ORIGINAL ARTICLE

MICROBIOLOGICAL SPECTRUM, ANTIBIOTIC RESISTANCE AND CLINICAL OUTCOMES OF PROSTHETIC JOINT INFECTIONS

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ABSTRACT

Objective: To determine the frequency of prosthetic joint infections (PJIs), causative organisms, their antimicrobial susceptibility profile, and clinical outcomes in patients who underwent joint replacement.

Study Design: Descriptive, cross-sectional study.

Place and duration of study: Sharif Medical City Hospital and Alrazi Healthcare Hospital, Lahore, 04 years (January 2021 to December 2025).

Methodology: The study was done after obtaining the ethical approval. A total of 843 patients with severe joint disease, who met the eligibility criteria for joint replacement surgery, were enrolled written, informed using a nonprobability convenience sampling technique. A written, informed consent was obtained from the participants. Patients received a single preoperative dose of second-generation cephalosporin and a post-operative broad-spectrum oral antibiotic for 1 week. Patients were followed up at 2 weeks, 6 weeks, and 3 months. For patients with PJIs, the causative organisms were isolated on culture, and their antimicrobial susceptibility was tested. Patients were treated either by using debridement, antibiotics and implant retention (DAIR) or two-staged revision. The Statistical Package for the Social Sciences version 27 was used for statistical analysis.

Results: Fifteen (1.8%) patients developed PJIs. Out of 15 infected cases, 7(46.7%) were Staphylococcus aureus, 4(26.6%) were Coagulase-negative Staphylococci(CoNS), 2(13.3%) were Streptococcus species, 1(6.7%) was Pseudomonas aeruginosa, and 1(6.7%) was E. coli. Three (42.9%) isolates of Staphylococcus aureus were methicillin-resistant Staphylococcus aureus (MRSA), while 4(57.1%) were methicillin-sensitive(MSSA). E. coli and Pseudomonas showed no resistance to imipenem, meropenem, and tazocin. Sixty and forty percent of the patients underwent DAIR and two-staged revision, respectively, and recovered completely. The incidence of PJIs was associated with advanced age and diabetes mellitus (p-value = 0.01).

Conclusion: Prosthetic joint infection occurred in 1.8% of joint replacement cases, with gram-positive cocci being the predominant pathogens. Vancomycin, linezolid, tigecycline, carbapenems, and piperacillin-tazobactam showed excellent antimicrobial efficacy. Both DAIR and two-stage revision were effective treatment strategies. Advanced age and diabetes mellitus were important risk factors for PJI.

Keywords: *Joint Prosthesis; Microbial Drug Resistance; Staphylococcus aureus.*

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INTRODUCTION

Prosthetic joint replacement is an extremely effective treatment for end-stage arthritis. It reduces pain significantly and improves functional outcomes of the joint. It is now becoming a popular regime for arthritis in low- to middle-income countries. Complications associated with arthroplasty are prosthetic joint infections (PJI), deep venous thrombosis, pulmonary embolism, prolonged hospitalization, increased healthcare costs, repeated surgical interventions, and substantial patient morbidity[1].

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The global incidence of PJI was reported to be approximately 1–2% following primary joint replacement procedures. This rate may vary depending on patient characteristics, healthcare infrastructure, and surgical practices[2]. In low & middle-income countries, including Pakistan, the increasing number of joint replacement surgeries poses additional challenges due to evolving antimicrobial resistance patterns and limited infection control resources[3]. Factors such as old age, obesity, and diabetes mellitus predispose to PJIs[2].

CAPSULE SUMMARY

The frequency of prosthetic joint infections (PJIs), causative organisms, their antimicrobial susceptibility profile, and clinical outcomes was determined in patients after joint replacement. Prosthetic joint infection(PJI) occurred in 1.8% of joint replacement cases, gram-positive cocci were the predominant pathogens. Vancomycin, linezolid, tigecycline, carbapenems, and piperacillin-tazobactam revealed excellent antimicrobial efficacy. Both DAIR and two-stage revision were effective treatment strategies. Advanced age and diabetes mellitus were important risk factors for PJI.

