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Surgeon-Specific Infection Rates and Risk Factors for Prosthetic Joint Infections

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ABSTRACT

Objective: Prosthetic joint infections (PJIs) can lead to extended hospital stays, necessitate additional surgeries, and require antimicrobial treatment, thereby increasing costs and causing significant morbidity. This study aims to ascertain surgeon-specific infection rates and identify risk factors associated with PJIs.

Materials and Methods: This research was conducted with two study arms between January 1, 2017, and February 28, 2019. In the first arm, all cases undergoing primary total knee and hip arthroplasty by the same surgeon were prospectively included and monitored for the development of PJIs. In the second arm, all patients admitted to the same surgeon due to PJI were included.

Results: The first arm comprised 152 patients, of whom five developed PJIs (3.2%). Risk factors for PJI development included diabetes mellitus (p=0.030), rheumatoid arthritis (p=0.014), superficial surgical wound infections in the same joint (p=0.001), and postoperative hematomas (p=0.008). In the second arm, 23 patients with PJIs were included. Gram-positive microorganisms (84.6%) were the most frequently isolated pathogens. The overall treatment success rate stood at 76%, with a treatment success rate of 72.2% for patients receiving daptomycin.

Conclusion: Effective measures such as perioperative glycemic control, regulation of immunosuppressive drugs, management of anticoagulant therapy, postoperative wound care by trained personnel, adherence to infection control protocols, and tailoring of PJI treatments based on local surveillance data are crucial for preventing PJIs and achieving treatment success.

Keywords: Prosthetic joint infections, daptomycin, risk factors, specific surgeon.

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INTRODUCTION

Joint arthroplasty stands as a highly effective surgical intervention, profoundly enhancing patient's quality of life by alleviating symptoms, optimizing limb or joint function, and promoting enhanced mobility. Conversely, the emergence of prosthetic joint infections (PJIs) gives rise to extended hospitalization periods, necessitates antimicrobial regimens, and elevates the likelihood of recurring surgical procedures, consequently engendering heightened morbidity and financial burdens.[1]

The majority of PJIs manifest within the initial two years post-surgery.[2] The spectrum of causative microorganisms fluctuates in accordance with local epidemiological dynamics and the incubation duration of the infection. The most common microorganisms are staphylococci. Staphylococci are responsible for 42–66% of all PJIs.[3] Gram-negative bacilli are considered causative agents in arthroplasty infections caused by acute or late hematogenous spread. Non-virulent microorganisms, including coagulase-negative staphylococci (CNS), viridans streptococci, gram-positive cocci, and *Corynebacterium spp*., mostly act as causative agents of low-grade infections that develop 3–24 months after surgery.[3]

Previously defined risk factors for PJIs include rheumatoid arthritis, psoriasis, steroid therapy, immunosuppression, malnutrition, obesity, diabetes, advanced age, superficial surgical wound infections, bacteremia, and malignancy.[3–5] Considering these risk factors, it is important to take measures to reduce the risk during the perioperative period.

One of the measures to prevent PJIs is providing surgeons with feedback on infection rates specific to their practices. This study aims to determine local epidemiology, surgeon-specific infection rates, and risk factors for PJIs.

MATERIALS AND METHODS

This prospective study was conducted in two departments: Orthopedics and Traumatology, and Infectious Diseases and Clinical Microbiology at a university hospital. In the first phase of the study, patients who underwent primary arthroplasty performed by a designated surgeon between January 2017 and February 2019 were included. All patients were followed for at least one year to monitor the development of PJI. To identify risk factors for prosthetic joint infections, statistical comparisons were made between patient groups with and without infections. In the second phase of the study, patients from the first arm who developed PJI and those who sought treatment for PJI after undergoing primary arthroplasty at another center between January 2017 and February 2019 were included (Fig. 1). The characteristics of this patient group were assessed, and they were followed for at least one year to evaluate the applied treatment. Patients aged 18 years and older were included.

Demographic data, history of any infection in the last three months, comorbidities, type and location of arthroplasty, potential risk factors for PJIs (such as superficial surgical wound infections of the same joint, prior surgical history of the same joint, previous non-surgical trauma to the same joint, postoperative hematoma, and BMI), indications for primary arthroplasty, PJI stage, clinical symptoms, laboratory findings, number of intraoperative tissue cultures per patient, number of intraoperative joint fluid cultures, microbiological culture results, antibiotic usage in the past two weeks, surgical interventions, antimicrobial treatments, treatment success, follow-up duration, were all recorded.

