Treatment of Infected Hip Arthroplasty

Philippe Hernigou[*,1,2], C.-H. Flouzat-Lachianette[2], R. Jalil[2], Sobrinho Uirassu Batista[3], I. Guissou[2] and A. Poignard[2]

[1]*University Paris XII,* [2]*Hôpital Henri Mondor, 94010 Creteil, France*

[3]*Hospital Edgar Santos, University Federal of Bahia, Salvador, Brazil*

Abstract: The clinical outcomes of a consecutive series of deep total joint infections treated with a prosthesis retaining protocol were reviewed. The treatment of deep periprosthetic joint infections is challenging. In recent years, two-stage exchange arthroplasty has emerged as the gold standard for successful elimination of infection. With success rates averaging 82% to 96%, this treatment method has both the highest and most consistent rate of infection eradication. Another alternative in the treatment of the deep periprosthetic infection is the single-stage exchange arthroplasty. Successful eradication of infection after single-stage exchange arthroplasty has been reported to average from 60% to 83% after total hip infections. While both the single and two-stage exchange arthroplasty are viable treatment options, they are associated with negative factors such as they are time consuming, expensive, and may entail a 6- to 12-week period with a minimally functioning extremity after prosthesis removal. This paper reports the general principles of management, the treatment of acute infection occurring in the postoperative period or later, and the treatment of chronic infection by exchange arthroplasty or resection arthroplasty.

Keywords: Arthroplasty, joint infection, antibiotics.

1. INTRODUCTION

The most effective treatment for an infected total hip replacement (THR) is controversial [1]. Many questions remain. For example, in patients with chronic infection requiring exchange arthroplasty, should the procedure be done in one or two stages? In acute infection, should the prosthesis be exchanged, or is soft-tissue debridement sufficient? Does resection arthroplasty provide better control of infection than exchange arthroplasty? In exchange arthroplasty, can cementless prostheses be used, or is antibioticloaded bone cement required? With the use of modern sterile surgical technique, unidirectional airflow systems, and preoperative antibiotics, the infection rate in total joint replacement has fallen to approximately 1% to 2.5%. Although this percentage is small, the annual number of primary arthroplasty procedures continues to grow dramatically due to an aging population. In order to limit patient morbidity and minimize the economic impact of infected revision arthroplasty, continued efforts should be directed to improve the treatments for deep periprosthetic infections.

We will discuss the general principles of management, the treatment of acute infection occurring in the postoperative period or later, and the treatment of chronic infection by exchange arthroplasty or resection arthroplasty.

Periprosthetic infection is a debilitating and costly complication of total joint arthroplasty.

*Address correspondence to this author at the Hôpital Henri Mondor, 94010 Creitel, France; Tel: 33.1.49.81.26.01; Fax: 33.1.49.81.26.08;
E-mail: philippe.hernigou@wanadoo.fr

2. GENERAL PRINCIPLES OF MANAGEMENT

The management strategy depends on whether the infection is confined to the soft tissues or extends to the bone. Selection of the best strategy requires evaluation by a multidisciplinary team which includes specialists in infectious disease but is co-ordinated by orthopaedic surgeons.

2.1. Nature of the Infected Tissues

The mechanism of the infection, whether by intraoperative contamination or delayed 'haematogenous' infection, has no bearing on the selection of treatment. Indeed, different mechanisms of infection lead to similar lesions. Both the acute infection which develops within a few days after intraoperative contamination and the delayed haematogenous contamination are initially confined to the soft tissues, so that there is no need to change the prosthesis or debride the bone [2-4]. Conversely, chronic infection involves both the soft tissues and bone. Under these circumstances, the bone must be debrided and the prosthesis changed irrespective of whether the patient has septic loosening diagnosed long after intraoperative contamination or delayed 'haematogenous' contamination with the gradual development of chronic osteitis despite systemic antibiotic therapy [5-7].

2.2. Mechanism of Infection

Four main mechanisms may lead to infection of a THR.

2.2.1. Intraoperative Contamination

This was formerly the most common mechanism, but the widespread use of prophylactic antibiotics have altered this.

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Intraoperative contamination is responsible for only a few cases of infection of orthopedic implants. The infection which follows intraoperative contamination has two clinical patterns. The first is acute postoperative infection. This is now exceedingly rare. The diagnosis is readily made on the basis of inflammation of the wound with fever. During the first few days, the infection is confined to the soft tissues, with no osteitis. The second is gradual septic loosening which is the most common presentation. Poor function after arthroplasty with loss of function over time is characteristic. Osteitis is consistently present.

