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PROSTHETIC JOINT INFECTION (S NODZO AND N FRISCH, SECTION EDITORS)

Indications and Guidelines for Debridement and Implant Retention for Periprosthetic Hip and Knee Infection

Douglas A. Zaruta[1] · Bowen Qiu[1] · Andrew Y. Liu[1] · Benjamin F. Ricciardi[1]

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Abstract

Purpose of Review Prosthetic joint infection is one the most common causes of revision surgery after hip or knee replacement. Debridement and implant retention (DAIR) is one method of treating these infections; however, significant controversy exists. The purpose of our review was to describe current knowledge about indications, intraoperative/postoperative patient management, and outcomes of DAIR.

Recent Findings Patient selection affects the success of DAIR. Medical comorbidities, duration of symptoms, and nature of infectious organism all influence outcomes. Intraoperative techniques such as open arthrotomy, extensive debridement, copious irrigation, and exchange of modular parts remain current standards for DAIR. Postoperative administration of antibiotics tailored to operative cultures remains critical. Antibiotic suppression may increase the success of DAIR.

Summary DAIR provides reasonable infection eradication between 50 and 80% with improved outcomes in appropriately selected patients. More research is needed on the use of adjuvant therapies intraoperatively and the role of postoperative antibiotic suppression.

Keywords Prosthetic joint infection · Debridement and implant retention · Irrigation and debridement · Antibiotic suppression · Hip infection · Knee infection

Introduction

Debridement, antibiotics, and implant retention (DAIR) has traditionally been the treatment of choice for acute prosthetic joint infection in the hip and knee [1–3]. In this review, we will speak about the preoperative considerations, intraoperative procedures, postoperative management considerations, and outcomes of DAIR with a focus on the past 10 years of studies. DAIR remains an important element in the management of PJI, and our understanding of its benefits and pitfalls continues to evolve.

This article is part of the Topical Collection on *Prosthetic Joint Infection*

✉ Benjamin F. Ricciardi
Benjamin_Ricciardi@urmc.rochester.edu

[1] Department of Orthopedic Surgery, University of Rochester School of Medicine, Highland Hospital, 1000 South Avenue, Rochester, NY 14620, USA

Preoperative Considerations for DAIR

In order to maximize the treatment success for patients with periprosthetic joint infections (PJI), a thorough patient history and preoperative workup must be performed. Preoperatively derived factors impact the success of DAIR, and optimizing patient selection for this procedure will maximize the potential for success.

Patient medical comorbidities are one consideration prior to DAIR; however, the effect of individual medical comorbidities on failure of DAIR is not clear. Obesity has been associated with risk of PJI after primary hip and knee replacement in multiple studies [4–7]. For example, Everhart et al. found that BMI as a continuous variable had a significant association with postoperative PJI after primary joint replacement, and patients with a BMI > 45 had an 8.6% risk of infection in their predictive model while a BMI > 60 had a 30% probability of infection [6]. The association between BMI and failure of DAIR is less clear. Multiple studies from large academic centers have not found an association between BMI and DAIR

treatment failure when using BMI as a continuous variable [8, 9•, 10•, 11•]. Triantafyllopoulos et al. did find that a BMI > 30 correlated with failure of DAIR in deep PJI of the hip [12]. Given the association of obesity with primary PJI, it is possible that some of these studies may have been underpowered to detect this difference due to small sample sizes, and further studies are needed to define the effect of obesity on DAIR.

Compromised host immunity may lead to inferior outcomes with DAIR. Since the implant is retained, DAIR may be more dependent on the patient's immunity to clear the underlying infection compared with other methods of treating PJI [13]. Diseases such as diabetes mellitus and inflammatory arthritis increase the risk of primary PJI; however, their association with failure of DAIR is less clear. Certain studies have found weak associations with immunosuppressive therapy, rheumatoid arthritis, and diabetes mellitus, but these associations were not strong or consistent across studies [9•, 14, 15•, 16]. Some of this may be explained by selection bias, where patients who have uncontrolled diabetes or immunosuppressed patients are not readily indicated for DAIR. Taken together, an optimized host maximizes the chances of success for DAIR, but individual comorbidities by themselves do not appear to provide a contraindication to the procedure.

