

Evidence-Based Protocols for the Prevention and Treatment of Prosthetic Joint Infection in Total Hip Arthroplasty: A Systematic Review

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Abstract:

Objective: This systematic review aimed to identify, synthesize, and critically analyze the available evidence on clinical protocols used for the prevention and treatment of prosthetic joint infection (PJI) in total hip arthroplasty (THA), based on studies published between 2000 and 2025. **Methods:** The review was conducted according to PRISMA guidelines. Electronic searches were performed in PubMed (MEDLINE), Scopus, Web of Science, and Embase between January and April 2025. Eligible studies included clinical trials, cohort studies, case-control studies, systematic reviews, and meta-analyses published in English that addressed either preventive or therapeutic strategies for PJI in THA. Study selection, data extraction, and quality assessment were carried out independently by two reviewers. Due to the heterogeneity of the included studies, a qualitative synthesis was performed. **Results:** A total of 32 studies were included. Preventive measures identified in the literature comprised combined antibiotic prophylaxis (cefazolin and gentamicin), multimodal perioperative protocols such as ACERTO, nasal decolonization for *Staphylococcus aureus*, silver-impregnated dressings, and structured post-discharge surveillance. Treatment strategies included DAIR (Debridement, Antibiotics, and Implant Retention), the DAPRI technique, one-stage and two-stage revision surgeries, muscle flap reconstructions, and protocols without spacers. These interventions were associated with significantly reduced infection rates and improved clinical outcomes when applied appropriately and in accordance with patient-specific factors. **Conclusion:** Effective prevention and treatment of PJI in total hip arthroplasty require a systematic and evidence-based approach. Integrated protocols—spanning preoperative optimization, meticulous intraoperative techniques, and rigorous postoperative monitoring—have proven effective in reducing infection incidence. In cases of established infection, surgical management must be tailored to the timing of infection, microbial profile, and host conditions. Two-stage revision remains the gold standard for complex infections, while one-stage revision and emerging techniques like DAPRI offer promising results in selected cases. This review contributes to the standardization of clinical practice and supports improved patient outcomes.

How to cite this paper:

Júnior, M. S. F., Neto, L. B., Prado, R. P., Bucar, H. L., Costa, H. M. C., Sampaio, L. F. S., & Silva Azevedo Nora, F. G. da. (2025). Evidence-Based Protocols for the Prevention and Treatment of Prosthetic Joint Infection in Total Hip Arthroplasty: A Systematic Review. *Online Journal of Surgery*, 1(1), 1–9.
DOI: 10.31586/ojs.2025.6138

Received: July 16, 2025

Revised: August 23, 2025

Accepted: September 1, 2025

Published: September 4, 2025



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Keywords: Total Hip Arthroplasty; Prosthetic Joint Infection; DAIR; Antibiotic Prophylaxis; Two-Stage Revision

1. Introduction

Total hip arthroplasty (THA) is among the most successful orthopedic procedures, widely performed to restore mobility and relieve pain in patients with degenerative joint diseases. Despite its clinical benefits, THA is not without complications. One of the most severe and challenging is prosthetic joint infection (PJI), which, although relatively infrequent, has devastating consequences for both patients and healthcare systems. PJI can lead to prolonged hospitalization, complex surgical interventions, functional impairment, and increased mortality rates [1-4].

Over the past two decades, there has been a significant shift in the scientific literature from focusing solely on the treatment of PJI to a broader emphasis on its prevention. This trend reflects an understanding that effective infection control strategies must begin before the surgical incision and extend throughout the perioperative period and postoperative care [5-10]. Risk factors such as diabetes, malnutrition, obesity, recent intra-articular injections, and nasal colonization by *Staphylococcus aureus* are now routinely screened and managed preoperatively [11-15]. Pre-surgical optimization, including immune-nutritional protocols and microbial decolonization, has been increasingly integrated into routine care [15,28,31].

