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Original Research

Periprosthetic Joint Infection Following Clean Hand Surgery: A Systematic Review

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Purpose: We assessed the rate of periprosthetic joint infection (PJI) following hand surgery in patients with prosthetic joints, and determined the efficacy of prophylactic antibiotics for preventing PJI in this patient subset.
Methods: A systematic review of PubMed (MEDLINE) and Scopus (EMBASE, MEDLINE, COMPENDEX) from 1968 to 2021 was conducted. Primary articles that studied PJIs following hand surgery in patients with prosthetic joints (hip, knee, shoulder, elbow, or ankle) and/or the use of prophylactic antibiotics prior to hand surgery in patients with prosthetic joints were included.
Results: A total of 3 studies (439,080 patients) met our inclusion criteria. Of the total study population, 9,070 patients (2.1%) had a prior total joint arthroplasty treated and subsequently underwent soft-tissue hand surgery. A single study reported a 0.2% prevalence of PJI secondary to hand surgery. The remaining 2 studies found no cases of PJI following hand surgery in patients with a history of total joint arthroplasty. On average, 16% (1,214 of 7,374) of patients with prosthetic joints received antibiotics prior to hand surgery. No significant relationships were found between hand surgery, antibiotic prophylaxis, and PJI risks.
Conclusions: There is a very low reported incidence of PJI following hand surgery in patients with existing prosthetic joints, with or without the use of prophylactic antibiotics. Therefore, the authors do not recommend the routine use of prophylactic antibiotics in this patient subgroup. The decision to use prophylaxis should be made on a case-by-case basis, accounting for patient-specific comorbidities and risk factors. Further research on hand surgery–associated PJI is warranted.
Type of study/level of evidence: Therapeutic III.

Periprosthetic joint infection (PJI) remains among the most devastating and costly complications following total joint arthroplasty (TJA), affecting 1% to 2% of all cases of hip and knee arthroplasty.[1,2] While the majority of PJIs occur within 2 years of the index arthroplasty, patients can develop infection throughout the life of the prosthesis.[3–5] Late-onset PJI (occurring >24 months following index arthroplasty) is often a result of subsequent hematogenous infections or indolent infections from the initial procedure.[6] Therefore, it has been theorized that antibiotics prior to any soft-tissue procedure may play a beneficial role in preventing transient bacteremia and hematogenous seeding in patients with existing prosthetic joints.[7,8] Most recent guidelines by the American Dental Association and American Academy of Orthopaedic Surgeons have recommended against the use of antibiotics prior to dental procedures in patients with a history of TJA, in view of the limited evidence demonstrating a significant relationship between dental surgery and PJI.[9] However, the current understanding of this phenomenon is limited to dental procedures, and no such guidelines have been established for patients undergoing other clean, soft-tissue procedures, such as hand surgery.[3]

The routine use of prophylactic antibiotics is a controversial topic in hand surgery.[10] Although current consensus guidelines recommend against the use of prophylaxis prior to clean, soft-tissue procedures, the perceived advantages of antibiotics have

