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REVIEW

Review of Recent Advances in Managing Periprosthetic Joint Infection After Total Knee Arthroplasty: DAIR Technique

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Abstract: Periprosthetic joint infection (PJI) is a significant complication that can arise after joint arthroplasty. The Debridement, Antibiotics, and Implant Retention (DAIR) approach is gaining popularity as a treatment to preserve the joint, especially in cases of early or acute infections. This review compiles recent evidence to assess the effectiveness, prognostic factors, and limitations of the DAIR method in managing PJI. Success rates for DAIR vary widely, ranging from 41% to 92%. These rates are significantly influenced by several factors, including the timing of the infection, the microbial profile, patient characteristics, and the surgical techniques used. Success rates for DAIR are generally highest (over 70–90%) when performed within 4–6 weeks of symptom onset, along with the exchange of modular components, particularly for patients who present a lower risk. Staphylococcus aureus infections, when coupled with delayed presentation and comorbidities like advanced age and chronic kidney disease, are associated with higher rates of treatment failure. The use of rifampin, especially when combined with fluoroquinolones, improves patient outcomes. However, the optimal antibiotic regimens have yet to be clearly established. Emerging techniques like DAPRI and novel antiseptic irrigation solutions (eg, Bactisure®) show promise but need further clinical validation. While DAIR offers significant benefits, its variable success highlights the importance of careful patient selection and the urgent need for high-quality clinical research to establish standardized protocols and enhance long-term outcomes.

Keywords: arthroplasty, replacement, knee, debridement, prosthesis-related infections, risk factors

Introduction

The use of prosthetic knee implants has increased due to greater life expectancy and the need for improved mobility among elderly patients. Arthroplasty procedures are generally safe and effective, playing a critical role in symptom relief and functional restoration. However, this rise in procedures has been accompanied by an increase in PJI.[1] The incidence of PJI following primary total knee arthroplasty (TKA) is approximately 1.08% across various regions[2] and ranges between 5.6% and 35.0% after revision surgeries.[3]

Although multiple definitions of PJI have been proposed, none have achieved universal acceptance.[4–7] This lack of standardization introduces bias when comparing data across studies and hinders the development of consistent diagnostic and treatment protocols. Additionally, the continuous emergence of new biomarkers and diagnostic technologies renders some existing definitions outdated.[7]

In response, a new definition was introduced in 2021 by the European Bone and Joint Infection Society (EBJIS), incorporating recent research insights while maintaining elements of previous definitions.[8,] Various treatment strategies have been suggested for managing PJI.

In the management of early or acute PJI cases, the use of DAIR is recommended as a joint-preserving alternative. This approach is particularly advantageous as it reduces the morbidity associated with the removal of implants.[9] DAIR

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demonstrates highly variable success rates, which are influenced by several factors, including the timing of intervention, the causative pathogen, the patient's overall health status, and the surgical technique used.[10,11] It is important to mention that the selection of antibiotics plays a crucial role in outcomes.[12] Recently, the modified DARPI method has been introduced as a safer option for treating early acute periprosthetic joint infections. This innovative approach enhances the success rate of treatment outcomes.[13] There are certain limitations associated with the use of Dair in cases of chronic infections, particularly due to the high rates of failure observed. In these circumstances, two-stage revision continues to be regarded as the gold standard treatment.[14] This review discusses current evidence regarding the DAIR approach, focusing on its indications, clinical outcomes, and limitations. It further explores prognostic factors, antibiotic regimens, and recent surgical innovations.

Definition

Many medical societies have developed "diagnostic criteria" to improve the accuracy of the diagnosis of PJI (Table 1).

The latest criteria were defined by the European Bone and Joint Infection Society (EBJIS) in 2021. The EBJIS 2021 definition of periprosthetic joint infection (PJI) is widely regarded as a major improvement over earlier diagnostic criteria because it resolves many of the limitations that existed in previous frameworks and emerged from a collaboration between EBJIS, EANM, ESR, and infectious disease experts. Its strength lies in being more sensitive, more clinically practical, and more realistic about the complexity of PJI, especially low-grade and biofilm-mediated infections.it integrates a broader range of diagnostic tools: It combines clinical signs, serum markers (CRP, ESR, D-dimer, IL-6), a wide range of synovial tests (WBC count, PMN%, leukocyte esterase, α-defensin, synovial CRP), advanced microbiology including prolonged cultures and implant sonication, histopathology, and even nuclear imaging techniques such as WBC-labelled scintigraphy and PET/CT. Provides a graded (3-tier) interpretation instead of a binary one, and recognition That No Single Test Has Perfect Accuracy.[8]

Table 1 Comparison Between Some Diagnostic Criteria, Recently Developed Between 2011 and 2019

Definition Source	Criteria
MSIS° 2011[4]	*PJI exists when:* **(1)** There is a sinus tract communicating with the prosthesis. or **(2)** A pathogen is isolated by culture from at least two separate tissue or fluid samples obtained from the affected prosthetic joint; or **(3)** *4 of the following 6 criteria exist:* (a) Elevated serum (‡‡**ESR**) and (†† **CRP**) concentration, (b) Elevated synovial leukocyte count, (c) Elevated synovial neutrophil percentage (## **PMN**%), (d) Presence of purulence in the affected joint, (e) Isolation of a microorganism in one culture of periprosthetic tissue or fluid, (f) Greater than 5 neutrophils per high-power field in 5 high-power fields observed from histologic analysis of periprosthetic tissue at 9400 magnification. *PJI may be present if <4 of these criteria are met.*

(*Continued*)

Table 1 (Continued).

