative area, usually occurring within 30 days of surgery [1]. It remains an important cause of hospital-acquired morbidity, particularly in orthopaedic patients, where implants, trauma, prolonged procedures and tissue devitalization increase the risk of bacterial colonization and delayed wound healing. SSIs may lead to pain, wound discharge, dehiscence, prolonged antibiotic use, repeat surgery, extended hospital stay, increased treatment cost and, in severe cases, sepsis or limb-threatening infection [2]. The development of infection depends on interaction between microbial contamination, local tissue damage and host factors such as diabetes mellitus, anaemia, malnutrition, obesity, malignancy and immunosuppression [1, 3]. Common bacterial isolates include Staphylococcus aureus, coagulase-negative staphylococci, Escherichia coli, Klebsiella species, Pseudomonas aeruginosa and Proteus species. Methicillin-resistant Staphylococcus aureus (MRSA) is of particular concern in orthopaedic surgical wounds because of its association with difficult-to-treat infection, biofilm formation and limited antibiotic options [1,4]. Increasing antimicrobial resistance further emphasizes the need for periodic local surveillance. Hence, the present study was undertaken to detect MRSA among Staphylococcus aureus isolates and to determine the antibiotic susceptibility pattern of bacterial isolates from postoperative orthopaedic wound infections.

Methods

The present bacteriological study was carried out in Rangaraya Medical College, Kakinada, among patients admitted in the orthopaedic wards with clinically diagnosed postoperative surgical site infections. During the study period from December 2014 to August 2016, a total of 1515 patients underwent clean Class I orthopaedic operative procedures, including spinal instrumentation, interlocking nailing for femur and tibia fractures, cobrahood plating for subtrochanteric fracture femur, dynamic condylar screw fixation for distal femoral fractures, hemiarthroplasty for fracture neck of femur, and Austin Moore prosthesis of the hip joint. Among these operated patients, 100 cases who developed features suggestive of SSI were included in the study and were subjected to bacteriological investigation. Institutional Ethics Committee approval was obtained before commencement of the study, and informed consent was taken from all participants. Detailed clinical history was recorded using a structured questionnaire, including demographic details and relevant risk factors such as diabetes mellitus, hypertension, advanced age, smoking, alcohol use, obesity and immunosuppression.

Specimen collection was done aseptically from the infected surgical site during wound dressing and before cleaning the wound with antiseptic solution. Two sterile cotton swabs were collected from each patient, taking care to avoid contamination with surrounding skin commensals. The samples were immediately transported to the microbiology laboratory for processing. The first swab was used for direct smear preparation and Gram staining, while the second swab was inoculated on MacConkey agar, nutrient agar and blood agar plates. MacConkey agar, nutrient agar and one blood agar plate were incubated aerobically at 37°C, while another blood agar plate was incubated in a candle jar with 5% CO_2. Culture plates were examined after 24 hours of incubation, and if no growth was observed, they were further incubated for another 24 hours. Growth-positive culture plates were examined for colony morphology, pigmentation, haemolysis, lactose fermentation and other cultural characteristics.

Bacterial isolates were identified by standard microbiological procedures based on Gram staining, colony morphology, motility and biochemical reactions as described in standard laboratory manuals [5]. Antibiotic susceptibility testing was performed by Kirby–Bauer disc diffusion method using bacterial suspensions adjusted to 0.5 McFarland turbidity standard. The inoculated plates were incubated at 37°C for 18–24 hours, and the zones of inhibition were measured and interpreted according to standard guidelines. Screening for MRSA isolates was done using oxacillin screen agar prepared with Mueller–Hinton agar containing 4% sodium chloride and 6 µg/mL oxacillin. Plates were inoculated with 10 µL of 0.5 McFarland suspension, incubated at 35°C for 24 hours, and any visible growth was considered indicative of methicillin resistance.