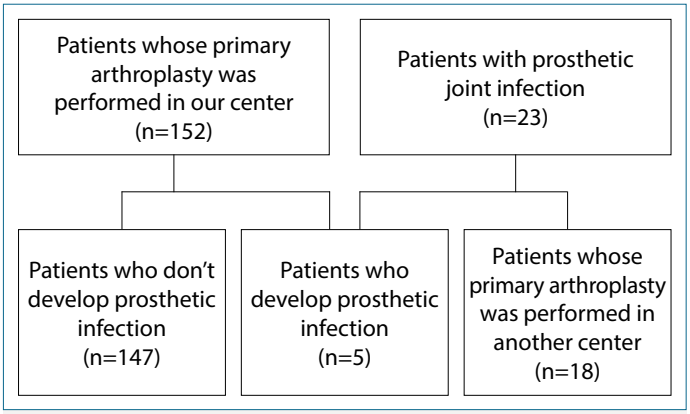

Figure 1. Distribution of patients in the first and second arms of the study.

Diagnostic Protocol

PJI diagnosis was considered for patients exhibiting a sinus tract over the prosthetic joint or experiencing acute or chronic joint pain that developed after a pain-free period following prosthesis implantation. Additionally, elevated erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) levels were considered. The diagnosis of PJI was based on the diagnostic criteria outlined by the Infectious Diseases Society of America (IDSA).[1] However, it was also evaluated in terms of patient distribution, taking into account the diagnostic criteria of the Musculoskeletal Infection Society (MSIS) and the International Consensus.[6,7]

Surgical Antimicrobial Prophylaxis Protocol

All patients (except two patients who received clindamycin due to beta-lactam allergy) were administered cefazolin at 8-hour intervals for 24 hours, with the first dose given within 30 minutes before surgery. In cases of two-stage replacement arthroplasty, a dynamic spacer containing gentamicin was utilized.

Antimicrobial Treatment Protocol

Empirical medical therapy involved administering antibiotic treatment to patients diagnosed with PJI following revision and Debridement, Antibiotics, and Implant Retention (DAIR) procedures. Pathogen-directed antimicrobial therapy was provided based on antimicrobial susceptibility results.

Table 1. Demographic data and characteristics of patients undergoing primary arthroplasty at our center

	Patients with prosthetic infection, n=5 (%)	Patients without prosthetic infections, n=147 (%)	p
Age median (min–max)	68 (50–71)	65 (26–96)	0.522
Gender (male)	1 (20.0)	32 (21.8)	0.925
Follow-up time (months), median (min–max)	26 (17–38)	24 (12–38)	0.796
Prosthesis location			
Knee	4 (80.0)	84 (57.1)	0.398
Hip	1 (20.0)	63 (42.9)	
Comorbid disease	5 (100.0)	101 (68.7)	0.190
Hypertension	4 (80.0)	72 (49.0)	0.367
Diabetes mellitus	3 (60.0)	29 (19.7)	**0.030**
Asthma-COPD	1 (20.0)	16 (10.9)	0.525
Immunosuppressive therapy	1 (20.0)	9 (6.1)	0.292
RA	1 (20.0)	3 (2.0)	**0.014**
Risk factors			
Superficial surgical wound infection of the same joint	5 (100.0)	2 (1.4)	**0.001**
Previous operation history of the same joint	1 (20.0)	46 (31.3)	0.680
Previous non-surgical trauma of the same joint	1 (20.0)	22 (15.0)	0.757
Postoperative hematoma	2 (40.0)	3 (2.0)	**0.008**
BMI median (min–max)	28 (27–42)	31 (19–48)	0.812
Indications for primary arthroplasty			
Ostearthrotosus	4 (80.0)	107 (72.8)	0.721
Trauma	1 (20.0)	19 (12.9)	0.645
Developmental hip dysplasia	0 (0.0)	13 (8.8)	0.487
Avascular necrosis of the femoral head	0 (0.0)	8 (5.4)	0.592

COPD: Chronic obstructive pulmonary disease; RA: Rheumatoid arthritis; BMI: Body mass index.

