THE INFECTED HIP REPLACEMENT

The two-stage standard in revision total hip replacement

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Two-stage exchange remains the gold standard for treatment of peri-prosthetic joint infection after total hip replacement (THR). In the first stage, all components and associated cement if present are removed, an aggressive debridement is undertaken including a complete synovectomy, and an antibiotic-loaded cement spacer is put in place. Patients are then treated with six weeks of parenteral antibiotics, followed by an ‘antibiotic free period’ to help ensure the infection has been eradicated. If the clinical evaluation and serum inflammatory markers suggest the infection has resolved, then the second stage can be completed, which involves removal of the cement spacer, repeat debridement, and placement of a new THR.

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Peri-prosthetic joint infection (PJI) remains a significant complication following total hip replacement (THR). Despite continued advances and efforts in the development of preventative strategies, and in identification of patients with specific modifiable risk factors, the incidence of PJI continues to range between 0.5% and 2% following primary THR.1 The goals of treatment include both eradication of the infection and restoration to a pain-free and a well-functioning THR.

A number of different treatment strategies have been described for management of patients with an infected THR. Irrigation and debridement (I&D) is appealing because of the relative ease of the procedure, especially for patients. However many studies have shown suboptimal results not only for chronic PJI, but also for acute hematogenous and acute post-operative infections,2-5 with failure rates ranging from 39% to 72%. One-stage exchange has been employed primarily in Europe: several centres have reported good outcome in eradication of PJI, with up to 100% success at two to seven years follow-up in patients selected according to strict criteria.6-8 These centres rely on cemented fixation of new components; techniques that are not commonly used in North America for revision THR. Chronic suppression is used sparingly in patients who are not candidates for more aggressive surgical management.9,10 Resection remains a viable salvage procedure in cases where the infection is unable to be eradicated, or if bone loss or soft-tissue deficiency precludes reconstruction.11,12

While there is increasing interest in the idea of a one-stage exchange under certain clinical circumstances,13 two-stage exchange remains the gold standard for an infected THR, with many recent studies reporting good success rates in eradicating infection (80% to 100%).1,6,7,14,15 Once eradication of infection has been achieved, clinical results are quite good, with many authors reporting Harris hip scores (HHS)16 of 80 to 87 points following re-implantation.6,15,17 The purpose of this review is to highlight key elements of a successful two-stage exchange strategy for the treatment of an infected THR, and to consider its recent developments.

The first stage

Identification of the organism. The chances of the success of a two-stage exchange depends in large part on the identity of the infecting organism, with lower success rates reported for both methicillin-resistant gram positive bacteria,18 as well as gram negative organisms.19 If the infecting pathogen and its antibiotic sensitivity profile can be identified pre-operatively, there may be an opportunity to tailor the antibiotics that are placed into the spacer, although in most cases vancomycin and an aminoglycoside are selected and cover most micro-organisms. The authors routinely aspirate the joint in an attempt to identify the infecting organism prior to every planned two-stage revision THR.

Debridement and removal of components. In order to remove all infected and non-viable tissue surrounding the hip joint, an extensive
Debridement and synovectomy should be performed. Loose implants are dealt with easily, while well-fixed devices should be removed carefully to avoid iatrogenic damage to the bone and surrounding viable soft tissues. Even in the setting of infection there should be a low threshold to perform an extended trochanteric osteotomy (ETO) in cases where otherwise considerable damage may be caused to the femur. Two retrospective studies have confirmed that ETOs heal reliably even in the setting of infection.20,21 An ETO is also required to remove a well-fixed cement mantle in order to eradicate the infection. However a single recent study has challenged this belief by demonstrating successful clearance of infection in 14 of 15 patients when an intact cement mantle was left in situ as part of a two-stage exchange.22 After all implants and foreign material have been removed, the existing bone should be debrided using a combination of reamers, curettes, and other tools as necessary.

Antibiotic spacer construction. The choice between an articulating and non-articulating spacer remains controversial, however most surgeons prefer articulating spacers when feasible in order to maintain leg length and soft tissue tension.23,24 These permit partial to full weight bearing, but there is an associated risk of dislocation. Non-articulating spacers are preferable in patients with extensive bone loss, or with deficient abductors secondary to a high risk of dislocation if an articulating spacer is selected.

There are numerous ways of constructing an articulating antibiotic loaded cement spacer, and each has its merits.23-25 Our preference is to use commercially available pre-formed moulds (Biomet, Warsaw, Indiana) which allow for independent sizing of the femur and acetabulum and have a modular neck adaptor to adjust leg length and offset (Fig. 1). Sometimes we use a low-friction articulating spacer, which can occasionally provide a good functional outcome if retained as a definitive procedure (Fig. 2). The length of the spacer has not been shown to have an effect on infection control,26 however the authors prefer a longer spacer if the metaphysis is not supportive, or if an ETO has been performed.