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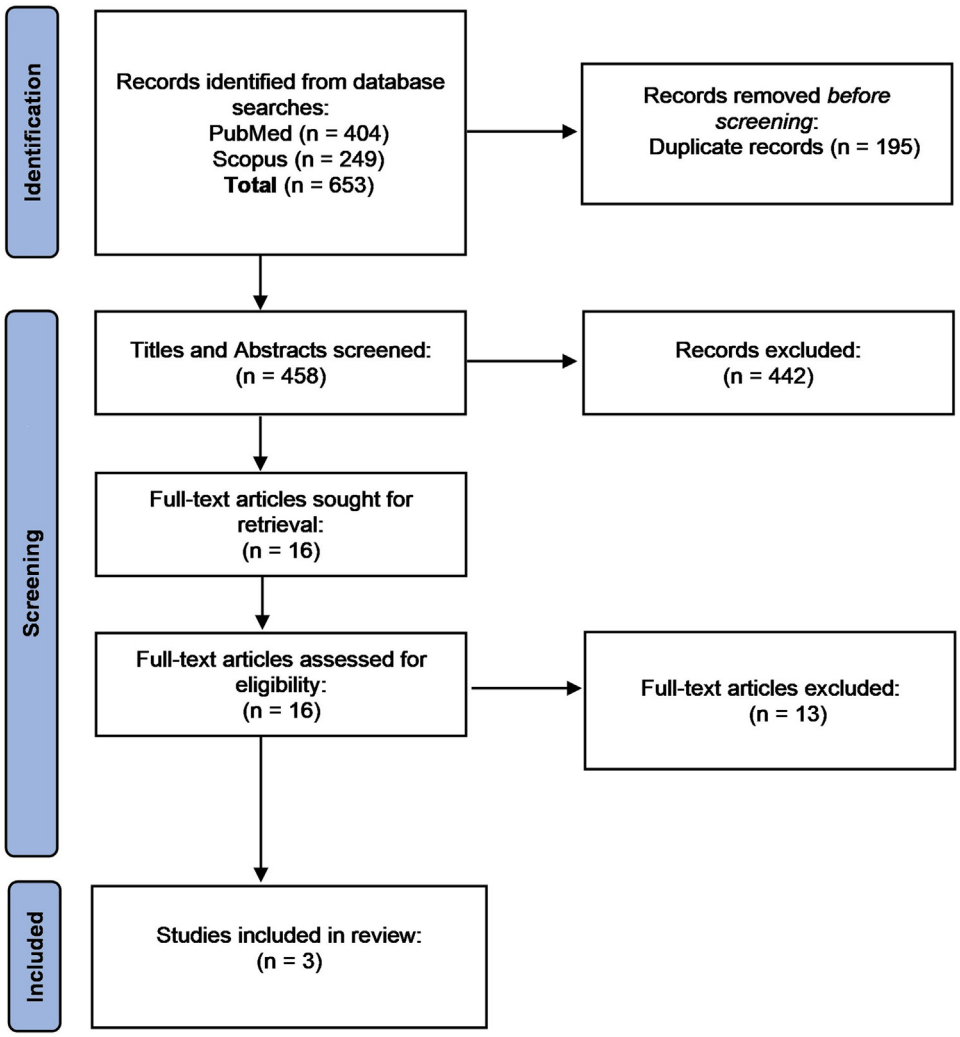

Figure. Flowchart used for the systematic review performed under Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines.

led to their widespread use.[10–14] Demonstrated benefits of prophylactic antibiotics have been reported in cases of dog and human bites, elbow arthroplasty, and emergency hand operations.[15–18] In contrast, evidence against prophylaxis suggests that surgical factors, such as poor sterile techniques and operating room setups, or patient-related factors, such as tobacco use and diabetes mellitus, may play greater roles in infection risk.[10,19] Nevertheless, few studies have investigated the roles of prophylactic antibiotics in hand surgery for preventing hematogenous seeding and subsequent PJI in patients with existing prosthetic joints.

The purpose of this systematic review was to assess the rate of PJI following hand surgery, as well as to determine the efficacy of prophylactic antibiotics for preventing PJI in this patient subset. Based on the best available evidence, we aim to provide recommendations on the use of prophylactic antibiotics in patients undergoing hand surgery. We hypothesize that subsequent clean, soft-tissue hand surgery does not provide an increased risk for PJI in patients with prosthetic joints.

Materials and Methods

Search strategy

A literature search was conducted in PubMed (MEDLINE) and Scopus (EMBASE, MEDLINE, COMPENDEX) databases from 1968 to September 2021, in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines (Fig.).[20] The aim of the literature search was to identify evidence regarding the use of prophylactic antibiotics in patients with prosthetic joints who subsequently underwent hand surgery. The keywords and search terms used were specific to elective, soft-tissue hand procedures; total joint arthroplasty; total joint protheses; and antibiotic prophylaxis (Table 1).

Selection criteria

All articles were included if they met the following criteria: (1) studied PJIs following hand surgery in patients with prosthetic joints (hip, knee, shoulder, elbow, ankle); and/or (2) studied antibiotic prophylaxis prior to hand surgery in patients with prosthetic joints; and (3) were published in English. The exclusion criteria were (1) case reports; (2) technique articles; (3) letters, commentaries, or expert opinions; and (4) guidelines papers. Reference sections from excluded articles were searched for relevant literature.

