



## Irrigation and debridement for periprosthetic hip infections: A systematic review

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We performed a systematic review of the literature regarding outcomes of early infection after total hip arthroplasty (THA). We searched multiple databases (PubMed, Web of Science, EMBASE, and Cochrane library) for articles in the area published from 1950 to 2016.

A total of 212 patients from 8 published studies were identified. The minimum follow-up was 4 months (range, 4–132 months). The most frequently isolated organisms were *Staphylococcus aureus* and coagulase-negative staphylococci. 153 of 212 (72%) patients were successfully treated, with no signs of infection or continued antibiotic treatment at the latest follow-up. In 48 of the 59 patients for whom treatment failed, infection was successfully treated with 1-stage or 2-stage reimplantation or resection arthroplasty. Overall mortality attributable to the infection of the hip was 2 % (four patients).

Our study has helped to further elucidate the clinical and functional outcome of early periprosthetic hip infections treated with debridement, antibiotics and implant retention. We believe DAIR is a reasonable treatment option in early infection after primary THA in selected patients.

**Keywords:** hip; arthroplasty ; infection ; debridement.

### INTRODUCTION

Despite the rates of infection falling to less than 2% of all primary total hip arthroplasty (THA) and less than 5% of revision THA, as the number of THA has increased due to the aging population (28), the absolute number of prosthetic joint infection (PJI) will be rising (1). Management of infection after THA is challenging, often requiring a prolonged course of treatment resulting in increased cost to the healthcare system and leading to dissatisfied patients with poor function (12). Debridement, antibiotics and implant retention (DAIR) has been often advocated for early or late infections with a short duration of symptoms, stable components, and no evidence of immunosuppression (10,19).

The overall success rate of infection eradication with DAIR varies in the literature between 21% and 100% at 2-10 years follow-up (5,6,18,23,30,31,34).

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Early studies examining outcomes of PJI treatment with prosthesis retention had poor outcomes, with success rates of <70% (4,26,35). Fehring et al. (13) demonstrated that 54 of 86 patients (63%) failed after DAIR and suggested the ability of debridement to control infection even in the early postoperative period is limited. On the contrary, Aboltins et al. (2) recently reported that patients treated for early PJI with DAIR results in not only successful treatment of infection but also significant improvements in functional and quality of life outcomes, which are similar to patients without PJI. Debridement without removal of prosthesis is certainly an interesting treatment option and a controversial issue due to the potential risk of relapse of infection. In case of relapse, all of the benefit for both patient and community is eliminated (18). Nevertheless, due to the insufficiency of standardized clinical and evidence-based guidelines, there is no appropriate therapeutic schedule. Although a few reviews of single institution experience exist on this subject, an absence of systematic literature reviews about the outcomes of DAIR following PJI provides the impetus for this systematic review.

The current study was designed to evaluate the success rate of DAIR for an early hip PJI with a review of the literature and pooled analysis. We therefore asked: (1) What are the most common organisms that cause early post-surgical infection? (2) What are the clinical characteristics and outcomes of prosthetic hip joint infection after DAIR?

## PATIENTS AND METHODS

We performed a systematic review of the available literature using multiple separate search strategies. Four computer databases (PubMed, Web of Science, Embase, and Cochrane Library) were searched with the search words “arthroplasty”, “hip”, “infection”, and “debridement” in different combinations. Two independent reviewers separately completed the search, and the results were duplicated two times by each reviewer. The initial search was performed on May 10, 2016 with an update in July 10, 2016, to ensure accuracy. No additional study was identified by repeating the search.