A number of classification systems have been used to stratify patients based on their underlying comorbidities including the McPherson classification (Table 1), American Association of Anesthesiologists (ASA) scores, and Charlson comorbidity index [17]. These may be more useful than individual comorbidities to decide who may be a candidate for DAIR. Bryan et al. found that DAIR had increased treatment failure rates after acute postoperative and acute hematogenous periprosthetic hip infection in McPherson host grade B and C relative to healthy individuals [18•]. Patients in the host grade C category had approximately 56% chance of success with DAIR at 4-year follow-up versus greater than 90% success in host A grade [18•]. This suggests that underlying global host characteristics should be important factors in the decision to perform DAIR. Other studies have found an association between higher American Association of Anesthesiologists (ASA) scores and DAIR failure. Fink et al. found that ASA independently correlated with failure of DAIR in both acute hematogenous and acute postoperative PJI of the knee and hip, with up to a 7-fold increased risk of treatment failure in higher ASA classification patients [9•]. Azzam et al. also found an independent increased risk for DAIR failure in patients with higher ASA (3 or 4) scores [14]. Taken together, a good host provides greater chances of DAIR success.

Table 1 McPherson classification for prosthetic joint infection

Category	Grade	Description
Infection type	I	Early postoperative (< 4 weeks)
	II	Acute hematogenous (< 4 weeks symptoms)
	III	Late chronic (> 4 weeks symptoms)
Systemic host	A	No compromise
	B	Compromised (2 or fewer factors[a])
	C	Significant compromise (> 2 factors) or absolute neutrophils < 1000/mm^3, CD T count < 100/mm^3, intravenous drug abuse, neoplasia of the immune system
Local factors	1	No compromise
	2	1–2 compromising factors[b]
	3	> 2 compromising factors

[a] Systemic host factors: age > 80, alcoholism, nicotine use, chronic indwelling catheter, chronic malnutrition, diabetes mellitus, liver insufficiency, renal insufficiency, pulmonary insufficiency

[b] Local factors: acute infection, multiple incisions, soft tissue loss, subcutaneous abscess > 8 cm^2, cutaneous fistula, posttraumatic

Patient risk factors that affect wound healing result in increased failure rates in DAIR, and an uncompromised soft tissue envelope is critical for successful implant retention. In the setting of a revision implant, which may be associated with deficient bone stock, compromised soft tissues, and involvement of foreign materials such as meshes or bone graft, DAIR may have higher failure rates [1, 6, 11•]. Reinfection rates were also significantly higher when multiple debridement procedures had been previously performed, likely secondary to the soft tissue disruption sustained with additional operations [2, 15•]. Finally, the presence of a sinus tract suggests a more chronic infection and is a risk factor for DAIR failure [13, 15•, 19]. Risk factors for postoperative wound healing problems may also compromise the results of DAIR. Nicotine use is strongly associated with both PJI development as well as DAIR failure with up to a 12-fold risk of infection recurrence [6, 9•]. Soft tissue healing is impaired in the revision setting and avoiding DAIR on patients with a compromised soft tissue envelope or those with risk factors of poor healing would be warranted.

The underlying organism may influence the outcome and decision to perform DAIR. Gram-positive bacteria are responsible for the vast majority of PJIs, compromising mostly Staphylococcus species and streptococci. *Staphylococcus aureus* infection is associated with higher rates of DAIR failure in multiple studies, and this may be worse with methicillin resistance [1, 6, 8, 13, 14, 20–24]. Buller et al. found that resistant organisms like methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococcus (VRE) had worse outcomes than other gram-positive or gram-negative organisms or culture negative infections with success rates less than 30% by 2 years [8]. Sendi et al. had two failures of DAIR, both occurring in patients with acute hematogenous infection with *S. aureus* [10•]. Azzam et al. found that Staphylococcal species infection was an independent predictor of DAIR failure with a confidence interval of 1.26–15.21 [14]. This finding is not uniform across studies, and a

number of recent studies have not found an association between DAIR failure in Staphylococcus species versus other organisms [9•, 25•, 26]. Grammatopolous et al. found that infection with Streptococcus species had lower overall complication rates compared to other organisms in total hip replacement PJI [25•]. Taken together, there may be a higher failure rate in PJI with Staphylococcal organisms; however, other factors should be incorporated into the decision-making process, and recent literature does not support avoiding DAIR completely in Staphylococcal infections.

