The Royal College of Surgeons of England

Ann R Coll Surg Engl 2004; **86**: 267–271
doi 10.1308/147870804579

Review

Infection after total hip arthroplasty

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Total hip joint replacement offers dramatic improvement in the quality of life but deep infection is the most feared complication of this procedure. The infection threatens the function of the joint, the preservation of the limb, and occasionally even the life of the patient. For the surgeon it is a disastrous anticlimax, which follows a procedure that may have given the patient freedom from pain and increased mobility.

Key words: Total hip arthroplasty – -Infection – Revision

Most elective orthopaedic operations, including joint replacements, are categorised as 'clean' procedures, for which the overall incidence of surgical site infection is low. The reported rate of deep infection after total hip replacement is now around 0.3–2%.

Microbiological considerations

Infection must arise either by contamination at the time of operation or later via the blood stream. The presence of foreign material increases the likelihood of infection from contamination by relatively few bacteria, and the species involved are often those thought usually to have negligible pathogenic potential (*e.g*. *Staphylococcus epidermidis*). There is little doubt that the airborne route is responsible for the major proportion of wound contamination and consequent sepsis.[4] The most frequent sources of contamination, as well as those providing the highest number of bacteria to the wound, are the physical environment, and unscrubbed personnel in the operating theatre. Many studies have demonstrated that individuals moving around the operating theatre contribute the largest proportion of pathogenic bacteria to the wound.

As reported in many series, the most prevalent organisms, are Gram-positive: *Staphylococcus aureus* which accounts for 50–65% of the infections; *Staph. epidermidis*, for 25–30%; and other bacteria, fungi, and mycobacteria, for 10–15%. There is an observed trend towards an increasing prevalence of *Staph. epidermidis* as the pathogenic organism for infections about prosthetic joints.

Several steps can be taken to minimise the risk of infection. Chief among these is the prophylactic use of antibiotics. The most important dose appears to be that administered immediately pre-operatively so that adequate levels of antibiotics are present in the haematoma that accumulates after the operation.

There is some additional evidence that the use of adjunctive measures, such as the use of clean-air systems and closed-air exhaust suits, may also substantially reduce the rate of infection.

Various factors increase the risk of infection after total joint replacement; some are inherent to the host and cannot be altered while others may be reduced or eliminated by meticulous pre-operative screening of the patient. Rheumatoid disease, open skin lesions on the affected extremity, a previous operation about the joint, a history of

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infection and length of procedure, have all been associated with a significant increase in the rate of deep infection. Open skin lesions should be noted and treated before the elective operation is performed. Staphylococcal organisms were responsible for infection in the majority of patients who had concurrent skin ulcerations. It is recommended that a 3-month interval of intact dermis over a previous ulceration, such as a venous stasis ulcer, should elapse before an elective total joint replacement is performed. Patients should also be screened to exclude a urinary tract infection. If a urinary infection is identified, it should be treated pre-operatively.

The orthopaedic surgeon should be aware that there are certain groups of patients who are at increased risk of developing infection. Patients with diabetes mellitus may pose an increased risk of infection due to the increased risk of wound healing problems. Patients with rheumatoid disease, in addition to being associated with the risk of acute infection, are also associated with a risk of late infection secondary to haematogenous bacterial seeding of the site of the prosthesis. Patients on systemic steroids and obese patients also appear to be associated with an increased rate of infection. Routine dental cleaning and extraction produces bacteraemia in nearly all patients. Conventional wisdom suggests that antibiotic prophylaxis in patients who have a joint prosthesis replacement is appropriate at the time of dental manipulation, but the topic remains controversial.

Classification of periprosthetic infections

The most widely accepted classification of periprosthetic infections of total joint replacements has been proposed by a group from the Mayo Clinic.[5]

Stage I infections(or acute)

These occur in the first 3 months after surgery and may be either superficial or deep.

Stage II infection (or delayed)

This is more indolent and may not become apparent until several months after the joint replacement. Typically, patients who have a stage II infection have never had a pain-free interval after the operation. The majority of these infections must be considered to have been derived at surgery.

Stage III infection

This occurs after 2 years and includes infections frequently caused by haematogenous dissemination of micro-organisms. The joint replacement may function very well after the operation, but later the patient has increasing symptoms of pain and impaired function.

The classification system described by the Mayo Clinic group still has clinical application but has recently been expanded to facilitate further the management of these patients. The newer classification comprises four categories as follows:

Positive intra-operative culture

This is an occult infection diagnosed after two specimens or more, obtained intra-operatively from different sites of the hip, have been cultured and found to be positive for the same organism. The infection should be treated with 6 weeks of intravenous administration of antibiotics and no operative intervention.

