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Original Article

Incidence and Factors Associated with Prosthetic Joint Infection Following Hip or Knee Revision Arthroplasty: A Retrospective Cohort Study

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Abstract

Objective: To determine the incidence of prosthetic joint infection (PJI) for patients who have undergone a hip or knee revision arthroplasty within a specific period of follow-up and to establish baseline host-related factors (prior skin infection, dental disease, diabetes, obesity, smoking, age, sex, and joint type) that are associated with the development of PJI.

Methodology: This Retrospective cohort study was conducted in the Department of Orthopedic Surgery at MTI Bacha Khan Medical College and Mardan Medical Complex, Mardan, in 2025. We reviewed medical records. Between January 2024 and August 2024. 40 patients undergoing elective revision hip or knee arthroplasty at MTI Bacha Khan Medical College and Mardan Medical Complex, Mardan, from January to August 2023. We followed patients for a mean of one year for PJI according to EBJIS 2021 criteria. We assessed associations using Fisher's exact test and independent t-tests. We used a parsimonious logistic regression model to evaluate age, diabetes, and dental disease. $P < 0.05$ was considered significant.

Results: Prior skin infection (22.5%), dental disease (32.5%), diabetes (27.5%), obesity (42.5%), and smoking (50.0%) were observed. Five patients (12.5%) developed PJI. Prior skin infection was strongly associated with PJI (55.6% vs. 0%; Fisher's exact $p < 0.001$; corrected OR, 77.0; 95% CI, 3.6–1640.5). Multivariable modeling was not feasible because of perfect separation.

Conclusion: Prior skin infection was strongly associated with PJI but warrants cautious interpretation because of the small sample and wide confidence interval. Age, diabetes, and dental disease were not significant. These findings support comprehensive preoperative optimization, including dermatological, metabolic, and oral health assessment.

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Introduction

Prosthetic joint infection (PJI) is one of the most serious complications of total joint arthroplasty (TJA), resulting in prolonged hospitalization, increased healthcare costs, repeated revision procedures, and poorer functional outcomes [1-3]. The prevalence of PJI after primary arthroplasty is typically around 0.5%-2%, but is much greater after revision surgery, especially in older patients and those who have several comorbidities [4]. PJI is a multifactorial complication, which results from a combination of host susceptibility, microbial virulence, and perioperative factors [5]. There are a few host-related factors that may be potentially modifiable and that can contribute to PJI risk, and hence are targets for optimization prior to surgery [6]. Diabetes and its related hyperglycemic control status can lead to a decrease in immune function and wound healing, which may predispose patients to postoperative infections [7,8]. Oral disease has also been investigated as a potential source of hematogenous microbial dissemination, but its clinical contribution to PJI is not fully understood [9]. Likewise, skin infections may reflect skin barrier disruption or contact with pathogens such as *Staphylococcus aureus*, which plays an important role in prosthetic infections [10]. Although these potentially modifiable factors are important, adequate characterization of these factors and their association with PJI in patients undergoing revision arthroplasty in Pakistan remains limited [11,12]. Risk assessment is especially important in patients undergoing revision arthroplasty because they are often older, have more comorbidities, and have prior exposure to orthopedic implants. Knowing patients who have easily determined risk factors preoperatively could help in identifying those that will benefit from further evaluation or optimization prior to revision surgery. But data relating to any of the above, such as skin infection, dental disease, diabetes, and other host factors, with PJI after revision arthroplasty is scarce in Pakistan. The novelty of the present study was the evaluation of these potentially modifiable host-related risk markers in hip or knee revision arthroplasty patients at a tertiary care hospital in Pakistan. In addition to estimating the incidence of confirmed PJI during follow-up, this study examined associations between previous skin infection, dental disease, diabetes, obesity, smoking, age, sex, and joint type and subsequent PJI. The findings may provide preliminary local evidence to support more systematic preoperative risk assessment and optimization in patients undergoing revision arthroplasty.

