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Aerobic Bacteriological Profile of Orthopaedic Device-Related Infections (ODRI) in a Tertiary Care Hospital

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ABSTRACT

Introduction: Orthopedic Device Related Infections (ODRIs) remains a significant complication in modern trauma and orthopaedic surgery leading to implant failure; in severe cases, it may result in amputation and mortality. Clinical outcomes are complicated by the emergence of multidrug resistant bacteria. The present study has been designed to study the microbiological profile and antibiotic sensitivity pattern in patients with orthopaedic device related infections (ODRIs).
Materials And Methods: The present study was a descriptive observational study carried out from November, 2023 - December, 2024 in the department of Microbiology, Andhra Medical College, Visakhapatnam. Samples were collected aseptically from a total of 102 patients with ODRI and were processed according to standard microbiological protocols.
Results: Of the 102 patient samples tested, 60 (59%) were culture positive and 42 (41%) were culture negative. Of the 60 positive cultures, 54 (90%) were monomicrobial, 6 (10%) were polymicrobial isolates. The total bacterial isolates were 66. Among the 66 (100%) bacterial isolates, 17 (26%) were Gram-positive cocci and 49 (74%) were Gram-negative bacilli. The most common bacteria isolated were *Staphylococcus aureus* 16 (24%) followed by *Pseudomonas aeruginosa* 14 (21%). Among the 49 Gram negative bacilli, 26 (53%) were ESBL producers. Among 16 *S. aureus* isolates, 10 (63%) showed methicillin resistance.
Conclusion: This study emphasizes the importance of aggressive early management of ODRIs, strict adherence to aseptic surgical techniques, routine screening for drug resistant organisms, and the need for tailored antimicrobial strategies.

Keywords: Implant, *Staphylococcus aureus, Pseudomonas aeruginosa,* MRSA, ESBL

INTRODUCTION

Orthopaedic implants are medical devices that are used in fixation and restore the function of accidentally fractured bones, age related degenerative joint diseases, limb length deformities and congenital disabilities. In simpler words, Implants in orthopaedics surgery are mainly used to restore the function of load-bearing joints and decrease the pain so that patients can be mobilized early and the duration of stay in the hospital can be reduced. Introduction of

an implant in the body is always associated with the risk of microbial infections leading to implant failure; in severe cases, it may result in amputation and mortality[1].

Orthopaedic device related infections (ODRIs) are the result of bacteria adhesion to an implant surface and subsequent biofilm formation at the implantation site[2]. The risk factors include advanced age, diabetes mellitus, obesity, smoking and immunosuppression which are patient related. Procedure related risk factors. In recent years, microorganisms identified from the patients with ODRIs have demonstrated growing resistance to routinely used first-line antibiotics. Relevant information regarding the most common causative organism and its sensitivity pattern is required when designing empirical therapy in any clinical setting. Timely administration of antibiotic prophylaxis, strict infection control practices, and formulating an effective antibiotic policy is essential to prevent and treat ODRIs, reducing the spread of antibiotic-resistant strains and improving patient outcomes.

The current study aims to evaluate the microbiological profile and its antibiotic sensitivity pattern in patients with orthopaedic device related infections (ODRIs).

MATERIALS & METHODS

Place of the study: Department of Microbiology, Andhra Medical College, Visakhapatnam.

Study design: Descriptive Observational study.

Duration of study: The present study was conducted from November 2023 to December 2024.

Sample size: The sample size (n) was calculate using the formula

$\mathbf{n = Z^2_{1-\alpha/2}\ (1-P)\ P\ /\ (\varepsilon \times P)^2}$

[Z = 1.96, Expected proportion (P) = 0.79 (where the prevalence is 79%), Relative precision (ε) = 10% i.e. 0.1]

$n = (1.96)^2 \times (1-0.79) \times 0.79 / (0.1 \times 0.79)^2 =$ 102.11 rounded to 102

Study population: Patients with orthopaedic device-related infections (ODRIs), who were diagnosed from the orthopaedic outpatient department and inpatient wards of King George Hospital in Visakhapatnam.

Inclusion criteria: Patients of all age groups, both sexes and open/closed fractures with ODRIs were included.

Diagnostic Criteria for ODRI: According to the Musculoskeletal Infection Society (MSIS) 2011[3] and the Infectious Diseases Society of America (IDSA) 2013[4], the two major criteria were (i) the existence of a sinus tract connecting to the implant and (ii) the isolation of a pathogen through culture from a minimum of two distinct tissue or fluid samples collected from the infected prosthetic joint.

