

An update on prosthetic joint infection for UK trainees

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Abstract

Prosthetic joint infection (PJI) is where a joint that has been replaced with an orthopaedic implant becomes infected. PJI is given special consideration because of difficulties in treatment and the potential for life- and limb-changing sequelae for patients. Management of PJI requires collaboration between multiple specialists and is best managed within a multidisciplinary team. This article provides an overview on the diagnosis and treatment of PJI. We have described clinical prediction rules used to aid diagnosis in challenging cases. We have outlined first-line treatment options (such as debridement, antibiotics and implant retention (DAIR) procedures, single-stage and two-stage revision surgery), and second-line treatments (including chronic antibiotic suppression and salvage procedures).

Keywords

Prosthetic joint infection

Revision

Re-operation

Arthroplasty

Debridement, antibiotics and implant retention

Introduction

From the moment we are born, the human body is *colonised* with bacteria and other microorganisms. These are present on our skin and line our gastrointestinal and respiratory tracts. Many of these bacterial colonies perform vital roles and, since the tissues they inhabit remain undamaged, the host is unaware and unconcerned by their presence. This is the normal “microbiome” of the host. However, where microorganisms enter normally sterile sites of the body, multiply and cause tissue damage, the result is recognised as *infection*.

Prosthetic joint infection (PJI) refers to the situation where a joint that has been replaced by an orthopaedic implant becomes infected. This is given special consideration because of difficulties in treatment (often due to the affinity of bacteria for the implant surface) and the potential for life- and limb-changing sequelae for patients. It is, perhaps, not widely appreciated that the five-year mortality associated with PJI of large joints (such as the hip or knee) may be as high as 25% (1), conveying a worse prognosis than some common cancer diagnoses (2).

This review article will provide an update on PJI for trainees. We will describe criteria for diagnosis and outline contemporary treatment options.

Diagnosis

The acutely infected prosthetic joint might reasonably be expected to be painful, red, hot and swollen with loss of function (the cardinal signs of inflammation). However, this description is best suited to ‘superficial’ joints (such as the knee) as many of these signs may be absent in ‘deep’ joints (such as the hip). There may be other obvious features of acute infection (such as dehiscence at the surgical site) or more subtle signs (such as a persistent ‘leaky’ wound beyond 1-3 weeks of surgery). Patients with *chronic* PJI often present with mild symptoms that are slow to progress. The description of a joint that was “never right” following surgery is a common feature in the patient history. Florid cases of chronic PJI may include the presence of a discharging sinus, but are rare by comparison.

An accurate diagnosis of PJI is essential to guide effective treatment. However, clinicians now have a bewildering array of diagnostic biomarkers at their disposal. To guide the consistent and valid selection and interpretation of these biomarkers, clinical prediction rules have been developed. The European Bone and Joint Infection Society (EBJIS) (3) and Musculoskeletal Infection Society (MSIS) (4) criteria are among the most widely used, though others have been described. Both EBJIS and MSIS describe clinical, serological, synovial, histological and microbiological biomarkers which are outlined in Table 1. The results of these biomarkers are combined to provide a “traffic-light system” for PJI. EBJIS describe three diagnostic states: “infection confirmed”, “infection likely” and “infection unlikely” (3), whilst MSIS opt for slightly different terminology: “infected”, “possibly infected/inconclusive” and “not infected” (4).

Biomarker type:	Method	Predictor/Determinant of PJI
Clinical	History Examination	Wound healing problems at the time of primary Recurrent pyrexia Exposed Prosthesis* Sinus tract*
Serological	Blood test	C-reactive Protein (CRP) > 10mg/L* Erythrocyte Sedimentation Rate (ESR) D-Dimer Interleukin-6 (IL-6) Tumour Necrosis Factor (TNF) – α Procalcitonin
Synovial	Joint aspiration	Leukocyte count > 3000cells/uL Alpha-defensin <ul style="list-style-type: none"> - Lateral Flow - Enzyme-linked Immunosorbent Assay (ELISA) Leukocyte Esterase Calprotectin
Histological	Tissue biopsy <ul style="list-style-type: none"> - Percutaneous - Arthroscopic - Open 	At microscopy 5 or more neutrophils in a single high-power field (HPF, 400x magnification) 5 or more HPFs containing 5 or more neutrophils* Presence of micro-organisms*
Microbiological	Synovial fluid culture Tissue culture <ul style="list-style-type: none"> - 5 different samples using separate instruments 	2 or more samples culturing the same microorganism up to 14 days of incubation*
Radiological	Plain Radiographs Cross-sectional Imaging <ul style="list-style-type: none"> - Computed Tomography (CT) - Magnetic Resonance Imaging (MRI) Nuclear Medicine <ul style="list-style-type: none"> - Bone Scintigraphy Hybrid Techniques	Evidence of loosening Detailed Imaging of periprosthetic tissues Image areas of high metabolic activity in bone Combine functional techniques such as single photon emission computed tomography (SPECT) and positron emission tomography (PET) with a structural modality such as CT and MRI

