MENTORS IN ORTHOPEDICS

DECISION-MAKING PROCESS IN PERIPROSTHETIC INFECTION TREATMENT MANAGEMENT: A MULTIMODAL APPROACH

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SUMMARY

Background: Periprosthetic joint infection (PJI) remains a significant complication in orthopedic surgery, necessitating complex multi-specialty management to prevent irreversible tissue damage and functional loss. Despite established protocols, debate persists regarding the optimal surgical methodology for infection eradication and limb salvage.

Objective: This review evaluates current surgical strategies for managing musculoskeletal infections, focusing on indications, success rates, and clinical outcomes of various intervention levels ranging from implant retention to terminal procedures.

Key Points: Debridement, antibiotics, and implant retention (DAIR) is indicated for acute infections (<3 weeks) involving low-virulence pathogens and stable implants, with higher success in hip (60-83%) versus knee (55-70%) arthroplasty. One-stage revision offers improved functional outcomes in selected patients with identified organisms and adequate soft tissue. Two-stage revision remains the standard for chronic or recalcitrant infections, utilizing articulating or intramedullary spacers to manage bone loss. For failed limb salvage, resection arthroplasty and arthrodesis serve as intermediary options; arthrodesis demonstrates infection eradication rates exceeding 90% but carries a 40% complication rate. Above-knee amputation and hip disarticulation are reserved as last-resort measures for unrelenting sepsis or massive bone loss. Amputation is associated with high mortality (50% at 5 years) and significant functional impairment, with only 44% of patients utilizing prostheses.

Conclusion: Successful PJI management requires a staged approach tailored to patient comorbidities, pathogen virulence, and soft tissue integrity. Surgical attempts at limb salvage should generally not exceed four to six procedures, after which the functional benefits of further reconstruction diminish relative to definitive terminal procedures.

KEYWORDS

Arthroplasty, Replacement, Knee; Arthroplasty, Replacement, Hip; Prosthesis-Related Infections; Reoperation; Amputation

INTRODUCTION

Musculoskeletal infection remains a challenging post-operative complication amongst orthopaedic surgeons, requiring multi-specialty coordination given its potential for irreparable damage. Periprosthetic infection outcomes are driven by a multitude of factors including the causative pathogen's virulence, immunocompetency and associated comorbidities of the patient, anatomic location of the prosthesis, age of the patient, and the extent of the bone and soft tissue loss. The goal remains to eradicate the infection while salvaging the limb as much as possible without compromising the patient's functional status. Understanding the specific indications, patient characteristics, and infection parameters is crucial for selecting the most appropriate approach and optimizing outcomes. However, the most well-prepared orthopaedic surgeon has also already considered the next options in the unfortunate event if the infection persists. There is continuous debate on indications for the best methodology of treating periprosthetic infection. We provide an overview on the different options available with suggestions on when their use would be most appropriate.

THREE MAIN SURGICAL OPTIONS

Understanding the nuances and evidence supporting DAIR and staged debridement approaches is crucial in guiding clinical decision-making and optimizing the management of musculoskeletal infections. Individual patient characteristics such as infection severity, implant stability, and soft tissue condition determine whether DAIR, one-stage, or two-stage revision will be selected for initial treatment. DAIR consists of aggressive debridement of infected tissues, intravenous antibiotics, and retention of the original implant with PE insert exchange, while staged debridement involves a multistep approach with implant removal, thorough debridement, and immediate versus delayed reimplantation. There is significant variability in treatment success of preliminary management of periprosthetic infections with DAIR, one-stage, or two-stage revisions as demonstrated in Table 1.