Early postoperative infection

Early postoperative infections presumably occur as a result of contamination with bacteria introduced at the time of surgery or early in the postoperative period. It becomes apparent within 1 month after implantation of the prosthesis. Infections that are diagnosed beyond 1 month after surgery (excluding acute haematogenous infection) rarely can be cured without prosthesis removal. However, no consensus exists on the period of time after surgery that defines an early infection, with definition ranging from 2 weeks to as long as 3 months.

Late chronic infection

Apparent more than 1 month after operation, the infection is characterised by an insidious clinical onset with gradual onset of pain and swelling. Initially, the primary consideration in the differential diagnosis is aseptic loosening of the joint replacement. Left untreated, the infection can progress to cause wound dehiscence, draining sinuses, and bone resorption. Systemic manifestations are minimal and bacteraemia is rare.

Acute haematogenous infection

As the name suggests, an acute haematogenous infection presents with an acute onset of symptoms in the affected prosthetic joint and it is associated with a documented or suspected bacteraemia. Although this infection can occur early or late in relation to joint surgery, the typical case involves a prosthesis that has been functioning well for months or years and that suddenly becomes painful and swollen; this is associated with systemic manifestations, such as fever and chills, An acute haematogenous infection differs from a late chronic infection (whose

source of infection may also be haematogenous) in the length of time that the infection is present in the joint before it becomes clinically apparent.

Diagnosis

Pain is the presenting symptom of most patients who have a deep infection. When pain occurs while the patient is at rest, the surgeon should be alerted to the possibility that it represents an inflammatory process. Drainage is the second most common symptom and is strongly suggestive of an infection if it is still present several weeks after the operation. A history of prolonged drainage after the operation in a patient who has persistent pain can be very helpful in establishing the correct diagnosis.[7–9]

Laboratory tests that are helpful in establishing the diagnosis of a periprosthetic infection include a full blood-cell count with differential, determination of the erythrocyte sedimentation rate (ESR) and C-reactive protein determination. The serum C-reactive protein level is a sensitive indicator of postoperative infection as it returns to normal more quickly than the ESR following surgery. A persistently elevated C-reactive protein is, therefore, more accurate in identifying patients with a deep infection.[1]

Radiographic evaluation of the joint may be helpful in the diagnosis of a periprosthetic infection if radiolucent lines, focal osteolysis, or periosteal bone formation are present. Of these radiographic findings, periosteal bone formation is strongly suggestive of a deep periprosthetic infection because of its high rate of association with this finding (Fig. 1).[4] The presence of radiolucent lines does not usually permit differentiation of aseptic from septic loosening. Endosteal erosions about the femoral canal are common radiographic findings, but can also occur with both aseptic and septic loosening. Unfortunately, the absence of any of these findings does not rule out the presence of an infection.

The use of special radiographic techniques, such as nuclear scanning, to confirm the diagnosis is less well established.[11]

If the clinical history and examination suggest that an infection is present, the next step in the diagnostic work-up is an aspiration of the hip.[2]

It is suggested that arthrography and aspiration can be used for the evaluation of patients with non-inflammatory arthritis and a painful total hip arthroplasty who have an elevated ESR or an elevated C-reactive protein concentration.[11] Occasionally, the results of cultures of fluid that has been aspirated from the hip are negative despite the