A number of classification systems have been used to describe PJI. Typically, they break it into three groups: early postoperative (within 4–6 weeks of surgery), late chronic (> 4–6 weeks after surgery or symptom development), and acute hematogenous (short duration of acute symptoms distant from the initial procedure in a well-functioning prosthesis) [27, 28]. The literature is ambiguous regarding whether this distinction affects failure rate for DAIR, and it appears either acute postoperative or acute hematogenous infections can be candidates for DAIR when other surgical and patient factors are appropriate. Buller et al. found that symptoms greater than 21 days had higher failure rates than patients with symptoms < 21 days [8]. Grammatopolous et al. found that patients treated within 6 weeks of symptoms had improved infection eradication rates relative those treated with a longer duration of symptoms [25•]. Triantafyllopoulos et al. found that symptom duration more than 5 days was an independent risk of failure of DAIR [12]. Some authors have described no significant difference in failure rate between acute hematogenous and acute postoperative PJI, while others have argued that acute hematogenous infection results in a higher risk for infection recurrence, with some studies reporting as much as an 8-fold higher risk for infection [9•, 26, 29]. Regardless of the type of infection, identifying PJI as early as possible from symptom presentation may improve overall outcomes of DAIR and should be the goal of any surgeon treating PJI [18•]. Chronic, late presenting infections appear to do poorly with DAIR and are better treated by component exchange, which may be due to implant biofilm formation.

Intraoperative Considerations for DAIR

Common components of DAIR include open arthrotomy, extensive debridement with synovectomy, thorough irrigation, retention of well-fixed components, and exchange of all modular components. Various adjunctive treatments have been used concomitantly in an attempt to improve local infection control and reduce biofilm, including the use of local antibiotics (e.g., antibiotic beads, sponges, and powder), chemical debridement and lavage with various antiseptic agents (e.g., betadine, chlorhexidine, peroxide, etc), and physical debridement or treatment of implants.

Exchange of Modular Parts

Modular components should routinely be exchanged with treatment of acute PJI. Retaining modular components can lead to persistent infection and higher failure rates due to a fibrin layer that can form between hard and soft bearings. Additionally, it may limit the extent of surgical debridement, especially in the knee. Previous studies have reported lower success rates with retention of modular implants (0–44%) compared to exchange of modular implants (53–59%) in acute hip and knee PJI [15•, 30]. Grammatopoulos et al. reported that exchange of modular parts was an independent risk factor for improving infection eradication, with overall 10-year survival rates of 86% in patients with modular exchange versus 68% in those without modular exchange, although this appeared to be most effective in the chronic setting [25•]. Currently, we recommend exchanging modular parts when possible although we recognize that there are times where this might not be feasible.

Synovectomy/Debridement and Irrigation

Radical debridement and synovectomy of all infected and potentially infected tissues should be performed [9•, 10•]. Wound margins should carefully debrided with removal of any necrotic soft tissue debris and excision of sinus tracts. [1]. Presence of purulent material around the implant was found to be associated with significantly higher rate of failure in one study so consideration to a prosthetic exchange in this setting would be warranted [14]. Multiple tissue samples should be taken from various sites and sent for culture and histology [1].