	Surgical Treatment	Success of infection control
HIP	DAIR	60-83%
	1-Stage	86-95%
	2 Stage (Primary)	94%
	2 Stage (Revision)	72%
	Girdlestone	90-97%
	Hip disarticulation	90%
KNEE	DAIR	55-70%
	1-Stage	86-98%
	2 Stage (Primary)	93%
	2 Stage (Revision)	82%
	Arthrodesis	84%

Table 1. Summary table of surgical treatment outcomes in periprosthetic infection

DAIR

DAIR aims at retaining the implant with thorough debridement and irrigation with PE insert exchange. It has shown favorable results in cases of early infections, well-fixed implants, and infections caused by low-virulence organisms [1]. It is commonly indicated in situations where the infection is identified acutely (usually less than 3 weeks after symptom development), the causative pathogen has low virulence, or the patients cannot tolerate an explant either due to medical conditions or limited life expectancy. Success rates of eradicating the infection via DAIR also vary depending on the infection location with a higher success rate in a total hip replacement (60-83%) as opposed to a total knee replacement (55-70%) [1],[2]. Radical debridement is one of the keys for success but has technical limitations with implants in place especially for TKA. Further risk factors that have been shown to significantly increase risk of failure after DAIR include insufficient soft tissue coverage, patients in the McPherson systemic host C group, and signs of chronic infection such as a sinus tract [3]. Additionally, DAIR has low success in immunocompromised patients with findings that risk of amputation for failed limb salvage increases by more than 6 times in such patients [4],[5]. DAIR offers the potential for implant salvage, minimizing the need for additional surgeries and preserving limb function, and is associated with shorter hospital stays, reduced costs, and decreased morbidity. However, DAIR may be less effective in cases of chronic or deep-seated infections, implant loosening, or compromised soft tissues.

One-Stage Revision

One-stage revision removes infected components with implantation of new prosthetic components during a single operation [6]. This method is beneficial due to the fewer number of procedures required and some studies have demonstrated equal or better functional outcomes relative to those after two-stage revisions [7]. However, it is only suitable for patients that meet certain criteria including sufficient and stable soft tissue, a well-identified causative organism, and absence of sinus tracts, which may also bias functional outcome results [8],[9]. Furthermore, patients with megaprostheses such as a total femur a one-stage revision might be preferred since an adequate mega spacer will immobilize the patient [10].

Two-Stage Revision

Staged revision surgery is often preferred for chronic or recurrent infections, implant loosening, and infections caused by highly virulent organisms. Although involving additional surgeries and longer treatment duration, it provides an opportunity for thorough debridement, resolution of infections, and implant exchange with improved stability. The staged approach allows for the assessment of infection control and optimization of local tissue conditions before reimplantation. Compared to single stage, two-stage revision requires prolonged hospitalization and is associated with higher rates of functional impairment and morbidity. Patients with chronic infections are at increased risk for more virulent pathogens or polymicrobial infections and usually present with not only poor-quality soft tissues, but also greater bone loss. As such, these patients are initially managed with a two-stage revision due to its greater potential for preserving bone stock than a one-stage revision [11]. Use of a mobile articulating spacer during the interim period permits early functional mobilization while maintaining joint stability and delivering local antibiotic therapy. This method has even shown to be effective utilizing large intramedullary spacers for large segmental bone defects at the knee [12].

BONE DEFECT MANAGEMENT

Extensive bone defects resulting from chronic infections are common and durable fixation remains a challenge. The introduction of porous metal wedges, cones and sleeves have significantly improved the fixation options for hips and knees. Bone transport, a technique based on the principles of distraction osteogenesis, has gained increasing attention for diaphyseal bony defects as a promising solution for managing such cases. Bone transport has demonstrated favorable outcomes however, for PJI it plays no role and will not be discussed here.

OVERVIEW OF PERIPROSTHETIC INFECTION MANAGEMENT

Patient care and counseling requires consideration of possible future reoperations and whether patients would be able to tolerate future procedures, as outlined in Figure 1. Patients who are indicated for further surgical management, regardless of the first procedure performed, the next step after failed infection control consists of a two-stage revision. If the infection continues to persist, more extensive surgical interventions are required [13]. Hip infections would require Girdlestone resection arthroplasty and very rare hip disarticulation. Unrelenting knee infection would be managed with arthrodesis, and if the infection continued to be poorly controlled, an above knee amputation (AKA). Given the high rates of morbidity and minimal improvement in functional and health status outcomes with additional limb-salvaging procedures, surgical attempts to limb-salvage should not exceed 4-6 procedures. After this many surgeries, the likely return on improvement in health outcome is diminished making amputation the best next step.