Prosthetic joint infection is predominantly caused by gram-positive organisms, particularly Staphylococcus aureus and coagulase-negative staphylococci (CoNS). These organisms have the ability to adhere to prosthetic surfaces and form biofilms[3]. This not only protects them from host immune responses but also reduces the efficacy of antimicrobials. Methicillin-resistant Staphylococcus aureus (MRSA) is linked to worse clinical outcomes and their treatment more difficult[4]. Recent literature highlighted that in PJIs, the involvement of gram-negative bacteria like, Escherichia coli and Pseudomonas aeruginosa, is increasing. These organisms are often associated with multidrug resistance, which makes their management more complicated[5]. As antimicrobial resistance patterns vary across different areas, local epidemiological data is essential for empirical antibiotic therapy and better treatment[6]. Inappropriate and excessive use of antibiotics, further increases the global burden of antimicrobial resistance[7]. The management of PJI requires early diagnosis, targeted antimicrobial therapy and appropriate surgical intervention. Treatment strategies such as debridement, antibiotics, and implant retention (DAIR), as well as revision surgeries depend on severity and chronicity of infection[8].

The data on PJIs, their causative organisms, and clinical outcomes is limited in Pakistan. This study was designed to determine the frequency of PJIs, causative organisms, their antimicrobial susceptibility profile, and clinical outcomes in patients who underwent joint replacement. This will help us in selecting appropriate empirical antibiotic therapy, developing local antimicrobial stewardship strategies, improving infection prevention protocols, enhancing patient outcomes, and reducing morbidity and healthcare costs associated with PJIs.

METHODOLOGY

This descriptive cross-sectional study was done at Sharif Medical City Hospital and Alrazi Healthcare Hospital, Lahore from January 2021 to December 2025, after ethical approval. The sample size of 753 was calculated, using 2% prevalence of PJIs, 1% margin of error and 95% confidence interval[9]. After obtaining informed, written consent, 843 patients who underwent knee and hip joint replacements were included using a nonprobability convenience sampling. All the patients who presented in the outpatient department (OPD) with severe joint disease, and fulfilled the criteria for joint replacement, according to clinical and radiological findings, were enrolled. The demographic profile and comorbidities of the patients were noted on a proforma. The exclusion criteria were patients who did not give consent, had evidence of acute infection or were unfit for anesthesia.

All surgeries were performed by the same Orthopedic surgeon with expertise in joint replacement in the modular operation theater, with laminar air flow and high-efficiency particulate filters. All the patients received a prophylactic single intravenous (IV) dose of 1.5g of Zinacef (Cefuroxime; second-generation cephalosporin) preoperatively, 30 minutes before the incision. To reduce the possibility of infection, stringent measures were implemented. Wound closure in all the patients was performed using a stapling device. Zinacef (Cefuroxime) was given in all the patients post-operatively. Initially 1.5g intravenous stat dose was given, followed by 750mg IV BD for 2 days. After discharge, 250mg was given per oral BD for 5 days to 1 week. The post-operative dressings were changed only if wet or soaked. Staple pins were removed after 2 weeks in the hospital setup. Follow-up of the patients was done at 2 weeks, 6 weeks, and 3 months. Prosthetic joint infection was diagnosed by suggestive clinical manifestations, X-rays and synovial fluid analysis & culture. The synovial fluid was sent to the laboratory for analysis and culture. The fluid was inoculated on blood, chocolate and macConkey agar, and incubated at 35-37°C for 24-48 hours. For positive cultures, antibiotic sensitivity testing was done, by the Kirby-Bauer method, using the recommended antibiotics, and was interpreted according to the Clinical and Laboratory Standards Institute (CLSI) guidelines 2026[10]. Prosthetic joint infection was diagnosed based on the Musculoskeletal Infection Society (MSIS) criteria. The patients were diagnosed as having PJI if 1 major criterion is positive or the score of minor criteria is ≥ 6. The score of 2-5 shows possible infection, for which intraoperative criteria could be evaluated[11] (Table 1).

Patients with PJIs were treated either by using DAIR or two-staged revision. In DAIR, patients underwent debridement along with antibiotic therapy and implant retention. In two-staged revision, the infected implant was removed, antibiotics were administered, using an antibiotic spacer, and a new prosthetic joint was implanted.