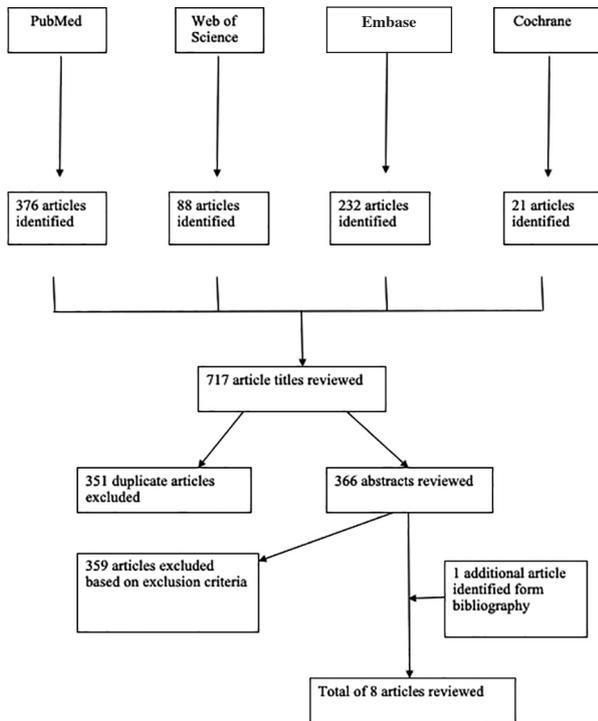
The inclusion criteria included (1) articles published from January 1, 1950 to May 10, 2016,

(2) English-written articles in human species, (3) electronic publications that reported cases of hip joint infection after arthroplasty, (4) both retrospective and prospective series, (5) Only those articles that evaluated the final outcomes including reinfection, and (6) early PJI (<3 months from implantation) (2,29).

The exclusion criteria included (1) conference presentations, (2) abstracts only, (3) articles without postoperative follow-up period and outcomes, (4) evaluation of any other lesion than the hip joint (knee (13,32) and shoulder), (5) native joint infection before arthroplasty, and (6) a chronic/late presenting PJI (8). Change of mobile part was not considered as an exclusion criteria. Due to the limited evidence available on the topic, case reports and case series were included in our study. Limits for the number of patients in each study or the minimum duration of follow-up were not used. During the study period, PJI was classified as being early when symptoms presented less than 3 months after arthroplasty (2,29).

Searching the aforementioned databases yielded a total of 717 articles. A simplified flow-chart depicting this process is seen in Figure 1. A first search of the PubMed database yielded 376 articles and a second search of the Web of Science database with use of the same search strategy yielded 88 articles. There were 351 articles that appeared in more than one of the four searches yielding a total of 366 unique articles. Abstracts and full texts of the retrieved articles were read by 2 authors independently, and all relevant articles were read in full. In addition, we screened the references of the obtained articles for any additional studies. Disagreements regarding inclusion were resolved by discussion. Stringent exclusion criteria were applied, leaving 8 articles appropriate finally. Including prospective studies, most of the larger cohorts giving an answer or at least an insight to clinical problems were selected for this review. The Preferred reporting items for systematic reviews and meta-analyses (PRISMA) guideline (20) was followed.

Data were extracted from the included studies by reviewer and checked by another. Where possible, corresponding authors were contacted to obtain missing data. The following data were extracted:



**Fig. 1.** – The flowchart details the method of retrieval of relevant articles for this study

demographics including age, gender, underlying disease, history of previous infection, risk factor, time to symptom after THA, preoperative erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP), diagnosis of infection, management of infection, postoperative antibiotic therapy, outcomes following treatment including clinical resolution, reactivation of infection, and other complications. PJI was treated with retention of the prosthesis and prompt, aggressive, repeated, open surgical debridement involving excision of all pathological-appearing tissue, large volume high-pressure lavage and change of modular parts at the last debridement operation (2,6). Treatment failure was defined as (i) persistence or recurrence of signs of PJI; (ii) DAIR followed by either of one-stage revision; two-stage revision or resection arthroplasty (i.e. Girdlestone operation); (iii) the need for long-term antibiotic suppression (28); (IV) death with PJI not healed before follow-up (6).