Data collection

Article titles and abstracts were independently screened by 2 authors (T.L.T. and G.S.G). Studies that met our predetermined

Table 1
Database Search Strategy

Database	PubMed (MEDLINE) and Scopus (EMBASE, MEDLINE, COMPENDEX)
Date	September 2021
Strategy	Population #1 AND Population #2 AND Intervention
Population #1	"Hand/surgery"[Mesh] OR Orthopedic hand surgery OR Orthopaedic hand surgery OR "Elective Surgical Procedures"[Mesh] OR Elective soft-tissue hand surgery OR "Carpal Tunnel Syndrome/surgery"[Mesh] OR Carpal tunnel release OR Carpal tunnel surgery OR clean hand surgery OR elective clean hand surgery OR Finger tendon sheath incision OR Trigger finger release OR Cubital tunnel release OR de Quervain release OR A1 pulley release OR Thumb basal joint arthroplasty OR Ulnar nerve transposition OR flexor tenosynovectomy OR Wrist dorsal compartment release OR Distal radius surgery OR distal radius repair OR distal radius open reduction internal fixation OR distal radius ORIF OR hardware removal OR Guyon canal release OR extensor digital quinti tendon tenosynovectomy OR Radical tenosynovectomy OR Thumb metacarpophalangeal joint arthrodesis OR Flexor carpi ulnaris release OR ORIF ulnar fracture OR Tenosynovectomy flexor digitorum profundus tendon OR Thumb carpometacarpal interposition arthroplasty OR Thumb trapeziectomy OR Wrist arthroscopic subtotal synovectomy
Population #2	"Arthroplasty, Replacement, Hip"[Mesh] OR Total hip arthroplasty OR "Arthroplasty, Replacement, Knee"[Mesh] OR Total knee arthroplasty OR "Arthroplasty, Replacement, Shoulder"[Mesh] OR Total shoulder arthroplasty OR Total joint arthroplasty OR TJA OR Joint arthroplasty OR Prosthetic joints OR "Arthroplasty, Replacement, Ankle"[Mesh] OR Total ankle arthroplasty OR "Arthroplasty, Replacement, Elbow"[Mesh] OR Total elbow arthroplasty OR "Hemiarthroplasty"[Mesh]
Intervention	"Antibiotic Prophylaxis"[Mesh] OR Prophylactic antibiotics OR prophylaxis OR "Anti-Bacterial Agents"[Mesh] OR antibiotics OR preoperative antibiotics OR postoperative antibiotics OR infection antibiotics OR SSI antibiotics OR surgical site infection antibiotics OR SSI antibiotics OR surgical antibiotic prophylaxis OR surgical prophylaxis OR prophylaxed OR cefazolin OR cephalosporin OR cefoxitin OR clindamycin OR vancomycin OR metronidazole OR macrolide OR tetracycline

ORIF, open reduction internal fixation.

Table 2
Characteristics of Included Studies

Author	Year Published	Study Period	Data Source	Study Design	Level of Evidence	Risk of Bias
Zeng et al[23]	2017	2012–2014	Single institution	Case series	IV	Serious
Li et al[25]	2019	2017–2015	United States National Claims Database	Retrospective cohort	III	Moderate
Warnick and Ilyas[24]	2020	2012–2018	Single institution	Case series	IV	Serious

inclusion and exclusion criteria were identified for full-text review. All discrepancies related to title and abstract screening were resolved by discussion. Subsequently, full-text articles were then extracted and reviewed by both authors. Upon final inclusion, the following data were extracted from each study: year published, author, title, study design, database used, study period, number of patients, number of procedures, patient demographics, comorbidities, hand surgeries performed, prior total joint arthroplasties performed, operative details of the respective procedures, use of antibiotic prophylaxis, and rate of PJI.