Intraoperative measures, such as antibiotic prophylaxis, antiseptic skin preparation, and controlled theatre environments, also play a pivotal role in reducing bacterial contamination during surgery [15-20]. However, some interventions—such as the use of laminar airflow systems—remain controversial due to inconsistent clinical results [20,21]. Postoperatively, enhanced surveillance, silver-impregnated dressings, and reduced fasting through multimodal protocols like ACERTO have shown promise in decreasing infection-related complications [15,28,31].

When prevention fails, appropriate and timely treatment becomes critical. Treatment strategies vary depending on the timing of infection onset, the virulence of the causative microorganism, host factors, and prosthesis stability. Conservative options like DAIR (Debridement, Antibiotics, and Implant Retention) are indicated for early infections with short symptom duration but are associated with high failure rates, especially in cases caused by *S. aureus* [4,6]. In contrast, surgical revision—whether in a single or two-stage approach—remains the gold standard for chronic or complex PJIs [1-3,17,23,26]. Innovative techniques such as DAPRI (Debridement, Antibiotic Pearls, and Retention of the Implant), muscle flaps for salvage in massive tissue defects, and antibiotic-loaded spacers or no-spacer protocols have also expanded therapeutic options [7,29,30].

Despite the abundance of studies, clinical decision-making remains highly variable, underscoring the need for consolidated, high-quality evidence to support standardized protocols. This is particularly important given the complexity of PJI management and the substantial differences in outcomes depending on the chosen strategy [22-27,32].

Therefore, the objective of this systematic review is to identify, synthesize, and critically analyze evidence from the last two decades regarding clinical protocols for the prevention and treatment of prosthetic joint infection in total hip arthroplasty. The justification for this review lies in the growing incidence and clinical relevance of PJI, the increasing volume of heterogeneous literature, and the need to guide best practices with evidence-based strategies.

2. Methodology

2.1. Study Design

This research was conducted as a systematic review, following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure methodological transparency, reproducibility, and rigor. The objective was to identify, synthesize, and critically evaluate existing literature regarding protocols for the prevention and treatment of prosthetic joint infection (PJI) in total hip arthroplasty.

2.2. Eligibility Criteria

The inclusion criteria for this systematic review were as follows: studies published between the years 2000 and 2025, written in English, and available in peer-reviewed scientific journals. Eligible study designs included clinical trials, cohort studies, case-control studies, systematic reviews, and meta-analyses. Furthermore, all studies had to report specific protocols for infection prevention or treatment in the context of total hip arthroplasty (THA), and be conducted on human adult populations.

Conversely, the exclusion criteria ruled out studies that focused exclusively on other joints such as the knee, as well as research involving animal models or in vitro experiments. Additionally, editorial materials, letters to the editor, conference abstracts, and narrative (non-systematic) reviews were excluded. Studies that did not present defined outcomes related to infection control—either in terms of prevention or therapeutic interventions—were also omitted from the final analysis.

2.3. Information Sources and Search Strategy

Electronic searches were systematically conducted across four major scientific databases: PubMed (MEDLINE), Scopus, Web of Science, and Embase. The search process took place over a four-month period, from January 1st to April 30th, 2025, ensuring that the most recent and relevant literature was captured.

The search strategy was designed using controlled vocabulary and free-text terms related to the topic. Key search terms included “total hip arthroplasty” or the abbreviation “THA”; “prosthetic joint infection” or “PJI”; and terms relating to prevention and treatment such as “infection prevention”, “infection control”, “one-stage revision”, “two-stage revision”, “DAIR”, “DAPRI”, and “muscle flaps”. These terms were combined using Boolean operators (AND/OR) to refine and optimize the retrieval of relevant studies.

An example of a search string used in PubMed was as follows: (“total hip arthroplasty” OR “THA”) AND (“prosthetic joint infection” OR “PJI”) AND (“prevention” OR “treatment” OR “revision” OR “DAIR” OR “DAPRI”). This strategy enabled the inclusion of a comprehensive range of studies that addressed both the preventive and therapeutic dimensions of PJI in total hip arthroplasty.

2.4. Study Selection

Two independent reviewers screened the titles and abstracts of all retrieved articles to assess their relevance to the research question. Studies that appeared to meet the inclusion criteria were selected for full-text review. In cases of disagreement between the reviewers regarding eligibility, a consensus was reached through discussion; if necessary, a third reviewer was consulted to make a final decision.

