

MINERVA

ORTOPEDICA E
TRAUMATOLOGICA

VOLUME 65 · N. 3 · GIUGNO 2014



EDIZIONI · MINERVA · MEDICA

Management strategies of prosthetic joint infections of the hip

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Prosthetic joint infection (PJI) of the hip remains a devastating and costly complication of total hip arthroplasty. The treatment depends on many factors: host comorbidities, the duration of symptoms and the infecting organism. Irrigation and debridement can be performed for acute cases accompanied by modular component exchange. For chronic infections, a single-stage or two-stage revision is possible depending on the patient's general health. If revision is not possible, antibiotic suppression or a resection arthroplasty (Girdlestone procedure) may be indicated. In all cases, a multidisciplinary team approach must be utilized, coordinated by the orthopedic surgeon and the specialist in infectious diseases. The eradication of infection is essential whilst maintaining optimal hip function.

KEY WORDS: Prosthesis implantation - Infection - Hip.

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Infection after total hip arthroplasty (THA) remains a severe, disabling and costly complication. The incidence of prosthetic joint infections (PJI) of the hip varies from 0.3% to 2.2% for primary THA and increases to 8% to 25% for revision THA. The average time to diagnosis of hip PJI is 1.2 years and 84% of cases are diagnosed within 2 years.¹ Hip PJI is the third most common cause for THA revision (15-20%) after aseptic loosening and dislocation.

The most effective option to treat a patient with hip PJI remains controversial and many questions remain unanswered.² Such issues include: 1) until when soft-tissue debridement with bearing change and implant retention can be performed in the acute setting? 2) criteria for performing a one-stage exchange; 3) criteria for performing a two-stage exchange with or without (antibiotic-loaded or not) cement spacer; and 4) criteria for performing a Girdlestone procedure.

The treatment of a patient with hip PJI must be multidisciplinary. The team in-

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cludes, but is not limited to the orthopaedic surgeon, infectious diseases specialist, radiologists and microbiologists. The orthopaedic surgeon coordinates this team of specialists and multidisciplinary meetings must be scheduled. Antibiotic therapy is usually started during surgery after biopsies have been performed. Three (if acute) to five (if chronic) bacteriological samples have to be sent to the microbiological laboratory as fast as possible, including the synovial fluid that has to be put in the operating room in blood culture bottles. Pathological analysis must be performed as well. C-reactive protein (CRP) may be normal but it is essential to evaluate the CRP trend. The combination of an abnormal sedimentation rate and CRP provides the best combination of sensitivity and specificity.³ CRP level reaches peak values 48 hours after surgery and return to normal within 2 to 3 weeks. White Blood Cell (WBC) count is usually unhelpful and cannot be relied upon to exclude infection.⁴ A plain radiograph should be performed in all patients.³

The management of a patient with an infected THA is different depending on the time of onset of symptoms after surgery.

Tsukayama⁵ classified PJI infections into 4 categories:

- positive intraoperative cultures during revision THA;
- early postoperative infections (less than 1 month postoperatively);
- acute haematogenous infections;
- late chronic infections (more than 1 month postoperatively).

The goal of treatment is to eradicate infection where possible, whilst always attempting to preserve hip function and quality of life.

The acutely infected THA

An acute infection is due to either intraoperative contamination or from haematogenous dissemination (skin, urinary tract, pulmonary system and dental infections). It can be defined as an early or late infection with a short duration of symptoms (less than 1 month). The time of onset of infection can

be difficult to evaluate. It represents 27% of the overall infection rate. Davis⁶ defined an acute infection as up to 2 weeks for early postoperative infection and up to 3 weeks for late haematogenous infection. Zimmerli suggested a period of 3 weeks.⁷

Intraoperative contamination is less frequent due to improvements in operating room discipline, careful antibacterial skin preparation, laminar airflow and prophylactic antibiotics given during anesthetic induction.

Preoperative aspiration is very useful, but more difficult to perform than for knees, to confirm infection and find the microorganism involved.

Irrigation and debridement/modular component exchange

In acute infections, and especially during the first week, it is possible that only soft tissues are contaminated with no evidence of osteomyelitis. A thorough synovectomy and debridement of fluid, soft tissues and bone (if necessary) must be performed immediately. Rapid intervention aimed to prevent the production of a bacterial biofilm is essential for a successful outcome.

The previous skin incision should be used. An approach has to be performed in a manner that provides adequate access to the joint and implant-bone interfaces. The fascial planes should be assessed for their integrity. If the iliotibial band is intact, superficial infection must be thoroughly debrided and cleansed before deeper layers are opened.