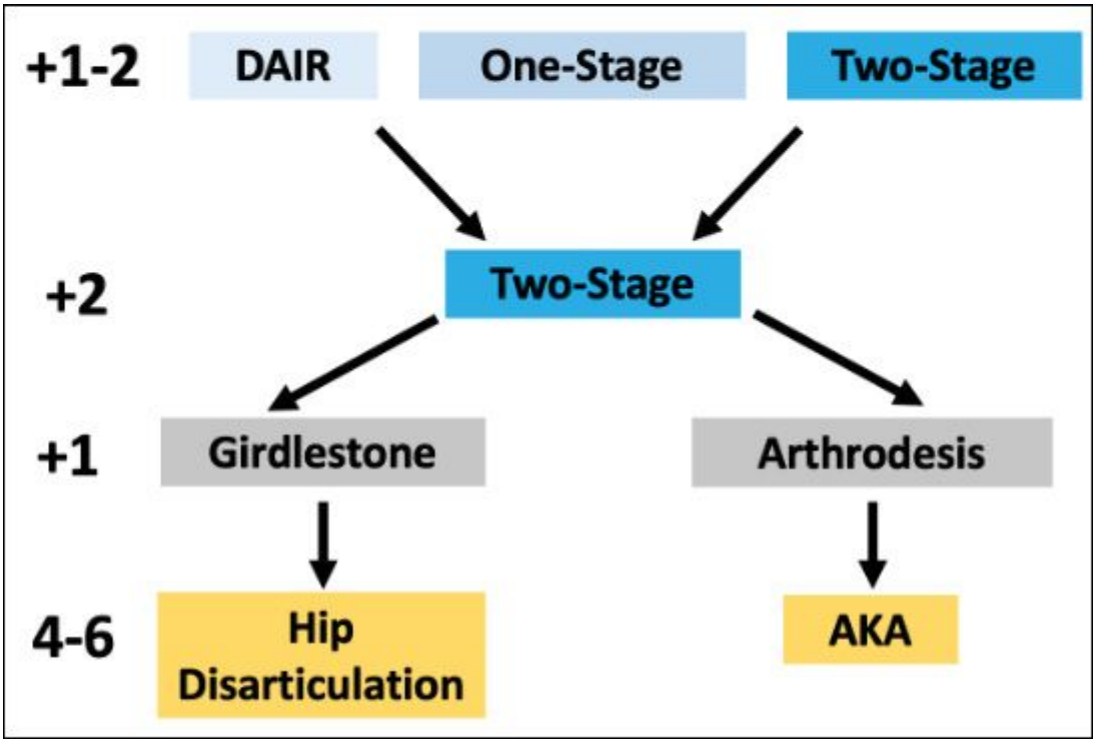

Figure 1. Overview of surgical management of periprosthetic infection

Resection Arthroplasty

Resection arthroplasty procedures follow failed attempts at DAIR and staged revisions. For complicated hip infections, the Girdlestone procedure, while not frequently utilized, has shown to be effective in controlling infection rates [14],[15]. However, functional results have not been very favorable with more than 90% of patients experiencing persistent pain and 83% are minimal community ambulators [14]. Resection arthroplasty for infected knees should be performed for wheelchair bound patients only.

Arthrodesis

Arthrodesis has a limited role in infected THA since resection arthroplasty represents the better alternative. When attempting to control TKA infections, arthrodesis can be a part of the staged revision procedures either by using this as a definitive primary procedure or after failed revision surgeries. It is usually indicated in circumstances involving an inadequate extensor mechanism, highly virulent organisms, or multiple failed attempts at limb salvaging [16]. Arthrodesis has a high success at eradicating infection with success rates over 90%, although complication rates are relatively high at 40%. It has been shown to have better functional outcomes than above-the-knee amputations [17]. However, Carr et. al determined significantly higher post-operative complication rates found in knee arthrodeses relative to above knee amputations, as summarized in Table 2 [18].

