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SCIENTIFIC ARTICLE - REVISION

FACTORS INFLUENCING POSTOPERATIVE INFECTION IN ARTHROPLASTIES

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ABSTRACT

Introduction: Periprosthetic infection (PI) is one of the most severe complications of total arthroplasty, with significant impact on morbidity, mortality, and healthcare costs. **Objective:** To synthesize the available evidence on factors that influence the development of postoperative infections in arthroplasty, providing evidence-based recommendations for clinical practice. **Methods:** A systematic search was conducted in the PubMed, Web of Science, and Scopus databases for studies published between 2006 and 2023 on periprosthetic infection in total arthroplasty. Observational studies, clinical trials, and meta-analyses evaluating risk factors for periprosthetic infection in total hip arthroplasty (THA) and total knee arthroplasty (TKA) were included. **Results:** Nine studies were included, totaling approximately 1,200,000 patients. The identified risk factors were classified into: (1) patient-related factors (comorbidities, nutritional status, smoking); (2) surgical factors (surgery duration, procedure type); and (3) hospital and socioeconomic factors. The risk factors most consistently associated with periprosthetic infection were diabetes mellitus (OR = 3.72), obesity (OR = 2.53–4.00), rheumatologic disease (RR = 1.71), smoking (RR = 2.37), prolonged surgical duration, and congestive heart failure. **Conclusion:** Multiple factors influence the development of postoperative infections in total arthroplasty. Identifying and optimizing these modifiable risk factors is essential to reduce the incidence of periprosthetic infection and improve clinical outcomes.

Keywords: Periprosthetic, Infection, Total arthroplasty, Risk factors, Surgical site infection.

INTRODUCTION

Arthroplasty is one of the most commonly performed surgical procedures worldwide, with more than two million procedures carried out annually.[1] Despite significant advances in surgical techniques, implant materials, and infection prevention protocols, periprosthetic infection (PPI) remains a devastating complication, adversely affecting patients' quality of life and generating substantial costs for healthcare systems.[2]

Periprosthetic infection is defined as the presence of viable microorganisms in periprosthetic tissue, confirmed by microbiological culture or histopathological findings.[3] This complication may occur at any time after arthroplasty and is commonly classified as early infection (up to 3 months), delayed infection (3–24 months), or late infection (>24 months).[4]

The incidence of periprosthetic infection varies considerably across studies, depending on the population analyzed, the type of arthroplasty (primary versus revision), the anatomical site involved (hip versus knee), and the duration of follow-up.[5] Recent studies suggest that the incidence of periprosthetic infection after primary total arthroplasty ranges from 0.3% to 2%, whereas in revision arthroplasty it may reach up to 10%.[6]

Risk factors for periprosthetic infection are multiple and complex and can be classified into three main categories: (1) patient-related factors (age, sex, comorbidities, nutritional status, smoking); (2) surgery-related factors (type of procedure, duration, and surgical technique); and (3) hospital-related and socioeconomic factors.[7] Identification of these risk factors is essential for preoperative risk stratification and for the implementation of targeted preventive strategies.[8]

The economic impact of periprosthetic infection is substantial. Recent studies indicate that the incremental costs associated with periprosthetic infection may range from US$ 20,000 to US$ 80,000 per patient, depending on infection severity and the need for revision procedures.[9]

Therefore, this systematic review was conducted with the aim of synthesizing the available evidence on factors influencing the development of postoperative infections in arthroplasty, providing evidence-based recommendations to support clinical practice.

METHODOLOGY

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[10] A systematic search was performed in the PubMed, Web of Science, and Scopus databases on [date], using the following search terms: ("periprosthetic infection" OR "prosthetic joint infection" OR "surgical site infection" OR "deep surgical site infection") AND ("total hip arthroplasty" OR "total knee arthroplasty" OR "hip replacement" OR "knee replacement") AND ("risk factors" OR "incidence" OR "epidemiology"). The search was limited to articles published in English between January 2006 and December 2023. Reference lists of included studies were also screened to identify additional relevant publications.

Observational studies (prospective and retrospective cohort studies, cross-sectional studies), clinical trials, and meta-analyses evaluating risk factors or incidence of periprosthetic infection in total arthroplasty were included. Studies involving adult patients (≥18 years) undergoing primary or revision total hip or knee arthroplasty were eligible, with no restrictions regarding sex, race, or ethnicity. The primary outcomes were: (1) risk factors associated with periprosthetic infection; and (2) incidence of periprosthetic infection.

The exclusion criteria were: (1) studies published in languages other than English; (2) studies including fewer than 100 patients; (3) narrative reviews, editorials, and commentaries; (4) studies focused exclusively on infection prevention without reporting incidence data or risk factors; and (5) studies with follow-up shorter than six months.