2.2.2. Delayed Contamination

This is now a common mechanism. The prosthesis, which is sterile initially, is contaminated from bacterial sources located elsewhere in the body, usually *via* the bloodstream but occasionally *via* the Iymphatics. Microbiological studies will identify the same organism in the remote focus and the hip, thus providing the mechanism of infection.

Delayed contamination after several years of satisfactory function is the most common pattern, and also the most typical. Pain in the hip and fever develop in a patient who has an active focus of infection, often in the skin, teeth, lungs or urinary tract. The risk of colonisation of the prosthesis is greatly increased by local inflammation of the hip, which may be due to synovitis in response to wear particles from the prosthesis. According to the geographic area (US versus Europe), there is difference on prophylaxis for dental procedures (US does and UK doesn't).

Haematogenous contamination can occur in the immediate postoperative period from a pulmonary, urinary tract, or catheter-related infection. The clinical pattern is similar to that of infection secondary to intraoperative contamination. However, the presence of the primary focus of infection and the identity of the pathogen at the two sites establishes the diagnosis of 'haematogenous' infection.

2.2.3. Contamination by Direct Spread

Although this mechanism occurs mainly at the knee in patients with delayed skin healing, it can occur at the hip, particularly in association with reoperation for a periprosthetic fracture.

2.2.4. Infections Related to Reactivation of an Indolent Infection

These occur mainly in patients with a pre-THR history of hip surgery, such as femoral osteotomy or treatment of an acetabular fracture. The infection goes unrecognised until it is reactivated by implantation of the prosthesis.

2.3. Nature of the Infected Tissues

This is the main consideration. Acute infection is confined to the soft tissues, at least during the first week. This is the case in delayed contamination in which the infection initially involves the tissues surrounding the prosthetic joint [8-10]. Another example is acute intraoperative contamination in which soft-tissue infection initially occurs without infection or necrosis of the bone. In acute infection, urgent surgery is needed to remove the infected soft tissues. The bone and prosthesis are left untouched.

There are exceptions to this rule, however, because some organisms produce slime, which deposits on the implant. Within 24 hours, the slime coating the prosthesis limits the effectiveness of antibiotic therapy, and surgical debridement of the prosthesis is not always aufficient to ensure decontamination.

Chronic infection extends into the bone. Surgical treatment is essential in this situation regardless of the mechanism of the infection, either intraoperative contamination manifesting secondarily as septic loosening or delayed contamination with the gradual development of infectious osteolysis. These lesions require removal of the infected prosthesis, excision of the necrotic bone and implantation of a new prosthesis.

Contamination by direct spread usually results in acute soft-tissue infection when diagnosed early, whereas reactivation of chronic infection typically manifests as chronic infection with osteitis.

2.4. Management should be Multidisciplinary

The goal of management is not only to eradicate the infection but also to preserve the function of the hip by protecting both bone stock and muscle function.

Help should be obtained from specialists in infectious diseases, particularly to ensure that the most appropriate systemic antibiotics are used. Resolution of the infection can be achieved without systemic antibiotics, as reported initially by Buchholz *et al*. [3], who obtained a cure rate of 77% in 583 revisions, but only at the cost of extensive bone and soft-tissue resection which compromises long-term function. Long-term palliative antibiotic therapy, however, can be used in patients whose poor general health poses unacceptable operative risks, but it merely alleviates the symptoms without eradicating the infection.

With systemic antibiotics, tissue which is infected but not necrotic can be left in place. This tissue has a blood supply and, consequently, can be sterilised by systemic antibiotics. Necrotic tissue, however, perpetuates the infection and therefore must be removed surgically. Prosthetic components which are colonised by slime should also be removed. The production of slime can be assessed on culture of aspirated fluid. However some autors have reported good results without prolonged course of antibiotic therapy. Stockley [11] reported a series of 114 patients with microbiologically-proven chronically-infected total hip replacement, treated between 1991 and 2004 by a two-stage exchange procedure with antibiotic-loaded cement, but without the use of a prolonged course of antibiotic therapy. The mean follow-up for all patients was 74 months (2 to 175) with all surviving patients having a minimum follow-up of two years. Infection was successfully eradicated in 100 patients (87.7%), a rate which is similar to that reported by others, but where prolonged adjuvant antibiotic therapy has been used. Using the technique described, a prolonged course of systemic antibiotics does not appear to be essential and the high cost of the administration of antibiotics can be avoided.