The Statistical Package for the Social Sciences version 27 was used for statistical analysis. Qualitative variables such as gender,

Table 1: The Musculoskeletal Infection Society (MSIS) Criteria for Prosthetic Joint Infections[11]

	Score	Decision
Major criteria (at least one of the following)		
Two positive cultures of the same organism		
Sinus tract with evidence of communication to the joint or visualization of the prosthesis		Infected
Minor criteria (preoperative)		
Elevated CRP or D-dimer (serum)	2	≥6: Infected
Elevated ESR (serum)	1	
Elevated synovial WBC count or LE (synovial)	3	2–5: Possibly infected
Positive alpha-defensin (synovial)	3	
Elevated synovial PMN (%) (synovial)	2	0–1: Not infected
Elevated synovial CRP (synovial)	1	
Intraoperative diagnosis		
Preoperative score	–	≥6: Infected
Positive histology	3	
Positive purulence	3	4–5: Inconclusive
Single positive culture	2	≤3: Not infected

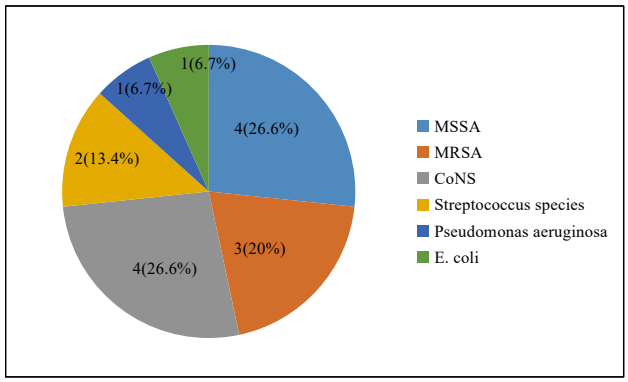

Figure 1: Organisms Isolated from Patients with PJIs

(MSSA: Methicillin-sensitive Staphylococcus aureus, MRSA: Methicillin-resistant Staphylococcus aureus, CoNS: Coagulase-negative Staphylococcus species)

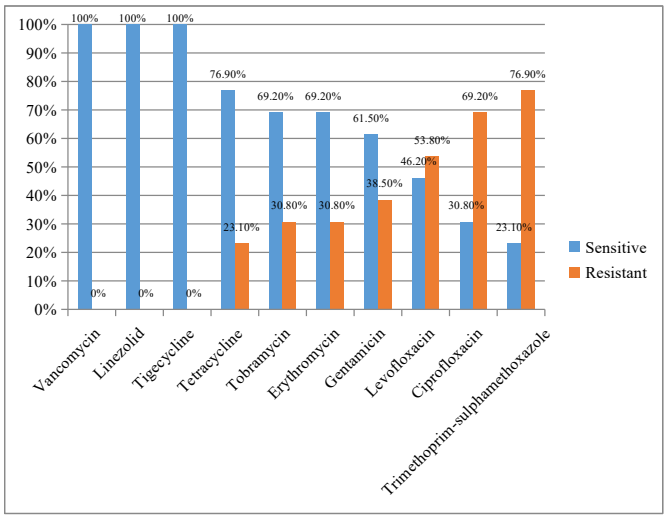

Figure 2: Antibiotic Sensitivity Pattern of Gram Positive Cocci

incidence of prosthetic joint infections, causative organisms, antibiotic sensitivity, and clinical outcomes were presented as frequencies and percentages, whereas quantitative variables such as age and body mass index (BMI) were reported as mean/standard deviation. The association of demographic variables and comorbidities with PJIs was evaluated by the Pearson Chi-square test, considering p-value <0.05 as significant.

RESULTS

The mean age of the patients was 65.3±5.73 years. Out of total 843 patients 72.4% were females, and 27.6% were males. Mean BMI of the patients was 33.9±4.25 kg/m2. Most of the patients were obese (65%), followed by overweight (24.9%) and normal weight (10.1%). Around 356(42.2%) of the patients were diabetic, 200(23.7%) were hypertensive and 90(10.7%) were smokers.

The 843 joint replacements consisted of 387(45.9%) knee and 456(54.1%) hip replacements. Out of these, 15(1.8%) of the patients developed PJIs. Eight (2.1%) of the infections developed in knee replacement patients and 7(1.5%) in hip replacement patients. Out of 15 infected cases, 7(46.7%) were Staphylococcus aureus, 4(26.6%) were CoNS, 2(13.4%) were Streptococcus species, 1(6.7%) was Pseudomonas aeruginosa and 1(6.7%) was E. coli (Figure 1).