Study selection and data extraction were independently performed by two reviewers using a standardized data extraction form. Extracted data included study characteristics (author, year, country, study design), population characteristics (number of patients, mean age, sex, type of arthroplasty), outcomes (infection incidence, risk factors), and methodological aspects (duration of follow-up, infection definition, statistical methods). Disagreements were resolved by consensus or consultation with a third reviewer. Studies were classified as having low, moderate, or high risk of bias.

RESULTS

The systematic search identified 1,232 studies. After application of the inclusion and exclusion criteria, 85 studies remained for full-text evaluation, of which 9 studies were ultimately included in the qualitative analysis (Figure 1). The 9 included studies were published between 2006 and 2023 and comprised a total sample of approximately 1,200,000 patients. Quality assessment of the included studies using appropriate appraisal tools indicated that 7 of the 9 studies were classified as high quality, while 2 studies were classified as moderate quality. No studies were classified as low quality.

Table 1: Characteristics of the 9 Studies Included in the Systematic Review

Study	Year	Country	Study design	N	Type of arthroplasty	Follow-up	Quality
Edmiston et al.[11]	2023	USA	Retrospective cohort	20.468	Primary and revision THA	12 months	High
Tella et al.[12]	2022	Italy	Prospective cohort	583	Primary THA	596 days	High
Bozic et al.[13] (ATQ)	2012	USA	Retrospective cohort	40.919	Primary THA	90 days	High
McMaster[14] MAC	2022	Canada	Retrospective cohort	129.613	Primary TKA	15 years	High
Ko et al.[15]	2021	South Korea	Retrospective cohort	560.954	Primary and revision TKA	Variablel	Moderate
Bozic et al.[16] (ATJ)	2012	USA	Retrospective cohort	83.011	Primary TKA	90 days	High
Kurtz et al.[17]	2010	USA	Retrospective cohort	69.663	Primary TKA	10 years	High
Chen et al.[18]	2013	China	Meta-analysis	57.223	Primary TKA	Variable	Moderate
Singh et al.[19]	2015	USA	Prospective cohort	7.926	Primary THA and TKA	Variable	High

THA = Total Hip Arthroplasty; TKA = Total Knee Arthroplasty; N = Number of patients.

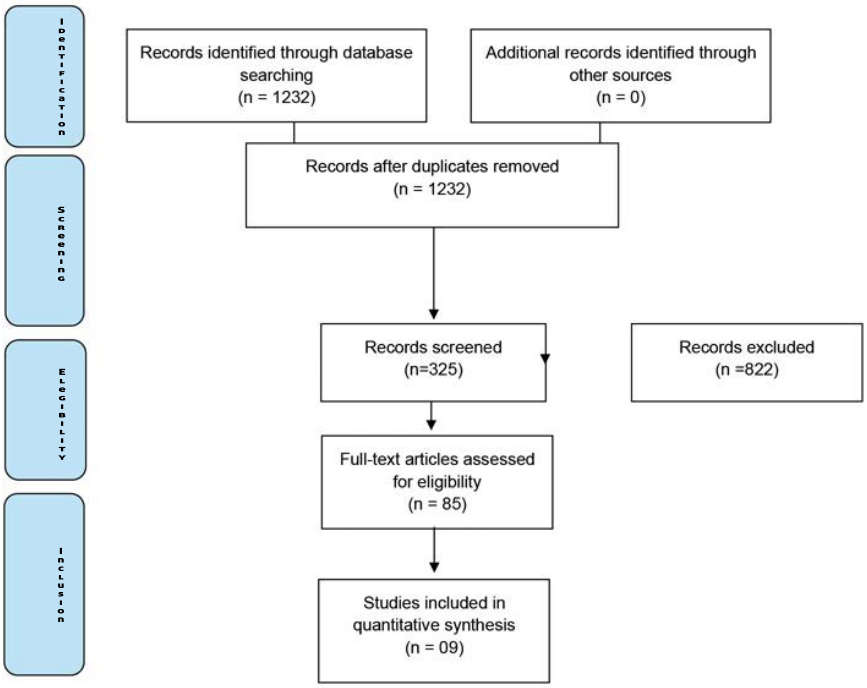

Figure 1: Flowchart of articles.