Modular components (femoral heads and acetabular inserts) must be removed and later exchanged. This leads to better exposure, more thorough debridement and facilitates cleaning between these interfaces. After debridement, it is possible for the prosthesis to become unstable due to a change in the soft tissue tension. One must therefore be prepared to implant a longer femoral neck and/or head. It is essential to know the brand and type of the previous components used and to have the correct inventory of components for exchange. This is especially the case if the patient has been operated on in

another hospital or by a different primary surgeon. Bone and well-fixed components are left intact. All wounds must be irrigated with at least 10 L of saline using a pulse lavage system. Suction drains have to be sent for bacteriological cultures. Irrigation and debridement (I&D) is followed by at least 6 weeks of antimicrobial therapy. The duration of antimicrobial therapy depends on several factors, especially risk factors for relapse and the type of pathogen.

The success rate of component retention is variable. Tsukayama⁵ reported a 71% eradication rate for intraoperative contamination and 50% for acute hematogenous infections. Fehring⁸ reported a 76% failure rate of I&D for acute infections. Brandt⁹ demonstrated that the success rate was better within 2 days after the onset of symptoms with 56% eradication rate vs. 13% after 2 days. Crockarell¹⁰ showed a 14% rate of eradication and advised to perform debridement no more than 2 weeks from the onset of symptoms. The failure rate also depends on the infecting organism:¹¹ 65% for streptococcal infections, 72% for methicillin-sensitive *Staphylococcus* and 76% for resistant species. Infection with Staphylococcal species, high ASA-scores and gross purulence were significant predictors of debridement failure.¹² Not removing modular component is an independent predictor of poor outcomes.¹³

Given the high failure rate of I&D, one-stage exchange can be a good option for acute postoperative infections.¹⁴ Estes¹⁵ described a new two-stage approach for acutely infected hips: antibiotic-loaded cement beads were placed during the initial debridement, 7 days after the beads were removed and modular parts exchanged.

The chronically infected THA

Sixty-five percent of hip PJI occurs between 1 month and 1 year postoperatively. Chronic infection may be caused by intraoperative contamination, contiguous spread from a superficial wound or hematogenous dissemination, and may present with septic loosening and/or loss of function. Labeled

leukocyte tracers (as Indium 111) do not accumulate in the absence of infection. Chronic infection extends down to the prosthesis and the bone leading to a periosteal reaction and endosteal osteolysis. Systemic antibiotic therapy alone is insufficient to eradicate chronic osteomyelitis, particularly in some cases where the implicated microorganisms produce an impenetrable biofilm. Surgeons must also be aware that in addition to osteomyelitis, there is often significant amounts of necrotic soft-tissue and bone present. This necrotic tissue cannot be treated by systemic antibiotic therapy alone because of the inherent lack of blood supply to this tissue. In this case, even if no loosening is found, it necessitates removal of the prosthesis and excision of all of the necrotic bone and soft-tissues. In addition to this radical debridement, systemic antibiotics and a local topical antibiotic cement preparation can help to complement the local sterilization process. The total duration of antibiotic therapy must be at least 3 to 4 months, and no longer than 6 months.

Two-stage revision

Two-stage revision involves a primary radical debridement and local and systemic antibiotics, followed by prosthetic re-implantation when the surgical area is considered sterile. The success rate of two-stage revisions varies from 80% to 95%.^{16, 17} The rate of complications, however, (fracture, dislocations, loosening) is 2 to 3 times higher (20%) compared with single-stage revision. This strategy requires two surgeries and a period of limited mobilization. It remains the gold standard in North America, for chronic infections and recurrence after I&D, due to its better control of the infection.

First stage

A radical debridement of all foreign and necrotic tissues is performed, including removal of retained cement. It may be necessary to perform multiple debridements to ensure that this stage is complete. Indeed, any retained tissues can act as a biofilm-encased nidus for micororganisms. Morley,¹⁸

however, reported good results for infection eradication when cement mantle was left in situ (15 patients). Implants should be carefully removed avoiding iatrogenic damage to bone and soft-tissues. Generic revision extraction instruments are sufficient in most situations but one should check with the manufacturer for specialized implant extraction instruments. Sonication of the removed implants has to be discussed with specialist in infectious diseases.

An extended trochanteric osteotomy (ETO) may be necessary^{19, 20} for a cemented stem with an intact cement interface and for fully coated cementless stems that are difficult to remove via the proximal femur. You have to maintain well-vascularized muscle attachments to ensure osteotomy union and prevent necrosis and sequestrum.