Definitions

Infections occurring within the first three months after joint replacement were classified as early; infections between 3 to 12 months were considered delayed, and infections manifesting after 12 months were designated as late PJIs.[8] Joint pain was considered acute if lasting less than six weeks, whereas pain lasting longer than six weeks was categorized as chronic.[9]

Treatment Success and Failure: Successful outcomes were defined by normal CRP values, the resolution of clinical and radiological signs of infection, and the absence of further surgical procedures in the subsequent period for the same infection.[7,10,11]

On the other hand, clinical, laboratory, or radiographic findings suggestive of PJI at any time after the operation, the appearance of infection in the joint, the necessity for additional surgical interventions, and patient mortality due to infection were deemed as failed results.[8]

Body Mass Index (BMI, kg/m^2) Limit Values in Adults (8): Weak: <18.5, Normal: 18.5–24.99, Overweight: 25–29.99, Obese: ≥30.[12]

In order to identify the risk factors for PJI, two patient groups, with and without infection after joint arthroplasty, were statistically compared in the first arm of the study.

Statistical Analysis: Statistical analysis was conducted using the Statistical Package for the Social Sciences (SPSS) software, version 22 (SPSS Inc., Chicago, Illinois, USA). Qualitative variables were analyzed using the chi-squared test or Fisher's exact test to determine risk factors for infection development. The Shapiro-Wilk normality test was applied to continuous variables.

For variables with a normal distribution, two independent sample t-tests were used for comparison, while the Mann-Whitney U test was employed for variables without a normal distribution. A significance level of $p<0.05$ was considered statistically significant.

Compliance with Ethical Standards: This study was approved by the Non-Invasive Clinical Research Ethics Committee (Approval date: 12.01.2018, Number: 2018/14). The study was conducted in accordance with the principles of the Declaration of Helsinki.

RESULTS

In the first arm of our study, a designated surgeon performed total hip arthroplasty (THA) and total knee arthroplasty (TKA) on 152 patients. During follow-up, PJI developed in five patients (3.2%) (Fig. 1). The knee PJI rate was 4.5% (n=4), and the hip PJI rate was 1.5% (n=1). Data for patients with and without PJI, including demographic data, location of the prosthesis, and indication for arthroplasty, are presented in Table 1. No significant differences were observed between patients who developed PJI and those who did not in terms of age, gender, prosthesis location, and primary arthroplasty indications. At least one co-morbid disease was present in all patients with PJI and 69% of patients without PJI. Diabetes mellitus (60%, 20%), rheumatoid arthritis (20%, 2%), superficial surgical wound infection of the same joint (100%, 1.4%), and postoperative hematoma (40%, 2%) were more prevalent in the PJI group compared to the non-PJI group. These differences were statistically significant (p=0.030), (p=0.014), (p=0.001), (p=0.008).

In the second arm of the study, there were 23 patients with PJI. Demographic data, clinical and laboratory findings of these patients are shown in Table 2.

The median age of the 23 patients with PJI was 67 (28–83) years, and six were male (26.0%). Of the included patients, 15 (65.2%) underwent knee arthroplasty, and eight (34.7%) had a history of hip prosthesis. At least 22 (95.6%) of the patients had at least one co-morbid disease. The most common co-morbidities were hypertension (60.8%) and diabetes (43.4%). A previous operation history of the same joint (52%) was the most common risk factor. The median BMI of the patients was 29.0 (21–46). Among all patients, 47.8% were classified as overweight. The most common primary arthroplasty indication was osteoarthrosis (69.5%). One (4.3%) patient was a smoker, and one (4.3%) patient tested positive for *Staphylococcus aureus* carriage in the nasal swab. Among the patients, 47.8% were in the early stage of PJIs. The median time for developing an infection after total joint replacement was 7 (1–180) months. The three most common clinical symptoms were joint swelling (60.8%), discharge (60.8%), and chronic joint pain (47.8%). All patients had elevated CRP and ESR upon admission. Thirteen patients (56.5%) underwent two-stage replacement arthroplasty, while 10 patients (43.4%) underwent DAIR. Positive cultures were obtained from perioperative or intraoperative specimens in 13 patients (56.5%). The median preoperative antibiotic treatment duration was 8.5 days (4–25), and after revision, the median follow-up time was 23 (14–38) months.

Intraoperative tissue specimens were obtained from 22 (95.6%) patients, and the median number of intraoperative tissue cultures sent per patient was 3 (1–7), with seven (31%) yielding positive cultures. Preoperative swab cultures were taken from ten patients (43.4%), with four (40%) showing positive growth. Preoperative joint fluid cultures were sent from seven patients (30.4%), and three (42%) had positive results. The distribution of isolated microorganisms according to the stage of prosthetic infection is shown in Table 3. Gram-positive bacteria were most frequently isolated in early-stage prosthetic infections. The two Gram-negative bacteria isolated were associated with late-stage infections.