Definition Source	Criteria
†**IDSA 2013**[5]	*One or more of the following criteria* 1. Sinus tract communicating with the prosthesis 2. Purulence without other etiology surrounding the prosthesis 3. Acute inflammation seen on histopathological examination of the periprosthetic tissue 4. ≥ 2 intraoperative cultures or a combination of preoperative aspiration and intraoperative cultures yielding an indistinguishable organism; The growth of a virulent microorganism (eg, *Staph. aureus*) in a single specimen of a tissue biopsy or synovial fluid is also considered indicative of a PJI.
‡**EBJIS 2018**[6]	*One or more of the following criteria* **1**. Purulence around the prosthesis or sinus tract **2**. Increase synovial fluid leukocyte count (>2,000 cells/mL or >70% granulocytes) **3**. Positive histopathology **4**. Confirmatory microbial growth in synovial fluid, periprosthetic tissue, or sonication culture
#**WAIOT 2019**[7]	*Rule **OUT** Tests: Sensitivity > 90%, Each negative test score −1, Each Positive test Score 0* **Serum**: ESR >30 mm/h, CRP >10 mg/L **Synovial fluid**: WBC >1,500/μL, LE (++), Alpha-Defensin immunoassay >5.2 mg/L **Imaging**: Tc99 bone scan, *Rule **IN** Tests, Specificity > 90%, Each positive test score +1, Each negative test Score is 0* **Clinical examination**: Purulence or draining sinus or exposed joint prosthesis **Serum**: IL-6 >10 pg/mL, PC >0.5 ng/mL, D-Dimer >850 ng/mL **Synovial fluid**: Cultural examination, ⊥ **WBC** >3,000/mL, § **LE** (++), Alpha-Defensin immunoassay >5.2 mg/L, lateral flow test **Imaging**: Combined leukocyte and bone marrow scintigraphy **Histology Frozen section**: 5 neutrophils in at least 3 §§ **HPFs** Positive Rule INminus Negative Rule OUT tests = <0 Biofilm-relatedImplant malfunction ≥0 Low-Grade PJI ≥1 High-Grade PJI + Clinical findings: Two or more of the following: pain, swelling, redness, Warmth, function less.

Abbreviations: °MSIS, Musculoskeletal Infection Society; †IDSA, Infectious Diseases Society of America; ‡EBJIS, European Bone and Joint Infection Society; #WAIOT, World Association against Infection in Orthopedics and Trauma;; ††CRP, C-reactive protein, ‡‡ESR, erythrocyte sedimentation rate; ###PMN, Polymorphonuclear neutrophil;⊥ WBC, white blood count; §LE, Leukocyte esterase strip; §§HPFs, high power fields.

They Classified Infections into

- Infection Unlikely: Generally indicated when all diagnostic findings are negative.
- Infection Likely: Typically requires two positive findings, one of which must be a positive clinical feature or raised C-reactive protein. The second one is another positive test from synovial fluid, microbiology, histology, or imaging.
- Infection Confirmed: Can be established by a single strong positive finding in several categories, such as purulence, high synovial fluid leukocyte counts, positive alpha defensin, multiple identical positive cultures, or specific histological/imaging results.

These guidelines emphasize that cautious interpretation of results should be carried out if other inflammatory conditions are present and if prior antibiotic use can affect microbiological tests. They also advise careful consideration of single positive cultures or low sonication counts alongside other evidence. Specific conditions also apply to certain tests, like alpha defensin, synovial fluid analysis, and sonication.[8] These criteria are helpful as diagnostic tools and as guides for decision-making procedures.

Classification of Infection

In the literature, many classification systems categorize PJI according to the timing of the infection:[15]

The Coventry system classifies PJIs into early infections occurring within 1 month. Infections occurring between 1 and 24 months and late infections occurring more than 24 months after the primary total knee arthroplasty (TKA).

The International Consensus Meeting ICM system divides PJIs into early (within 90 days since primary TKA) and late (more than 90 days since primary TKA) infections.

The Auckland system distinguishes between early (less than 1 year) and late (more than 1 year) PJIs.