Thorough irrigation of involved tissues with copious volumes of fluid is performed following debridement. While there is no evidence for an acceptable volume of fluid, most studies report a range of 3 to 9 l of fluid [10•, 14]. Arthroscopic irrigation alone is not recommended in the treatment of acute PJI. Despite some limited success reported with arthroscopic lavage [31, 32], there is demonstrable evidence that outcomes are worse when compared to open treatment [1, 33, 34]. Byren et al. reported 47% success rates with arthroscopic lavage compared with 88% success rates for open treatment [1]. Limitations of arthoscopic lavage include inability to perform adequate tissue debridement, synovectomy, and exchange of modular implants.

Irrigation is performed with sterile saline and may be mixed with antibiotic or antiseptic solution. Various antiseptic agents have been used, including aqueous chlorhexidine, octenidine, polyhexadine, dilute betadine, and hydrogen peroxide-based solutions [1, 9•, 35]. Chlorhexidine gluconate (0.05%) solution has been shown in vitro to be better than pulsed saline lavage at reducing bacteria colony counts using a titanium disk biofilm model [36]. Octenidine (Octenisept) and

polyhexanide (Lavasept) have been used in European studies for their antimicrobial activity against gram-positive and gram-negative bacteria [9•, 10•]. Fink et al. described routine lavage with octenidine solution for 3 min followed by saline, as well as scrubbing of retained implants with octenidine. DAIR success rates using the antiseptic lavage solution as an adjuvant resulted in overall success rates of 72%, and it appeared to work better in the acute postoperative setting [9•]. Currently, no single method has been shown to be superior and technique largely depends on surgeon and institutional preference. Further studies are needed to define the role of adjuvants in DAIR, and studies do not consistently support any one method use over another.

Local Antibiotic Treatments

Local antibiotic also can be used as adjuvants intraoperatively during DAIR. Antibiotic carriers in the form of beads, sponges, or powder increase the local concentration of antibiotics and provide a slower release into the surrounding tissues. Different carriers have been used in attempt to improve success of DAIR treatment, although their effectiveness is debated [2].

Beads composed of polymethylmethacrylate (PMMA) impregnated with antibiotics such as gentamicin provide a local depot of antibiotic in infected tissues. The reported advantage of antibiotic beads is to allow high concentration of antibiotic in local tissues while avoiding potential systemic side effects [2]. Success rates of DAIR combined with antibiotic beads have been shown to be as high as 75–100% [27, 37, 38]. Downsides of antibiotic bead usage include a rapid drop in local antibiotic concentration that occurs as quickly as 24 h after implantation, possible colonization by bacteria, formation of biofilms, and the need additional surgery to remove the beads [26].

Calcium sulfate beads have recently been proposed as an alternative to traditional cement beads. Despite increased cost, the proposed advantages of calcium sulfate beads include a bioabsorbable antibiotic delivery system that obviates the need for additional surgery. There may also be higher sustained concentration of local antibiotics and higher resistance to biofilm formation compared to PMMA beads. However, Flierl et al. reported only 52% success rate with antibiotic-impregnated calcium sulfate beads in their retrospective review of 32 patients [26]. Based on these equivocal results, significant cost, and potential for hypercalcemia, they were unable to support the routine use of calcium sulfate beads [26, 39].

Resorbable gentamicin-loaded sponges have similarly been used as a depot for local antibiotic in infected tissues, with success rates of 70% in one retrospective study [40]. Kuiper and Vos et al. found significantly higher success with use of gentamicin sponges and significantly higher failure rates with use of beads in univariate analysis of a 90 patient retrospective review, although this was not supported in multivariate analysis [41]. Potential disadvantages include reports of increased wound secretion for up to 6 weeks postoperatively [37].

Other adjunct modalities that are used include vancomycin powder and antibiotic beads. Riesgo et al. found that the combination of vancomycin powder and a dilute betadine lavage to DAIR improved success rates from 63 to 83% [42]. Larger studies with better controls are necessary to evaluate the various adjuvants used in order to provide better evidence-based recommendations.

Postoperative Drains

The use of in situ drain is generally recommended after treatment with DAIR to reduce deadspace and prevent fluid accumulation within the operative wound. Drains should be left in place until there is minimal drainage, most often for a period 48–72 h postoperatively [1, 10•].

