

## Implant retention after acute and hematogenous periprosthetic hip and knee infections: Whom, when and how?

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### Abstract

Periprosthetic joint infections (PJI) of the hip and the knee are grossly classified as early post-operative, acute hematogenous and late chronic infections. Whereas two-stage exchange arthroplasty is the standard of care in North America for treating chronic infections, irrigation and debridement (I and D) with retention of implants has been used in an attempt to treat the other two types of PJIs. The rationale of this approach is that a PJI may be eradicated without the need of explanting the prostheses, as long as it has not transitioned into a chronic state. With the present paper, we review current evidence regarding the role of I and D with implant retention for treating PJIs of the hip and the knee. While a very wide range of success rates is reported in different studies, a short period of time between initiation of symptoms and intervention seems to play a prominent role with regards to a successful outcome. Moreover, pathogens of higher virulence and resistance to antibiotics are associated with a poorer result. Specific comorbidities have been also correlated with a less favorable outcome. Finally, one should proceed with serial I and Ds only under the condition that a pre-defined, aggressive protocol is applied. In conclusion, when treating a PJI of the hip or the knee, all the above factors should be considered in order to decide whether the patient is likely to benefit from this approach.

**Key words:** Irrigation and debridement; Periprosthetic infection; Total knee arthroplasty; Implant retention; Total hip arthroplasty

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**Core tip:** An infected total joint arthroplasty represents a significant burden to patients, as well as to orthopaedic surgeons. Previously, irrigation and debridement with retention of implants has been advocated for certain types of periprosthetic infections. The purpose of the present paper is to review the indications, success rates and factors determining the outcome of this treatment option for periprosthetic infections of the hip and the knee.

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## INTRODUCTION

### **Periprosthetic hip and knee infections: Trends, diagnosis, classification and treatment**

Total joint arthroplasty (TJA) is a very useful tool in the hands of orthopaedic surgeons, as it can relieve symptoms and significantly improve the quality of life in patients with end-stage arthritis of the hip and the knee. In the past decades, the use of this modality has known a remarkable growth, which is expected to continue in the future. For example, by the year 2020 the estimated annual number of total hip arthroplasties (THAs) will exceed 500000 procedures<sup>[1]</sup>. On the other hand, this will also lead to an increase in complications related with TJA, among which periprosthetic joint infection (PJI) is one of the most devastating for the patient. In spite of preventive measures available, the incidence of PJI remains substantial as it ranges from 1% to 3% after primary TJA<sup>[2-5]</sup>, and can be 4 times greater after revision TJA<sup>[6]</sup>.

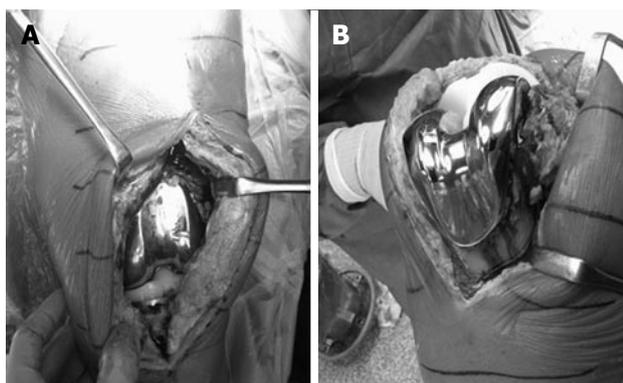
Implant colonization may occur with either intraoperative contamination, spreading from an adjacent infectious site or hematogenous seeding from a distant site<sup>[7]</sup>, with coagulase-negative staphylococci and *Staphylococcus aureus* species being the most dominant pathogens<sup>[8-11]</sup>. Diagnosis can be easily made when obvious sequelae of infection are present, such as a draining sinus. However, in many cases such signs are absent and a complex diagnostic evaluation is needed. No single method provides 100% diagnostic specificity and sensitivity. The Musculoskeletal Infection Society introduced specific criteria for the diagnosis of a PJI<sup>[12]</sup>. The combination of different modalities significantly increase sensitivity and specificity for diagnosing PJI<sup>[13,14]</sup>. Moreover, synovial biomarkers, including alpha-defensin and leukocyte esterase, have been proven accurate diagnostic tools for PJI with high sensitivity and specificity<sup>[15]</sup>. Nonetheless, sophisticated methods are expensive and not widely available, and therefore cannot be recommended for routine use.