Materials and Methods

This retrospective cohort study was conducted in the Department of Orthopedic Surgery at MTI Bacha Khan Medical College and Mardan Medical Complex, Mardan, a tertiary-care hospital. From January 2024 and August 2024. The study protocol received approval from the Institutional Review Board of MTI Bacha Khan Medical College and Mardan Medical Complex (Letter No. 397/BKMC, dated 10/10/2023). The retrospective review included patients who had undergone elective revision arthroplasty between January and August 2023. We identified baseline clinical and host-related factors from patients' medical records and, where necessary, from documented clinical histories. We followed patients from the date of index revision surgery to determine whether confirmed PJI developed during the observation period. The mean follow-up duration was one year (SD, 101.5 days), and two of 40 patients were lost to follow-up before the end of the available observation period. Because only 5 PJI events occurred, we used a pre-specified parsimonious binary logistic regression model including age (<65 versus ≥65 years), diabetes, and dental disease to minimize the risk of model overfitting. An exploratory model including sex, joint type, obesity, smoking history, and prior skin infection was also attempted but failed to converge because prior skin infection perfectly separated patients with and without PJI. Therefore, we evaluated the association between prior skin infection and PJI using Fisher's exact test and, because of the zero cell, calculated a Haldane-Anscombe continuity-corrected odds ratio by adding 0.5 to each cell of the 2×2 contingency table. We considered a two-tailed p-value <0.05 statistically significant.

Sample Size

The minimum sample size was calculated using the single-proportion formula from OpenEpi:

$$n = Z^2 P(1-P) / d^2$$

We assumed an anticipated prevalence of 30% for a major PJI risk marker based on previously published arthroplasty cohorts, with a 95% confidence level ($Z=1.96$) and a margin of error of 14.5%. These assumptions yielded a minimum sample size of approximately 39 patients. We therefore included all 40 eligible patients undergoing elective hip or knee revision arthroplasty during the predefined study period from January 2023 to August 2023 using consecutive non-probability sampling. Because revision arthroplasty represents a relatively small proportion of the institution's surgical workload, we included all eligible consecutive cases during the study period to maximize case capture and reduce selection bias.

Inclusion Criteria

- Patients age ≥ 18 years old
- Patients who are going to receive elective revision hip/knee arthroplasty
- All participants gave written informed consent.

Exclusion Criteria

- All patients who underwent emergency re-operation within 30 days of the first joint replacement surgery.
- Patients with an active infection from any location who are being treated with antibiotics
- If the patient cannot communicate or give a reliable history because of a severe cognitive impairment

Data Collection Procedure

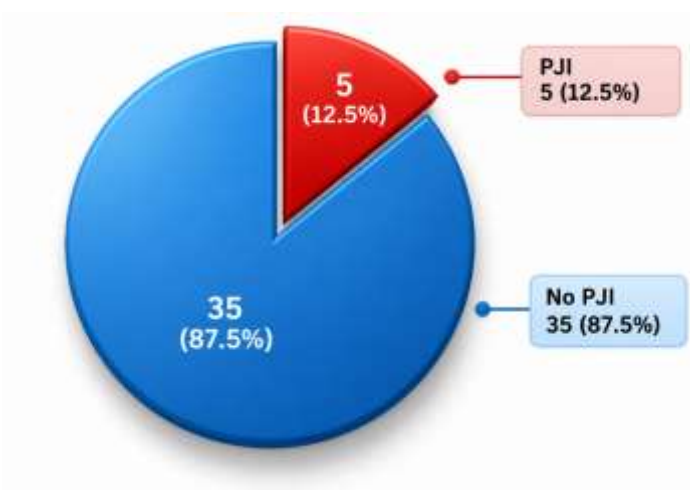
We used a structured proforma to retrospectively collect demographic and clinical data, including age, sex, BMI, joint type, diabetes, dental disease, smoking, obesity, and previous skin infection. We reviewed relevant medical, laboratory, dermatology, and dental records where available. We defined diabetes, dental disease, and previous skin infection using predefined criteria. Two research assistants coded the data, verified them, and resolved discrepancies by rechecking the original records.

Results

We analyzed 40 patients undergoing elective hip or knee revision arthroplasty. The mean age was 65.0 ± 6.8 years, with 21 (52.5%) aged ≥65 years and 22 (55.0%) males. We performed knee revision in 23 (57.5%) patients and hip revision in 17 (42.5%) patients. Previous skin infection was present in 9 (22.5%) patients, dental disease in 13 (32.5%), diabetes in 11 (27.5%), obesity (BMI ≥30 kg/m²) in 17 (42.5%), and smoking history in 20 (50.0%). Two patients (5.0%) were lost to follow-up. During follow-up, 5/40 (12.5%) developed confirmed PJI, while 35/40 (87.5%) remained PJI-free (Table 1; Figure 1). On univariate analysis, previous skin infection showed the strongest association with PJI. PJI occurred in 5/9 (55.6%) patients with previous skin infection compared with 0/31 (0.0%) without it (Fisher exact $p<0.001$). PJI was also more frequent among patients aged ≥65 years (4/21, 19.0% vs. 1/19, 5.3%; $p=0.3451$), males (5/22, 22.7% vs. 0/18, 0.0%; $p=0.0530$), those with dental disease (3/13, 23.1% vs. 2/27, 7.4%; $p=0.3065$), diabetes (2/11, 18.2% vs. 3/29, 10.3%; $p=0.6030$), obesity (4/17, 23.5% vs. 1/23, 4.3%; $p=0.1437$), and smoking history (4/20, 20.0% vs. 1/20, 5.0%; $p=0.3416$). PJI rates were similar after knee and hip revision (3/23, 13.0%).