The Tsukayama system PJIs are categorized as follows: early if they occur within the first month, acute haematogenous if they occur after one month with symptoms lasting less than seven days, and chronic if symptoms persist for more than seven days.[15]

Treatment

The objectives of treating infected knee prostheses are to eliminate infection, alleviate pain, and enhance joint function.[16] The choice of treatment depends on several factors: The timing of the infection (whether it is early/acute or late/chronic), the responsible microorganism, the status of the adjacent soft tissues, the implant's stability, the surgeon's skill, and the patient's overall health and functional abilities. Furthermore, considering the presence of systemic infection symptoms and the patient's willingness or ability to undergo multiple surgical procedures is crucial in determining the most appropriate management method.[11,17]

Treatment options differ from DAIR to prosthesis replacement, either in two stages (which is the most commonly used technique) or in a single stage, and in rare and extreme cases, arthrodesis or even amputation.[5]

The Indications of DAIR

In 2013, the International Consensus of Periprosthetic Joint Infection[18] Considered DAIR to be a valid option for acute early postoperative infection (< 4 weeks after surgery). It is used especially in the period when biofilms are still immature and susceptible to antibiotic treatment. This evidence was supported by two recent studies in 2021 and 2024.[19,20]

This technique can be used in late acute haematogenous infection, especially in individuals who have a stable and well-functioning prosthesis, with no evidence of infection seen in radiographs, and with a favorable soft tissue envelope without any fistula.[21] These indications are supported by an updated systematic review in 2024 by Longo et al[20] and by many other papers.[11,21–24] Manning et al[25] recommended that more randomized controlled trials are needed to draw firm conclusions, as the results vary significantly between studies, and the success rate ranges between 41% and 92%.

It is worth mentioning that many papers showed no differences in implant retention rates between single or double DAIR,[26,27] implying that an additional debridement provides minimal extra advantages. We introduced an algorithm to illustrate the eligibility for the DAIR technique. (Figure 1).

Prognostic Factors

Factors Associated with Treatment Success

By analyzing 21 papers between 2018 and 2025 (Table 2), we could find that many prognostic factors associated with successful DAIR Outcomes should be taken into account. They can be summarized as follows:

- Timing and Presentation: Early intervention in the postoperative period (within the first 4 to 6 weeks) and a shorter duration of symptoms before debridement are linked to successful outcomes.[9,28]
- Surgical and Institutional Factors: The expertise of the surgical team plays a critical role, with fellowship-trained arthroplasty surgeons demonstrating higher success rates in managing infections.[41] Successful outcomes are strongly associated with meticulous debridement and the exchange of modular components, such as the polyethene liner.[21,33,35] Additional techniques that enhance treatment efficacy include combining DAIR with muscle flap procedures.,[34] meticulous surgical debridement (aided by methylene blue), delivering local antibiotics through vancomycin beads or calcium sulfate, and performing surgical synovectomy.[36]