For the studies deemed eligible, a standardized data extraction form was developed and tested prior to use. This form was designed to systematically collect relevant information from each study. Extracted data included study characteristics (such as author name, year of publication, and country of origin), study design and sample size, the type of protocol described (prevention or treatment), detailed descriptions of interventions (e.g., antibiotic regimens, surgical techniques), and key reported outcomes (such as infection rates, treatment failure, length of hospital stay, and postoperative complications). Additionally, the level of evidence provided by each study was recorded.

All collected data were entered into Microsoft Excel, which served as the platform for initial data organization and analysis. Studies were grouped into thematic categories and summarized in structured tables, specifically differentiating between prevention protocols and treatment strategies for prosthetic joint infection in total hip arthroplasty.

2.5. Data Synthesis

Given the substantial heterogeneity observed across the included studies—in terms of design, intervention types, and reported outcomes—a qualitative synthesis was deemed the most appropriate analytical approach. To enhance clarity and interpretability, the studies were organized according to the type of protocol addressed: either prevention or treatment of prosthetic joint infection (PJI).

Within the prevention category, interventions were further stratified into three temporal phases: preoperative, intraoperative, and postoperative measures. For treatment strategies, classification was based on the surgical approach and the timing of intervention, encompassing techniques such as DAIR (Debridement, Antibiotics, and Implant Retention), one-stage revision, and two-stage revision procedures.

Quantitative outcomes—such as infection rates, treatment failure rates, and complication rates—were extracted and reported descriptively using absolute values and percentages. These findings were systematically presented in summary tables. Due to the high degree of clinical and methodological variability among studies, a formal meta-analysis was not conducted, to avoid compromising the validity of pooled estimates.

2.6. Ethical Considerations

As this systematic review was conducted exclusively using data from publicly available, peer-reviewed literature, no interactions with human subjects occurred. Therefore, ethical approval from an institutional review board and informed consent from participants were not required.

3. Results

Table 1 presents the major infection prevention protocols implemented in total hip arthroplasty (THA), all supported by robust clinical evidence. These strategies encompass the entire perioperative continuum, including microbial control, pharmacological prophylaxis, postoperative surveillance, and surgical environment optimization. The organization follows a progressive numbering system to ensure clarity and traceability. The implementation of these protocols has shown significant reductions in surgical site infections (SSIs) and postoperative complications.

Table 1. Infection Prevention Protocols for Total Hip Arthroplasty (THA)

Protocol	Components	Reported Outcomes
Antibiotic Prophylaxis [1,15,17,18]	Cefazolin + gentamicin; timing critical (≥ 45 min pre-incision)	SSI reduced from 1.19% to 0.55%
S. aureus Decolonization [15]	Nasal swab + decolonization (mupirocin, chlorhexidine)	Infection rate reduced from 22% to 3%
Silver-impregnated Dressings [15]	Antimicrobial dressings reduce acute PJI incidence	Reduces acute postoperative infection
ACERTO Protocol [31]	Shorter fasting, immune nutrition, limited IV fluids	Reduced LOS and CRP, improved recovery metrics
Multimodal Surveillance (Passive) [20]	95% of deep infections detected within 90 days	Efficient detection of post-discharge infections
(LAF) [20]	Airborne contamination control; conflicting evidence for SSI reduction	No consistent benefit; may increase deep infections

Legend: THA = Total Hip Arthroplasty; PJI = Prosthetic Joint Infection; SSI = Surgical Site Infection; CRP = C-reactive Protein; LOS = Length of Stay; LAF = Laminar Airflow.

Antibiotic prophylaxis is essential for reducing the microbial burden during surgery. A combination of cefazolin and gentamicin is preferred, with dosing adjusted for patient weight and administration initiated at least 45 minutes before the surgical incision [1,15].

The timing is critical, as delayed administration correlates with increased SSI rates. Studies by Bosco *et al.* [16] and Babis *et al.* [17] have confirmed a significant reduction in SSI—1.19% to 0.55%—when this regimen is properly implemented. Simon *et al.* [18] also emphasizes the consequences of underdosing, particularly in obese patients.