Specialists in infectious diseases who contribute to the management of patients with an infected arthroplasty should be aware that systemic antibiotics have only limited access to scar tissue and to tissues which have lost their blood

supply because of implantation of the prosthesis. Adjuvant local treatment with antibiotics may be used under these conditions.

The orthopaedic surgeon should be in charge of co-ordinating the treatment because the objective is not only to eliminate the infection but also to ensure functional recovery. For instance, treatment which is somewhat less effective in terms of control of infection may have a lower rate of mechanical complications and ultimately lead to better function. Satisfactory function is paramount to the patients who are not enthusiastic about full recovery from the infection at the expense of loss of function.

Patients with infections of moderate severity will benefit more from 'adapted' surgery than from aggressive surgery. The latter involves a two-stage procedure or femorotomy and ensures control of the infection in most of patients, but with mechanical complications in about 25%. Only about 75% of patients have a good functional result.

'Adapted' surgery (one-stage procedure, endofemoral technique) may control the infection in a less number of patients, but as mechanical complications occur in only 10%, about the same number of patients have a good functional result. In addition to this functional benefit, the treatment is shorter, less demanding to the patient, and less costly.

Thus, the orthopaedic surgeon must tailor the strategy to the needs of each patient. Adjuvant local antibiotic therapy should be used whenever this is likely to reduce the extent of the surgical procedure.

3. ACUTE INFECTION TREATED WITH DEBRIDEMENT

The original incision is reopened, the prosthesis is dislocated to facilitate excision of infected soft tissue, and the extraosseous parts of the prosthesis is cleaned but left in place [12-14]. It can be strongly recommended within the first three weeks afterarthroplasty. Furthermore, the rate of recovery seen with this minor procedure between three and six weeks after THR is valuable, particularly in frail patients. By contrast, synovectomy is rarely effective beyond the sixth week, and radiological evidence of osteitis is associated with an extremely high rate of failure.

Every effort should be made to prevent acute infections. Prophylactic antibiotics should be given. Antibiotic-loaded bone cement seems to protect against 'haematogenous' infection for at least six months. Indolent foci of infection (teeth, sinuses) should be eliminated before arthroplasty. Venous catheters should be removed early.

4. RESECTION ARTHROPLASTY IN CHRONIC INFECTION

Most patients have radiological evidence of both endosteal osteolysis and a femoral periosteal reaction. The osteolysis usually affects both the stem and the cup. Aspiration of the hip confirms the diagnosis and identifies the pathogen. Factors of adverse prognostic significance must be sought before deciding on whether to perform exchange or resection arthroplasty [15].

4.1. Factors of Adverse Prognostic Significance

At least three factors are of adverse prognostic significance.

4.1.1. The Nature of the Organism

Gram-negative organisms, polymicrobial infection, and failure to identify an organism despite histological evidence of infection may be associated with a poor outcome. Coagulase-negative staphylococci are often less susceptible to antibiotics than *Staphylococcus aureus*. Methicillin-resistant *Staph. aureus* (MRSA) is a dreaded organism, mainly because of the precautions required to prevent its dissemination, rather than because of its resistance to antibiotics.

4.1.2. Local Factors

These particularly include the presence of a draining sinus, soft-tissue scarring related to multiple surgical procedures, factors associated with a high risk of complications during removal of the prosthesis such as a wellfixed fully-coated stem and well-fixed cement, or extensive osteolysis requiring reconstruction of bone stock by allografting.

4.1.3. General Health Status

This includes the ASA score, the psychological status, the need for chronic anticoagulant therapy, etc.

4.2. Resection Arthroplasty

Resection arthroplasty is associated with poor function and does not seem to decrease the risk of death as compared with exchange arthroplasty. Control of infection is no better than with exchange arthroplasty. For these reasons, resection arthroplasty should be reserved for patients whose medical condition is poor (ASA 3 or 4) and have a history of failed prosthesis-sparing surgery.

5. EXCHANGE ARTHROPLASTY IN CHRONIC INFECTION

Exchange arthroplasty raises several important questions [16-29]. In terms of the control of infection is there a difference between direct exchange and two-stage exchange or between cementless prostheses and prostheses secured with antibiotic-loaded bone? Do direct exchange and two-stage exchange provide similar functional results? Do techniques such as femorotomy or the use of a spacer improve the results?