Results

A total of 100 postoperative orthopaedic surgical site infection samples were processed bacteriologically, of which 56 showed aerobic bacterial growth, giving a culture positivity rate of 56%; all culture-positive cases yielded monomicrobial growth (Table 1). Gram-positive cocci were more common than Gram-negative bacilli, accounting for 33 isolates (58.92%), while Gram-negative bacilli constituted 23 isolates (41.07%) (Table 2). Staphylococcus aureus was the predominant organism isolated, accounting for 30 cases (53.57%) among culture-positive samples, followed by Klebsiella pneumoniae and Pseudomonas aeruginosa, each contributing 7 isolates (12.50%). Escherichia coli was isolated in 6 cases (10.71%), while coagulase-negative Staphylococcus and Proteus species were isolated in 3 cases each (5.35%) (Table 1). Among the 30 Staphylococcus aureus isolates, 18 were methicillin-resistant, showing an MRSA prevalence of 60%, while 12 isolates (40%) were methicillin-sensitive (Table 3). Antibiotic resistance among Gram-positive cocci was highest to penicillin (75.75%), followed by cotrimoxazole (54.54%), ciprofloxacin (33.33%) and amoxyclav (30.30%). Linezolid and vancomycin showed the least resistance, with only 3.03% resistance each (Table 4). Among Gram-negative bacilli, maximum resistance was observed to ciprofloxacin and ceftriaxone, each 52.17%, followed by cefotaxime (47.82%) and ceftazidime (34.78%). Lower resistance was observed to amikacin and gentamicin, each 13.04% (Table 4). These findings indicate that Staphylococcus aureus, particularly MRSA, was the major pathogen in postoperative orthopaedic wound infections, and antibiotic resistance was common among both Gram-positive and Gram-negative isolates.

Table 1: Culture positivity and bacterial isolates among postoperative orthopaedic surgical site infections

Parameter / Organism	Number	%
Culture positive samples	56	56
Culture negative samples	44	44
Staphylococcus aureus	30	53.57
Coagulase-negative Staphylococcus	3	5.35
Klebsiella pneumoniae	7	12.5
Pseudomonas aeruginosa	7	12.5
Escherichia coli	6	10.71
Proteus species	3	5.35
Total isolates	56	100

Table 2: Distribution of Gram-positive and Gram-negative isolates

Category	Isolate	Number	%
Gram-positive cocci	S. aureus, CONS	33	58.92
Gram-negative bacilli	Klebsiella, Pseudomonas, E. coli, Proteus	23	41.07

Table 3: Methicillin resistance among Staphylococcus aureus isolates

Staphylococcus aureus phenotype	Number	%
MRSA	18	60
MSSA	12	40
Total S. aureus isolates	30	100

Table 4: Overall antibiotic resistance pattern of Gram-positive and Gram-negative isolates

Antibiotic	Gram-positive resistant n/N (%)	Antibiotic	Gram-negative resistant n/N (%)
Penicillin	25/33 (75.75)	Ciprofloxacin	12/23 (52.17)
Cotrimoxazole	18/33 (54.54)	Ceftriaxone	12/23 (52.17)
Ciprofloxacin	11/33 (33.33)	Cefotaxime	11/23 (47.82)
Amoxyclav	10/33 (30.30)	Ceftazidime	8/23 (34.78)
Cefotaxime	8/33 (24.24)	Amoxyclav	6/23 (26.08)
Gentamicin	3/33 (9.09)	Imipenem	4/23 (17.39)
Amikacin	2/33 (6.06)	Piperacillin-tazobactam	4/23 (17.39)
Vancomycin	1/33 (3.03)	Cefoperazone-sulbactam	4/23 (17.39)
Linezolid	1/33 (3.03)	Amikacin	3/23 (13.04)
—	—	Gentamicin	3/23 (13.04)

Discussion

Postoperative orthopaedic surgical site infections remain an important clinical problem because they increase morbidity, delay rehabilitation, prolong hospital stay, increase treatment cost and may compromise the outcome of fracture fixation or implant surgery. In the present study, 100 clinically suspected postoperative orthopaedic wound infection samples were processed, and 56% showed aerobic bacterial growth. This culture positivity is comparable to several published reports, although variation is expected depending on prior antibiotic use, sample collection technique, timing of collection, wound depth and laboratory methodology. Orthopaedic wounds are unique because of the frequent use of metallic implants, dead space, haematoma formation and reduced local vascularity after trauma or surgery. These factors favour bacterial adherence and persistence. Recent orthopaedic SSI studies have also emphasized that microbiological surveillance is essential because the pattern of infecting organisms varies between hospitals and over time [1, 6]. Therefore, the present findings provide useful local evidence for guiding empirical therapy and strengthening infection control practices in orthopaedic wards.

In the present study, Gram-positive cocci constituted 58.92% of isolates, while Gram-negative bacilli accounted for 41.07%. Staphylococcus aureus was the most common isolate, contributing 53.57% of all culture-positive cases. This finding is consistent with the established role of S. aureus as a leading pathogen in orthopaedic wound and implant-associated infections. The organism is well adapted to colonize skin and anterior nares, contaminate surgical wounds and adhere to bone or implant surfaces. Once established, S. aureus may form biofilm, reducing antibiotic penetration and enabling chronic or recurrent infection. Das et al. reported that S. aureus was an important pathogen among SSIs following orthopaedic procedures, while Latha et al. from South India identified MRSA as a major orthopaedic pathogen [1, 7]. In the present study, the predominance of S. aureus also suggests the importance of preoperative skin preparation, aseptic surgical technique, hand hygiene, screening of high-risk patients and appropriate perioperative prophylaxis.