## RESULTS

Our systematic literature review of PubMed, Web of Science, Embase, and Cochrane literature searches revealed a total of 212 patients from 8 selected articles which have been reported from 1996 to 2016 including one prospective study (34). Although complete

Table I. – Demographic information in the studies (NA, not available)

Author	Journal	Year	Study period	Country	Number of patients	Male/ Female	Mean age (range)
Bergkvist et al.	Hip Int	2016	January 2007 - December 2012	Sweden	35	10/25	74 (51-93)
Aboltins et al.	Intern Med J	2013	January 2006 - December 2009	Australia	19	9/10	68.5 (+ 10.1)
Sukeik et al.	Clin Orthop Relat Res	2012	1999-2006	United Kingdom	26	10/16	69.5 (51-86)
Westberg et al.	Acta Orthopaedica	2012	January 1998 - December 2005	Norway	38	15/23	75 (32-89)
Klouché et al.	Orthop Traumatol Surg Res	2011	November 2002 - December 2008	France	12	5/7	69 (53-85)
Waagsbo et al.	Scand J Infect Dis	2009	1997-2007	Norway	40	11/29	73.6
Krasin et al.	J Hosp Infect	2001	January 1995 - December 1997	Israel	7	4/3	67.6 (29-87)
Tsukayama et al.	J Bone Joint Surg Am	2009	1980-1991	USA	35	NA	63 (29-87)

data were not available, data such as age, gender, underlying medical/surgical conditions, reactivation of infection and postoperative complications were collected. Age, pathogen organism, mean follow-up time, and treatment outcome were clearly identified in all the reports.

The mean age of the patients was 70.3 years. Mean duration of follow up after the surgical procedure was 45.9 months (range, 4–132 months). 175 (82%) of the postoperative infections were associated with a primary replacement and 37 (18%), with a revision. Demographic information is detailed in Table I.

The median duration from joint insertion until first debridement was 17.4 days (three studies[19, 30, 33] were not included). It was difficult to analyze blood levels of CRP and ESR at presentation due to reporting inconsistencies. Staphylococcus aureus was found to be the most common pathogen organism, with a pooled percentage of 42% (88/212). Coagulase-negative staphylococci was the second most common pathogen organism (25%) (Table II). According to five studies (2,18,19,30,33),

the mean duration of intravenous antibiotic therapy for all patients was 4.3 weeks. Antibiotic therapy duration ranged from 1 week to 18 weeks, and the antibiotic treatment involved combination therapy with multiple agents (most commonly vancomycin, rifampin, and b-lactam drugs). It was difficult to analyze post-surgical oral antibiotics due to a wide variation.

After DAIR, 153 of 212 (72%) patients were successfully treated, with no signs of infection or continued antibiotic treatment at the latest follow-up. 119 patients needed 1 debridement only, 34 required repeated debridement (one patient required 10 DAIR procedures before the PJI healed[6]). Forty eight patients (23%) underwent removal of the prosthesis eventually and were treated with one-stage or two-stage exchange arthroplasty or resection arthroplasty (Table III). Four patients (2%) were treated with long-term antibiotic suppression. There were 4 death (2%) related to the PJI following THA. The majority of complications were medical and were made up of drug reactions (vancomycin or b-lactam-induced) (2). Surgical complications

Table II. – The number of patients infected with each microbe

	Bergkvist et al.	Aboltins et al.	Sukeik et al.	Westberg et al.	Klouche et al.	Waagsbo et al.	Krasin et al.	Tsukayama et al.
S. Aureus	15	9	7	10	2	23	4	18
CoNS	9	10	8	7	0	3	3	13
Gr.B Streptococci	2	0	2	2	3	2	0	4
E. Faecalis	2	6	0	1	2	1	0	3
P. Mirabilis	4	2	0	0	0	0	0	0
K. Pneumoniae	2	0	0	0	0	0	0	0
K. Oxytoca	2	0	0	0	0	0	0	0
Gr.G Streptococci	2	0	0	0	3	0	0	0
E.coli	0	5	0	0	0	0	0	0
Corynebacterium	1	1	2	0	0	0	0	0
Morganella sp	1	1	0	0	0	0	0	0
Pseudomonas	1	0	2	0	0	0	0	3
Propionibacterium	1	0	2	1	0	0	0	0
Acinetobacter	0	0	2	0	0	0	0	0
Culture negative	0	1	0	2	0	0	0	0
Other	4	1	1	0	3	8	0	5

