



The incidence of deep prosthetic infections in a specialist orthopaedic hospital

A 15-YEAR PROSPECTIVE SURVEY

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The Control of Infection Committee at a specialist orthopaedic hospital prospectively collected data on all episodes of bacteriologically-proven deep infection arising after primary hip and knee replacements over a 15-year period from 1987 to 2001.

There were 10 735 patients who underwent primary hip or knee replacement. In 34 of 5947 hip replacements (0.57%) and 41 of 4788 knee replacements (0.86%) a deep infection developed. The most common infecting micro-organism was coagulase-negative staphylococcus, followed by *Staphylococcus aureus*, enterococci and streptococci. Of the infecting organisms, 72% were sensitive to routine prophylactic antimicrobial agents.

Of the infections, 29% (22) arose in the first three months following surgery, 35% between three months and one year (26), and 36% (27) after one year. Most cases were detected early and treated aggressively, with eradication of the infection in 96% (72). There was no significant change in the infection rate or type of infecting micro-organism over the course of this study.

These results set a benchmark, and importantly emphasise that only 64% of peri-prosthetic infections arise within one year of surgery. These results also illustrate the advantages of conducting joint replacement surgery in the isolation of a specialist hospital.

More than 40 000 total hip and knee replacements are performed annually in the UK. Deep infection has been recognised for many years as the most challenging complication.¹ Much effort has been expended on reducing its incidence. The use of ultra-clear-air theatres, peri-operative antibiotics and antibiotic-loaded cement have helped to reduce the risk significantly.¹⁻³ The quoted rate for deep infection varies from 0.28% to 4% for primary hip replacement with similar rates⁴⁻⁹ for primary total knee replacement ranging from 0.39% to 3.9%.¹⁰⁻¹³ The management of these infections ranges from conservative treatment with antibiotics to complex two-stage revision arthroplasty.¹⁴

We report our experience of the diagnosis, including causative organisms and subsequent management, of deep infection following over 10 000 primary joint replacements carried out over 15 years in a specialist orthopaedic hospital with a proactive Control of Infection Committee.

Patients and Methods

Prospective data on all infective episodes in patients undergoing primary joint replacement have been collected since 1987. All cases of potential infection were identified from posi-

tive cultures in the microbiology laboratory and were cross-referenced to patients who had undergone a hip or knee replacement at the hospital. We categorised the infection as either deep or superficial. Deep infection was defined as infection within the prosthetic cavity,¹⁵ whereas superficial infection involved only the wound, without extension deep to the fascia. Infection was diagnosed according to the following criteria: a positive culture taken from inside a prosthetic hip or knee joint, radiological or haematological evidence of infection, and clinical features consistent with infection (e.g. pain, fever, restricted movement of the joint, sinus, discharge).

All positive cultures from the hip or knee joint in patients who had previously had a primary joint replacement were recorded, and unless the infection had obviously arisen from haematogenous spread from another source, were presumed to be due to bacterial contamination at the time of the primary operation. The notes of all patients with bacteriologically-proven deep infection who underwent primary hip or knee replacements between 1 January 1987 and 31 December 2001 were reviewed in 2004 to identify the risk factors, management and outcome of the infection. During this

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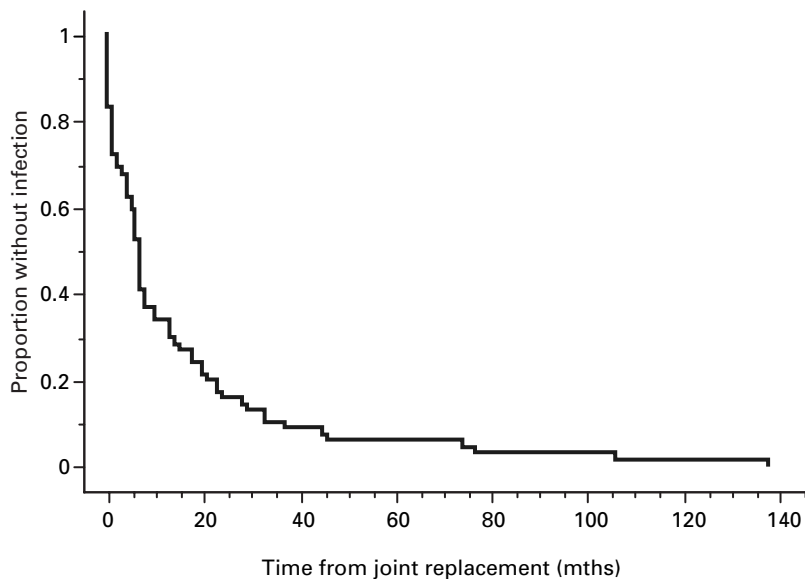


Fig. 1
Proportion of the cohort without infection, by time from surgery.

period 5947 primary total hip and 4788 primary total knee replacements were performed.