*Table 1: Different biomarkers of infection *indicates a diagnostic criterion (EBJIS/MSIS)*

Management

Multidisciplinary team working and clinical networks

The successful management of PJI requires clearly defined pathways of care and collaboration between orthopaedic, radiology, microbiology, plastic surgery and therapy teams. The British Orthopaedic Association (BOA) Specialty Standard (BOAST) provides guidance on the care expected from teams investigating and managing suspected PJI in the context of knee replacement (5). One of the key standards is that all cases of suspected or confirmed PJI be discussed in an infection multidisciplinary team (MDT) meeting. Complex cases are recommended for referral to tertiary centres. There is ongoing consultation on the formation of clinical networks for referral of patients with suspected PJI after hip and knee replacement (6,7). These pathways are likely to share similarities to networks found in trauma and cancer services and may expand to involve other subspecialities performing joint replacement.

Debridement, antibiotics and implant retention (DAIR)

In some patients, it is possible to clear infection whilst retaining the existing prosthesis. This situation is typically found in patients with early infection where bacterial biofilm (a complex structure of bacteria which adhere to a foreign surface in the host) has not had time to mature. Antibiotics seldom penetrate this biofilm and this makes PJI extremely difficult to eradicate unless surgical debridement is utilised. The time frame for acute infection varies depending on patient and microbiological factors, but typically may be up to 6 weeks.

DAIR aims to treat PJI prior to formation of a mature biofilm. It must include radical debridement of infected tissues, by an experienced surgeon. A suitable technique for the knee is described in a further article by our group (8). DAIR procedures are not to be confused with a simple joint “washout”, where no debridement is performed. These procedures have little place in the treatment of PJI, perhaps only to reduce the bacterial load in a septic patient who would not tolerate more extensive surgery. Table 2 details contraindications to DAIR. Patients are placed on broad spectrum antibiotics following DAIR, and then switched to one

or more specific antimicrobial agents once organism sensitivities are known. Traditionally, patients received antibiotics for six months or more following DAIR. However, newer evidence suggests that good results may be achieved with around 8 weeks of treatment (9,10).

Table 2: Contraindications to DAIR

Contraindications to Debridement, antibiotics and implant retention (DAIR):
<i>Loose implant</i>
<i>Instability</i>
<i>Misalignment</i>

Single-stage revision

In a single-stage revision for PJI, the infected prosthesis is removed, the joint debrided and irrigated, and a new prosthesis inserted under the same anaesthetic. Many surgeons choose to re-scrub, and to change drapes and instruments before implantation of the new prosthesis to minimise the risk for contamination. The success of single-stage revision is dependent on the general health status of the patient, the environment at the surgical site and the infecting microorganism. The accepted indications for single-stage revision include:

- a healthy patient host
- adequate soft tissues to permit primary wound closure
- identification of a susceptible organism prior to surgery

Table 3: Relative contraindications to single stage revision

Contraindications to single stage revision
<i>Culture-negative infection</i>
<i>Infection with fungal organisms or highly aggressive/multi-drug resistant bacteria</i>
<i>Being unable to perform adequate debridement (e.g. infected tissue includes the neurovascular bundle)</i>
<i>Failed previous single-stage revision</i>

After surgery the patient will receive intravenous antibiotics tailored to the infecting organism. For most patients, these can be converted to oral antibiotics to complete a treatment course of approximately 6 weeks (11).