(Other includes single infection by C. Koseri, C. Prefringens, E. Cloacae, Alfastreptococcus, Proteus sp, Bacteroides, Streptococcus pneumoniae, Streptococcus mitis, Citrobacter freundii, Enterobacteriaceae, Candida albicans, Rothia dentocariosa)

Table III. – Outcome of the studies

Author	Successful DAIR treatment (single/repeated)	Revision surgery (2-stage/1-stage)	Resection arthroplasty	Died with PJI	Others
Bergkvist et al.	17/5	8/0	1	4	0
Aboltins et al.	0/17	1/0	0	0	1 (long-term antibiotic suppression)
Sukeik et al.	16/4	5/0	0	0	1 (long-term antibiotic suppression)
Westberg et al.	22/5	5/2	4	0	0
Klouche et al.	9/0	0/2	0	0	1 (long-term antibiotic suppression)
Waagsbo et al.	25/2	2/0	9	0	2 (long-term antibiotic suppression, one case of hospital transfer)
Krasin et al.	5/0	1/0	1	0	0
Tsukayama et al.	25/1	3/0	4	0	2 (died, not attributable to infection)
Total	119/34	25/4	19	4	7

included dislocation, fractured acetabulum, fractured greater trochanter and transient sciatic nerve palsy (34) (2).

## DISCUSSION

PJI is a devastating complication of hip arthroplasty surgery, often associated with prolonged antibiotic treatment, lengthy hospital stay, late aseptic loosening and a poor functional outcome (9). DAIR with or without exchange of modular components remains an attractive alternative to two-stage reimplantation in acutely infected THAs but with variable results from previous studies (28). The aim of this study was to evaluate the success rate of DAIR in early PJI with a pooled analysis of the reported cases.

In order to cure an infected hip prosthesis, orthopedic surgery followed by long lasting pathogen-directed antibiotic therapy is required (35). In contemporary studies, the most commonly cultured microorganisms are coagulase-negative staphylococci (in 30 to 43 percent of cases) and *Staphylococcus aureus* (12 to 23 percent), followed by mixed flora (10 to 11 percent) (3,25,27,35).

However, as bacterial prevalence varies dependent upon geography the results from these studies may not be representative of the epidemiology for the wider population (3). The significant difference in infecting organism profile observed between centers demonstrates the geographical variability further highlighting the need for population level data analysis employed by the present study (16). Consequently, the pathogens found during revision surgery in this cohort of early PJI were quite similar to those reported in other Scandinavian or European studies, with a high prevalence of *Staphylococcus aureus* and coagulase negative staphylococci, followed by streptococci, Gram-negative bacteria and enterococci (9,14,24). In combination with patient and surgical factors, the outcome following treatment for PJI is influenced by prophylactic antibiotics, the ability to isolate organisms at time of procedure, the virulence of such an organism and its antimicrobial sensitivity profile. Nevertheless, there is no general consensus regarding the type and dose of antibiotic agents that can be administered systemically to treat this challenging condition. We believe that both prophylactic and therapeutic antibiotic regimes

should be focused on targeting Staphylococci as they are the most frequently isolated organisms (16). Rifampin should be administered in combination with an anti-staphylococcal beta-lactam to prevent emergence of antimicrobial resistance, when the staphylococcal PJI diagnosis is established (33). Most authors suggested a minimum duration of antibiotic therapy of 4 weeks (18,19,30). According to one recent study (24), the duration of antibiotic treatment is 3 months for TKA PJIs and 2 months for THA PJIs treated with DAIR. In our pooled analysis, the mean duration of antifungal therapy was 4.3 weeks (range, 1 week-18 weeks). We recommend that intravenous antibiotics should be used until there are no clinical symptoms and signs suggesting the presence of infection including abnormal levels of CRP or ESR. Selecting the appropriate antibiotic treatment requires a multi-team approach involving the treating orthopedic surgeon, infectious disease specialists, and clinical pharmacologists. In addition, the increasing global threat of antibiotic resistance necessitates close examination and interpretation of epidemiological data at population level in order to guide appropriate prophylactic and therapeutic management strategies (16).