ODRI can be classified as early (<2 weeks), delayed (2-10 weeks) and late (>10 weeks) depending upon the duration of onset of symptoms [5].

Exclusion criteria: Patients with neurovascular deficit, chronic illnesses like tuberculosis, malignancy, those on long term steroids or immunosuppressive therapy and samples devoid of pathogenic bacteria were excluded from the study.

Ethical approval: The present study was accepted, and the Institutional Ethics Committee of Andhra Medical College in Visakhapatnam issued an ethical clearance certificate with serial number 210/EC AMC/SEP 2023.

Sample collection and transport: Following informed written consent, two samples (tissues/synovial fluid/pus) from the implant site/sinus tract were collected aseptically from each patient who presented with clinical evidence of infection (purulent discharge from the sinus tract, drain, or implant). Samples were collected in a sterile universal container, labelled and sent to the Microbiology Laboratory at Andhra Medical College in Visakhapatnam along with the test request form.

Sample processing: All samples were processed using standard microbiological procedures such as direct microscopic examination, inoculation of samples onto Nutrient agar, Blood agar, MacConkey agar, and preliminary identification of growth by colony morphology, Gram stain, Oxidase, catalase tests, and motility. Standard biochemical tests were utilized to characterize genera and species **(Fig-1)**. Antibiotic sensitivity testing (AST) was performed using the Kirby-Bauer disk diffusion (KBDD) method and interpreted according to CLSI M100 ED33 (2023) standards[6]. Resistant organisms were further examined phenotypically for the development of ESBLs among Gram-negative bacilli (GNB) and methicillin resistance among *Staphylococcus aureus*.

ESBL detection: The GNB with a zone of ≤22mm for Ceftazidime 30µg (CAZ) disk were evaluated by combination disc method using Ceftazidime 30µg (CAZ) and Ceftazidime-clavulanic acid 30/10µg (CAC) discs to confirm ESBL formation. An isolate with a zone diameter increase of > 5mm for CAC when compared to CAZ alone will be confirmed for ESBL production.[6] **(Fig-2)**.

Methicillin resistance detection: *S. aureus* was tested for methicillin resistance using a Cefoxitin 30µg (CX) disk. *S. aureus* isolates with a Cefoxitin zone of ≤21mm were identified as Methicillin-resistant (MRSA).[6] **(Fig-3).**

Vancomycin Screen Agar: AST for Vancomycin in *S. aureus* isolates was evaluated using Vancomycin Screen Agar (VSA) on Brain Heart Infusion agar with 6 µg/ml vancomycin. Strains that showed no growth on VSA were considered sensitive, whereas those that showed growth were considered resistant **(Fig-4)**.

Quality control: *Staphylococcus aureus* ATCC 25923, *Escherichia coli ATCC* 25922 and *Pseudomonas aeruginosa* ATCC 27853 strains were used for quality control.