Out of the patients, 20 (86.9%) received empirical treatment, while three (13.0%) were treated with pathogen-directed antimicrobial therapy. In postoperative empirical antibiotic treatment, 13 (56.5%) patients were given Daptomycin (6 mg/kg IV q24)/Piperacillin-Tazobactam (4.5 gm IV q8h), while three (13.0%) patients received Daptomycin (6 mg/kg IV q24)/Ertapenem (1 gm IV q24h). In the postoperative period, Daptomycin (6 mg/kg IV q24)//Rifampicin (600 mg PO q24h) treatment was administered to three (13.0%) patients as an agent-oriented approach. Antibiotic treatment was continued with oral maintenance therapy in 17 (73.9%) patients and was completed parenterally in six (26%) patients.

Treatment success was achieved in 16 patients (76.1%). The success rate was 75% in two-stage replacement arthroplasty operations and 77.7% in DAIR operations. Treatment success was achieved in all five patients whose arthroplasty was performed by the same surgeon. Among the treatment-failed patients, three (60%) underwent two-stage replacement arthroplasty, while two (40%) were patients who underwent DAIR surgery. The treatment success rate for patients receiving Daptomycin was 72.2%.

When patients were evaluated according to MSIS, International Consensus, and IDSA diagnostic criteria, 16 (69.5%) patients met the MSIS diagnostic criteria, 18 (78.2%) patients meeting the International Consensus criteria, but all patients met the IDSA diagnostic criteria.

Table 2. Demographic data, clinical, and laboratory findings of patients with prosthetic joint infection

	n=23 (%)
Age median (min–max)	67 (28–83)
Gender (male)	6 (26.0)
Prosthesis location	
Knee	15 (65.2)
Hip	8 (34.7)
Comorbid diseases	22 (95.6)
Hypertension	14 (60.8)
Diabetes mellitus	10 (43.4)
Other diseases	13 (57.3)
Risk factors	
Previous superficial wound infection of the same joint	13 (56.5)
Previous operation history of the same joint	12 (52.1)
A history of infection in the past 3 months	7 (30.4)
Previous prosthetic infection of the same joint	7 (30.4)
BMI median (min–max)	29.0 (21–46)
Indications for primary arthroplasty	
Osteoarthrotosus	16 (69.5)
Trauma	4 (17.3)
Infection stage	
Late stage	9 (39.1)
Early stage	11 (47.8)
Delayed stage	3 (13.0)
Duration of infection after total joint replacement (months), median (min–max)	7 (1–180)
Clinical symptom	
Swelling in the joint	14 (60.8)
Discharge in the joint	14 (60.8)
Chronic joint pain	11 (47.8)
Redness in the joint	9 (39.1)
Acute joint pain	9 (39.1)
Fistula in the joint	8 (34.7)
Laboratory	
White blood cell (µL) median (min–max)	7970 (5240–14830)
C-Reactive protein (mg/L) median (min–max)	38 (12–194)
Erythrocyte sedimentation rate (mm/h) median (min–max)	51 (16–138)
Surgical procedure performed	
Two-stage replacement arthroplasty	13 (56.5)
Debridement, antibiotics and implant retention	10 (43.4)
Follow-up time (months), median (min–max)	23 (14–38)

BMI: Body mass index.

Table 3. Isolated microorganisms based on infection stage in patients with cultured samples

Isolated microorganisms	Total		Early		Delayed		Late	
	n	%	n	%	n	%	n	%
Gram positive	**11**	**84.6**	**6**	**46.1**	**1**	**7.6**	**4**	**30.7**
MRSA	1	7.6	1	7.6	0	0.0	0	0.0
MSSA	3	23.0	1	7.6	1	7.6	1	7.6
MRSE	3	23.0	3	23.0	0	0.0		
MRCNS	2	15.3	1	7.6	0	0.0	1	7.6
Enterococcus spp.	2	15.3	0	0.0	0	0.0	2	15.3
Gram negative	**2**	**15.3**	**0**	**0.0**	**0**	**0.0**	**2**	**15.3**
Escherichia coli	2	15.3	0	0.0	0	0.0	2	15.3
Total	**13**	**100**	**6**	**46.1**	**1**	**7.6**	**6**	**46.1**

MRSA: Methicillin-resistant *Staphylococcus aureus*; MSSA: Methicillin-susceptible *Staphylococcus aureus*; MRSE: Methicillin-resistant *Staphylococcus epidermidis*; MRCNS; Methicillin-resistant coagulase-negative *Staphylococci*.