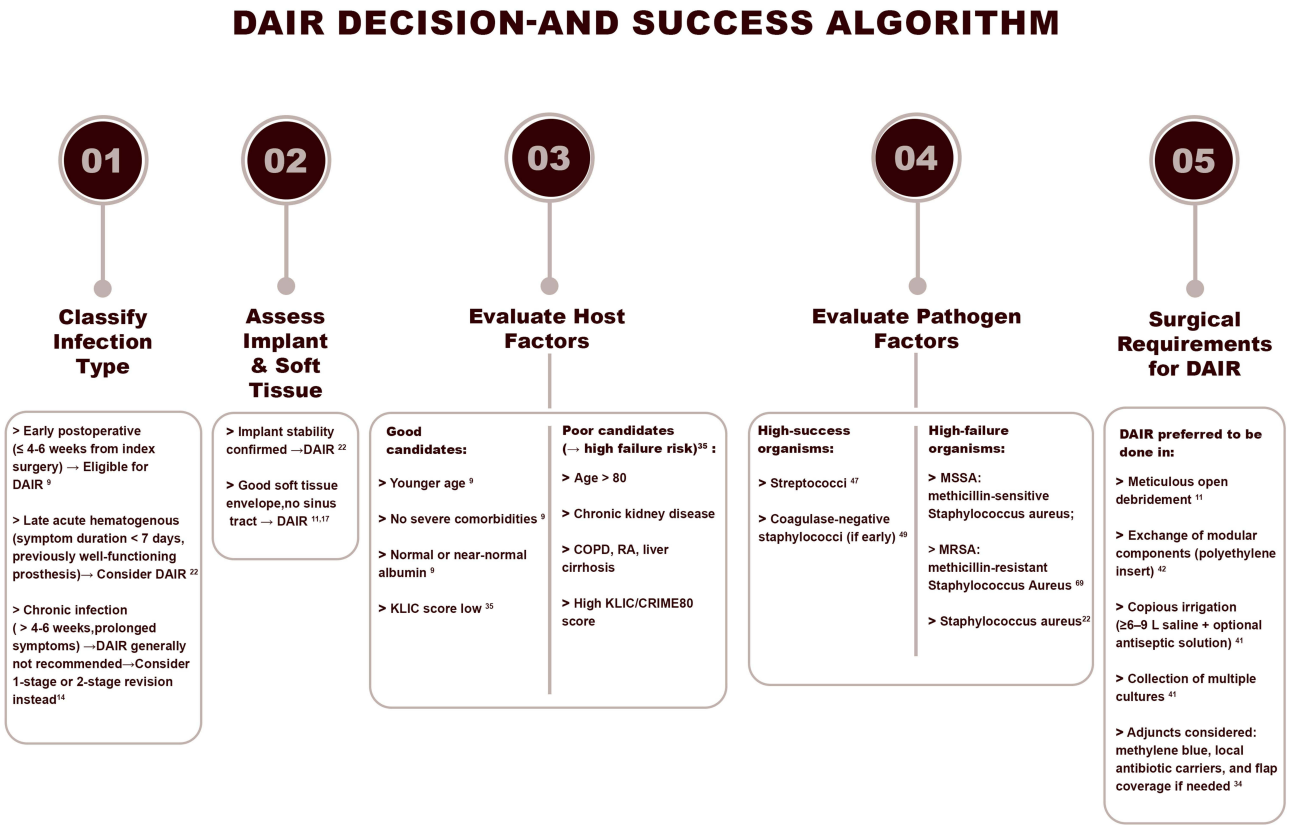

Figure 1 A flowchart illustrating the eligibility criteria for DAIR treatment.

- Patient and Host Factors: Success is more likely in younger patients with good physiological status (eg, higher serum albumin) and no significant comorbidities. DAIR shows a higher success rate in the hip than in the knee.[9]
- Biomarkers and Scoring Systems: A low KLIC score[39] High synovial fluid glucose levels (>44 mg/dL), a low serum-to-synovial glucose ratio predict successful outcomes.,[42] strictly standardized culture protocol and high pathogen ID rate with advanced diagnostics (mNGS).[31]

Factors Associated with Treatment Failure

- Infection Characteristics: Timing and nature of the infection are key predictors of failure. Late-acute, chronic PJI presentations[9] or acute hematogenous,[41] and the type of the infecting pathogen, especially MSSA or MRSA, are critical negative factors.[9,29,35,36]
- Patient or Host Factors: Patient frailty and comorbidities increase failure risk, including age over 80, male gender, and smoking. In addition to conditions like chronic kidney disease, liver cirrhosis, rheumatoid arthritis, and COPD. High-risk patients can be identified using objective criteria, such as a high KLIC score.[39] The fracture as the indication for arthroplasty also augments this risk.[28,35]
- Biomarkers and Scoring Systems: elevated systemic inflammatory markers such as C-reactive protein (CRP > 150 mg/L)[35] Adverse local biomarkers, like low synovial fluid glucose levels, are strong indicators of potential treatment failure.[42]
- Treatment Factors: Not allowing modular component exchange during the DAIR procedure.[35] And multiple previous joint surgeries.[34] Increases the risk of a poor outcome. On the other hand, pathogen-oriented antibiotic therapy[22] and a combination of rifampin with a fluoroquinolone[35] Have a positive impact on the results.

Thus, according to all these factors, we can conclude that making careful patient selection and adherence to strict protocols is crucial for achieving optimal outcomes. These results are supported by many review papers that are summarized in Table 3.

Table 2 Analysis of 21 Papers About the Results of DAIR and Factors Affecting the Results