PJIs of the hip are classified into four types, as proposed by Tsukayama *et al.*<sup>[16]</sup>. Type I includes positive intraoperative cultures in patients undergoing revision surgery for non-infectious etiology; Type II represents early infections developing within one month postoperatively; late infections presenting within more than one month postoperatively are characterized as Type III infections; finally, Type IV infections are of acute hematogenous nature and are correlated with an identifiable event leading to bacteremia. A similar system has been introduced for PJIs of the knee<sup>[17]</sup>: Type I includes positive intraoperative cultures obtained during a revision surgery for a cause other than infection; Type II PJIs are early infections presenting within 4 wk after surgery and include Types II A (superficial) and II B (deep); acute hematogenous deep infections with an onset of more than 4 wk postoperatively are classified as Type III infections; lastly, Type IV PJIs of the knee are late deep infections developing after 4 wk since the index procedure.

The standard of treatment for PJI is a combination of surgical interventions with the goal of reducing microbial load and administration of antibiotics. Two-stage revision is considered to be the gold standard for management of late chronic PJIs in North America<sup>[18]</sup>. On the other hand, eradicating infection with retention of the prosthesis when possible may be associated with superior functional outcomes. Irrigation and debridement (I and D) with exchange of prosthetic modular parts has been long used with respect to that goal. The purpose of the present paper is to review the indications, success rates and risk factors that determine the outcome of I and D for PJIs of the hip and the knee.

## I AND D: PROCEDURE DESCRIPTION

The patient should be off any antibiotics for at least 5 d before the procedure. The affected limb is prepped and draped, the previously healed incision is used and the affected joint is adequately exposed (Figure 1A). A total number of six tissue samples should be obtained and sent for cultures and sensitivity testing. Next, the modular parts, including femoral head and polyethylene liner for a THA and the polyethylene liner for TKA, are removed to gain access to all aspects of the joint and a thorough debridement is performed. All grossly infected and necrotic soft-tissues are meticulously excised (Figure 1B). Great care should be taken to circumferentially debride the articular capsule in both the hip and the knee. After the joint is debrided to macroscopically healthy tissues, the joint is copiously irrigated with antibiotic containing saline. Modular parts are exchanged and the wound is closed. It should be noted that even though exchange of modular parts is advised<sup>[18]</sup>, it may not be always feasible, especially in settings where implant availability is limited. There is no consensus on the duration of intravenous antibiotics administration after the procedure<sup>[19]</sup>. A common approach is to place the patient on a 6 wk treatment with



**Figure 1** Irrigation and debridement for an infected total knee arthroplasty with retention of implants. A: The joint is exposed through the previously healed incision; B: Note the extensile debridement of the synovium on the anterior aspect of the femur. Debridement of the infected tissues should be carried out throughout the joint, including the posterior capsule.

antibiotics (two weeks of intravenously administered antibiotics followed by another 4 wk of p.o. antibiotics), based on culture and sensitivity results.

The technique described above is the open technique with exchange of modular parts. In the previous years, there was a trend towards performing I and D arthroscopically, especially for periprosthetic infections of the knee<sup>[20,21]</sup>. However, recently there has been a recommendation against this approach, as it does not allow access to all aspects of the joint and therefore the debridement may be suboptimal<sup>[22]</sup>.

## INDICATIONS

Previously, Del Pozo *et al.*<sup>[23]</sup> have outlined the indications of I and D for treating PJIs. According to the authors, these include an infected prosthesis that was implanted within less than 3 mo or a hematogenous infection, with duration of symptoms of less than 3 wk, absence of sinus tract or abscess, stability of implants and a pathogen other than multi-drug resistant microorganisms, Enterococcus species, quinolone-resistant *Pseudomonas* and fungi.

Recently, the participants of a consensus meeting on periprosthetic infections strongly agreed that I and D may be a viable alternative for patients with early infections that develop within 3 mo post index procedure, as well as with late hematogenous infections; symptoms should have a duration of less than 3 wk<sup>[19]</sup>. Eradicating infection while avoiding removal of the prostheses may allow for lower morbidity and better function. Published series of patients treated with I and D for PJI of the hip and the knee show great variability in methodology, success rates and identified prognostic factors with regards to outcome.