DISCUSSION

Many of the modifiable risk factors for prosthetic infections are infection control measures applied to various surgical site infections. Therefore, it is important to understand the local epidemiology, monitor compliance with infection control measures, and provide feedback to relevant surgeons through regular surveillance.[13]

In the first arm of this study, diabetes was identified as a risk factor for the development of PJIs. Elevated glucose levels can increase biofilm formation, impair leukocyte function, and induce microvascular changes that may affect wound healing and the development of superficial surgical site infections in patients with diabetes.[14] In a cohort of 20,171 patients who underwent total hip and knee arthroplasty procedures, a significantly higher risk of PJIs was observed among patients diagnosed with diabetes, those using diabetes medications, and those with perioperative hyperglycemia.[15] It has been reported that setting specific targets for perioperative glycemic control and closely monitoring blood glucose can reduce the rate of PJI.[16] While diabetes itself is not preventable, its associated risk can be mitigated by implementing glycemic control during the perioperative period.

This study also identified rheumatoid arthritis as another risk factor. Previous research conducted over the past decade has consistently highlighted rheumatoid arthritis as a risk factor for PJI.[5,17] This connection might be attributed to the widespread use of systemic immunosuppressive agents among patients with rheumatoid arthritis, who are often elderly and dealing with various comorbidities. It is recommended not to alter the treatment of non-biological agents used for rheumatic diseases and to consider a temporary pause in biological agents, depending on the specific biological agent and rheumatic condition. Preoperative dose adjustment is also advised due to the elevated risk of perioperative PJI in patients undergoing high-dose glucocorticoid therapy.[18,19]

In this study, postoperative hematoma was identified as increasing the risk of PJI by a factor of 97, corroborated by findings from prior research.[4] Two distinct risks can be associated with postoperative hematomas. The first pertains to anticoagulant treatments employed for therapeutic reasons, while the second relates to venous thromboembolism prophylaxis. Avoidance of aggressive anticoagulation and the utilization of low-dose anticoagulants for prophylaxis have been proven effective in preventing postoperative hematomas.[13] It is advisable to determine the duration of anticoagulant prophylaxis on a case-by-case basis, considering the risk-benefit ratio.[20] Several factors, such as ensuring patient hemodynamics, implementing appropriate surgical techniques, irrigation methods, and employing suitable suture materials, could contribute to the development and management of hematomas.[21]

In the initial phase of this study, it was observed that superficial surgical site infections (SSSI) significantly raised the risk of prosthetic joint infections. All five instances of PJIs detected in arthroplasty procedures conducted by a single surgeon were linked to preceding superficial SSSIs. A notably high rate (56%) of SSSI was noted among all 23 PJI patients. Two separate case-control studies, involving 189 and 924 patients respectively, established an association between SSSI and the risk of PJI.[17,22] Therefore, performing post-operative wound care by trained professionals and adhering to infection control measures during wound care, both in the hospital and at home, can contribute to a reduction in infection risk.

Among the patients monitored for prosthetic joint infection, the two most prevalent symptoms were wound discharge (60.8%) and joint swelling (60.8%). In general, early-stage prosthetic joint infections often manifest through wound site discharge, pain, swelling, and induration at the implant site.[23] These findings affirm that a majority of prosthetic joint infections (47.8%) in this study occurred within the initial three months following implantation.

In this study, the median duration from joint replacement to infection development was 7 (1–180) months. The most frequent (47.8%) occurrence was in early-stage prosthetic joint infections. Bacteria commonly associated with early-stage infections are usually contracted during the surgical procedure.[23] These infections can be prevented by administering appropriate perioperative antimicrobial prophylaxis, cleansing the incision area with suitable antiseptic solutions and techniques, employing proper dressing, adhering to laminar airflow, and implementing other infection control practices.

Within this study, no growth was observed in 43.4% (n=10) of our patients. Literature indicates that the pathogen cannot be detected in approximately 7% of patients.[24] Factors such as prior antimicrobial treatment, limited incubation time for tissue cultures (maximum of three days), absence of anaerobic culture, omission of samples for microorganisms that do not thrive in standard aerobic or anaerobic environments (for example, fungi or mycobacteria), and delayed delivery of samples to the laboratory can all contribute to false negative culture results.