No	Author, Year	Study Type	Joint Type	Success/Failure Rates	Factors Influencing Outcome
1	**Kristensen et al 2025**[28]	National registry-based cohort study (5,178 DAIRs)	TKA	**Failure Rate**: 20.5% at 1 year, 36.4% at 17 years.	**Positive**: DAIR within 4 weeks of primary TKA, female, younger age. **Negative**: Male sex, age >75
2	**Davis et al 2022**[9]	Multicenter Prospective Cohort (653 patients)	THA & TKA	**Overall Success**: 56%. Early PJI: 74%. Late-acute PJI: 49%. Chronic PJI: 44%	**Positive**: Younger age, hip as the index joint, early infection, and higher baseline serum albumin. **Negative**: *S. aureus*, knee joint, comorbidities. Rifampicin or ciprofloxacin use had no effect.
3	**Shaik et al 2025**[29]	Retrospective Cohort (37 patients)	TKA & THA	**Success**: Early: 88% (TKA), 91.7% (THA). Late: 0%.	**Positive**: Early intervention. **Negative**: Late infection, *S. aureus* [a], higher ASA grade.
4	**Perdomo-Lizarraga et al 2025**[30]	Retrospective Cohort (291 patients)	THA & TKA	**Success**: There is no significant difference between Group A (DAIR within 4 weeks) at 64.4% and Group B (DAIR within 5–12 weeks) at 55.6% after 5 years.	**Key finding**: Overall success rate decreased from 75.6% to 62.2% in the last 3 years of follow-up.
5	**Wouthuyzen-Bakker et al 2019**[21]	Multicenter Observational Study (340 patients)	THA & TKA	**Failure Rate**: 45.0%.	**Positive**: Exchange of mobile components. **Negative**: *S. aureus* infection, high CRIME80 score [b].
6	**Tseng et al 2024**[31]	Retrospective Cohort (119 patients)	TKA	**Success**: 75.6%.	**Negative**: Smoking, higher preoperative CRP. Validated a new scoring system for predicting success.
7	**Gavaskar et al 2024**[32]	Retrospective Comparison (86 patients)	THA & TKA	**Success**: 71% overall. No advantage found for modular component exchange (69% vs 74%).	**Positive**: DAIR within 45 days of primary surgery.
8	**Zhang et al 2020**[23]	Retrospective Cohort (24 patients)	THA & TKA	**Success**: 91.7% overall. 100% for staphylococcal infections.	**Positive**: strictly standardised culture protocol, high pathogen ID rate with advanced diagnostics (mNGS).[c]
9	**Mulpur et al 2021**[19]	Retrospective Cohort (80 patients)	TKA	**Success**: 68.75%.	Found no significant influence from patient comorbidities, culture status, Gram staining characteristics, or pathogenic bacteria identity in this cohort.
10	**Awad et al 2024**[33]	Prospective Cohort (25 patients)	THA & TKA	**Success**: 76%.	**Positive**: Adherence to a strict protocol, including modular exchange.
11	**Boadas-Gironès et al 2024**[34]	Retrospective study of 18 patients	TKA	**Healing Rate**: 66.6% in the group with combined DAIR and flap procedure vs 33.3% in the isolated flap group.	**Positive**: The authors recommend associating the muscle flap procedure with DAIR for acute soft tissue defects after TKA. **Negative**: in patients with multiple previous joint surgeries.
12	**Wouthuyzen-Bakker et al 2018**[35]	Retrospective, multicenter study of 340 patients	THA & TKA	Overall **Failure Rate**: 45.0%. Failure dominated by S. aureus: 54.7%.	**Positive**: Exchange of mobile components was the strongest predictor of success. **Negative**: fracture for prosthesis indication, rheumatoid arthritis, age >80, male gender, CRP >150 mg/L.
13	**Abdull Sitar et al 2024**[36]	Case series of 3 patients.	TKA	**Success** 100% with DAIR and local antibiotics.	**Positive**: early intervention, meticulous surgical debridement (aided by methylene blue), and local antibiotic delivery via vancomycin beads or calcium sulfate.

(*Continued*)

Table 2 (Continued).

No	Author, Year	Study Type	Joint Type	Success/Failure Rates	Factors Influencing Outcome
14	**McCormick et al 2024**[37]	Retrospective multicenter study / 52 patients	UKA	**Success**: 80.8% infection-controlled success at 1 year. **Failure**: 19.2% failure rate, with all failures requiring revision to TKA. **Other**: 14.3% of successful DAIR cases required conversion to TKA within 5 years for arthritis.	**Positive**: Surgical synovectomy was significantly associated with the eradication of infection. **Negative**: Staphylococcal infections. 70% of failures were due to MSSA[d] or MRSA[e]. Specifically, 4 out of 5 MRSA infections failed DAIR.
15	**Asadollahi et al 2024**[38]	Retrospective single-institution study / 16 patients	UKA	**Success**: 57% infection-free survivorship at 5 years (88% at 1 year). **Failure**: All-cause revision-free survivorship was 52% at 5 years.	**Positive**: Patients with a successful DAIR had excellent functional outcomes (median Oxford Knee Score of 45). **Negative: MSSA** was the most common organism identified (50%). The study suggests the potential for inadequate debridement through a small UKA incision as a factor in failure.
16	**Oliveira Filho et al, 2024**[39]	Retrospective study (17 patients)	TKA	35% **failure** rate 100% failure with chronic kidney disease.	**Negative Factors**: • High KLIC score[f] • Comorbidities in intermediate KLIC patients • Chronic kidney disease (100% failure rate) **Predictive Tools**: • KLIC and CRIME80 scores effectively predict failure.
17	**Chao et al, 2024**[40]	10-Year Cohort Study (108 patients)	TKA	**Cumulative Failure Rates**: 52.5% within 1 year • 79.1% within 5 years	**Positive Factors**: Monitoring patients 1 to 5 years post-DAIR is recommended, as most failures happen then. **Negative Factors**: High early failure (within 1 year) is likely due to biofilm formation.
18	**Tubin et al, 2024**[41]	Retrospective Cohort (112 patients	TKA	**Overall failure rate**: 59.8%. Success rates: - 51.5% for fellowship-trained (FT) surgeons. • 22.7% for non-fellowship-trained (NoFT) surgeons.	**Positive Factors**: DAIR by a fellowship-trained surgeon improved success. **Negative Factors**: Most DAIRs were for acute hematogenous PJI, linked to higher failure rates.
19	**Davis et al, 2022**[9]	Prospective Observational Cohort (653 patients	THA & TKA	Success Rate: • Overall: 54% • Late-acute DAIR: 49% • Early post-implant: 79% • Late-acute presentations: 72% • Chronic PJI: 56%	**Positive Factors**: • Hip joint • Early post-implant infection • Higher baseline serum albumin • Shorter symptom duration **Negative Factors**: • Knee joint • Staphylococcus aureus infection • Late-acute or chronic infections • Comorbidities (eg, chronic renal disease, malignancy) **No Association Found With**: • Extent of debridement • Exchange of mobile parts • Use of rifampicin • Duration of antibiotic therapy