## WHAT IS THE EVIDENCE?

### *I and D for PJI of the Hip*

Implant retention with I and D of the hip for a Type II

or IV PJI has been previously reported to be 70% in a previous large series<sup>[24]</sup>. Westberg *et al.*<sup>[25]</sup> have reported a 71% success rate of I and D in early hip PJIs. In the series of Tsukayama *et al.*<sup>[16]</sup>, retention of implants was attained in 70.3% of cases. Barberán *et al.*<sup>[26]</sup> had a success rate of 71.9%, and Vilchez *et al.*<sup>[27]</sup> reported that I and D successfully treated infection with implant retention in 75.5% of patients. On the other hand, other authors have published greatly variable results, with success rates ranging from 14% to 100%<sup>[21,28-46]</sup> (Table 1).

Symptom duration is a significant factor predicting the outcome of I and D of the hip. When a cut-off point of 5 d of symptom duration was used, it was noted that patients with symptoms of more than 5 d had 95.2% lower odds of success compared to patients with shorter duration of symptoms<sup>[24]</sup>. Similarly, Sukeik *et al.*<sup>[36]</sup> found that performing I and D more than 5 d after the onset of symptoms led to less favorable outcomes. Others have proposed an even prompt intervention, in as shortly as within 2 d from symptom onset<sup>[30]</sup>. In other studies, the suggested duration of symptoms within which such an intervention is more probable to be successful ranges from one to four weeks<sup>[40,42,45]</sup>. Despite this variability, we may conclude that once the diagnosis of a type II or IV PJI of the hip is established, action should be prompt from the part of the surgeon when the goal is to retain the implants. The decrease in the probability of successful I and D has been calculated to be 17.7% for each additional day of delay in treatment<sup>[24]</sup>. A greater duration of symptoms allows formation of the biofilm layer, which provides protection against immune response and resistance against antibiotics. Once this biofilm is formed, I and D with implant retention is less probable to control the infection<sup>[43]</sup>.

The type of pathogen also plays a role in the outcomes of I and D of the hip. Patients with methicillin-resistant staphylococci have been correlated with worse outcomes<sup>[24]</sup>. Barberán *et al.*<sup>[26]</sup> also reported worse outcomes in patients infected with methicillin-resistant *Staphylococcus aureus* (MRSA). In addition, infections with MRSA, methicillin-resistant *Staphylococcus epidermidis* and vancomycin-resistant Enterococci have been associated with inferior success rates after I and D<sup>[40]</sup>. Staphylococcal infections have been identified as a negative prognostic factor by other investigators as well<sup>[21,29,31,41,42]</sup>. In cases of infections with multi-drug resistant pathogens, a more aggressive treatment strategy is warranted and even exchange arthroplasty (either in one or two stages) may be considered.

Other factors that have been found to predict outcomes of I and D of the hip include obesity<sup>[24]</sup>, ASA score and purulence<sup>[29]</sup>, a history of previous infection<sup>[40]</sup> and elevated inflammatory markers<sup>[27,34,40,42]</sup>. These factors are associated either with host's impaired immune system response to infection, or with severity of infections and should be considered for decision-making. Additionally, patients with one or more local or systemic compromises according to the Cierny classification have been also correlated with inferior outcomes after I and D for a PJI

**Table 1** Reported success rates of irrigation and debridement for treating periprosthetic infections of the hip and the knee