The antibiotic sensitivity pattern of Staphylococcus aureus showed that 3(42.9%) isolates of Staphylococcus aureus were MRSA and 4(57.1%) were MSSA. The Streptococcus species

Table 2: Association of Prosthetic Joint Infections with Risk Factors

Risk Factors		Prosthetic Joint Infections		Total	Chi-Square Statistic	p-value
Yes		No		n(%)		
Age (Years)	51-60	1	84	85(10.1)	8.512	0.01*
	61-70	5	526	531(63)		
	71-80	9	218	227(26.9)		
	Total n(%)	15(1.8)	828(98.2)	843(100)		
BMI (kg/m^2)	18.5-24.9 (Normal)	3	82	85(10.1)	4.354	0.11
	25-29.9 (Overweight)	6	204	210(24.9)		
	>30 (Obese)	6	542	548(65)		
	Total n(%)	15(1.8)	828(98.2)	843(100)		
Diabetes mellitus	Diabetic	11	345	356(42.2)	6.048	0.01*
	Nondiabetic	4	483	487(57.8)		
	Total n(%)	15(1.8)	828(98.2)	843(100)		
Hypertension	Hypertensive	3	197	200(23.7)	0.116	0.73
	Nonhypertensive	12	631	643(76.3)		
	Total n(%)	15(1.8)	828(98.2)	843(100)		
Smoking	Smoker	1	89	90(10.7)	0.257	0.61
	Nonsmoker	14	739	753(89.3)		
	Total n(%)	15(1.8)	828(98.2)	843(100)		

Significant p-value

were sensitive to penicillin, ampicillin, amoxicillin and tazocin. The sensitivity pattern of gram-positive cocci to other antibiotics is shown in Figure 2.

E. coli was sensitive to ciprofloxacin, levofloxacin, gentamicin, tobramycin, amikacin, tazacin, imipenem, and meropenem but resistant to amoxicillin-clavulanate, cefotaxime, ceftazidime, ceftriaxone, and trimethoprim-sulphamethoxazole. Pseudomonas aeruginosa had sensitivity to imipenem, meropenem, tazocin, and resistance to ciprofloxacin, levofloxacin, amikacin, tobramycin, gentamicin, and ceftazidime.

Nine (60%) patients with PJIs underwent DAIR, and in 6(40%) patients, a two-staged revision was done. All the patients recovered completely. The incidence of PJIs was associated with advanced age and diabetes mellitus. The association of prosthetic joint infections with the risk factors is shown in Table 2.

DISCUSSION

Prosthetic joint infection is a serious complication that occurs after joint replacement surgery (like hip or knee replacement). It involves infection of the implanted prosthesis and surrounding tissues. The present study reported 1.8% frequency of prosthetic joint infections. Similar rates of PJIs, ranging between 0.5–2% for primary joint replacement procedures, were reported globally[12]. Three studies showed 0.5%, 2.18% and 2.6% prevalence of PJIs[13-15]. Another study revealed 4.03% frequency of PJI after total hip replacement and 2.94% after total knee replacement[16]. The frequency of PJIs was 1.08% according to a study, but the frequency differs in various geographical regions[2].

Our results revealed the mean age of the patients to be 65.3±5.73 years. Similarly, the average age was 67±13.2 years in another study[17]. In our study, 72.4% of the patients were females, and the mean BMI of the patients was 33.9±4.25 kg/m2. In another study, males constituted 51.96% of the study population, and the mean BMI was 30.59 kg/m2[18]. There were 58.2% female patients in a study by da Salva et al[17]. Females constituted 85.2% of the patients, and the average age was 69.2 years[13]. In contrast, in a study, the majority of the patients were males (94.8%). The mean BMI was greater than 30 kg/m2 in most of the cases[19].