The practicality of applying specific surgical methods remains a subject of controversy.[1] Success rates for debridement of infected prostheses range widely, from 14% to 100%.[1] In a retrospective evaluation of 340 patients who underwent DAIR for late acute PJI in a multicenter study, an overall failure rate of 45% was observed.[25] An assessment of the success rates of two-stage replacement arthroplasty for the hip reported figures between 87% and 100%.[8] In the present study, treatment success rates were comparable for patients undergoing DAIR and two-stage replacement arthroplasty (77.7% for DAIR and 75% for two-stage replacement arthroplasty). Beyond surgical methods, the timely administration of appropriate antimicrobial therapy plays a pivotal role in ensuring the success of PJI treatment. This study saw a higher application rate of treatment combinations containing daptomycin (70%). A retrospective study spanning two years, involving 16 patients treated with daptomycin for resistant staphylococcal PJIs,[26] yielded a treatment success rate of 87.5% (14 out of 16 patients). A recent systematic review focusing on 162 patients with total knee and hip PJIs who received daptomycin treatment[27] reported a median treatment success rate of 70%. The study found treatment success rates ranging from 63% to 80% for patients undergoing DAIR, and 73% to 76% for those undergoing two-stage replacement arthroplasty. The current study's treatment success rates for patients receiving daptomycin (75% and 70%) aligned with those of previous research. This study identified gram-positive microorganisms (84.6%) as the most frequently isolated pathogens in knee and hip PJIs. Methicillin resistance was noted in 54% of cases. Thus, the inclusion of daptomycin in empirical treatment is a reasonable option, especially for patients with renal failure or glycopeptide antibiotic intolerance, as daptomycin demonstrates superior efficacy against both growth-phase and stationary-phase bacteria within biofilms compared to other antibiotics such as vancomycin, linezolid, and tigecycline.[28] However, it's essential to acknowledge the limitation of a limited case quantity in this study.

In our center, 80% of infected patients who underwent primary arthroplasty presented with early-stage prosthetic joint infections. All five infected patients received DAIR, and a 100% treatment success rate was achieved. Among patients who had primary arthroplasty performed at another center, 50% were diagnosed with late-stage prosthetic joint infections. Of these infected patients, five (27.7%) underwent DAIR, while 13 (72.2%) opted for two-stage replacement arthroplasty. A treatment success rate of 61% was achieved for 11 patients, with the success of two patients remaining unevaluated. The high treatment success rate for patients undergoing primary arthroplasty at our center might be attributed to factors such as early intervention, close follow-up, the absence of prior prosthetic joint infection episodes, and no prior joint surgeries. Conversely, delayed intervention, previous occurrences of prosthetic joint infections, and multiple joint surgeries could potentially reduce treatment success rates.

Despite numerous studies on prosthetic joint infections spanning several years, there remains a lack of adequate standardized diagnostic criteria. In recent years, various groups, including the International Consensus IDSA MSIS, have proposed or endorsed definitions for diagnosing prosthetic joint infections. While these definitions may differ, a study indicated significant agreement between IDSA and MSIS definitions.[29] When evaluating patients in this study based on the MSIS, International Consensus, and IDSA diagnostic criteria:

- 16 patients (69.5%) met the MSIS diagnostic criteria, while 7 patients (30.4%) couldn't be evaluated due to missing data.
- 18 patients (78.2%) met the International Consensus diagnostic criteria, and five patients (21.8%) couldn't be evaluated due to missing data.
- All 23 patients (100%) met the IDSA diagnostic criteria.

Synovial fluid sampling was omitted in 22 patients, and histopathological examination of periprosthetic tissue was not conducted in seven patients. Consequently, certain criteria, such as the presence of acute inflammation in histopathological periprosthetic tissue examination, which are supportive criteria for MSIS and the International Consensus, including leukocyte count in synovial fluid and increased neutrophil percentage, could not be evaluated in some patients. Given that our hospital's routine laboratory and clinical practices indicated a higher diagnostic rate according to the IDSA criteria, it was deemed more appropriate to use the IDSA diagnostic criteria for diagnosing prosthesis infections at our center.

This study has several limitations. Firstly, the follow-up period for all patients was at least one year, with a median of two years, resulting in unknown late outcomes for some patients. Secondly, only seven (30.4%) patients underwent preoperative diagnostic examinations and joint fluid culture. Additionally, culture was unsuccessful in 44% of cases. Factors such as prior antimicrobial treatment, three-day incubation time for tissue cultures, lack of anaerobic culture, absence of samples for microorganisms that don't grow in typical aerobic or anaerobic environments (e.g., fungi or mycobacteria), and delayed delivery to the laboratory could contribute to false negative culture results. Undoubtedly, this impacts the treatment's success. Thirdly, the sample size was insufficient in the first arm of the study.