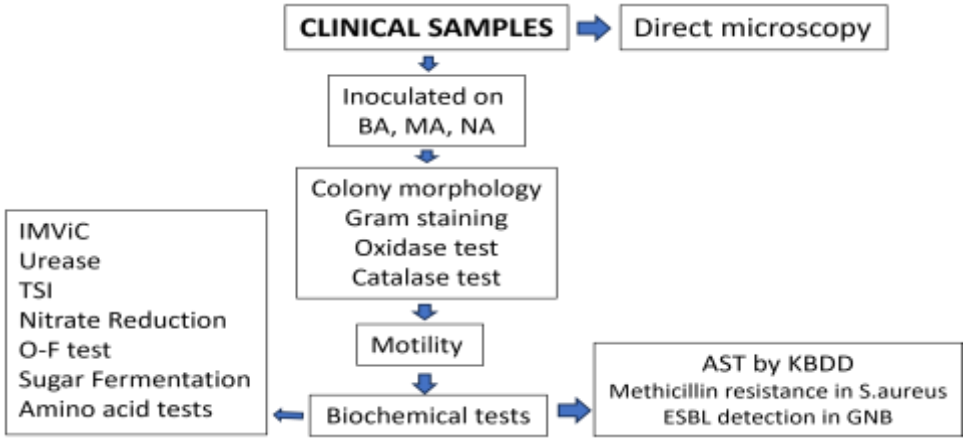

Fig 1: Flow chart showing Sample Processing

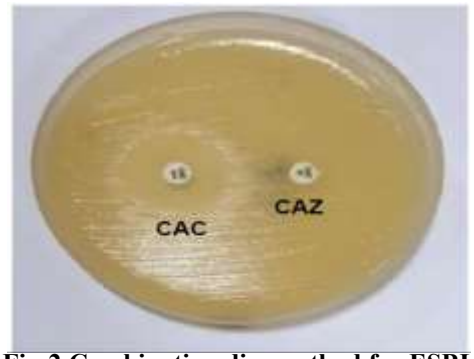

Fig-2 Combination disc method for ESBL

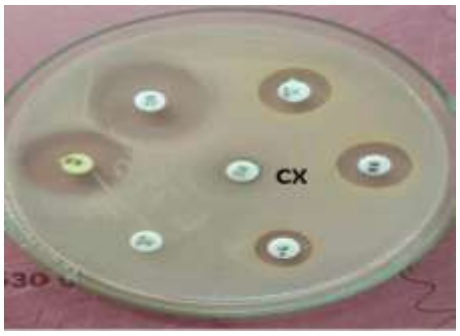

Fig-3 Methicillin resistance detection

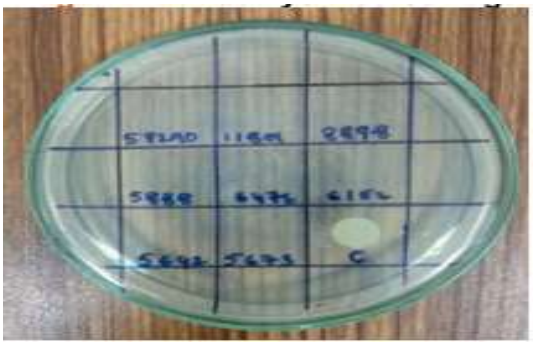

Fig-4 Vancomycin Screen agar test for *S.aureus*

Statistical Analysis

The data was recorded in an excel sheet and the data was calculated as percentages and proportions using descriptive statistics in MS 365 Excel 2021 version.

RESULTS

Out of 102 samples tested, 81(79%) were from males and 21(21%) were from females. The majority of samples were between 40-60 years of age (mean age is 42.15 ± 15.14) **(Fig-5).** Early onset infection was observed in 46 (45%), delayed infection in 27 (27%) and late infection in 29 (28%) cases. Closed fractures were 81(79%) and open fractures were 21(21%).

Among 102 samples processed, 60(59%) were culture positive and 42(41%) were culture negative. Among 60 culture positive samples, 54(90%) samples were monomicrobial and 6(10%) samples were polymicrobial isolates (**Table 1**). Total number of bacterial isolates were 66. The microorganisms isolated in this study are shown in **Table 2**. Out of 66 (100%) bacterial isolates, 17 (26%) were gram-positive cocci and 49 (74%) were gram-negative bacilli. Staphylococcus aureus was the predominant organism isolated, accounting for 16 (24%), followed by Pseudomonas aeruginosa 14 (21%).

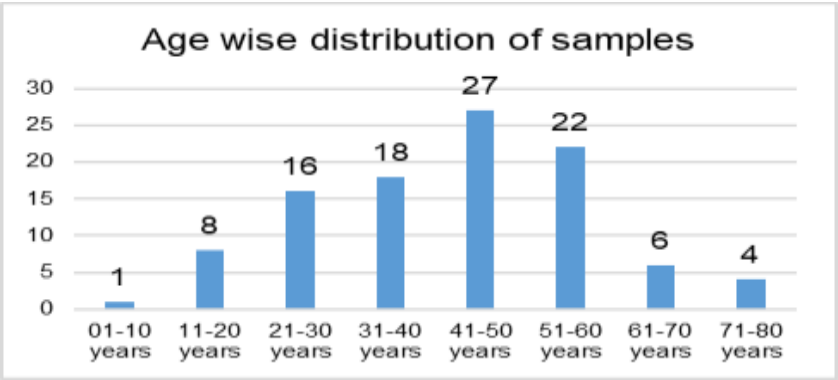

Fig-5 Age wise distribution of samples (n=102)

Table 1: Details of samples and bacterial isolates showed polymicrobial growth in the study (n=6)

S. No.	Organisms Isolated	No. of Samples
1	*Klebsiella pneumoniae + Pseudomonas aeruginosa*	2
2	*Escherichia coli + Pseudomonas aeruginosa*	1
3	*Klebsiella pneumoniae + Enterobacter spp.*	1
4	*Pseudomonas aeruginosa + Acinetobacter baumanii*	1
5	*Pseudomonas aeruginosa + Citrobacter koseri*	1
	Total	6

Table 2: Bacterial profile of organisms isolated in the study (n=66)