Preoperative *Staphylococcus aureus* decolonization protocols, which include nasal screening followed by treatment with mupirocin and chlorhexidine, are particularly effective. Rezaie *et al.* [15] documented a reduction in infection rates from 22% to just 3% in institutions adopting this protocol. Similarly, silver-impregnated dressings have demonstrated a preventative effect on acute PJI. While their role in long-term infection control remains under investigation, their short-term efficacy in reducing wound complications is supported in the same body of work [15].

The ACERTO protocol, developed as part of enhanced recovery after surgery (ERAS) strategies, integrates reduced preoperative fasting, immune-enhancing oral supplements, and restricted intravenous fluid administration. Its effectiveness was demonstrated in a randomized pilot study by Alito and Aguilar-Nascimento [31], showing significant reductions in CRP levels and hospital LOS, along with better functional recovery. The protocol emphasizes the importance of systemic optimization beyond antimicrobial strategies alone.

Effective surveillance is critical for early identification of infections. Lower *et al.* [20] demonstrated that passive multimodal surveillance systems—utilizing electronic health records and routine clinical follow-up—identified 95% of deep infections within 90 days of discharge. This supports scaling back extended active monitoring when robust passive systems are in place. However, the benefits of laminar airflow (LAF) systems are less clear. While theoretically effective in reducing airborne contaminants, McHugh *et al.* [20] reports that LAF may paradoxically increase infection risk when improperly managed or disrupted by intraoperative traffic.

Table 2 outlines the major surgical protocols used to treat prosthetic joint infection (PJI) in total hip arthroplasty (THA), ordered by ascending citation number. The table captures a range of treatment modalities—both implant-retaining and revision-based—reflecting the complexity and individualized nature of PJI management. These protocols are chosen based on infection chronicity, pathogen profile, host condition, and anatomical considerations.

Table 2. Treatment Protocols for Prosthetic Joint Infection (PJI)

Protocol	Indications	Reported Outcomes
DAIR [4,6]	Acute PJI (<4 weeks); stable implant; short symptom duration	Higher failure in <i>S. aureus</i> (21%) vs. <i>Streptococcus</i> spp. (0%)
No-Spacer Protocol [2]	Severe infection or joint destruction; reduces spacer complications	33% failure rate; avoids spacer-related complications
Two-stage Revision [2,3,17,26]	Resistant/multimicrobial infections; poor soft tissue quality	High eradication (82-100%), but higher morbidity
DAPRI [7]	Modified DAIR with biofilm-targeting techniques	80% success rate; improved biofilm eradication
One-stage Revision [1,23]	Known organism, stable patient, no sinus tract or sepsis	Lower morbidity, shorter LOS, fewer complications
Muscle Flaps [30]	Large soft tissue defects or failed revision; used in limb salvage	97-100% success rate; provides durable coverage and infection control

Legend: PJI = Prosthetic Joint Infection; THA = Total Hip Arthroplasty; DAIR = Debridement, Antibiotics, Irrigation, and Retention; DAPRI = Debridement, Antibiotic Pearls, and Retention of the Implant; LOS = Length of Stay.

The DAIR procedure (Debridement, Antibiotics, Irrigation, and Retention) indicates for acute infections (typically within 4 weeks) where the prosthesis remains stable. It is less invasive than revision strategies but has variable outcomes depending on the causative organism. Betz *et al.* [4] and Lee *et al.* [6] report significantly higher failure rates in infections caused by *Staphylococcus aureus* (21%) compared to *Streptococcus* spp. (0%). Its success hinges on early diagnosis and surgical timing.

The No-Spacer Protocol, as studied by Hipfl *et al.* [2], is a variation of two-stage revision that omits the interim antibiotic-loaded spacer. It may be advantageous in severely infected or structurally compromised hips, as it avoids complications related to mechanical failure of spacers. However, it is associated with a higher treatment failure rate (33%) and is best reserved for cases where spacers are contraindicated due to anatomical or infection-related concerns.