Table 2: Risk Factors for Periprosthetic Infection Identified in the Included Studies

Risk factor	Effect measure	Confidence interval	Type of arthroplasty	Study
Diabetes Mellitus	OR = 3,72	2.30-6.01	TKA	Chen et al.
Obesity (BMI > 40)	OR = 4,00	1.23-12.98	TKA	Chen et al.
Obesity (BMI > 30)	OR = 2,53	1.25-5.13	TKA	Chen et al.
Rheumatologic disease	RR = 1,71	-	THA	Bozic et al.
Rheumatoid arthritis	OR = 1,83	1.42-2.36	TKA	Chen et al.
Heart failure	Independent risk factor	-	TKA	Bozic et al.
Chronic pulmonary disease	Independent risk factor	-	TKA	Bozic et al.
Preoperative anemia	RR = 1,36	-	THA	Bozic et al.
Smoking (deep infection)	RR = 2,37	1.19-4.72	THA/TKA	Singh et al.
Smoking (implant revision)	RR = 1,78	1.01-3.13	THA/TKA	Singh et al.
Male sex	Risk factor	-	TKA	Ko et al.
Household income	Risk factor	-	TKA	Ko et al.
Length of hospital stay ≥ 35 days	Risk factor	-	TKA	Ko et al.
Blood transfusion requirement	Risk factor	-	TKA	Ko et al.

THA = Total Hip Arthroplasty; TKA = Total Knee Arthroplasty; OR = Odds Ratio; RR = Risk Ratio; BMI = Body Mass Index.

Table 3: Incidence of Periprosthetic Infection by Type of Arthroplasty

Type of arthroplasty	Subtype	Incidence	Study
THA	Primary – Superficial infectionl	0.67% (IC 95% 0,55%-0,79%)	Edmiston et al.
THA	Primary – Deep infection	0.30% (IC 95% 0,22%-0,39%)	Edmiston et al.
THA	Revision – Superficial infection	4.8% (IC 95% 4,0%-5,6%)	Edmiston et al.
THA	Revision - Deep infection	8.9% (IC 95% 7,8%-10,0%)	Edmiston et al.
TKA	Primary - 1 year	0.51%	McMaster MAC
TKA	Primary - 5 years	1.12%	McMaster MAC
TKA	Primary - 10 years	1.49%	McMaster MAC
TKA	Primary - 15 years	1.65%	McMaster MAC
TKA	Primary - 2 years	1.55%	Kurtz et al.
TKA	Primary - 2-10 years	0.46%	Kurtz et al.

THA = Total Hip Arthroplasty; TKA = Total Knee Arthroplasty; CI = Confidence Interval.

DISCUSSION

The results demonstrate that periprosthetic infection is a multifactorial complication in which multiple patient-related, surgical, and socioeconomic factors interact to determine the overall risk of infection. This systematic review synthesized the available evidence on factors influencing the development of postoperative infections in total arthroplasty, revealing important insights into the complexity and multiplicity of the associated risk factors.

The findings of this review confirm that comorbidities are major risk factors for periprosthetic infection.[18] Diabetes mellitus was identified as one of the most significant risk factors, with an odds ratio of 3.72 in a meta-analysis of 12 studies,[18] indicating that diabetic patients have approximately a 3.7-fold higher risk of developing periprosthetic infection compared with non-diabetic individuals. This finding is consistent with the literature demonstrating that hyperglycemia impairs immune response through multiple mechanisms, including neutrophil dysfunction, impaired chemotaxis, and reduced bactericidal activity,[20] in addition to compromising wound healing via adverse effects on angiogenesis and collagen synthesis.[21-23] The clinical relevance of this finding is substantial, suggesting that optimization of perioperative glycemic control in diabetic patients may be an effective strategy for reducing periprosthetic infections.[21]

Rheumatologic disease was identified as a significant risk factor in multiple studies, with a reported risk ratio of 1.71 in a cohort of 40,919 patients,[13] while a meta-analysis found an odds ratio of 1.83 specifically for rheumatoid arthritis.[18] This association may be attributed to the immunosuppressive effects of both the underlying rheumatologic condition and the medications used in its treatment, particularly biologic agents and corticosteroids. In addition, patients with rheumatologic diseases frequently present with other comorbidities that further increase infection risk, creating a cumulative risk effect.[22] Congestive heart failure was also identified as an independent risk factor for periprosthetic infection,[16] likely due to impaired tissue perfusion and compromised immune response. Reduced cardiac output and venous congestion result in tissue hypoxia, which negatively affects wound healing and diminishes the ability of immune cells to combat infection.[23]

Nutritional and metabolic factors also played an important role in the findings of this review. Obesity was identified as a significant risk factor for infection, with odds ratios ranging from 2.53 for body mass index (BMI) >30 kg/m^2 to 4.00 for BMI >40 kg/m^2,[18] indicating a progressive increase in risk with greater degrees of obesity. The literature further demonstrates that obesity impairs tissue perfusion, prolongs surgical duration, and compromises immune response through multiple mechanisms, including chronic inflammation, T-cell dysfunction, and reduced opsonization.[24] In addition, obese patients often experience longer operative times, increased blood loss, and a greater need for blood transfusion, all of which contribute to an elevated risk of infection.[24]