The use of an antibiotic-loaded cement spacer can deliver high-dose local antibiotics and may be used at the end of the first stage. Vancomycin and tobramycin (less than 2 g to avoid mechanical cement weakening) can be mixed into each 40 g of cement. The combination of both antibiotics improves the elution of each antibiotic.²¹ The antibiotics have to be mixed in powder form without exceeding 10% of the PMMA (PolyMethylMethAcrylate) powder. The admixture of antibiotics may alter the polymerization and affect the processing time of the cement. Antibiotic release from the spacer depends upon the cement viscosity; the less viscose the cement, the better the release of antibiotics. It must be borne in mind that these antibiotics have a risk of nephrotoxicity due to their systemic absorption. The peak concentration and elution from the cement occurs between 3 and 18 hours after implantation.²² So the antimicrobial activity of antibiotic cement is limited to the first few weeks.²³ The use of PMMA has raised concerns, as its surface is amenable to biofilm formation.

Success has been reported with both static and articulating spacers. Static spacers generate less debris but don't allow motion of the hip, which is preferred by some surgeons, because immobilization improves immunologic clearance of infection. Articulating spacers can be modeled freehand or with

commercially available silicon molds (PROSTALAC, DePuy, Warsaw, IN / InterSpace, Exactech, Gainesville, FL/Stage One, Biomet Inc, Warsaw, IN). They allow the maintenance of leg length and the soft-tissue envelope. If used, the spacer has to be stable and easy to remove. Patients with articulating spacers have higher hip scores, shorter hospital stays, better walking capacity between stages, shorter operative times and less blood loss during re-implantation.²⁴ Cement beads, on the other hand, have an increased area allowing higher elution of antibiotics.²⁵

Interval between stages

Suctional drains must be sent for cultures: if the infecting organism is found, it is a risk factor for relapse and repeat I&D must be discussed.²⁶ The patient must be carefully monitored during the perioperative period. Patients must be closely followed by an internist, a nutritionist and an infectious disease specialist. A minimum 6-week course of intravenous antibiotics is recommended. A PICC (Peripherally-Inserted Central Catheter) line must be placed because of the peripheral venous toxicity of antibiotics. Early switch to oral administration could be effective in treating PJI after THA.²⁷ After the antibiotic course is completed, clinical symptoms, appearance of the wound and inflammatory markers must be monitored for signs of persistent infection. Erythrocyte Sedimentation Rate (ESR) is much less specific than CRP but some authors advocate its use in combination with CRP. The trend of the CRP rate is more important than one specific value. CRP can remain persistently elevated in 25% of patients with infection eradication.²⁸ Delaying the second stage may be detrimental to a successful outcome. Increased CRP trend, wound erythema and wound drainage require iterative I&D with spacer exchange (22% of patients).²⁹ IV antibiotics are stopped two weeks before reimplantation.

Second stage

Reoperation usually occurs around 6 weeks after the first stage. If it is not allowed

(due to significant medical comorbidities), the antibiotic spacer left in situ provides reasonable functional results.³⁰ Five sets of cultures (bone and tissues) must be obtained and sent during procedure. A thorough repeat I&D is important to remove all persistent infected tissues and cement debris from the antibiotic spacer (third-body wear).³¹ Recent studies have demonstrated that cementless components result in a similar low rate of recurrence compared with cemented implants³²⁻³⁴ and high rate of bone ingrowth. In France, to reduce the dislocation rate, dual-mobility cups are currently implanted.

Intravenous antibiotic therapy should last until all cultures results are final.

Single-stage revision

A single-stage revision involves radical debridement and prosthetic re-implantation during the one setting. It is followed by 6 weeks of IV antibiotics. This procedure may only be suitable in a select group of patients³⁵ where the exact infectious agent is known preoperatively.³⁶ The general health status of the patient should be considered if a curative procedure is being contemplated. In the elderly or debilitated patients, a single-stage revision is preferred rather than subjecting the patient to multiple lengthy anesthetics and debridements.

Initial debridement involves removal of all necrotic, infected, devitalized tissues (soft-tissues, bone) and all foreign materials (wires, cement). After debridement, all of the THA components must be extracted. After this first procedure, the surgical site must be re-prepared and draped. The second stage is the component re-insertion. The acetabular bone must be reamed to remove devitalized tissues and the new component is usually 2 mm larger.

The literature reveals that during re-implantation, antibiotic-impregnated cement was used in 99% of one-stage revision. The use of antibiotic cement appears to be more successful to control infection (83%) than plain cement (60%).³⁷ This may be due to the fact that despite the best surgical tech-

nique, it is almost impossible to excise all infected tissue during prosthesis removal. The use of antibiotic loaded cement may be able to eradicate the remaining infected tissue. Bori³⁸ found a 96% rate of infection control in chronic cases with one-stage arthroplasty and use of a cementless stem at almost 4-year follow-up.