The Two-Stage Revision remains the gold standard for chronic and complex infections, especially those involving resistant or polymicrobial organisms. Research by Faschingbauer *et al.* [3], Babis *et al.* [17], and Sandiford *et al.* [26] confirms its high infection eradication rate (82-100%). Despite its efficacy, it carries a substantial burden of morbidity due to multiple surgeries, longer treatment duration, and higher complication rates, including mechanical failure of spacers [3].

In contrast, One-Stage Revision offers comparable eradication outcomes in carefully selected patients while reducing patient morbidity, hospital LOS, and intraoperative risks. Blom *et al.* [1] and Zahar & Gehrke [23] showed that when applied to patients with known, susceptible organisms and good soft tissue conditions, one-stage revision was not inferior to two-stage revision in terms of infection control and provided significant advantages in early recovery and cost-effectiveness.

For persistent or recalcitrant infections, the DAPRI technique provides a modified approach to DAIR by incorporating aggressive biofilm disruption methods such as calcium sulphate antibiotic beads, chlorhexidine brushing, and argon beam coagulation. Ghirardelli *et al.* [7] reported an 80% success rate, making it a promising strategy for acute hematogenous infections and selected chronic cases.

Finally, Muscle Flaps, used for salvage in patients with massive soft tissue loss or failed previous revisions, offer reliable coverage and enhanced local immune response. Rovere *et al.* [30] found success rates between 97-100% in this highly specialized approach, demonstrating its vital role in limb preservation and infection resolution when standard revisions are insufficient.

4. Discussion

The data summarized in Tables 1 and 2 provide a comprehensive framework for understanding contemporary practices in the prevention and treatment of prosthetic joint infection (PJI) following total hip arthroplasty (THA). These findings, grounded in 32 peer-reviewed studies, reveal both the progress made and the complexity that remains in managing this devastating complication.

Infection prevention is best achieved through bundled, protocol-driven care, as emphasized in Table 1. Prophylactic antibiotic regimens remain a central pillar. The combination of cefazolin and gentamicin, when dosed appropriately and administered ≥ 45 minutes before incision, has shown substantial reductions in surgical site infections (SSI), from 1.19% to 0.55% [1,15-18]. This reinforces the necessity of precise timing, correct antibiotic selection, and dose adequacy, especially in patients with comorbidities such as obesity or renal impairment [16,18].

The ACERTO protocol introduces a systemic approach to perioperative optimization. By combining shortened preoperative fasting, immune-modulating nutrition, and restricted intravenous fluids, this protocol results in lower CRP levels and shorter hospital stays [31]. Its impact extends beyond infection control, contributing to enhanced recovery, consistent with broader enhanced recovery after surgery (ERAS) principles [28,31].

S. aureus decolonization protocols have achieved some of the most dramatic reductions in infection rates, lowering PJI incidence from 22% to 3% in targeted populations [15]. This effect is particularly valuable in high-risk patients or institutional settings with high colonization rates. Meanwhile, the use of silver-impregnated dressings has gained traction as a non-invasive adjunct to reduce acute infection rates [15], although long-term data are still evolving.

Environmental control strategies, such as laminar airflow (LAF), present more ambiguous outcomes. Despite theoretical benefits in reducing airborne contamination, registry-based data suggest LAF may not significantly reduce PJI and could even increase infection rates if poorly maintained or disrupted [20]. Surveillance strategies offer a more robust value proposition. Passive multimodal surveillance can detect 95% of deep infections within 90 days, supporting its use as a resource-efficient alternative to extended active monitoring [20,21].

Treatment strategies, detailed in Table 2, reflect the heterogeneity of PJI cases. The DAIR (Debridement, Antibiotics, Irrigation, and Retention) procedure is indicated for early postoperative infections (<4 weeks) and offers a prosthesis-preserving approach. However, its success is pathogen-dependent. Betz *et al.* [4] and Lee *et al.* [6] reported markedly poorer outcomes in *S. aureus* infections, with failure rates reaching 21%, compared to 0% in *Streptococcus* spp.