Our results showed that 46.7% of the isolated organisms were Staphylococcus aureus, followed by CoNS species (26.6%). Gram-negative rods constituted 13.4% of the organisms. This is in strong agreement with other studies. Staphylococcus was the most common organism in PJIs[16]. In another study, 73.4% of the PJIs were caused by gram-positive cocci, with CoNS being the most predominant. Around 12.8% of the infections were caused by gram-negative rods[18]. da Silva et al. revealed that Acinetobacter was the most common causative organism, followed by Staphylococcus aureus (20.2%). Other organisms were Enterobacter (13.3%), Klebsiella (10%), E. coli (8.3%), Proteus (6.7%), and Pseudomonas (5%)[17]. In another study, CoNS was the most common organism (30%), followed by Staphylococcus aureus (26%)[20]. Staphylococcus aureus was responsible for 42.1% of the cases of PJIs, Streptococcus

species for 36.8%, CoNS for 10.5%, and gram-negative rods for 5.2% of the patients in a study[13]. In our study, 57.1% of the Staphylococcus aureus were MSSA and 42.9% were MRSA. Another study showed 76.2% MSSA and 23.8% MRSA in PJIs[17]. Yoon et al. revealed that out of Staphylococcus species, 75% were MSSA and 25% were MRSA[13]. According to a study, Staphylococcus aureus and CoNS were responsible for causing 50-60% cases of PJIs. Streptococcus and gram-negative rods also caused PJIs, but they were less frequent than Staphylococcus[14]. In another study, gram-positive organisms caused 48.2% and gram-negative rods caused 11.1% of the infections[19]. Tekin-Tas et al. reported MSSA as the most frequent pathogen (35.2%), followed by Klebsiella (23.5%) and Pseudomonas (11.7%) in PJIs[21]. According to a study by Chang et al., Staphylococcus accounted for 58.91% of the cases of PJIs and gram-negative rods were responsible for 14.36% of the cases. Similar to our study, Chang et al. reported that all the gram-positive cocci were sensitive to vancomycin, linezolid, and tigecycline[22]. In our study, E. coli was sensitive, but Pseudomonas was resistant to ciprofloxacin, gentamicin, tobramycin, and amikacin. Both strains were resistant to cephalosporins but sensitive to imipenem and meropenem. In another study, greater than 50% of the gram-negative rods were resistant to cephalosporins, gentamicin, ciprofloxacin and tobramycin[22].

In our study, DAIR was done in 60% and two-staged revision in 40% of the patients with PJIs. These findings are in line with current literature suggesting that DAIR is effective in PJIs[23]. In another study, DAIR was done in 50% of the patients, while 20% of the patients underwent two-staged revision surgery[20]. The frequency of prosthetic joint infections was associated with advanced age and diabetes mellitus in our study. This is consistent with a previous study showing delayed wound healing and impaired immune response in advanced age and diabetic patients[24]. In contrast, diabetes mellitus and obesity were not linked to PJIs according to another study[15]. In our study, high BMI did not show a statistically significant association with PJI. On the contrary, another study found obesity to be an independent risk factor associated with PJI[25]. According to our results, hypertension and smoking were not significantly associated with PJI. Similar results were also reported in another study[9]. The risk factors associated with PJIs in a study were hypertension, smoking, increased BMI, anemia, and heart failure[19].

CONCLUSION

Our study showed 1.8% frequency of prosthetic joint infections after joint replacement. Gram-positive cocci, including Staphylococcus aureus and Coagulase-negative Staphylococcus species, account for the majority of the cases of PJIs followed by gram-negative rods. The antimicrobials of choice for gram-positive cocci are vancomycin, linezolid, and tigecycline. For gram-negative rods, carbapenems and tazocin showed no resistance.. Advanced age and diabetes mellitus are linked to a higher incidence of PJIs.

Recommendations: The findings of this study reinforce the predominance of gram-positive organisms in PJIs, highlight the growing challenge of antimicrobial resistance, and emphasize the importance of infection control practices and evidence-based management strategies.

ETHICAL APPROVAL: *SMDC/SMRC/384A-25/2025.*
CONSENT FOR PUBLICATION: *Written, informed consent was obtained from the study participants.*
AVAILABILITY OF DATA: *Data is available from the corresponding author on a justified request.*
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AUTHORS' CONTRIBUTION

- ***Aqsa Aslam:*** *Drafting the article.*
- ***Farooq Azam Khan:*** *Conception and design, Acquisition of data.*
- ***Muhammad Kashif Jamal:*** *Acquisition of data.*
- ***Bilal Ahmad Abbas:*** *Acquisition of data.*
- ***Sadaf Nasir:*** *Critical revision.*
- ***Maria Aslam:*** *Analysis and interpretation of data.*

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