The literature also identifies some positive results with single-stage revision. Wolf³⁹ demonstrated that the one-stage approach was favored over a two-stage procedure in terms of mortality and functional recovery. Langlais⁴⁰ reported a 86% success rate with antibiotic-loaded cement vs. 59% without cement or using plain cement. Winkler⁴¹ demonstrated a 92% successful eradication of infection at 4 years. Jackson and Schmalzried⁴² identified the following factors allowing for a one-stage procedure: 1) no wound complications after initial THA; 2) methicillin-sensitive *Staphylococcus epidermidis*, *S. aureus* and *Streptococcus* species; 3) organism sensitive to antibiotic cement. Factors associated with failure of single-stage revision included: 1) polymicrobial infection; 2) gram negative organisms; 3) methicillin-resistant *S.epidermidis* and group D *Streptococcus*. At an average 4.8-year follow-up, the success rate was 83%.⁴²

Resection arthroplasty (Girdlestone procedure) without reimplantation

This procedure is usually considered to be palliative in most patients and it is reserved for ASA grade 3 or 4 patients, non-ambulant patients, or with recurrent THA dislocations due to infection, failed multiple two-stage procedures or major bone loss or soft-tissue deficiencies. A resection arthroplasty is not commonly performed because it leads to poor function and a significant limb length discrepancy (at least 3 cm, up to 10 cm). It does not improve the rate of infection control whilst usually leading to a damaging functional loss. Patients need assistive devices to walk. Velocity is 41% of normal and oxygen consumption is 264% of normal.⁴³ A *vastus lateralis* muscle flap interposition can be performed.⁴⁴

Antibiotic suppression

Where a curative procedure is not possible due to significant patient comorbidities or chronic superficial cellulitis, antibiotic suppression of infection should be considered. It is often a palliative treatment. The infecting organism has to be identified and be sensitive to the antibiotic orally delivered. Infection is controlled rather than eradicated.

Recurrent infection

Recurrent infection is associated with resistant organisms, obesity and poor health status.⁴⁵ A two-stage revision should be performed for healthy patients. Otherwise, a resection arthroplasty is indicated. After re-revision, 36% of patients remain infection-free.⁴⁶ Arthrodesis is an alternative treatment. Hip disarticulation is rarely indicated in uncontrollable and life-threatening infections.

Conclusions

The overall rate of control of infection in hip PJI is approximately 85%. The treatment of hip PJI must be in a multidisciplinary setting. Eradication of the infection should coincide with full recovery in terms of function. Multiple factors are involved in the management principles of successfully treating a patient with PJI of the hip. These factors guide whether a cure is possible or whether implant retention and life-long suppression with antibiotic treatment is necessary. If a cure is possible, surgical technique is paramount. In acute infections, cure with debridement and implant retention is usually feasible. In chronic infections, the decision to perform a single- or two-stage revision depends on the patient's overall health, microbiology of the infection and surgeon preference. A resection arthroplasty is rarely indicated and considered a palliative procedure. Further prospective, multicenter studies have to be performed to define, for example, the role of one-stage exchange and oral antibiotic therapy in two-stage procedure.

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Acknowledgements.—Lyon Bone and Joint Infection (BJI) Study Group.

Physicians – Tristan Ferry, Thomas Perpoint, André Boibieux, François Biron, Florence Ader, Judith Karsenty, Florent Valour, Fatiha Daoud, Johanna Lippman, Evelyne Braun, Marie-Paule Vallat, Patrick Miaillhes, Christian Chidiac, Dominique Peyramond; Surgeons – Sébastien Lustig, Philippe Neyret, Olivier Reynaud, Vincent Villa, Olivier Guyen, Jean-Baptiste Bérard, Anthony Viste, Frédéric Dalat, Olivier Cantin, Romain Desmarchelier, Michel-Henri Fessy, Cédric Barrey, Francesco Signorelli, Pierre Breton, Ali Mojallal, Fabien Boucher, Charles Hirtum, Hristo Shipkov; Microbiologists – Frederic Laurent, François Vandenesch, Jean-Philippe Rasigade, Céline Dupieux; Nuclear Medicine – Isabelle Morelec, Marc Janier, Francesco Giammarile; PK/PD specialists – Michel Tod, Marie-Claude Gagnieu, Sylvain Goutelle; Clinical Research Assistant – Eugénie Mabrut.

Conflicts of interest.—The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.