S. No.	Name of the organism	No. Of isolates	Percentage
1	*Staphylococcus aureus* *a. MRSA* *b. MSSA*	16 10 (out of 16) 6 (out of 16)	24%
2	*Pseudomonas aeruginosa*	14	21%
3	*Klebsiella pneumoniae*	12	18%
4	*Escherichia coli*	11	17%
5	*Acinetobacter species*	6	9%
6	*Citrobacter species*	3	4%
7	*Proteus species*	2	3%
8	*Enterobacter species*	1	2%
9	*Enterococcus species*	1	2%
	TOTAL	66	100%

Table 3: Antibiotic susceptibility of Gram-Positive cocci (n=17)

Antibiotics	MRSA (n=10)	MSSA (n=6)	Enterococcus spp. (n=1)
Cefoxitin CX (30µg)	0	6 (100%)	-
Erythromycin E (15µg)	5 (50%)	3 (50%)	1 (100%)
Tetracycline TE (30µg)	3 (30%)	3 (50%)	-
Doxycycline DO (30µg)	4 (40%)	3 (50%)	-
Clindamycin CD (2µg)	6 (60%)	4 (67%)	-
Gentamicin GEN (10 µg)	6 (60%)	4 (67%)	-
High–level Gentamicin HLG (120 µg)	-	-	1 (100%)
Ciprofloxacin CIP (5 µg)	5 (50%)	3 (50%)	1 (100%)
Cotrimoxazole COT (25 µg)	5 (50%)	3 (50%)	-
Linezolid LZ (30 µg)	10 (100%)	6 (100%)	1 (100%)
Vancomycin (30 µg)	-	-	1 (100%)
Vancomycin screen agar	10 (100%)	6 (100%)	-

Table 3 showed the antibiotic susceptibility pattern of Gram-positive cocci. Gram-positive cocci showed the maximum sensitivity to Vancomycin (100%), Linezolid (100%), and the lowest sensitivity to Tetracycline (30%).

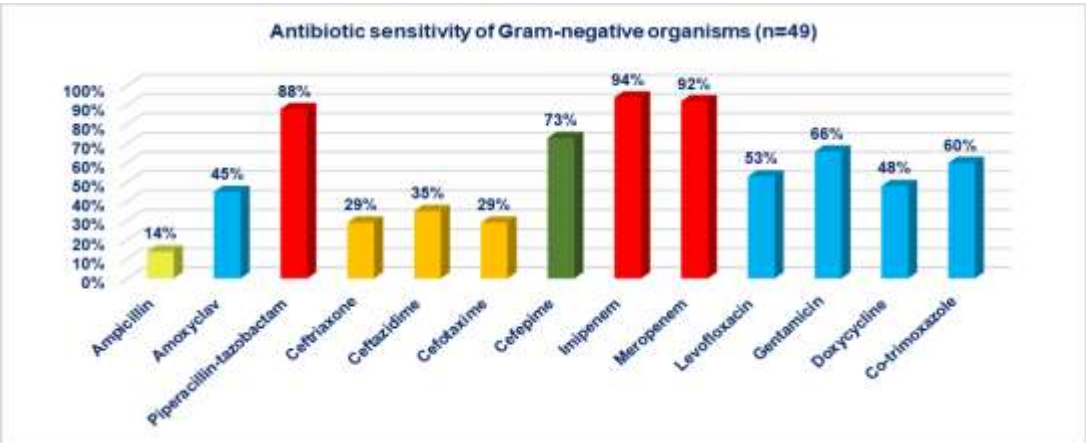

Figure 6: Antibiotic Sensitivity of Gram-negative organisms (n=49)

Figure 6 showed the antibiotic susceptibility pattern of Gram-negative Bacilli, where the GNB showed high sensitivity to Imipenem (94%), Meropenem (92%) followed by Piperacillin-tazobactam (88%) and least sensitivity to Ceftazidime (35%), Ceftriaxone (29%), Cefotaxime (29%) and Ampicillin (14%).

Out of 49 gram-negative isolates, 26 (53%) isolates were identified as ESBL producers **(Table 4).**

Table 4: ESBL producers among Gram negative isolates (n=49)

Microorganisms	Total no. of. Isolates	No. of. ESBL producers in Gram-negative isolates
Escherichia coli	11	9
Klebsiella pneumoniae	12	8
Acinetobacter species	6	4
Pseudomonas aeruginosa	14	3
Citrobacter species	3	1
Proteus species	2	1
Enterobacter species	1	0
Total	**49 (100%)**	**26 (53%)**

DISCUSSION

This study discovered a male preponderance, which was connected to greater incidence of trauma from accidents, sports injuries, and workplace incidents. This study revealed a high prevalence of ODRIs among the actively employed group aged 41-60 years. Open fractures were frequently related to ODRIs, most likely due to direct contamination at the injury site and maintaining sterility during emergency operations.