vs. 2/17, 11.8%; $p=1.0000$). Thus, previous skin infection was the only statistically significant univariate factor (Table 2; Figure 2). Because no PJI occurred among patients without previous skin infection, the conventional odds ratio could not be estimated directly because of the zero cell; the Haldane–Anscombe correction yielded an odds ratio of 77.0 (95% CI, 3.6–1640.5). The wide confidence interval reflects the small sample and limited number of events. In the pre-specified parsimonious logistic regression model, age ≥ 65 years (AOR 3.35, 95% CI 0.32–35.33; $p=0.314$), diabetes (AOR 1.52, 95% CI 0.19–12.14; $p=0.694$), and dental disease (AOR 2.73, 95% CI 0.35–21.11; $p=0.336$) were not statistically significant. The exploratory full model including previous skin infection failed to converge because of perfect separation. Table 3 presents effect estimates.

Figure 1. Overall incidence of prosthetic joint infection



Overall distribution of patients according to development of confirmed PJI. Five of 40 patients (12.5%) developed PJI, whereas 35 (87.5%) remained free of PJI.

Table 1. Baseline demographic and clinical characteristics of the study population

Characteristic	Total (n=40)
Age, years, mean $\pm$ SD	65.0 $\pm$ 6.8
Age ≥ 65 years, n (%)	21 (52.5)
Male sex, n (%)	22 (55.0)
Knee revision, n (%)	23 (57.5)
Hip revision, n (%)	17 (42.5)
Previous skin infection, n (%)	9 (22.5)
Dental disease, n (%)	13 (32.5)
Diabetes mellitus, n (%)	11 (27.5)
Obesity (BMI ≥ 30 kg/m ²), n (%)	17 (42.5)
Smoking history, n (%)	20 (50.0)
Lost to follow-up, n (%)	2 (5.0)
PJI developed, n (%)	5 (12.5)

Data are presented as mean $\pm$ standard deviation or number (percentage), as appropriate. PJI = prosthetic joint infection; BMI = body mass index.

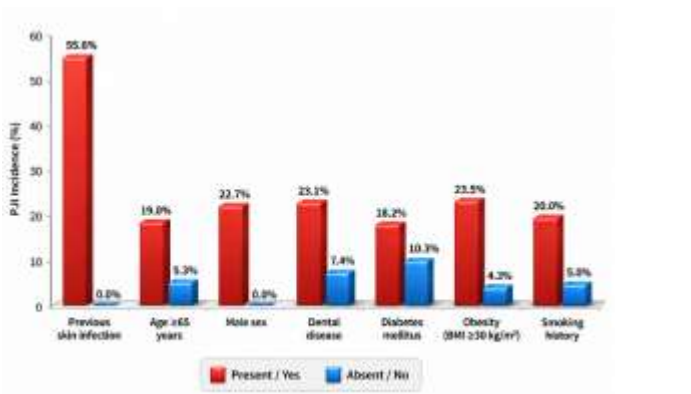
Table 2. Univariate analysis of factors associated with prosthetic joint infection

Variable	PJI, n/N (%)	No PJI, n/N (%)	p-value
Age ≥ 65 years	4/21 (19.0)	17/21 (81.0)	0.3451
Age < 65 years	1/19 (5.3)	18/19 (94.7)	–
Male sex	5/22 (22.7)	17/22 (77.3)	0.0530
Female sex	0/18 (0.0)	18/18 (100.0)	–

Knee revision	3/23 (13.0)	20/23 (87.0)	1.0000
Hip revision	2/17 (11.8)	15/17 (88.2)	–
Previous skin infection	5/9 (55.6)	4/9 (44.4)	0.0002*
No previous skin infection	0/31 (0.0)	31/31 (100.0)	–
Dental disease	3/13 (23.1)	10/13 (76.9)	0.3065
No dental disease	2/27 (7.4)	25/27 (92.6)	–
Diabetes mellitus	2/11 (18.2)	9/11 (81.8)	0.6030
No diabetes mellitus	3/29 (10.3)	26/29 (89.7)	–
Obesity (BMI ≥ 30 kg/m ²)	4/17 (23.5)	13/17 (76.5)	0.1437
No obesity	1/23 (4.3)	22/23 (95.7)	–
Smoking history	4/20 (20.0)	16/20 (80.0)	0.3416
No smoking history	1/20 (5.0)	19/20 (95.0)	–

PJI = prosthetic joint infection; BMI = body mass index. Percentages are calculated within each exposure category. *Fisher exact test; $p<0.05$ was considered statistically significant.