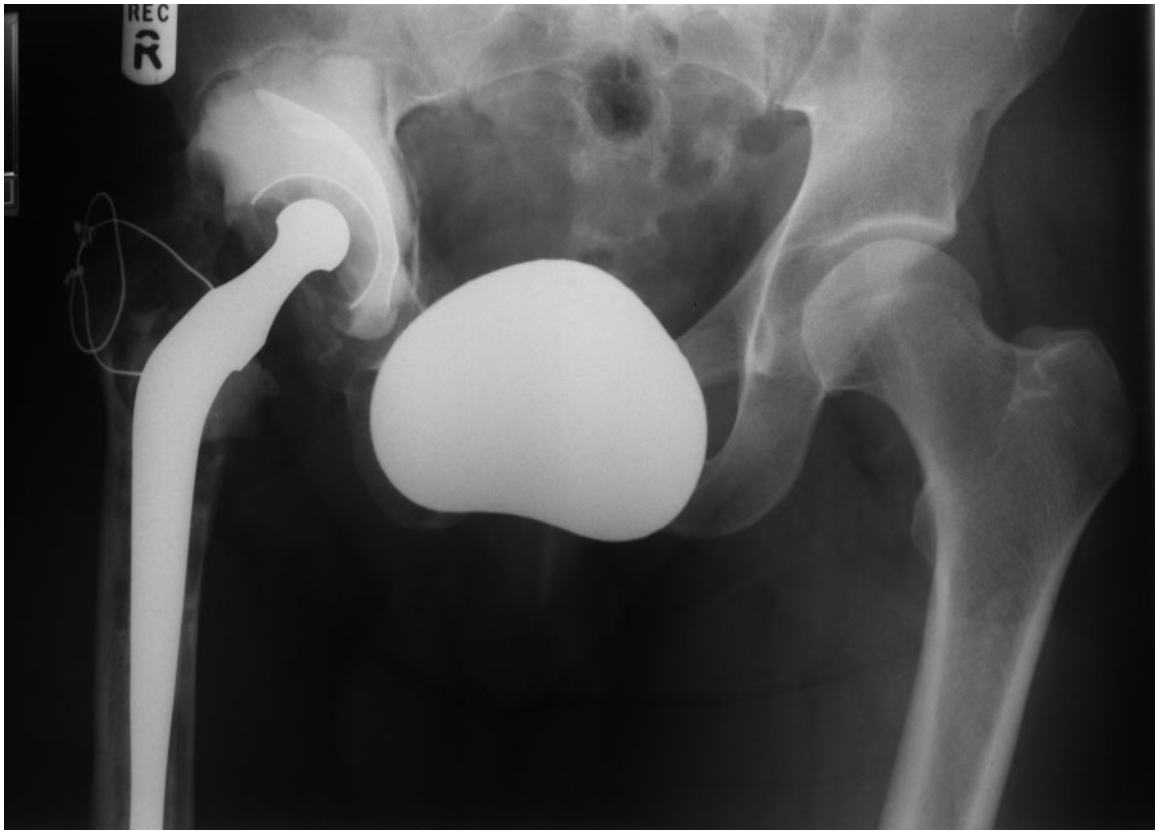

Figure 1 Radiological appearance of an infected total hip replacement.

presence of a deep infection. Aspiration of fluid from the joint may not be successful because of the technical difficulties with appropriate placement of the needle. The patient may also be receiving antibiotics at the time of the aspiration, and this may result in a false-negative culture. Lastly, despite successful aspiration of infected fluid and bacteria from the joint, the laboratory may not be successful in performing the culture and identifying the organism. If a culture of aspirated fluid is negative but other criteria suggest an infection, then obviously a revision procedure may still be indicated, During the revision, surgical specimens should be sent to the microbiology laboratory for aerobic and anaerobic incubation to confirm the pathological diagnosis. It is important to send several specimens to both laboratories. Three specimens are recommended for histology one from the pseudo-capsule, one from the membrane between the bone and the acetabular component or acetabular bone–cement interface, and one from the membrane between the femoral component and the femur or the femoral bone–cement interface and the femur.

Treatment protocols

The goals of treatment are the eradication of the infectious process and the restoration of function of the affected limb. Restoration of function by maintaining or re-inserting a prosthesis is preferred when it is medically possible. All of these approaches utilise extensive health-care resources and are extremely expensive.

Antimicrobial therapy without operative treatment

Suppressive antibiotic therapy without concomitant surgery has been used in the past for patients with significant medical problems who are considered to be at too high a risk for surgical treatment of an infected total hip arthroplasty. While antibiotic therapy alone has been reserved for patients considered too ill to withstand a major surgical procedure, newer techniques have evolved which may make such treatment a viable alternative.

Surgical treatment

Debridement with retention of the prosthesis

Operative debridement and antibiotic therapy are the mainstays of treatment and are necessary regardless of how the infection is categorised or classified. The debridement includes the excision of all infected and necrotic tissue and the removal of cement, wires, cables, plates, screws, non-absorbable sutures, and the prosthesis if it is not well fixed. The removal of these materials does not depend on the type of micro-organism. After specimens of the debrided tissue have been obtained, typically more than one specimen is sent for culture. After the wound has been appropriately debrided, antibiotics are administered to the patient. The selection of the antibiotic depends on the sensitivity of the pathogens as identified by the culture and sensitivity studies of the pre-operative aspirate. When previous cultures and sensitivity studies are not available, the administration of cephalosporin is recommended. The duration of parenteral antibiotic therapy has varied widely, but most authors have reported durations of 4–6 weeks.