Preoperative anemia was identified as a significant risk factor, with a reported risk ratio of 1.36,[13] a finding consistent with the pathophysiological role of anemia in reducing oxygen delivery to tissues—an essential factor for wound healing and effective immune response. Tissue hypoxia resulting from anemia impairs neutrophil bactericidal activity and reduces collagen synthesis, thereby compromising surgical wound integrity.[25]

Smoking was identified as a significant risk factor for deep infection, with a risk ratio of 2.37, and for implant revision, with a risk ratio of 1.78,[19] findings that align with extensive literature demonstrating the deleterious effects of smoking on wound healing.[26] Tobacco use induces vasoconstriction and reduces tissue perfusion, impairs neutrophil and macrophage function, decreases collagen synthesis, and promotes a proinflammatory state.[26] Moreover, smokers frequently present with additional comorbidities, such as chronic pulmonary disease, which further increase the risk of postoperative complications.[19] These findings have important clinical implications, suggesting that smoking cessation prior to elective surgery may be an effective strategy for reducing periprosthetic infections.[26]

Prolonged surgical duration was also identified as a risk factor for infection,[19] with infected patients exhibiting a mean operative time of 127 minutes compared with 94 minutes in non-infected patients—a difference of 33 minutes. This finding is consistent with evidence demonstrating that longer surgical duration increases the risk of intraoperative contamination due to prolonged wound exposure, greater risk of hypothermia, and potential inadequacy of antibiotic prophylaxis.[9] Furthermore, prolonged operative time often reflects greater surgical complexity or technical difficulty, both of which are associated with increased tissue trauma and heightened inflammatory response.[9] Notably, surgical duration showed positive correlations with patient weight, BMI, and number of comorbidities,[19] suggesting that high-risk patients are more likely to undergo prolonged procedures, thereby creating a cumulative risk effect.

Demographic and socioeconomic factors also influenced the development of infection.[15] Male sex was identified as a risk factor in multiple studies,[15] a finding that may reflect differences in postoperative activity patterns, adherence to weight-bearing restrictions, and general risk-related behaviors.[8] Household income and length of hospital stay were identified as socioeconomic factors associated with increased infection risk,[15] potentially reflecting disparities in access to high-quality postoperative care, adherence to follow-up, and opportunities for preoperative optimization.[7] These findings suggest that socioeconomic inequities may significantly influence total arthroplasty outcomes, representing an important public health and health equity concern.[7]

The findings of this review carry several important clinical implications for orthopedic practice. First, routine preoperative risk stratification should be implemented, with patients presenting multiple risk factors undergoing rigorous preoperative evaluation and optimization of comorbidities.

Diabetic patients should receive optimized perioperative glycemic control, with maintenance of blood glucose levels between 140 and 180 mg/dL during the perioperative period.[21] Obese patients should be counseled regarding preoperative weight loss, with studies suggesting that a 5–10% reduction in body weight may significantly reduce the risk of complications.[7] Smokers should be advised to cease smoking at least four weeks prior to surgery, as this period is necessary for partial reversal of tobacco-related impairment in wound healing.[26] Patients with anemia should receive iron supplementation or preoperative transfusion as indicated, with maintenance of hemoglobin levels above 10 g/dL.[25] Patients with rheumatologic diseases should have their immunosuppressive regimens optimized in consultation with rheumatology specialists, with consideration of adjustments to antibiotic prophylaxis.[22]

Minimization of surgical duration through efficient surgical techniques and surgeon experience is essential, as studies suggest that high-volume surgeons demonstrate lower infection rates.[9] Consideration of minimally invasive techniques in high-risk patients may reduce tissue trauma and inflammatory response.[9] Appropriate antibiotic prophylaxis, including redosing during prolonged procedures, is critical. Enhanced postoperative surveillance should be implemented in high-risk patients, with careful monitoring for early signs of infection and patient education regarding warning symptoms. Detailed preoperative counseling should be provided to patients with identified risk factors, informing them of the increased risk of periprosthetic infection and emphasizing the importance of adherence to activity restrictions and postoperative follow-up.[21]

CONCLUSION

This systematic review identified multiple factors that influence the development of postoperative infections in arthroplasty. The most significant risk factors included diabetes mellitus (OR = 3.72), obesity (OR = 2.53–4.00), rheumatologic disease (RR = 1.71), smoking (RR = 2.37), prolonged surgical duration, congestive heart failure, and preoperative anemia.

Identification and optimization of these modifiable risk factors are essential to reduce infection incidence and improve clinical outcomes. Targeted preventive strategies—including glycemic control, weight reduction, smoking cessation, and optimization of comorbid conditions—should be implemented in high-risk patients.

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EDITORIAL AND REVIEW

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