CONCLUSION

In Summary

1. Risk factors for PJI include DM, rheumatoid arthritis, superficial surgical wound infections of the same joint, and postoperative hematomas.
2. While diabetes and rheumatoid arthritis are unavoidable risk factors, perioperative glycemic control, immunosuppressive drug regulation, and anticoagulant management can mitigate these risks.
3. Preventing PJIs can involve providing wound care training for patients, their families, and staff during the postoperative period.
4. Empirical therapy incorporating daptomycin in combination therapy might enhance treatment success.

Peer-review: Externally peer-reviewed.

Ethics Committee Approval: The Erciyes University Non-Invasive Clinical Research Ethics Committee granted approval for this study (date: 12.01.2018, number: 2018/14).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Author Contributions: Concept – NM, AUK, ZTY, AG, GKÜ; Design – NM, AUK, ZTY, AG, GKÜ; Supervision – NM, AUK, ZTY, AG, GKÜ; Materials – NM, AUK, AG; Data Collection and/or Processing – NM, AUK, AG; Analysis and/or Interpretation – NM, AUK, AG, ZTY, GKÜ; Literature Search – NM, AUK; Writing – NM; Critical Reviews – NM, AUK, AG, ZTY, GKÜ.

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REFERENCES

1. Osmon DR, Berbari EF, Berendt AR, Lew D, Zimmerli W, Steckelberg JM, et al; Infectious Diseases Society of America. Diagnosis and management of prosthetic joint infection: Clinical practice guidelines by the Infectious Diseases Society of America. Clin Infect Dis 2013; 56(1): e1–e25.
2. Honkanen M, Jämsen E, Karppelin M, Huttunen R, Eskelinen A, Syrjänen J. Periprosthetic Joint Infections as a Consequence of Bacteremia. Open Forum Infect Dis 2019; 6(6): ofz218. [CrossRef]
3. Arisoy A. Kemik ve eklemlerin protez enfeksiyonları. In: Enfeksiyon hastalıkları ve mikrobiyolojisi, sistemlere göre enfeksiyonlar. Topçu AW, Söyletir G, Doğanay M, editors. Nobel Tıp Kitabevleri: İstanbul; 2017.p.1250–7.
4. Berbari EF, Osmon DR, Carr A, Hanssen AD, Baddour LM, Greene D, et al. Dental procedures as risk factors for prosthetic hip or knee infection: a hospital-based prospective case-control study. Clin Infect Dis 2010; 50(1): 8–16. [CrossRef]
5. Cipriano CA, Brown NM, Michael AM, Moric M, Sporer SM, Della Valle CJ. Serum and synovial fluid analysis for diagnosing chronic periprosthetic infection in patients with inflammatory arthritis. J Bone Joint Surg Am 2012; 94(7): 594–600. [CrossRef]
6. Parvizi J, Gehrke T, Chen AF. Proceedings of the international consensus on periprosthetic joint infection. Bone Joint J 2013; 95-B(11): 1450–2. [CrossRef]
7. Parvizi J, Zmistowski B, Berbari EF, Bauer TW, Springer BD, Della Valle CJ, et al. New definition for periprosthetic joint infection: from the Workgroup of the Musculoskeletal Infection Society. Clin Orthop Relat Res 2011; 469(11): 2992–4.
8. Tande AJ, Patel R. Prosthetic joint infection. Clin Microbiol Rev 2014; 27(2): 302–45. [CrossRef]
9. Hübscher O, Pattern recognition in arthritis. In: Rheumatology. Hochberg MC, Silman AJ, Smolen JS, Weinblatt ME, Weisman MH, editors. Elsevier; 2015. p. 225. [CrossRef]
10. Ascione T, Balato G, Mariconda M, Rotondo R, Baldini A, Pagliano P. Continuous antibiotic therapy can reduce recurrence of prosthetic joint infection in patients undergoing 2-Stage exchange. J Arthroplasty 2019; 34(4): 704–9.