The current study's culture positive rate was 62%, which was consistent with the findings of Gomez et al., 2003[7] (60%); and Shakthi et al., 2023[8] (72%). The current study reported monomicrobial growth in 90% culture positive samples and polymicrobial growth in 10% culture positive samples, which was in line with the studies done by Roopashree S et al., 2015[9] (93% monomicrobial and 7% polymicrobial); and Cheemala et. al., 2021[10] (85% monomicrobial and 15% polymicrobial). *Staphylococcus aureus* was the predominant isolate in this study which was consistent with studies done by Kiran et al., 2023[11]; Shakthi et al., 2023[8], and Kaipa et al. 2023[12]. In the present study *Pseudomonas aeruginosa* was predominant Gram-negative isolate, which was in line with the studies done by Kaipa et al., 2023[12]; and Sarangi et al., 2019[13].

In this study, Gram-positive isolates demonstrated high sensitivity to Linezolid (100%), Vancomycin (100%), which was consistent with the findings of Sarangi et al., 2019[13]; Saatvika Rathor et al., 2022[14]; and Benazir et al., 2018[20]. In the present study, gram-negative isolates exhibited a high sensitivity to Imipenem (94%), Meropenem (92%), and Piperacillin-tazobactam (88%), which was consistent with the studies done by P Ganesh Perumal et al., 2021[16], Satya Chandrika V et al., 2016[15] and Benazir et al., 2018[20].The present study revealed 50% of Methicillin-resistant Staphylococcus aureus (MRSA) among gram-positive isolates, which was in line with the studies done by Fernandes et al., 2013[17] (50%); Philip et al., 2018[18] (51%); Shakthi et al., 2023[8] (54.8%); and Kaipa et al., 2023[12] (44.7%). The present study revealed that 53% of gram-negative isolates produced ESBLs, which was consistent with the studies done by Satya Chandrika V et al., 2016[15] (60%), Saroj Golia et al., 2017[19] (61%) and P Ganesh Perumal et al., 2021[16] (65%).

CONCLUSION

Orthopaedic Device-Related Infections (ODRI) remain a major problem in clinical practice. Higher incidence of trauma from traffic accidents, sports injuries, and industrial occurrences among the actively

working population, who are more likely to develop injuries requiring orthopaedic procedures. The exposure of bone and soft tissues to the outside environment considerably increases the risk of infection, especially when initial debridement is required. As disinfection may be delayed or insufficient, maintaining sterility remains a concern during emergency treatments. A high prevalence of early postoperative infections suggests shortcomings in aseptic protocols, such as inadequate disinfection and the use of contaminated instruments or implants. Furthermore, the presence of metallic implants may compromise local immune responses, enhancing the risk of infection.

Bacteria such as Staphylococcus aureus, Pseudomonas aeruginosa, and Klebsiella pneumoniae are known for their ability to build biofilms and cause illnesses, particularly in polymicrobial environments. Another cause for concern is the rise of MRSA isolates and ESBL-producing GNB, which complicate treatment because they are resistant to multiple antibiotic classes.

This study emphasizes the necessity for intensive early therapy of ODRIs, strict adherence to aseptic surgical methods, routine screening for ESBL-producing organisms, and targeted antimicrobial regimens. A multidisciplinary approach involving orthopaedic surgeons, microbiologists, infectious disease specialists, and wound care teams for early detection, targeted antimicrobial therapy, surgical debridement, and infection control is required to reduce the burden of ODRI, reduce morbidity, and improve patient care.

Limitations of the Study:

Major limitation of the present study was exclusion of less pathogenic organisms like Coagulase negative staphylococci and Corynebacterium spp. as the criteria were not met as per MSIS and IDSA guidelines. Other limitations were exclusion of identification of anaerobic, fungal, viral pathogens and biofilm production.

Declaration By Authors

Authors Contributions:

First author of the study M Srivalli contributed conceptual design, literature search, collected the data. The second author S Swapna contributed data analysis, Statistical analysis and wrote the first draft of the manuscript. The third author P Ratna Kumari guided the work and corrected the manuscript.

Ethical Approval: Approved

Acknowledgement: None

Source of Funding: Nil

Conflict of Interest: The authors declare no conflict of interest.

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