The high proportion of methicillin-resistant Staphylococcus aureus is the most important finding of this study. Among 30 S. aureus isolates, 18 were MRSA, giving an MRSA prevalence of 60%. This indicates that more than half of S. aureus wound infections in this setting were resistant to beta-lactam antibiotics commonly used for MSSA. Similar concerns have been reported in recent orthopaedic studies, where MRSA carriage and infection were associated with postoperative wound complications and implant-related infections [8, 9]. MRSA is clinically important because it is associated with limited treatment options, increased cost and higher risk of persistent infection. Orthopaedic infections caused by MRSA can be difficult to treat due to biofilm formation and the need for prolonged antimicrobial therapy or surgical intervention. The low resistance observed to vancomycin and linezolid in the present study supports their role as reserve drugs for serious Gram-positive infections; however, these agents should be used judiciously to prevent emergence of resistance. Routine MRSA detection and periodic antibiogram review are therefore necessary.

Gram-negative bacilli were also important contributors to postoperative wound infection in this study. Klebsiella pneumoniae and Pseudomonas aeruginosa each accounted for 12.50% of isolates, followed by Escherichia coli at 10.71% and Proteus species at 5.35%. This Gram-negative burden is clinically relevant because many of these organisms are associated with environmental contamination, hospital reservoirs, moist surfaces, urinary or gastrointestinal sources and prolonged hospitalization. Studies from different settings have reported increasing Gram-negative involvement in SSI, particularly in resource-limited settings and in patients with prolonged inpatient stay [10, 11]. Pseudomonas aeruginosa is especially significant in orthopaedic and implant-associated infections because it is intrinsically resistant to several antimicrobials, survives in hospital environments and can form biofilm on implants [12]. The isolation of Klebsiella, E. coli and Proteus also suggests the need for strict wound care, environmental cleaning, rational catheter use and improved postoperative infection prevention practices.

The antibiotic resistance profile observed in this study highlights the importance of local antimicrobial policy. Among Gram-positive cocci, resistance was highest to penicillin (75.75%), followed by cotrimoxazole (54.54%), ciprofloxacin (33.33%) and amoxyclav (30.30%). In contrast, linezolid and vancomycin showed the least resistance. This pattern indicates that penicillin and cotrimoxazole may not be reliable empirical choices for suspected Gram-positive orthopaedic wound infections in this setting. Among Gram-negative bacilli, maximum resistance was observed to ciprofloxacin and ceftriaxone, each 52.17%, followed by cefotaxime (47.82%) and ceftazidime (34.78%). Lower resistance was observed to amikacin and gentamicin, each 13.04%. Similar studies have shown that inappropriate or excessive use of broad-spectrum antibiotics contributes to emergence of multidrug-resistant bacteria in surgical infections [13, 14]. Hence, empirical therapy should be based on local resistance data and modified according to culture and sensitivity results.

Overall, the findings of the present study indicate that postoperative orthopaedic surgical site infections are caused by both Gram-positive and Gram-negative organisms, with S. aureus and MRSA occupying a dominant position. The high MRSA prevalence and considerable resistance among Gram-negative bacilli emphasize the need for integrated infection control and antimicrobial stewardship. Preventive strategies should include optimization of patient-related risk factors such as diabetes, anaemia, malnutrition, smoking and obesity, strict aseptic precautions, appropriate timing of prophylactic antibiotics, careful implant handling, proper wound care and early identification of infection. Current reviews emphasize that SSI prevention requires a multidisciplinary approach involving surgeons, microbiologists, infection control nurses, pharmacists and hospital administrators [15, 16]. Regular bacteriological surveillance of postoperative wound infections should be performed in every tertiary care hospital so that empirical treatment protocols remain updated. The present study therefore reinforces the need for continuous monitoring of MRSA and antibiotic susceptibility patterns in orthopaedic surgical units.

Conclusion

The present study showed that postoperative orthopaedic surgical site infections were predominantly caused by aerobic bacteria, with a culture positivity rate of 56%. Gram-positive cocci were more frequent than Gram-negative bacilli, and Staphylococcus aureus was the leading isolate. A high MRSA prevalence of 60% among S. aureus isolates indicates the need for routine MRSA screening and strict infection control measures. Considerable resistance was observed among both Gram-positive and Gram-negative organisms, particularly to commonly used antibiotics. Regular bacteriological surveillance and antibiotic susceptibility testing are essential for guiding empirical therapy and improving postoperative outcomes.

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