11. Balato G, Ascione T, Rosa D, Pagliano P, Solarino G, Moretti B, et al. Release of gentamicin from cement spacers in two-stage procedures for hip and knee prosthetic infection: An *in vivo* pharmacokinetic study with clinical follow-up. J Biol Regul Homeost Agents 2015; 29(4 Suppl): 63–72.
12. World Health Organization (WHO). Obesity: Prevention and management of the global epidemic. Report of a WHO consultation. World Health Organization Tech Rep Ser 2000; 894: 1–253.
13. Alamanda VK, Springer BD. The prevention of infection: 12 modifiable risk factors. Bone Joint J 2019; 101-B(1_Supple_A): 3–9. [CrossRef]
14. Berbudi A, Rahmadika N, Tjahjadi AI, Ruslami R. Type 2 Diabetes and its Impact on the Immune System. Curr Diabetes Rev 2020; 16(5): 442–9. [CrossRef]
15. Maradit Kremers H, Lewallen LW, Mabry TM, Berry DJ, Berbari EF, et al. Diabetes mellitus, hyperglycemia, hemoglobin A1C and the risk of prosthetic joint infections in total hip and knee arthroplasty. J Arthroplasty 2015; 30(3): 439–43.
16. Palermo NE, Garg R. Perioperative management of diabetes mellitus: Novel Approaches. Curr Diab Rep 2019; 19(4): 14. [CrossRef]
17. Peel TN, Dowsey MM, Daffy JR, Stanley PA, Choong PF, Buising KL. Risk factors for prosthetic hip and knee infections according to arthroplasty site. J Hosp Infect 2011; 79(2): 129–33. [CrossRef]
18. Goodman SM, Springer B, Guyatt G, Abdel MP, Dasa V, George M, et al. 2017 American College of Rheumatology/American Association of hip and knee surgeons guideline for the perioperative management of antirheumatic medication in patients with rheumatic diseases undergoing elective total hip or total knee arthroplasty. Arthritis Rheumatol 2017; 69(8): 1538–51. [CrossRef]
19. George MD, Baker JF, Winthrop K, Alemao E, Chen L, Connolly S, et al. Risk of biologics and glucocorticoids in patients with rheumatoid arthritis undergoing arthroplasty: A cohort study. Ann Intern Med 2019; 170(12): 825–36.
20. Marmor S, Kerroumi Y. Patient-specific risk factors for infection in arthroplasty procedure. Orthop Traumatol Surg Res 2016; 102(1 Suppl): S113–9. [CrossRef]
21. Glotzbecker MP, Garg S, Akbarnia BA, Vitale M, Hillaire TS, Joshi A. Surgeon practices regarding infection prevention for growth friendly spinal procedures. J Child Orthop 2014; 8(3): 245–50. [CrossRef]
22. Berbari EF, Hanssen AD, Duffy MC, Steckelberg JM, Ilstrup DM, Harmsen WS, et al. Risk factors for prosthetic joint infection: case-control study. Clin Infect Dis 1998; 27(5): 1247–54. [CrossRef]
23. Gül HC, Artuk C, Yıldız C. The diagnosis, treatment and management of prosthetic joint infections. J Clin Anal Med 2013; 4(4): 332–9.
24. Berbari EF, Marculescu C, Sia I, Lahr BD, Hanssen AD, Steckelberg JM, et al. Culture-negative prosthetic joint infection. Clin Infect Dis 2007; 45(9): 1113–9. [CrossRef]
25. Wouthuyzen-Bakker M, Sebillotte M, Lomas J, Taylor A, Palomares EB, Murillo O, et al; ESCMID Study Group for Implant-Associated Infections (ESGIAI). Clinical outcome and risk factors for failure in late acute prosthetic joint infections treated with debridement and implant retention. J Infect 2019; 78(1): 40–7. [CrossRef]
26. Chang YJ, Lee MS, Lee CH, Lin PC, Kuo FC. Daptomycin treatment in patients with resistant staphylococcal periprosthetic joint infection. BMC Infect Dis 2017; 17(1): 736. [CrossRef]
27. Telles JP, Cieslinski J, Tuon FF. Daptomycin to bone and joint infections and prosthesis joint infections: a systematic review. Braz J Infect Dis 2019; 23(3): 191–6. [CrossRef]
28. Smith K, Perez A, Ramage G, Gemmell CG, Lang S. Comparison of biofilm-associated cell survival following *in vitro* exposure of meticillin-resistant *Staphylococcus aureus* biofilms to the antibiotics clindamycin, daptomycin, linezolid, tigecycline and vancomycin. Int J Antimicrob Agents 2009; 33(4): 374–8. [CrossRef]
29. Melendez D, Osmon D, Greenwood-Quaintance K, Hanssen A, Patel R. Comparison of the 2011 Musculoskeletal Infection Society (MSIS), the 2013 International Consensus Meeting (ICM) and the Infectious Diseases Society of America (IDSA) Diagnostic Criteria for Prosthetic Joint Infection (PJI). Opem Forum Infect Dis 2014; 1(Suppl 1): S196. [CrossRef]