Causative organism type and virulence have been associated with the outcome of DAIR (4,11). Meehan et al. (21) reported only a 10.5% (2/19) failure rate in a series of streptococcal infections. On the contrary, Azzam et al. (4) reported DAIR failure rates of 72 % and 60 % for resistant Staphylococcus and sensitive Staphylococcus, respectively. Despite these results, DAIR is not an absolute contraindication even for a highly virulent organism and this procedure remains a commonly used treatment option, because advocates claim that a 30-40 % chance of success may still be attractive if it minimizes the risk and the burden of a two-stage procedure (23).

For infection after THA, there are numerous reports of successful results of infection control. However, most of them are related to staged revision and few papers describe the retention treatment for THA infection (8,33). DAIR is still the issue of discussion. In general, retention treatment reportedly has lower success rates than staged revision arthroplasty in PJI (15,35). Our cohort

study on 212 hip arthroplasties with an early PJI, treated according to the DAIR protocol, yielded a success rate of 72% at a median follow-up of approximately 4 years. Our results for infection control are consistent with those previously reported in the literature (6,28,34). Previously, one systematic review provided evidence that DAIR, even if performed within the most often recommended period of time from the onset of a periprosthetic infection, did allow to achieve a durable infection control only in one out of two patients (52%), on the average (26). However, the limitation of the study was that hip and knee prosthesis were considered together. Furthermore, multiple factors that can affect the likelihood of infection control, including pathogen and extent of infection were not considered (31). Selection of patients infected with a single organism, organisms of low pathogenicity, non-S. aureus bacterium, and well-fixed components with no radiographic evidence of osteitis may increase the chances of success (7,19). In addition, it has been reported that there were no significant differences in the number of additional operative procedures, total length of hospital stay, and duration of treatment between the debridements and staged revisions group (7). The functional outcome after this surgical strategy appears to be acceptable (2,34). Our data confirm current literature and suggest there may be a role for DAIR in controlling acute postoperative and hematogenous infections after THA. In the present study, several patients underwent multiple DAIR procedures. However, it has been well demonstrated that additional DAIR are rarely effective in the control of infection after the failure of the initial DAIR (17). More recently, similar success rates for single and multiple debridement surgery for acute hip arthroplasty infection were reported (22). We believe that multiple DAIR should be avoided and the treatment protocol should be changed to exchange or resection arthroplasty after initial failure. The decision to re-operate (multiple debridements) must be weighed against the risk of additional surgeries in this fragile patient population. Further multicenter studies are needed to establish objective treatment guidelines for early infection following THA before this method attains widespread use.

Our study has some limitations. First, because this is a pooled analysis of several retrospective case series with a heterogeneous cohort of patients, a few patients with short term follow-up (The minimum follow-up was 4 months) were included in our study. Second, the study population was heterogeneous in relation to the type of original operation (primary versus revision) and type of infection (postoperative versus hematogenous). Different definitions of acute PJI, with length varying from 4 weeks to 3 months, make analysis of these studies difficult. Third, there were no established guidelines for the type and duration of the antimicrobial treatment; each regimen was chosen individually by the treating surgeon. Different antibiotic protocols and periods were used postoperatively.

### CONCLUSION

Based on this systematic review, in the consideration of early periprosthetic hip joint infections treatment, DAIR combined with adequate systemic antibiotic therapy could be recommended as a first choice of treatment option in selected patients. Patients should be adequately informed prior to undergo this salvage procedure. Additional long-term follow-up studies with involvement of larger number of patients with early infection to include a wide range of ethnic backgrounds will help improve our ability to avoid the devastating outcomes.

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