(*Continued*)

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Table 2 (Continued).

No	Author, Year	Study Type	Joint Type	Success/Failure Rates	Factors Influencing Outcome
20	**Sabater-Martos et al, 2025**[42]	Retrospective Prognostic Study (32 patients) (To investigate the predictive value of synovial fluid glucose for DAIR outcomes).	TKA	**Failure rate**: 31.3%	**Positive Factors**: • Synovial glucose > 44 mg/dL • Serum-to-synovial glucose ratio < 50% **Negative Factors**: • Low synovial glucose (< 44 mg/dL) • High serum-to-synovial glucose ratio (> 50%) • Extreme alterations in synovial glucose are linked to earlier failure
21	**Wouthuyzen-Bakker et al, 2018**[35]	International Retrospective Study (340 patients)	Late Acute PJI (Hip & Knee	**Failure Rates**: • Overall, 45.0% • When S. aureus is present, 54.7% • 81.1% of failures happen within the first year	**Positive Factors**: Exchange of mobile part, Combination of rifampin with a fluoroquinolone for staphylococcal infections. **Negative Factors**: Staphylococcus aureus infection• Prosthesis needed due to fractur• Rheumatoid arthritis• Age > 80; Male • CRP > 150 mg/L• Chronic obstructive pulmonary disease.

Notes: >150 mg/L, Chronic obstructive pulmonary disease, Rheumatoid arthritis, fracture as an Indication for the prosthesis, Male gender, not exchanging the mobile components during debridement, and an age above 80 years; CRP: C-reactive protein; [c]mNGS: metagenomic Next-generation sequencing; [d]MSSA: methicillin-sensitive Staphylococcus aureus; [e]MRSA: methicillin-resistant Staphylococcus Aureus; UKA: Unicompartmental Knee Arthroplasty; [f] KLIC: an evaluation scale proposed by Tornero et al in 2015.
Abbreviations: [a]*S. aureus*, Staphylococcus aureus; ASA, American Society of Anesthesiologists; [b]CRIME80, C-reactive protein.

Table 3 Summary of 4 Recent Review Papers

No	Author, Year	Study Type	Joint(s) Studied	Success Rate	Conclusions
1	**Longo et al (2024)**[20]	Systematic Review (970 patients)	THA + TKA	71% (range 55.5% to 90%).	• Highlights general effectiveness of DAIR • Notes a lack of high-quality comparative trials (RCTs).
2	**Balato et al (2022)**[22]	Systematic Review (430 knee implants)	TKA	Mean rate = 41%	Positive factors: Intervention within 1 week of symptoms, modular component exchange, and a pathogen-oriented antibiotic therapy. Negative factors: *S. aureus*.
3	**Sendi et al (2025)**[43]	Narrative Review	THA + TKA	For a chronic infection after DAIR from 28% to 45%.	Stresses the "crucial four" criteria for success: stable implant, short symptom duration, healthy soft tissue, susceptible organism.
4	**Sigmund et al (2025)**[10]	Literature review	THA + TKA	Range widely from 7–55%	Many factors include: 1. Infection type, 2. Host factors (eg, comorbidities, age), 3. Prosthesis stability, 4. The causative microorganism and its susceptibility, 5. Soft tissue condition, 6. Surgical technique.

Surgical Technique (Debridement, Irrigation, and Implant Replacement)

It is recommended to aspirate the knee and collect fluid for culture immediately after making the skin incision to prevent contamination during the procedure. If sufficient fluid is obtained, the samples are divided into three parts: one sterile container for microscopic examination, cell counting, and culture, and two blood culture bottles for aerobic and anaerobic cultures.[44]

The first step is always the debridement.