For patients with complex infections or poor bone/soft tissue quality, the two-stage revision protocol remains the standard of care. Studies consistently report eradication rates between 82% and 100% [2,3,17,26]. However, these results come at the cost of increased morbidity, longer treatment timelines, and complications associated with spacer usage—including dislocation and fracture [3,26].

In contrast, one-stage revision offers a viable alternative in select patients. Randomized data from Blom *et al.* [1] and further evaluations by Zahar and Gehrke [23] show equivalent reinfection rates, faster recovery, and reduced surgical burden. These findings support broader adoption of one-stage procedures where patient selection criteria (e.g., known organism, good soft tissue envelope, no sinus tract) are strictly met.

Emerging techniques like DAPRI (Debridement, Antibiotic Pearls, and Retention of the Implant) expand upon the DAIR model by incorporating biofilm-disruption strategies such as argon beam coagulation and local antibiotic bead placement. Early reports indicate success rates near 80%, particularly in acute or hematogenous infections [7].

In patients with recurrent PJI or massive soft tissue loss, muscle flaps represent a critical salvage strategy. These techniques provide vascularized tissue coverage, obliterate dead space, and enhance local antibiotic perfusion. Rovere *et al.* [29] and Osmanski-Zenk *et al.* [30] reported infection resolution rates exceeding 97%, underlining their value in limb preservation.

The “no-spacer” two-stage protocol, which avoids interim spacers, is a niche option for patients with extensive bone destruction or spacer-related risk factors. While it avoids spacer complications, Hipfl *et al.* [2] reported a 33% failure rate, limiting its use to specific clinical contexts.

Together, the data from Tables 1 and 2 reinforce the necessity of personalized, evidence-based care pathways in arthroplasty. Prevention should include universal antimicrobial prophylaxis, risk factor optimization, and surveillance, while treatment must be tailored to infection chronicity, host status, and organism type. Innovations like DAPRI and one-stage revisions expand therapeutic options but require surgical expertise and institutional readiness.

The breadth of the literature—ranging from randomized controlled trials [1,31], systematic reviews [9,29], registries [20], and observational studies [15-18,26]—confirms that successful PJI management is achievable when protocols are selected and implemented based on patient-specific and pathogen-specific criteria.

5. Conclusion

The prevention and treatment of prosthetic joint infection (PJI) in total hip arthroplasty (THA) require a comprehensive, evidence-based, and multidisciplinary approach. The data reviewed from 32 studies demonstrate that both infection prevention and management protocols have evolved substantially over the past two decades, with strong emphasis on tailored interventions based on patient risk profiles, microbial characteristics, and operative context.

Preventive strategies, including appropriate timing and dosing of antibiotic prophylaxis [1,15-18], implementation of the ACERTO protocol for perioperative metabolic optimization [28,31], *Staphylococcus aureus* decolonization [15], and passive multimodal surveillance systems [20,21], have shown substantial reductions in surgical site infections and improved clinical recovery. These measures emphasize the importance of adopting bundled protocols that integrate pharmacologic, nutritional, and environmental controls to mitigate infection risks effectively.

For established infections, surgical strategies must be selected based on infection chronicity and host factors. While DAIR offers a conservative, prosthesis-preserving approach in acute infections, its effectiveness is limited by pathogen virulence—particularly in *S. aureus* cases [4,6]. Two-stage revisions remain the gold standard for complex and resistant infections [2,3,17,26], though they carry higher morbidity. One-stage revision, when used in carefully selected patients, demonstrates comparable infection eradication with reduced recovery time and cost [1,23]. Newer approaches like DAPRI and salvage procedures such as muscle flaps further expand the treatment armamentarium, offering valuable alternatives in challenging clinical scenarios [7,29,30].

Ultimately, the optimal management of PJI in THA hinges on early identification, risk stratification, and the disciplined application of standardized protocols. Institutions should prioritize multidisciplinary coordination and continuous protocol evaluation to ensure alignment with the latest clinical evidence. Future research should continue to refine patient selection criteria for one-stage revisions, improve the durability of conservative strategies, and optimize perioperative care pathways to minimize infection-related complications.

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