Outcomes of DAIR

Duration of Postoperative Antibiotics

Most studies support up to 6 weeks of intravenous antibiotic administration tailored to the offending organism postoperatively after DAIR. In a retrospective study of 87 hip or knee PJI treated with DAIR, Chaussade et al. did not find a difference between 6 and 12 weeks of intravenous antibiotics with overall success rates of 69% [23]. In a randomized control trial of 44 knee and hip PJI, Lora-Tamayo et al. found that an 8-week course of levofloxacin plus rifampin could be as effective as longer term regimens for acute Staphylococcal infections [43]. Byren et al. showed that the length of antibiotics did not affect the likelihood for recurrence but that most of their recurrence occurred within the 4 months of stopping antibiotics, noting a four-fold increase during this period (HR 4.3) [1]. This suggests a possible role for chronic antibiotic suppression in some patients with PJI.

Addition of Rifampin

Rifampin has been used to treat bacterial infection due to its ability to penetrate into biofilm as well as its activity against Staphylococcal infections [44]. Zimmerli et al. in a small randomized controlled study showed a 100% cure rate of staphylococcal infection for rifampin-ciprofloxacin vs 58% in the ciprofloxacin monotherapy group [45]. Fiaux et al. found that rifampin combination therapies were associated with better remission rates for streptococcal infections when conducted after DAIR than when other antibiotics were used [46]. These studies suggested that combining rifampin with another antibiotic may improve bacterial eradication and help avoid the rapid resistance that develops with rifampin monotherapy.

Overall Modern Outcomes of DAIR

The outcomes of DAIR have varied considerably in the literature depending on the duration of infection, underlying infectious organism, definition of reinfection, underlying host characteristics, and intraoperative/postoperative treatment regimen. Success rates have varied from less than 30% to greater than 80% with a high degree of methodological variation with regard to antibiotic duration, inclusion criteria for DAIR (inclusion of chronic infections, resistant organisms, postoperative versus hematogenous infection), surgical technique (exchange of modular parts, open versus arthroscopic), use of adjuvant therapies, use of oral antibiotic suppression, and definition of failure (Table 2).

Although some studies have shown that arthroscopic knee washouts can be used for acute knee PJI in certain settings, other studies have shown poor outcomes with arthroscopic washouts with an increased risk of failure relative to open procedures [1, 16, 31, 33, 34, 47]. Because of the inability to exchange the original polyethylene insert, arthroscopic washouts may not allow for sufficient debridement. Given the narrow indications and the mixed outcomes, we do not recommend arthroscopic debridement in the setting of PJI.

Studies over the past decade have shown mixed results with open DAIR [1, 8, 9•, 10•, 11•, 12, 14, 18•, 21, 23, 24, 25•, 26, 29, 30, 40–43, 48–53]. One multicenter study published in 2011 showed success rates of 35% with DAIR in the setting of *Streptococcal* organisms versus less than 30% with *Staphylococcal* organisms [51]. Many of these failures were in the setting of infection distant from the index joint replacement and symptom duration was not documented making it unclear how many of these were chronic PJIs [51]. Another multicenter study with a similar group of institutions found that even within 4 weeks of surgery, success rates were only 45% for DAIR although postoperative management was not specifically reported or uniform across the seven institutions [48]. Azzam et al. found a 44% success rate after DAIR; however, the mean time of first debridement was 26 days, which is a longer duration of symptoms than more recent studies [14]. Despite this, in a subset of patients who had surgery within 2 weeks of symptoms, success was 52% overall [14].

Some authors have expressed concerns that DAIR may increase failure rates of subsequent two-stage revision suggesting additional downsides to this procedure [54–57]. Recently, Rajgopal et al. suggested that failure rates of two-stage exchange with infected TKA after DAIR were 24 versus 16% in those without previous DAIR [57]. The confidence intervals were wide however (1.01–3.71), and other recent studies from US institutions do not uniformly support these conclusions [54, 55]. For instance, Nodzo et al. found an 82% success rate in patients undergoing DAIR prior to a two-stage revision TKA versus 83% success in patients without a previous DAIR [54]. Studies like these have called into question the utility of DAIR as a treatment for PJI.