Included studies were assessed for levels of evidence and methodologic risks of bias using the Oxford Center for Evidence-Based Medicine Levels of Evidence criteria, as well as the Cochrane Risk of Bias in Nonrandomized Studies of Interventions tool.[21,22]

Results

A total of 458 records were identified from the literature search. Following screening, 3 studies met the inclusion criteria (Fig.).[23–25] Table 2 summarizes the characteristics of the included studies. Two of the studies, Zeng et al[23] and Warnick and Ilyas,[24] were retrospective case series (level IV evidence), and 1 study, Li et al,[25] was a retrospective cohort study (level III evidence). The risk-of-bias evaluation noted that 2 studies had serious risks and 1 study had a moderate risk of bias.[23–25]

The patient demographics, procedural data, inclusion criteria, and PJI criteria are described in Table 3. Two studies reviewed hand surgery populations with a history of TJA, while the third study reviewed a TJA population that subsequently underwent hand surgery.[23–25] Periprosthetic joint infections were defined using either PJI-specific International Classification of Diseases, Ninth Edition, and Current Procedural Terminology codes; a review of the medical records; or patient confirmation via telephone calls.[23–25] Follow-up periods for PJIs differed between the studies, as 2 assessed PJIs within 90 days of hand surgery and 1 assessed PJIs within 6 months of carpal tunnel release.[23–25]

A total of 9,015 hand surgery patients and 430,065 patients with a history of TJA were pooled and retrospectively reviewed. Among the hand surgery population, 581 (6%) had a history of TJA. Of the TJA population, 8,489 (2%) subsequently underwent hand surgery within 2 years of their index arthroplasty. All 3 studies investigated the prevalence of PJI following hand surgery.[23–25] Li et al[25] reported a 0.2% prevalence of PJI secondary to hand surgery (Table 4). A similar PJI rate of 0.2% was also observed in TJA patients that did not undergo a subsequent hand procedure.[25] Warnick and Ilyas[24] reported 3 cases of PJI following hand surgery (0.9%). However, 1 case occurred after direct trauma to the prosthetic knee, and the remaining 2 cases occurred outside of the follow-up period (Table 4).[24] The authors attributed the 1 incidence of PJI within the follow-up period to the traumatic injury and not the associated hand surgery. The final study reported no cases of PJI following open or endoscopic carpal tunnel release.[23] None of the studies described or analyzed causative organisms related to PJI.

All 3 studies investigated the effects of prophylactic antibiotics on the rate of PJI following hand surgery.[23–25] On average, 16% (1,214 of 7,374) of patients with prosthetic joints received antibiotics prior to hand surgery (Table 4). Zeng et al[23] reported an additional 12 patients (4% of their cohort) that received postoperative antibiotics following carpal tunnel release. Five (42%) of these patients were being treated for superficial surgical site infections.[23] Specific antibiotic agents or dosages were not reported by any of the studies. Furthermore, none of the included studies found a significant relationship between antibiotic prophylaxis and PJI risks.

Zeng et al[23] further investigated the association between a hand surgeon's knowledge of the patient's prosthetic joint and their

Table 3
Patient Demographics, Procedural Data, and PJI Criteria of Included Studies