Ref.	Patients	Success rate for PJI of the hip	Success rate for PJI of the knee	Cumulative success rate
Aboltins <i>et al.</i> <sup>[28]</sup>	13	92%	85.70%	90%
Azzam <i>et al.</i> <sup>[29]</sup>	53	47.83%	45.30%	44.60%
Barberán <i>et al.</i> <sup>[26]</sup>	32	71.90%	57.20%	65%
Bradbury <i>et al.</i> <sup>[52]</sup>	19	-	16%	-
Brandt <i>et al.</i> <sup>[30]</sup>	7	28.60%	38.50%	36.40%
Buller <i>et al.</i> <sup>[40]</sup>	62	56.50%	50.60%	51.80%
Burger <i>et al.</i> <sup>[49]</sup>	39	-	17.90%	-
Byren <i>et al.</i> <sup>[21]</sup>	52	86.50%	74.50%	80.60%
Chiu <i>et al.</i> <sup>[51]</sup>	40	-	30%	-
Choi <i>et al.</i> <sup>[31]</sup>	92	50%	-	-
Choong <i>et al.</i> <sup>[32]</sup>	14	78.60%	-	-
Cierny <i>et al.</i> <sup>[48]</sup>	43	-	-	66%
Crockarell <i>et al.</i> <sup>[44]</sup>	42	14%	-	-
Engesæter <i>et al.</i> <sup>[46]</sup>	180	76%	-	-
Estes <i>et al.</i> <sup>[57]</sup>	20	100%	87.50%	90%
Fehring <i>et al.</i> <sup>[43]</sup>	86	37.50%	37%	37.20%
Gardner <i>et al.</i> <sup>[50]</sup>	44	-	43.20%	-
Geurts <i>et al.</i> <sup>[45]</sup>	69	82.60%	85%	83.10%
Klouche <i>et al.</i> <sup>[63]</sup>	12	75%	-	-
Konigsberg <i>et al.</i> <sup>[33]</sup>	20	80%	77.30%	78.50%
Koyonos <i>et al.</i> <sup>[41]</sup>	60	30%	38.50%	35%
Kuiper <i>et al.</i> <sup>[42]</sup>	62	61.30%	75.90%	66%
Marculescu <i>et al.</i> <sup>[56]</sup>	91	-	-	60%
Martel-Lafarriere <i>et al.</i> <sup>[59]</sup>	34	-	-	60%
Martínez-Pastor <i>et al.</i> <sup>[34]</sup>	15	73.30%	75%	74.50%
Meehan <i>et al.</i> <sup>[35]</sup>	19	66.70%	100%	89.55%
Mont <i>et al.</i> <sup>[53]</sup>	24	-	83.30%	-
Peel <i>et al.</i> <sup>[60]</sup>	43	71.40%	93%	79.10%
Rasouli <i>et al.</i> <sup>[38]</sup>	10	83.30%	0%	50%
Segawa <i>et al.</i> <sup>[55]</sup>	28	-	78%	-
Sukeik <i>et al.</i> <sup>[36]</sup>	26	77%	-	-
Tattevin <i>et al.</i> <sup>[57]</sup>	69	-	-	38.20%
Teeny <i>et al.</i> <sup>[54]</sup>	21	-	29%	-
Triantafyllopoulos <i>et al.</i> <sup>[47]</sup>	78	-	55.10%	-
Triantafyllopoulos <i>et al.</i> <sup>[24]</sup>	60	70%	-	-
Tsukayama <i>et al.</i> <sup>[16]</sup>	106	70.30%	-	-
Van Kleunen <i>et al.</i> <sup>[61]</sup>	13	-	-	61.50%
Vilchez <i>et al.</i> <sup>[27]</sup>	18	88.90%	68.60%	75.50%
Westberg <i>et al.</i> <sup>[25]</sup>	38	71%	-	-
Zürcher-Pfund <i>et al.</i> <sup>[20]</sup>	21	-	33%	-

PJI: Periprosthetic joint infection.

of the hip<sup>[48]</sup>.

### I and D for PJI of the knee

Buller *et al.*<sup>[40]</sup>, in their large series of 247 patients with PJI of the knee, reported a success rate of 50.6% for I and D. Similarly, in a series of 78 patients with PJI of the knee treated with I and D, the success rate was found to be 56.3%<sup>[47]</sup>. A higher success rate (74.5%) was reported by Byren *et al.*<sup>[21]</sup> among 51 patients with PJI of the knee. In contrast, in the study of Koyonos *et al.*<sup>[41]</sup>, I and D was successful in only 38.5%. In the literature, there are studies with highly variable success rates, that range from 16% to 100%<sup>[20,26-30,33-35,37,42,43,45,49-55]</sup> (Table 1). These studies, however, show significant methodological inconsistencies.