Considerations to favor DAIR despite failure rates up to around 50% include lower patient morbidity than implant removal and modifications to DAIR that may improve upon historical outcomes. One benefit of DAIR may be improved functional outcomes relative to patients undergoing two-stage exchange, and consideration may need to be given to the lower morbidity of implant retention [49]. Additionally, other groups have more recently shown better success highlighting the controversy that still remains in this area. Grammatopoulos et al. reviewed 122 PJIs undergoing DAIR and found overall success rates of 68% in the first DAIR and 85% when multiple DAIRs were used [25•]. Independent risk factors for failure were interval between index surgery and DAIR, where less than 6 weeks was best, and exchange of modular parts [25•]. Lora-Tomayo et al. found increased risk of failure with hematogenous PJI associated with *S. aureus* infection with 59% success rates in post-surgical PJI versus 45% in acute hematogenous infection [15•]. Fink et al. also found that acute postoperative infections had greater success than acute hematogenous infection (82 vs 57% success, respectively) [9•]. The duration of infection appears to be important although there is some variation in the literature about the exact time to debridement that is necessary and whether acute hematogenous infection should be treated differently from acute postoperative infection. Avoiding chronic infection would be recommended, and ideally, DAIR should be limited to acute settings. Koyonos et al. found a success rate of only 21% for DAIR in the chronic hematogenous setting [21]. The use of intraoperative adjuvant therapies like vancomycin powder, betadine lavage, and postoperative therapies like chronic antibiotic suppression may improve upon the results of previous studies as well (Table 2). More work is needed to clearly define the use of these treatments.

Is There a Role for Chronic Antibiotic Suppression?

Siqueria et al. looked at long-term oral suppression versus standard antibiotic treatment in PJI cases including DAIR ($N = 206$) and two-stage exchange ($N = 162$) [11•]. Patients treated with chronic antibiotic suppression after DAIR had an increased 5-year infection-free survival rate (64.7% [95% CI = 49.7 to 77.3%]) compared with the non-suppression group (30.4% [95%CI = 22.4 to 39.6%]; $p < 0.0001$) with a minimum suppression regimen of 6 months [11•]. In a Cox proportional hazards model, chronic antibiotic suppression and non-*S. aureus* infection were the only risk factors that protected against PJI recurrence [11•]. In a recent study looking at data from the Mayo Clinic, Bryan et al. found that

Table 2 Selected outcomes of DAIR in the past 10 years

Study	Year	Site	Number of patients	Mean follow-up (month)	Acute hematogenous; Acute postoperative; Chronic	Resistant organisms	Duration of intravenous antibiotics (median)	Chronic antibiotic suppression	Adjuvants	Success rates
Byren	2009	Hip and Knee	112	–	-- 69% (< 90 days from surgery) --	8%	6 weeks (28% less than 4 weeks due to intolerance)	Yes; 12+ months if possible (mean 1.5y)	Chlorhexidine lavage	78% after 3 years (allowed for multiple DAIR) 4 fold increased risk of failure in patients who stopped suppressive antibiotics
Van Kleunen	2010	Hip and Knee	29 (18 < 28 days; 11 28–90 days) (superficial and deep infection)	31	0% 62% 38%	17%	6 weeks	No	No	72% (< 28 days) (repeat DAIR in 3 patients) 64% (28–90 days)
Azzam	2010	Hip and Knee	106	66	45% 55% 0%	30%	6 weeks	Not reported	No	44%
Koyonos	2011	Hip and Knee	136	54	37% 38% 45%	34%	6 weeks	No	No	35% (33% acute postoperative, 46% acute hematogenous, 21% chronic)
Odum	2011	Hip and Knee	150	–	-- 31% --	Not reported	Variable	Not reported	Not reported	31% (34% < 28 days postop)
Fehring	2013	Hip and Knee	86	46	-- 66% --	26%	Variable	Not reported	Not reported	47%; 44% in acute postoperative
Lora-Tamayo	2013	Hip and Knee	328	–	15% 62% 23%	23%	Variable	Yes; Variable duration	No	55%
Kuiper	2013	Hip and Knee	91	35	35% 57% 8%	2%	Min. 6 weeks	No	Yes; Gentamicin beads or sponge	34%
Siqueira	2015	Hip and Knee	206	69	-- -- --	22%	6 weeks	Yes (92 patients); mean 64 months	No	65% suppression v 30% no suppression DAIR
Triantafyllopoulos	2015	Knee	78	47	55% 45% --	28%	6 weeks	Yes; 6 weeks	No	55% (56% open, 50% arthroscopic
Fink	2017	Hip and Knee	67	42	42% 58% --	3%	2 weeks	Yes; 4 weeks	Octenidine	72% (57% acute hematogenous, 82% acute postoperative)
Flierl	2017	Hip and Knee	33	13	55% 45% --	12%	Min 6 weeks	Variable	Calcium sulfate Abx beads (100%)	52%
Grammatopoulos	2017	Hip	122	84	13% 61% 26%	Not reported	6 weeks	Yes; variable duration (6 months to 3 years)	No	84% (68% with one DAIR; allowed for multiple DAIR)