Author	Total Patients	Hand Surgery + Prosthetic Joint (%)	Control Group	Age, y	Male/Female	Hand Surgery Procedures	Prior Arthroplasty Performed	Inclusion Criteria	PJI Criteria
Zeng et al[23]	2,914	250 (9)	N/A	70.5	114/136	Carpal tunnel release	Total hip arthroplasty, total knee arthroplasty, total shoulder arthroplasty (N = 275)	All carpal tunnel release patients with a history of total hip, knee, or shoulder arthroplasty.	Patients were contacted by telephone to confirm the presence or absence of PJI after carpal tunnel release. Follow-up period: ≤6 mo following carpal tunnel release.
Li et al[25]	430,965	8,489 (2)	Patients treated with arthroplasty but did not undergo subsequent hand surgery Total: 422,476 Propensity Matched: 8,489	63 (SD, 11)	180,965/250,000	Carpal tunnel release, trigger finger release, ganglion excision, retinacular cyst excision, de Quervain Release, excision of soft tissue or tumor from hand or finger	Total hip arthroplasty, total knee arthroplasty (N = 430,865)	Hand surgery performed within 2 years of the index arthroplasty.	PJI was defined using PJI-specific ICD-9 diagnosis codes (ICD-9 996.66) and CPT codes (CPT 27030, 27310, 27091, 27488). Follow-up period: ≤90 d following hand surgery
Warnick and Ilyas[24]	6,137	331 (5)	N/A	73 (range, 47–97)	150/181	Carpal tunnel release, finger tendon sheath incision, trigger finger release, A1 pulley release, first dorsal compartment, tenosynovectomy of the wrist, cubital tunnel release, thumb basal joint arthroplasty, ulnar nerve transposition, finger flexor tenosynovectomy, wrist first dorsal compartment release, distal radius and bridge plate removal, Guyon canal release, hand extensor digital quinti tendon tenosynovectomy, radical tenosynovectomy of the fourth dorsal compartment of the wrist, thumb metacarpophalangeal joint arthrodesis, flexor carpi ulnaris release, open reduction internal fixation of open distal radius and ulna fracture, tenosynovectomy of the flexor digitorum profundus, tendon thumb carpometacarpal interposition arthroplasty, thumb trapeziectomy, wrist arthroscopic subtotal synovectomy, de Quervain release	Total hip arthroplasty, total knee arthroplasty, total shoulder arthroplasty, total ankle arthroplasty (N = 331)	All hand surgery patients with a history of total hip, knee, shoulder, or ankle arthroplasty performed at the same institution.	PJI criteria not described. Follow-up period: ≤3 mo following hand surgery

CPT, Current Procedural Terminology; d, days; ICD-9, International Classification of Diseases, Ninth Edition; mo, months; N/A, not available.

Table 4
Prevalence of PJI, Antibiotic Prophylaxis, and Main Findings From Included Studies

Author	PJI Prevalence, %	Preoperative Antibiotics Received (%)	Postoperative Antibiotics Received (%)	No Antibiotics Received (%)	Main Findings
Zeng et al[23]	0	43/275 (16)	12/275 (4)	220/275 (80)	No patients were evaluated or treated for PJI following carpal tunnel release. Antibiotic prophylaxis did not influence the rate of PJI following carpal tunnel release. Hand surgeon knowledge of a patient's prosthesis (prior TJA) had no effect on their choice to use antibiotics.
Li et al[25]	16/8,489 (0.2)	1,128/6,768 (17)	N/A	5,640/6,768 (83)	Hand surgery following joint arthroplasty was not associated with a significant increase in the PJI risk (OR, 1.39; 99% CI, 0.60–3.22; $P = .31$). Antibiotic prophylaxis prior to hand surgery did not result in a significant decrease in the PJI risk (OR, 0.42; 99% CI, 0.03–6.08; $P = .4$).
Warnick and Ilyas[24]	3/331* (0.9)	43/331 (13)	N/A	288/331 (87)	No significant relationship was found between PJI and clean hand surgery. Preoperative antibiotics did not influence the rate of PJI following clean hand surgery.

CI, confidence interval; OR, odds ratio; N/A, not available.
* One PJI occurred 7 weeks after hand surgery, following direct trauma to the prosthetic knee. The 2 remaining PJIs both occurred approximately 30 months following hand surgery, which was outside the 3-month study period.

decision to use prophylactic antibiotics. Patients with and without a documented history of TJA received preoperative antibiotics at similar rates (21% and 18%, respectively), thus suggesting that physician knowledge of a patient's prosthesis did not influence the choice to use antibiotic prophylaxis, which was ultimately based on surgeon preference.

Discussion

Although patients are at the highest risk for PJI within the first 2 years of their index arthroplasty, hematogenous seeding from a systemic infection places the prosthetic joint at lifelong risk of this devastating complication.[3] Thus, patients with prosthetic joints undergoing invasive soft-tissue procedures have historically received antimicrobial prophylaxis to reduce the risks of transient bacteremia and resultant PJI.[3] However, with respect to dental surgery, most recent American Academy of Orthopaedic Surgeons' clinical practice guidelines recommend against the use of antibiotic prophylaxis due to the limited evidence on the association between invasive dental procedures and PJI risks.[3,9,26] In the field of hand surgery, no such guidelines have been developed, and there remain conflicting arguments both for and against the routine use of antibiotic prophylaxis prior to elective, soft-tissue hand procedures.[10] Notwithstanding, only a few studies in hand surgery have explored the use of prophylactic antibiotics in populations at risk for hematogenous seeding, such as those with prosthetic joints, and few studies have evaluated the prevalence of this devastating complication.[23–25]