Pre-formed spacers do not allow the surgeon to control the quantity or type of antibiotics. In cases where on the table construction of antibiotic cement spacer is contemplated, several packages of bone cement and heat-stable antibiotics are required in powder form (e.g. gentamycin, tobramycin, vancomycin, and daptomycin). We commonly use three to five 40 g units of cement depending on the size of the spacer needed. Recommendations regarding the quantity of added antibiotics vary throughout the literature and is often based on little scientific evidence.27 The authors prefer to use a combination of 3 g to 4 g of vancomycin and 1.2 g to 2.4 of tobramycin per 40 g bag of antibiotic cement, although this can be modified if the sensitivity of the infecting organism identified pre-operatively suggests otherwise, or if there is a concern over the patient’s renal function. Adding antibiotic powder as the cement monomer and polymer are mixed may improve the elution characteristics,28 as can using a high viscosity cement preparation which has been shown to have superior elution properties.29 In any case the concentration of antibiotics achieved in the periprosthetic tissues should be sufficient to treat PJI for at least six weeks after the first stage.30
**Interval treatment between stages**

A multidisciplinary team approach is necessary when treating patients with PJI. An infectious disease specialist should be engaged to tailor antibiotic selection, ensure therapeutic antibiotic levels are being reached, and monitor any adverse effects of prolonged antibiotic therapy. A nutritionist can provide guidance to these patients who are often malnourished. The assistance of an internist is helpful to maintain the general health of the patients, including any metabolic disorders such as diabetes that may affect the ability of the patient to clear the infection and heal.

**Antibiotic treatment.** Although recent studies have raised the possibility of a shorter antibiotic durations and earlier transition to oral agents, most physicians recommend intravenous antibiotic administration for six weeks. If medically stable, patients can receive antibiotics in their home through a peripherally inserted central catheter (PICC) line. Antibiotics are tailored to the specific pathogen if cultures and sensitivities are available. When cultures fail to demonstrate an infecting organism, wide spectrum antibiotics such as vancomycin combined with a broad spectrum cephalosporin such as cefepime should be administered as guided by the infectious disease specialist.

**Monitoring infection resolution.** Following the first stage resection, patients should be observed clinically for any signs of persistent infection such as increasing pain, swelling, or problems with wound healing. They should also be monitored with use of weekly serum inflammatory markers including erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP). Although having normal values is reassuring, the serial trend is the more important predictor of successful treatment. A recent retrospective study demonstrated that these laboratory values remain persistently elevated in nearly one-quarter of patients in whom the infection had been eradicated, therefore waiting for these to return to normal may delay a the planned second stage reconstruction unnecessarily. After completion of the six-week course of intravenous antibiotics, the authors feel it is important to observe an antibiotic-free period of at least several weeks. During this time, patients should continue to be monitored clinically and with serum inflammatory markers to ensure that the laboratory values and the patient’s symptoms do not increase, which suggests persistent infection and the need for a second debridement as opposed to a reimplantation procedure.

The authors routinely schedule the second stage reimplantation approximately nine weeks following the first. If signs of persistent infection are identified either pre-operatively or intra-operatively, a repeat irrigation and debridement with placement of a new spacer should be performed.17

**The second stage**

Contraindications proceeding reimplantation at a second stage include persistent infection or significant medical comorbidities that would preclude a major surgical procedure or that can be optimised prior to reimplantation such as diabetes control or nutritional status.

Define treatment with the temporary spacer is an option that often gives a reasonable level of function and pain relief in patients who are poor surgical candidates for re-implantation, particularly if a low-friction articulating spacer is used (Fig. 2).

However the majority of patients will be able to proceed to reimplantation. During the second stage, the hip is routinely aspirated after exposure of the posterior capsule. A recent study found that the optimal threshold for identifying persistent PJI at the time of reoperation is a white blood cell count (WBC) of 3528 cells/μL, with a differential of 79% polymorphonuclear cells per high-power field.32 Values below these levels are consistent with successful eradication of the infection. The authors routinely take approximately five sets of tissue cultures at the time of reimplantation to ensure infection eradication.

The reimplantation procedure also affords the surgeon another opportunity to perform a thorough debridement and irrigation of the surrounding soft tissues and bone prior to placement of the definitive components. This is important not only to reduce the burden of any persistently compromised or infected tissue, but also because it removes any cement abrasion debris that may have come from the antibiotic spacer a potential cause of future third body wear.34 Definitive reconstruction should be performed based on the femoral and acetabular bone stock and quality of the periprosthetic soft tissues. Although we routinely continue intravenous antibiotics until all culture results are known to be negative (typically 72 hours post-operatively), any potential benefit of extended oral antibiotic therapy after two-stage exchange remains unknown.

In our hands, two-stage exchange remains the gold standard for a chronically infected THR. By using this type of systematic approach discussed, the authors have been able to achieve successful eradication of infection and restoration of function in the vast majority of patients, consistent with results reported by many authors.

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**References**

Prolonged suppressive antibiotic therapy