This surgical procedure encompasses the removal of skin margins, excision of any sinus tracts, radical synovectomy, and the exchange of removable implants. It is essential to remove the polyethylene tibial insert to facilitate access to the posterior aspect of the joint.[45] This procedure should be performed with an open arthrotomy. It is crucial that all damaged or devitalized tissues and bones, including scar tissue, sinus tracts, osteolytic areas, sequestra, and other non-viable tissues, are excised until healthy bleeding margins are achieved.[11]

Irrigation must be the next step. Specific protocols are in place. The wound should be thoroughly irrigated with 6 to 9 liters of normal saline until the fluid becomes clear. Additionally, the knee should be soaked for five minutes in a 2% aqueous chlorhexidine solution.[44]

Despite decades of use, there is still no high-quality evidence demonstrating that higher volumes, particular antiseptic concentrations, or even the use of antiseptic solutions at all lead to superior clinical outcomes. This underscores a fundamental problem: much of the current approach is driven by expert opinion rather than validated clinical efficacy.

The 2022 review by Caid et al[46] highlights a significant gap in the existing evidence. Although they examined a wide range of antiseptic irrigants— including povidone-iodine, chlorhexidine, hydrogen peroxide, acetic acid, antibiotic solutions, taurolidine, and polyhexanide—the review ultimately revealed that the current studies are inconsistent, methodologically flawed, and poorly controlled. Their inability to recommend a preferred solution does not indicate that all solutions are equivalent; rather, it reflects the inadequacy of the available evidence.

Attempts to introduce new solutions, such as Bactisure®, have not yet resolved these uncertainties. The retrospective cohort published by Andriollo et al[47] (2024), while reporting an 87.2% infection-recurrence-free survival rate, offers limited scientific value due to its inherent design weaknesses. Without randomization, blinding, or standardized control groups, it is impossible to discern whether the observed outcomes are attributable to the solution itself or to confounding variables—such as surgical expertise, host factors, or selection bias.

The randomized trial protocol outlined by Oleo-Taltavull et al.[48] Signifies progress in theory; however, we cannot assume that Bactisure® or any other proprietary agent is superior to simple saline until the results are published and critically evaluated. Given the commercial interests linked to biofilm-targeting technologies, it is essential to interpret such trials with caution, focusing on potential conflicts of interest, funding sources, and the rigor of the methodology.

Antibiotics

The Type of antibiotics

An empirical antibiotic regimen must be administered following thorough debridement. Once definite microbiology results are available, antibiotic therapy is changed to a more specific therapy.[49] Antibiotic treatment depends on the specific type of pathogen, its susceptibility to antibiotics, and the type of surgery performed.[49,50]

Studies show that the debate over the benefits of rifampicin in treating staphylococcal PJIs remains ongoing[50–52] (Table 4). Its effectiveness is influenced by the treatment duration,[53] and in combination with certain antibiotics like fluoroquinolones.[12,54] A short-term treatment strategy generally yielded better results.[55] Rifampicin efficacy seems highest when combined with a fluoroquinolone, and its benefit may be more pronounced in knees than in hips.[51]

However, the evidence quality is limited due to the nature of the studies, indicating a need for more rigorous research on rifampicin's optimal use in these infections (Table 5).

Duration of Antibiotics

After performing debridement, irrigation, and inserting the prosthesis, pathogen-specific intravenous antibiotic therapy is recommended for 2–6 weeks. This should be combined with oral rifampin 300–450 mg twice daily. Following this initial treatment, patients should continue taking rifampin along with a complementary oral medication for 6 months.[5] There is an ongoing debate in the medical community about the optimal length of antimicrobial treatment after DAIR.[57] In 2024, Chao R and colleagues[58] Conducted a cohort analysis on extended antibiotic treatment for PJI failure in TKA. They found that a year of extended treatment significantly reduced PJI failure risk compared to the standard 6-week course, with benefits plateauing after one year. There were no significant differences in adverse event rates between the two groups.

Table 4 Recent Systematic Reviews Showing the Efficacy of Rifampicin Use

The Study	Population Size & Focus	Key Findings on Rifampicin
Scheper et al (2021)[52]	64 studies (4,380 patients) with Staphylococcal (S. aureus and coagulase-negative staphylococci) hip or knee PJI.	Rifampicin offers a small overall benefit. The evidence is weak and may be restricted to knee PJI.
Cortés-Penfield et al (2022)[12]	8 studies (from Scheper et al) with Staphylococcal PJI.	Rifampin's benefit appears conditional on its partner drug; effective with fluoroquinolone but not with others.
Yusuf et al (2024)[50]	14 studies (1,150 patients with Staphylococcal PJI undergoing DAIR).	Adding rifampicin to DAIR increases the likelihood of therapeutic success (moderate level of evidence).
Gachet et al (2024)[54]	A total of 405 patients from six different studies focusing on acute staphylococcal PJI managed with DAIR.	The review highlighted five common rifampicin-based combinations as recommended by IDSA guidelines (with fluoroquinolone, clindamycin, ciprofloxacin, linezolid, or trimethoprim-sulfamethoxazole).