Our systematic review found that 581 (6%) of hand surgery patients had a history of TJA, and 8,489 (2%) patients with a history of TJA underwent elective hand surgery within the first 2 years of their index arthroplasty. It can be expected that this prevalence will continue to grow, as the number of arthroplasties performed annually is projected to increase over the next decade.[27] Moreover, there remains limited evidence supporting an association between hand surgery and increased PJI risks. The current literature only includes a single study that reported a 0.2% rate of PJI within the first 3 months following hand surgery.[25] It should be noted that with only 0.4% of elective, clean hand surgeries being complicated by infection, multiple, large-scale investigations would be needed to effectively study this relationship.[19] Currently, no high-level evidence has endorsed the use of antibiotic prophylaxis in this TJA subpopulation. Although 16% of the patients studied received antibiotics prior to hand surgery, this did not have a substantial impact on the rate of PJI. Zeng et al[23] also showed that a history of TJA had little to no effect on a hand surgeon's decision to give prophylactic antibiotics. The overuse of antibiotics has not only exacerbated the public health crisis of antimicrobial resistance, but also led to growing concerns regarding subtherapeutic antibiotic levels and the emergence of resistant bacterial strains within the joint, further underscoring the need for strict antibiotic stewardship programs across health care institutions.[28,29] Based on the available evidence, it is likely that current prescribing habits are based on the surgeon's experience and preference, highlighting the need for additional research and evidence-based guidelines on the appropriateness of this perioperative measure.

The present study must be interpreted in light of its limitations. First, the included studies were all retrospective in design, contributing to the overall low level of evidence and moderate-to-high risk of bias. Second, there was heterogeneity in patient populations, outcome measures, and PJI criteria across studies. Therefore, we were limited in the ability to pool study data without introducing confounding. Third, short-term follow-up periods were used, ranging from 3 months to 2 years. While this helps to minimize confounding, it is likely that patients with late-presenting infectious complications could have been missed. In the single study that assessed PJI in patients with a history of TJA undergoing subsequent hand surgery, a window of 2 years following index arthroplasty was used. Although this time frame has been reported to confer the highest risk for PJI, this may not account for the occurrence of late-onset PJI (>2 years).[6,30] Reports have shown that PJI due to hematogenous seeding can occur up to 13 years following the index arthroplasty, and that there is a cumulative increase in the incidence of hematogenous seeding with a prolonged prosthesis indwelling time.[4,5,31] Fourth, although Warnick and Ilyas[24] reported a relatively high rate of PJI secondary to hand surgery (0.9%), none of these cases were found to be the result of transient bacteremia following hand surgery (ie, additional trauma and time

passed). This subjects the clinical recommendation to potential bias. Fifth, the study conducted by Zeng et al[23] only investigated the risk of PJI following carpal tunnel release. While this is a commonly performed procedure, the results from this study lack generalizability to all hand procedures, namely those that are more invasive. Lastly, since a very low number of hand surgery–associated PJIs were reported, a regression analyses could not be performed to assess the relationship between antibiotic prophylaxis and PJI risks in any of the included studies.

This systematic review demonstrated an extremely low incidence of PJI following hand surgery in patients with existing prosthetic joints, with or without the use of prophylactic antibiotics. Due to the limited data available on this topic, evidence-based conclusions could not be drawn with regards to the associated risk factors and efficacy of antibiotic prophylaxis, and only low-quality evidence supports the use of prophylaxis to reduce the risk of hematogenous spread of transient bacteremia following hand surgery. Consequently, the authors are unable to provide evidence-based recommendations regarding the routine use of prophylactic antibiotics in this patient subgroup. The decision to use prophylaxis should therefore be made on a case-by-case basis, accounting for patient-specific comorbidities and other risk factors. As the population ages and the volume of orthopedic procedures continues to increase, further research on hand surgery–associated PJI is needed to determine the optimal management of these patients.

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