Single-stage exchange arthroplasty

Buchholz *et al*.[3] introduced the one-stage exchange arthroplasty. This procedure includes excision of the infected components, surgical debridement, and immediate reconstruction with a cemented total hip arthroplasty. The basis of this procedure is the addition of antibiotics in powdered form to polymethylmethacrylate (acrylic bone cement). The advantage of this technique is self-evident. It avoids multiple operative procedures, particularly important for this group of patients who may have many other medical problems, and the risks of additional procedures can be cumulative. However these benefits must be weighed against the lower rates of eradication of infection that are reported after one-stage compared with two-stage procedures.[12]

Two-stage surgical procedure

The two-stage technique has been the treatment of choice for the past two decades. McDonald *et al*.[12]reported that their initial experience with a two-stage procedure was that it was successful in approximately 85% of the patients treated. If all of the polymethylmethacrylate is carefully removed, antibiotics are administered for at least 4 weeks, and there is an interval of a year between the Girdlestone resection arthroplasty and the reconstruction, the percentage of patients without recurrent infection will increase. Some surgeons have found that the surgical implantation of antibiotic-loaded polymethylmethacrylate beads into the wound at the time of closure can enhance the eradication of the remaining micro-organisms.

A prospective study addressing this technique has not yet been performed. Initially, it was recommended that the beads be pulled from the wound one per day beginning 2 weeks after surgery. This has proved to be painful for the patient, leading many surgeons to leave the beads in place until the time of reconstruction.

The ideal timing of the second stage remains to be defined. For example, should the interval between resection arthroplasty and hip reconstruction be longer for patients with more virulent infections? Unfortunately, a database of sufficient size to address this question does not yet exist. Fitzgerlad[9] had suggested to perform reconstruction three or more months after resection

arthroplasty in patients with less virulent infections, but to delay reconstruction for at least 1 year in patients with more virulent infections. Others have reported success with shorter intervals between the Girdlestone resection arthroplasty and reconstruction of the hip.[10]

The ^{111}In-labelled autologous white blood cell scintigram must be negative and the ESR and CRP must be normal before proceeding with the second stage. Depending on the degree of destruction of the acetabulum by the infectious process before the Girdlestone resection arthroplasty, structural allografts may be necessary to achieve a mechanically stable acetabular component during the reconstructive procedure. There is little data available on which to judge the advantages of mixing antibiotics with the polymethylmethacrylate used for fixation in a two-stage reconstruction of an infected total hip arthroplasty.

Most surgeons use the antibiotic in Simplex P rather than in Palacos acrylic cement. Palacos affords both a higher local concentration of the antibiotic and a more sustained release. Simplex P is easier to inject, which is especially useful when multiple batches are necessary to cement the femoral component. Thus, while Palacos has theoretical advantages for a two-stage reconstruction of an infected total hip arthroplasty when antibiotic-impregnated polymethylmethacrylate is thought to be advantageous, Simplex P may be the wiser choice, because the cement can be injected in a low-viscosity state.

Duncan and Beauchamp[6] have described another technique, which obviates the patients having to ambulate with a short and difficult to control extremity in the interval between resection arthroplasty and reconstruction. They implant an articulated spacer (PROSTALAC) which is constructed from antibiotic-impregnated Palacos acrylic cement about a femoral stem and polyethylene acetabulum. With the introduction of the uncemented total hip arthroplasty, it was only natural for reconstructive arthroplasty with uncemented components to be extended to patients with a resection arthroplasty performed as treatment of an infection.

Resection arthroplasty

Resection arthroplasty is a treatment option for some patients who have a periprosthetic hip infection. The decision to perform a resection arthroplasty as a definitive procedure without re-implantation of a second prosthesis is based on the bacteria's resistance to antibiotic therapy, the quality of the local soft tissues, the complexity of the reconstruction, the patient's refusal to have another operation after removal of the implant, the patient's over-all health, or a combination of these factors. Patients who have a resection arthroplasty can expect to have less pain than they did when the infection was present, but their functional recovery is inferior to that which can be obtained after sterilisation of the joint and re-implantation with a total hip prosthesis. These patients need aids to walk, have a noticeable limp, and must use a shoe-lift to help to equalise the lengths of the limbs and to improve gait.

Conclusions

The incidence of deep postoperative wound infections complicating total joint replacement has decreased significantly as a result of improvements in operating room discipline and surgical technique, more assiduous pre-operative assessment of the patient, and the prophylactic administration of antimicrobial agents. However, when is does occur it is a major problem. The treatment of a patient with an infected total joint arthroplasty uses an extensive array of hospital resources to eradicate the infectious process successfully and restore function to the involved extremity. In addition to the obvious human cost at the site of an infected total hip prosthesis are the financial implications for the individual or the institution that must pay for the treatment. Revisional total hip operations necessitate a longer stay in the hospital than a primary procedure. In addition, the operating time is longer, the blood loss is greater and the rate of complications as well as the cost of implants are higher.

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