Figure 2. PJI incidence according to selected demographic and clinical risk factors



Observed PJI proportions across selected risk-factor categories. Previous skin infection showed the largest difference (55.6% vs. 0.0%), followed by obesity (23.5% vs. 4.3%), dental disease (23.1% vs. 7.4%), smoking (20.0% vs. 5.0%), age ≥ 65 years (19.0% vs. 5.3%), and diabetes mellitus (18.2% vs. 10.3%).

Table 3. Effect estimates for previous skin infection and parsimonious multivariable logistic regression

Predictor	Effect estimate	95% CI	p-value
Previous skin infection	OR 77.0*	3.6–1640.5	$<0.001^\dagger$
Age ≥ 65 years	AOR 3.35	0.32–35.33	0.314
Diabetes mellitus	AOR 1.52	0.19–12.14	0.694
Dental disease	AOR 2.73	0.35–21.11	0.336

Alternatively, OR = odds ratio; AOR = adjusted odds ratio; CI = confidence interval. *Haldane–Anscombe continuity-corrected OR because one cell contained zero events; † Fisher exact p-value. Interpret the corrected OR cautiously because of the small number of PJI events and complete separation.

Discussion

In this retrospective cohort of 40 patients undergoing hip or knee revision arthroplasty, 5 patients (12.5%) developed confirmed PJI during follow-up. The principal finding was a statistically significant association between previous skin infection and subsequent PJI. All 5 PJI events occurred among the 9 patients with a history of previous skin infection (55.6%), whereas none of the 31 patients without such a history developed PJI.

This finding is biologically plausible because previous skin infection may indicate disruption of the skin barrier, recurrent colonization, or increased exposure to organisms such as *Staphylococcus aureus*, which are important causes of PJI [13,14]. New studies also suggest that a history of skin or soft tissue infection could help identify patients at higher risk of developing prosthetic infection [15,16]. However, given the small number of PJI events (n=5), interpret the association observed in the present study as a hypothesis until larger cohorts prove it. Because of the zero cell, we could not directly estimate a conventional odds ratio; no PJI events occurred among patients with no previous skin infection. We estimated the odds ratio to be 77.0 (95% CI, 3.6–1640.5) after Haldane–Anscombe continuity correction. This wide confidence interval reflects limited data to estimate the effect size and a small number of outcome events, so it should not be taken as a precise estimate. The statistically significant Fisher's exact test supports the association, but larger studies are needed to confirm its magnitude and independence. The three prespecified factors (age ≥ 65 years, diabetes, dental disease) in the primary multivariable model were not statistically significant. This result should be taken with the caveat of the small number of outcome events. Diabetes mellitus is a significant patient-related risk factor for PJI following TJA, as shown in previous systematic reviews and meta-analyses [17,18]. Likewise, investigators of large observational studies have reported that diabetes was associated with an increased risk of PJI, especially if glycemic control is sub-optimal [19]. In contrast, diabetes was not statistically significant in our multivariable model. This should not be interpreted as diabetes being unrelated to PJI; however, because there were only 5 PJI events in the present study, power to detect moderate associations was limited. Peri-operative glycemic optimization remains clinically relevant in patients undergoing revision arthroplasty. Male patients had a greater numerical PJI rate than female patients (22.7% vs. 0.0%, respectively; $p=0.053$). This difference was not statistically significant, but the direction of the finding was consistent with previous systematic reviews which found that male sex may be a risk factor for PJI [20,21]. The lack of statistical significance in the current study should be taken with a grain of salt because of the limited number of events and the sample size. Larger cohorts are needed to determine whether dental disease is an independent risk factor for PJI after revision arthroplasty. The PJI rates among patients with reported dental disease and those without were similar (7.4% vs. 23.1%, respectively; $p=0.307$). Previous studies have examined the possible association between oral disease, dental procedures, bacteremia, and hematogenous PJI, but the significance and strength of this association remain unclear [22,23]. While our data do not prove dental disease to be an independent risk factor for PJI, they suggest that future studies should investigate this relationship. Furthermore, some dental history was self-reported in our cohort, which could have led to misclassification or recall bias. However, assessing and managing oral disease remains a sensible part of comprehensive pre-op optimization. Diabetes, increased BMI, and other patient factors were noted previously in Pakistan as potential factors for PJI after primary total knee replacement [24]. In a similar 10-year study in Saudi Arabia, patient-related risk factors were shown to be important in the development of PJI, and the multidirectional nature of prosthetic infections was highlighted [25]. In conclusion, we contributed to this regional literature by examining incident PJI after hip and knee revision arthroplasty in a Pakistani tertiary care setting. Interestingly, the incidence in our cohort (12.5%) is higher than the reported incidence after primary arthroplasty, reflecting the increased infection risk associated with revision surgeries [4,26]. Interpret comparisons with caution, as many factors influence PJI incidence, including patient selection, revision indication, follow-up length, infection definitions, and institutional practices. The most significant finding is the association between prior skin infection and PJI. A previous skin infection may indicate persistent or recurrent colonization or underlying susceptibility to infection. The absence of PJI in all patients without a prior skin infection created a strong statistical signal, but also considerable uncertainty about the effect estimate. Thus, these results should not be considered as proof of causality or as evidence that the presence of a