5.1. Control of Infection

5.1.1. Systemic Antibiotic Therapy

There is evidence that acceptable rates of control of infection can be achieved without systemic antibiotics:77% in a series of 583 exchange arthroplasties with antibiotic-loaded bone cement alone [3]. However, systemic antibiotic therapy is now used routinely because it increases further the control rate of infection. It is, however, only one of the factors leading to control.

Data from different series indicate that the optimal duration of systemic antibiotic treatment is three to four months. Therefore, when two-stage exchange is performed, the interval between the two stages should be between 45 days and three months. This delay requires the use of an appropriate spacer. Systemic antibiotics should not be given for more than six months.

Starting systemic antibiotics before the excision procedure does not improve the rate of control of infection and can interfere with the interpretation of intraoperative bacteriological specimens.

5.1.2. Antibiotic-Loaded Bone Cement or Cementless Prosthesis?

The difference of results is not statistically significant in the litterature. Again, this insignificant difference does not mean that using antibiotic-loaded bone cement to secure the final prosthesis had no effect. The decision to use antibiotic-loaded bone cement was often based on the severity of the infection. patients who did not receive a prosthesis secured with antibiotic-loaded bone cement had usually no MRSA, as compared with patients treated with antibiotic-loaded bone cement. Treatment without antibiotic-loaded bone cement to secure the prosthesis provided high cure rates in patients with moderate infection, but adding antibiotic-loaded bone cement produced higher cure rates in severe infections.

5.2. Functional Results

These were evaluated on the basis of perioperative complications, function and survival of the prosthesis. There has been concern that the multiple procedures needed for two-stage exchange may be associated with a higher rate of intraoperative fractures, damage to soft tissues, particularly the gluteal muscles with dislocations, and compromise of the blood supply to the bone with an increased risk of non-septic loosening in the medium and long term.

The rate of mechanical complications is two to three times higher with two-stage exchange than with direct exchange. In two-stage exchange, the first and second procedures are associated with similar rates of fracture and perforation, so that the final rates were doubled as compared with those of direct exchange. Dislocation is increased in patients with two-stage exchange.

Survival of the prosthesis should also be evaluated carefully. There are marked differences in complication rates and prosthesis survival. Complications occur in fewer than 10% of patients with direct exchange, which is less than half the rate seen with two-stage exchange. The slightly better rates of control of infection with two-stage exchange are obtained only at the expense of much less satisfactory functional results. It follows that two-stage exchange should be used only when the infection is so severe as to leave no other option.

5.3. Influence of Surgical Techniques

5.3.1. Femorotomy

The femur is opened like a book by cutting an anterolateral flap with a pedicle of vastus lateralis. The flap is used to remove material which cannot be extracted *via* the proximal route such as a fully-coated stem or distal well-fixed cement. Furthermore, the flap allows thorough cleansing of the infected tissue. Femorotomy is useful in decreasing the rate of complications during removal of the prosthesis, particularly in patients with cementless prostheses.

5.3.2. Spacer

The use of a spacer allowed a delay of several months between the two stages, a distinct advantage since control of infection may sometimes need several months of postoperative antibiotic therapy [30-42]. The use of a spacer should furfil several criteria as follows:

- The spacer should contain antibiotic-loaded cement, in particular to cancel out the foreign-body effect in a minimally infected environment.
- Stability should be aufficient to avoid shortening of the limb and to allow early mobilisation and walking for at least three months, since this is a possivble interval between stages.
- Removal should be easy, with no fracturing or migration during the second procedure.

The disadvantages of spacers which are composed only of methacrylate include insufficient stability with mobility in the femoral shaft or, on the contrary, cancellous penetration making removal difficult, and friction of the methacrylate on the raw acetabular bone, which may cause pain and shedding of methacrylate particles which inhibit physiological defence mechanisms against infection. Some surgeons prefer to use a 'prosthesis-spacer'. Its shape ensures stability. The antibiotic-loaded cement is separated from the bone by a thin layer (< 0.5 mm) of resorbable cellulose Surgicel. This is aufficient to ensure stability allowing weight-bearing without pain and easy removal of the cement which does not penetrate the cancellous bone. In addition, the metal-polyethylene prosthesis facilitates rehabilitation and prevents abrasion of the cement.