Similarly to the hips, duration of symptoms is also identified as a factor predicting the outcomes of I and D. In studies where PJIs of both the hip and the knee were included, favorable outcomes were reported when the

intervention was undertaken within an interval ranging from 1-4 wk<sup>[40,42,45,56]</sup>. In other reports, the suggested timing for a successful outcome is within 5 d since symptom onset<sup>[47,57]</sup>. Others have proposed an even lower cut-off point of 2 d<sup>[30]</sup>. For each additional day that treatment delays, a 7.5% decrease in the odds of success has been calculated<sup>[47]</sup>. This highlights the importance of timely intervention, as the gradual formation of the protective biofilm may prevent eventual eradication of the pathogen without removal of the prosthesis.

The type of pathogen also predicts outcomes of I and D in the setting of a PJI of the knee. As is the case for the hip, MRSA infections have been associated with poorer outcomes<sup>[26,40,47]</sup>. Treatment failure has been correlated with staphylococcal infections in several previous reports<sup>[21,29,33,41,56]</sup>. This may be explained by the higher microorganism virulence<sup>[58]</sup>, the formation of biofilm and the increased rates of resistance to antibiotics that characterize staphylococcal strains.

For PJI of the knee, ASA score and joint purulence<sup>[29,56,59]</sup>, preoperative levels of inflammatory markers<sup>[34,40,42]</sup>, and prior infection<sup>[40]</sup> have been also identified as factors affecting outcomes of I and D. In contrast to the hip, revision surgery<sup>[21]</sup>, as well as thyroid disease<sup>[47]</sup>, has been reported as additional prognostic factors for I and D of a knee PJI.

### The role of serial I and Ds

In a previous consensus meeting, the participants recommended against performing serial I and Ds, unless this approach is included in a specific protocol<sup>[22]</sup>. Studies utilizing a predefined protocol of serial interventions exhibit high success rates. When gentamycin-loaded cement beads were used in combination with a repeat I and D after 2 wk, infection control was established in 83.1% of patients<sup>[45]</sup>. Kuiper *et al.*<sup>[42]</sup> used a similar protocol, with a success rate of 66.1%. A more aggressive approach was adopted by Peel *et al.*<sup>[60]</sup>, which included three I and Ds within 7-10 d; the authors reported an 86% success rate. Estes *et al.*<sup>[37]</sup> performed 2 I and Ds 7 d apart using antibiotic-loaded cement beads and reported a 90% success rate. With a protocol consisting at least 2 I and Ds within 2-3 d, Choong *et al.*<sup>[32]</sup> reported successful outcomes in 78.6% of patients. On the other hand, in studies where no particular protocol for performing serial I and Ds is followed, the results have been more variable and range from 25% to 100%<sup>[20,21,25,27-29,31,36,53,61,62]</sup>.

Time is still a significant factor when the approach of serial I and Ds is chosen. It has been shown that performing a subsequent I and D within more than 20 d after the first procedure is associated with 97.4% lower odds of implant retention<sup>[62]</sup>. Specific protocols with serial I and Ds involve performing the subsequent procedure in no more than 14 d and, as already described, were associated with superior results. Again, longer duration of symptoms has been also associated with failure of multiple I and Ds<sup>[62]</sup> as it allows for biofilm formation and transition to infection chronicity, as previously described.

Serial I and Ds have been found less likely to be of success in PJIs of the knee than in hip infections<sup>[62]</sup>. This may be attributed to differences with regards to the soft-tissue envelope of each joint, as well as to vascular supply. In the same study, patients treated with multiple I and Ds were more likely to have vascular disease<sup>[62]</sup>. These findings, however, have not been reproduced by other reports and therefore further investigation is needed in order to elucidate their potential impact.

### CONCLUSION

I and D with the goal of implant retention is still an important tool in the armamentarium of the orthopaedic surgeon for early postoperative and late acute hematogenous PJIs. In such cases, intervention should be timely and aggressive, as each additional day lowers the odds for a successful outcome. Furthermore, the ideal candidate should have an infection with a low-virulence

pathogen and be without comorbidities that have been associated with a less favorable result. Finally, after one failed I and D, the surgeon should be very cautious about repeating the procedure, unless a structured and aggressive protocol incorporating serial I and Ds within a short time interval is applied.

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