	Arthrodesis	AKA	
Post-operative Infection	14.5%	8.3%	p<0.0001
Blood transfusions	55.1%	46.8%	p<0.0001
Systemic complications	31.5%	25.9%	p<0.0001
In-patient Mortality	3.7%	2.1%	p<0.0001
Hospital length-of-stay	11 days	7 days	p<0.0001
90-day readmission rate	19.4%	16.8%	p=0.009

Table 2. Comparison of outcomes after knee arthrodesis vs above-knee amputation after failed TKA [18]

Knee arthrodesis, common in the early 1900s, is an uncommon outcome of failed TKA. The most common reason for knee arthrodesis in modern times is failed treatment of PJI with TKA [19]. Patients with substantial metaphyseal bone loss, inadequate ligamentous restraints, multiple failed revisions, inadequate soft tissue coverage with loss of extensor mechanism and infection with virulent organisms should be considered for knee arthrodesis. Patients with failed two stage reimplantation may be candidates for arthrodesis. There are newer implants available that are considered arthrodesis endoprostheses that can bridge limited bone defects and allow for weight bearing [20]. Given the low functional outcomes of AKA versus arthrodesis, when treating a patient who requires multiple revision surgeries, earlier intervention with an arthrodesis is considered before amputation is the only viable option remaining.

Amputation

Amputations are an absolute last resort when considering treatment options for infected TKA. They are usually considered in cases of severe sepsis, unrelenting local infection with concomitant massive bone loss and uncontrollable pain [21]. Amputations are rarely considered due to the high percentage of low functional outcomes given the high energy expenditure required with at least half of patients ultimately requiring a wheelchair (22). This is why when treating a patient who requires multiple revision surgeries, earlier intervention with an arthrodesis is considered before amputation is the only viable option remaining.

In some cases, above knee amputation (AKA) for a chronically infected total knee arthroplasty is the only option. There have been several reports on the subject and various contributing factors can be identified. Severe soft-tissue loss, more than 6 reoperations, and prior flap reconstruction, correlate with the need for AKA [23]. Due to poor functional outcomes, amputations are considered an absolute last resort when considering treatment options for infected TKA [24]. Infection is the most common complication that results in the rare indication for an amputation after a TKA (0.025%) due to the higher prevalence of infection than other complications such as vascular injury and compartment syndrome (21). Similarly, hip disarticulation is a rare outcome of a chronically infected total hip arthroplasty, occurring about 0.3% of hip PJIs. Options such as Girdlestone can be chosen earlier and may eliminate the need for hip amputation (25). Patients with PJI after tumor megaprostheses are at higher risk of amputation at all levels. Jeys and Grimer found that amputation rates due to infection vary according to anatomic location of the prosthesis with the highest rates occurring at the tibia (7.8%), distal femur (2.4%), and pelvis (2.0%) [26].

Mozella found that the incidence of amputation as a result of complications from TKA was 0.41% incidence with recurrent infection responsible for 81% of cases [28]. Failure after DAIR for PJI of TKA was significantly associated by a number of factors including the presence of a sinus tract, infection due to methycillin-resistant Staph.

Aureus, the immunocompromised status of the patient, treatment delays, relatively short antibiotic duration, and retention of exchangeable prosthetic components [27].

With significant surgeries such as an AKA, it is relevant to evaluate the functional and psychosocial impact on patients. Of the patients that were amputated, 44% were utilizing prostheses while 62.5% were functionally walking [28]. Ambulatory status after AKA has not shown to significantly worsen- about half of patients continuing to be nonambulatory while about a quarter remain home ambulators or community ambulators, respectively [29]. In Orfanos' retrospective analysis identified a 50% mortality rate at 5 years after AKA for PJI[30]. The majority of patients in their study (86%) were satisfied with their AKA and 42% reported that in hindisight, they would have done it sooner [30].

Currently, surgical treatment decision-making for periprosthetic infection requires careful balancing between preparing for feared and unknown outcomes while prioritizing patient safety and preservation of function. Given its ubiquity within orthopaedic surgery, we must continue to develop and improve treatment strategies and protocols to minimize infection risk.

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