5.4. Direct or Two-Stage Exchange?

In specialised departments in which tissue excision is performed according to stringent rules and the surgeons work in collaboration with specialists in infectious diseases the rate of control of infection is 85%, with a variety of techniques. When necessary, control of infection and functional results should be weighed against each other, bearing in mind that the more aggressive surgical techniques for combating infection may increase the risk of functional complications in the perioperative period and subsequent aseptic loosening.

Thus, treatment should be tailored to the severity of the infection.

In patients with moderate infection, direct exchange with antibiotic-loaded bone cement and two-stage exchange without antibiotic-loaded bone cement provide similar results. However, preference should be given to direct exchange, since the functional results are clearly better. In patients with very severe infection, all available therapeutic weapons, both two-stage exchange and antibiotic-loaded bone cement, should be used.

These considerations allow the following strategy for the patients:

5.4.1. Moderate Infection

Either of the following treatments can be used: a) direct exchange with antibiotic-loaded bone cement, particularly

when the prosthesis can be removed without a femoral flap, or b) direct exchange with a cementless prosthesis, either as the first choice, or as the best mechanical possibility when a femoral flap is needed. Long hydroxyapatite-coated stems are more stable in this situation than cemented prostheses anchored only at their distal end.

5.4.2. Severe Infection

As a rule, direct exchange with antibiotic-loaded bone cement should be used. two-stage exchange is advocated only if a need for a femoral flap or a cortical allograft arises during the procedure.

5.4.3. Very Severe Infection (Multiple Resistance or Unidentified Organisms, Failure of Well-Conducted Direct Exchange)

In this instance, two-stage exchange should be used and a spacer with antibioticloaded cement used between the procedures. Although a cementless prosthesis can be used for the final procedure, we believe that a prosthesis with antibiotic-loaded bone cement is preferable whenever satisfactory metaphyseal mechanical fixation can be achieved.

The general health status of the patient should also be considered. We recommend direct exchange in elderly or severely debilitated patients, in whom the slightly lower rate of controll of infection is more than compensated for by the reduced incidence of mechanical complications, which are poorly tolerated by older patients.

6. CONCLUSIONS

Specialised multidisciplinary care produces encouraging results in revision surgery for an infected arthroplasty. The rate of control of infection is about 85% in patients with acute infection treated within the first three weeks, or with chronic infection treated with direct exchange or two-stage exchange.

In acute postoperative infections, further surgery with excision of infected soft tissues and cleaning of the prosthesis produces good results in 80% of patients within the first three weeks.

In acute infections related to secondary contamination of the prosthesis after several years of normal function, the same procedure should be performed in patients seen within three weeks of the onset of the infection. This minor procedure ensures recovery in one-third of patients if they have no radiological evidence of loosening or osteitis. After six to 12 weeks, the infection involves the bone and requires exchange or resection arthroplasty.

Simple resection arthroplasty (Girdles/one's procedure) does not increase the rate of control of infection (84%) as compared with exchange arthroplasty and produces devastating functional loss. This technique should be reserved for patients whose poor general health precludes function-salvaging procedures.

Exchange arthroplasty, whether direct or in two stages, is effective in controlling the infection, with more than 85% of patients having a good result. It is, however, associated with mechanical complications which require further surgery in a number of cases (10% with direct exchange and 20% with two-stage exchange).

Studies of series of THR revisions in patients with moderate or severe infection show that similar rates of control of infection have been achieved with the various treatment strategies. The explanation for this similarity in results is that the least aggressive treatments involving direct exchange and cementless prostheses, have been used in moderate infections and the more aggressive treatments involving two-stage exchange and antibiotic-loaded bone cement in complex cases. Data in the literature indicate that, as compared with direct exchange without antibiotic-loaded bone cement, either two-stage exchange or the use of antibiotic-loaded bone cement produces a similar improvement in control of infection. The rate of mechanical complications, however, is noticeably higher with two-stage exchange.

Consequently, the least aggressive surgical techniques should be used in patients with moderate infection (direct exchange, possibly with a cementless prosthesis). Direct exchange with antibiotic-loaded bone cement is indicated in patients with severe infection and/or with poor general health making repeated surgery undesirable. two-stage exchange with an antibiotic-loaded spacer prosthesis is the best choice in patients with very severe infections.

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