In the UK, the proportion of single-stage revision procedures to treat infection appears to be increasing (12). Over the past five years, 50.9% of revision THR and 48.2% of revision TKR procedures for infection were performed with the intention to treat the patient in a single operation (12). The advantages of single-stage (as opposed to two-stage) surgery for the patient and healthcare system are clear, provided that infection eradication can be achieved. There are currently no randomised trials available to guide practice although some are ongoing. For example, the INFORM trial is investigating this question for revision THR (13). The primary outcome measure is patient-reported pain and function (measured by the WOMAC Index) (14). Secondary outcome measures will include comparison of patient complications, quality of life and cost-effectiveness (13). A number of meta-analyses of non-randomised studies have investigated these procedures after revision knee replacement, with mixed results. Two systematic reviews found no difference in re-infection rates (14,15), whilst one found that two-stage procedures had lower rates of re-infection (16). With respect to joint function, Kunutsor et al (15) found no difference between one- and two-stage procedures, whilst Nagra et al (17) concluded that function was better after single-stage surgery.

Two-stage revision

Two-stage revision is considered by many to be the “gold-standard” treatment for PJI, and – as outlined above – remains prevalent in the UK. The absolute indications for two-stage revision have already been framed above as the contraindications to single-stage revision. In a two-stage revision procedure, the patient undergoes two planned operations. The first operation is to remove the infected implant, debride the surrounding tissues, and usually to insert a temporary joint replacement (known as a “spacer”). A broad range of spacers are in current use. For the knee joint, spacers are often subclassified as “articulating” or “static”, depending on whether they allow the joint to exercise through its range of motion. Articulating spacers include primary implants, silver-coated implants (which release silver

ions into the surrounding tissues), and implants made from bone cement (either prefabricated or moulded intra-operatively [by hand or using a silicone mould]).

After a “first-stage” procedure, the patient completes a course of antibiotics, and their clinical and laboratory response is closely monitored. Some centres then perform a “test of cure” where the joint is resampled to confirm the absence of infection. Many centres also institute an “antibiotic holiday” of at least two weeks prior to a second operation, though evidence for this practice is limited. If there is any doubt about the eradication of infection, a repeat first stage procedure may be performed; else, the patient proceeds to the “second-stage”. In many respects, this procedure resembles a single-stage revision, where the joint is further debrided and a definitive prosthesis implanted. The patient receives broad-spectrum antibiotics as surgical prophylaxis for the second-stage procedure. These are typically continued for 48-72 hours until culture results are known. If these cultures are positive, then a longer duration of antibiotic treatment may need to be considered.

Chronic antibiotic suppression

Not all patients with an infected joint prosthesis are suitable for, or wish to consider, further surgery. These are typically patients with significant medical comorbidities, where surgery is deemed too high risk. Many of these patients are treated with chronic antibiotic suppression, where the principle of treatment is to reduce the bioburden to a level where the patient remains systemically well. The infection is seldom eradicated and, as such, treatment is typically lifelong. The ideal patient candidate for chronic antibiotic suppression has a well-fixed implant that is infected with a low-virulence organism, sensitive to an oral antibiotic that they can tolerate. The presence of further implanted medical devices (such as an artificial heart valve) is a relative contraindication to this strategy. The inability of patients to tolerate long-term antibiotics is a frequent source of treatment failure.

Salvage procedures

For some patients, further reconstructive options to the joint may have been exhausted due to loss of bone or compromise to the soft tissues. These patients may wish to consider a

salvage procedure, where the goal of surgery is to manage the infection at the planned expense of joint function. These procedures include resection of the joint (such as the Girdlestone procedure in the hip), fusion of the joint (known as arthrodesis) and amputation of the limb. Patients considering amputation may benefit from consultation with a prosthetist prior to surgery to discuss their expected function and their suitability for a prosthesis.

Conclusion

Prosthetic joint infection is a difficult surgical complication to treat and carries a significant burden on patients. It is best managed within a multi-disciplinary team which should include orthopaedic, radiology, microbiology, plastic surgery and therapy teams. This article has highlighted current guidelines for diagnosis and management.

Practice Points

- Prosthetic joint infection (PJI) is where a joint that has been replaced by an orthopaedic implant becomes infected.
- Clinical outcomes after PJI are poor, with mortality rates of up to 25% at five years (worse than some common cancer diagnoses).
- Management of PJI requires collaboration between orthopaedic, radiology, microbiology, plastic surgery and therapy teams and is best managed within a multi-disciplinary team.
- Challenging cases require application of a clinical prediction rule for diagnosis – with criteria from EBJIS and MSIS the most widely used.
- First-line treatment options include debridement, antibiotics and implant retention (DAIR) procedures, single-stage and two-stage revision surgery
- Second-line treatment options include chronic antibiotic suppression and salvage procedures (such as joint excision, arthrodesis and amputation).

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