previous skin infection is a risk factor for PJI in itself. Clinically, the results suggest close monitoring of past skin infections during the pre-operative evaluation of patients undergoing revision arthroplasty. This evaluation should be used alongside existing preventive measures, such as

optimizing blood glucose control, controlling obesity and smoking, managing active infections, and reviewing other potentially modifiable health issues [17,18,26]. Given the association between skin infection and PJI observed in this study (and only five PJI cases), however, larger studies are needed before routine clinical practice adjustments based on a history of skin infection. Overall, these findings support a multidisciplinary approach to preoperative optimization that considers dermatological history, metabolic status, oral health, smoking, obesity, and other established patient-related factors. Future prospective, multicenter studies with larger sample sizes, standardized definitions of previous skin infection and dental disease, systematic microbiological assessment, and adequate numbers of PJI events are needed to determine whether previous skin infection independently predicts PJI following revision arthroplasty. This study has several limitations. First, statistical power was limited by the small sample size and the occurrence of only 5 PJI events. Consequently, the study may not have detected moderate associations, and the continuity-corrected odds ratio for prior skin infection had a very wide confidence interval. Second, the study was conducted at a single tertiary-care center, which may limit generalizability to other healthcare settings. Third, some dental and dermatological histories were based partly on available clinical documentation or patient-reported information, potentially introducing recall or information bias. Fourth, two of 40 patients were lost to follow-up before the planned endpoint. Finally, we did not systematically assess preoperative microbiological colonization; therefore, the observed association between previous skin infection and subsequent PJI may be influenced by unmeasured confounding factors. Larger multicenter prospective studies are required to validate these findings and determine the independent contribution of prior skin infection, diabetes, dental disease, and other patient-related factors.

Conclusion

Among 40 patients undergoing hip or knee revision arthroplasty, 5 (12.5%) developed PJI during follow-up. Prior skin infection was significantly associated with subsequent PJI in this cohort, with all observed PJI events occurring among patients with a history of prior skin infection. However, because of the small number of events and the very wide confidence interval of the continuity-corrected odds ratio, this finding should be considered hypothesis-generating rather than a definitive estimate of risk. Age, diabetes, and dental disease were not statistically significant in the pre-specified multivariable model, although the study had limited power to detect moderate associations. These findings support careful assessment and optimization of potentially modifiable factors before revision arthroplasty and highlight the need for larger multicenter studies to determine whether previous skin infection independently predicts PJI.

Ethical approval

Ethical approval was obtained from the Institutional Review Board of MTI Bacha Khan Medical College and Mardan Medical Complex, Mardan (Letter No. 397/BKMC, dated 10/10/2023). We obtained written informed consent from all participants.

Disclaimer: None.

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

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Authors' Contributions

Zahir Khan: Conceptualization, study design, methodology, data collection, data analysis and interpretation, manuscript drafting, critical revision, and final approval of the version to be published.

Aimon Zia: Study methodology, data collection, data curation, literature review, manuscript drafting, critical revision, and final approval of the version to be published.

Arsalan Azmat Swati: Data collection, statistical analysis, interpretation of results, literature review, critical revision of the manuscript, and final approval of the version to be published.

All authors contributed substantially to the work, approved the final version of the manuscript, agreed to be accountable for all aspects of the work, and accept responsibility for ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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