Table 2 (continued)

Study	Year	Site	Number of patients	Mean follow-up (month)	Acute hematogenous; Acute postoperative; Chronic	Resistant organisms	Duration of intravenous antibiotics (median)	Chronic antibiotic suppression	Adjuvants	Success rates
Sendi	2017	Hip	29	48	41% 59% --	Not reported	1 week; oral 11 weeks	Variable	Polyhexanid lavage	90% (allowed for multiple DAIR in 3 cases)
Bryan	2017	Hip	90	72	37% 73% --	31%	6 weeks	Yes (88% of eligible pts)	No	83% (failures include second DAIRs)
Riesgo	2018	Hip and Knee	74 (36 iodine/vanco powder; 38 no adjuvant)	27	Not stated, no chronic pts. included	2%	6 weeks	Variable; 8% iodine and vanco powder; 0% control	49% iodine lavage and vancomycin powder	83% (iodine and vanco powder) 63% no adjuvant

"–" not separately reported

DAIR in the setting of hip PJI had an overall 83% success rate with chronic antibiotic suppression used in the majority of patients for the life of the implant [18•]. There was no difference between acute hematogenous versus acute postoperative failure rates [18•]. This study highlights that permanent antibiotic suppression in all DAIR patients may be worthwhile to prevent failure, although Byren et al. found a four-fold increased risk of DAIR failure in patients on chronic antibiotic suppression that stopped treatment relative to those who did not [1]. These studies suggest that chronic antibiotic suppression seems to improve results after DAIR; however, the necessary duration of therapy may need to be lifelong to continue the benefit. Additionally, they do not address the broader issue of antibiotic resistance, and more studies are needed to better define this treatment.

Conclusions

Current studies have a wide variability in inclusion criteria, definition of failure, and intraoperative/postoperative patient management making it difficult to provide definitive conclusions on DAIR. Based on current studies, some best practices for DAIR may include the following:

1. A short duration between infection/symptom development and treatment, preferably within 3–4 weeks, ideally as short as possible (1–2 weeks).
2. A non-immunocomprised host;
3. Sensitive organisms tend to respond better than resistant organisms although this is not uniform;
4. Open arthrotomy, extensive debridement, copious irrigation, and modular component exchange when possible;
5. More data needed on local adjuvants, not enough studies support any particular regimen or overall need;
6. Antibiotic regimens tailored to the specific organism, including rifampin for *Staphylococcal* infections when using certain antibiotic regimens;
7. Six to eight weeks of intravenous antibiotics appears to be appropriate, longer regimens do not appear to improve outcomes;
8. Consider extended or permanent oral antibiotic suppression when possible, more data needed about lifelong versus stopping after certain duration.

Compliance with Ethics Guidelines

Conflict of Interest The authors declare that they have no conflicts of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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