Table 5 The Role of the Duration of Rifampicin in PJI Treatment

Study	Study Type & Scope	Population Size & Focus	Key Findings on Rifampicin
Becker et al (2020)[53]	Retrospective multicenter cohort	79 patients with early-onset acute Staphylococcal hip or knee PJI.	The duration of rifampin therapy, not dose or delay, is the critical factor for success.
Suzuki et al (2022)[51]	Retrospective cohort study	4,624 patients with S. aureus PJI (hip or knee).	Adjunctive rifampin significantly reduces recurrence for up to 180 days. The benefit is prominent for knee PJI but not statistically significant for hip PJI.
Scheper et al (2022)[55]	A prospective, multicenter, registry-based cohort study	200 adult patients with staphylococcal PJI treated with DAIR or a 1-stage exchange.	A short-term strategy (5 days of rifampicin) followed by clindamycin or flucloxacillin monotherapy was as effective as traditional 12-week rifampin therapy. Treatment duration was four weeks shorter with similar cure rates.
Jang et al (2024)[56]	Retrospective case series from a single institution	24 patients with staphylococcal PJI who underwent either DAIR or resection arthroplasty with a destination spacer.	For patients who received rifamycin, the success rate was 85.7% in the DAIR group and 100% in the destination spacer group.

Recent studies indicate that there is limited support for the use of suppressive antibiotic therapy (SAT) in treating periprosthetic joint infections. The outcomes appear to be similar whether SAT is maintained or discontinued[59,60] Overall, the quality of the evidence is low. The average rate of side effects from long-term antibiotic use is 15.4%.[61] Highlighting the need for more robust, high-quality research in this field.

A key question is: If DAIR fails to eradicate the infection, does this jeopardize the success of later staged revision procedures? The answer is controversial. J. Christopher Sherrell et al[62] found that failed DAIR can negatively affect outcomes in two-stage revision TKA, while K. Kim et al[63] reported no difference in success rates for subsequent staged revisions following a failed DAIR. Therefore, the potential benefits of a successful DAIR procedure must be carefully balanced against the possible risks associated with treatment failure.[21]

Debridement, Antibiotic Pearls, and Retention of the Implant DAPRI

In 2019, Calanna et al proposed some modifications to the surgical technique of DAIR.[57] They invented debridement, antibiotic pearls, and retention of the implant by adding antibiotic pearls (DAPRI) to improve the chances of saving an infected total knee replacement, and to eliminate bacterial biofilms. It could be a safer option for treating early

acute periprosthetic joint infections, improving the success rate. This finding is consistent with a recent systematic review.[13]

Limitations

While the DAIR is a suitable option for treating PJI following TKA, it has some limitations. Specifically, it requires a strict and narrow window for intervention in cases of early and acute infections, and it has a high failure rate when used for chronic infections.[9,43]

The effectiveness of this approach also depends on the specific microorganisms involved[21] as well as patient health and host factors.[9,39] These considerations may lead clinicians to depend on revision exchange in some circumstances.[14]

Although DAIR is considered a "less invasive" option and has lower initial costs compared to two-stage revisions, total costs may increase if further treatments become necessary after a failure.[64]

Functional outcomes and quality of life are now key metrics of success in DAIR procedures. By preserving the prosthesis and minimizing soft-tissue disruption, successful DAIR leads to faster recovery, earlier ambulation, and better knee mobility. Evidence from Chang et al shows that patients who underwent modified DAIR achieved greater maximal knee flexion (103° vs 90°), improved WOMAC scores (24 vs 30), and higher satisfaction (VAS 8 vs 5) compared to those receiving two-stage revision, with similar infection control rates.[65]

Similarly, Okafor et al found that DAIR generally provides better functional knee scores, reduced morbidity, and a less invasive recovery compared to revision strategies, highlighting the need for strict patient selection to optimize outcomes.[66]

In summary, when DAIR succeeds, it eradicates infection, preserves long-term joint function, and improves post-operative quality of life compared to more extensive revision procedures.

Future Directions

DAIR continues to be a vital treatment option for many acute periprosthetic joint infections, particularly when implemented promptly and for well-chosen patients. While some adjunctive methods, such as the use of rifampin and techniques like DAPRI, show potential, the current evidence remains inconsistent, especially concerning long-term outcomes and the effectiveness of suppressive antibiotic therapy. Future research should focus on developing high-quality evidence for using DAIR in acute periprosthetic joint infection. Large, multicenter prospective studies and randomized controlled trials are essential to establish patient-selection criteria, standardize surgical techniques, and determine optimal intervention timing. Comparative studies should assess long-term outcomes, quality of life, and cost-effectiveness compared to one-stage and two-stage revisions. Investigating pathogen-specific factors, biofilm-disrupting adjuncts, and local antibiotic carriers may enhance treatment protocols. Standardized clinical pathways based on robust data will be crucial for improving outcomes and supporting evidence-based decisions for DAIR candidates.

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Author Contributions

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