A total of 104 patients were identified with positive cultures, of whom 27 were found to have had a superficial infection only and in a further two patients the records were missing, so these 29 were excluded. The remaining 75 patients had bacteriologically-proven deep infection. A total of 34 deep infections occurred in patients with total hip replacements and 41 in patients with total knee replacements, giving an incidence of 0.57% and 0.86%, respectively.

Of these 75 patients, 38 were women and 37 were men. The indication for the joint replacement was osteoarthritis in 68 patients, rheumatoid arthritis in six and failure of fixation of a femoral neck fracture in one. The mean age of the patients at the time of their index surgery was 67.6 years (49 to 85). The grade of surgeon carrying out the original operation for those patients who subsequently developed a deep infection was a consultant in 40 cases (53%) and a trainee in 35 (47%). No one operating theatre or surgeon appeared to have a greater risk than any other. All patients received prophylactic antibiotics at the time of surgery, the majority receiving cefuroxime, with one dose at the time of induction of anaesthesia and either two or three further doses. All operations were performed in a clean-air enclosure.

Of the patients who developed an infection, five were known to be diabetic at the time of their operation and five were on steroids. There were 22 patients who had undergone a previous intervention on the affected joint, comprising seven arthroscopies, four osteotomies and seven intra-articular injections. The other four patients had undergone a variety of procedures, including internal fixation of a fracture around the joint, patellectomy, synovectomy, and the removal of gunshot.

Results

The mean time to diagnosis of deep infection was 13.8 months (0 to 138) for both types of joint replacement. When categorised by time to infection, using the classification system proposed by Coventry¹⁶ in 1975 and subsequently modified by Fitzgerald et al,¹⁷ 29% (22) of the infections arose early (within the first three months), 52% (39) between three months and two years (with 35% (26) arising between three and 12 months), and 19% (14) after two years. The proportion of patients in the cohort without infection is shown in Figure 1.

There was no significant difference in the rate of infection over the period of this study, although there was a peak in one year (1998), which was investigated by the Infection Control team without identifying an obvious cause (Fig. 2). The raised infection rate following total knee replacement in the early years of the study may be attributable to the large proportion of constrained knee replacements performed at that time, which were associated with a high infection rate.¹⁸ The rate of deep infection remained remarkably constant, despite a large increase in the number of primary replacements performed.

The presenting features of the infections varied according to the time at which they manifested themselves. In early infections a sinus or discharge was most common, whereas in late infections, pain and stiffness were the most common presenting features. At the time of diagnosis the erythrocyte sedimentation rate (ESR) was raised (> 11 mm/hr) in all but four cases, and the C-reactive protein (CRP) was abnormal (≥ 10) in all but one case (who had an elevated ESR). The white blood cell count was not usually abnormal, except in cases of acute infection.

In all cases the diagnosis of deep infection was confirmed by positive microbiology, either from joint aspira-

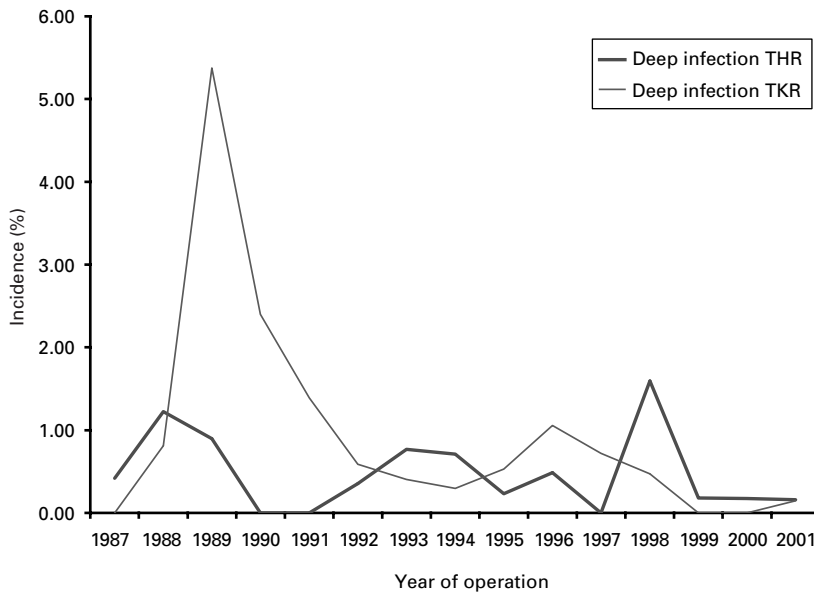


Fig. 2
Incidence of deep infection by year of surgery (THR, total hip replacement; TKR, total knee replacement).

Table I. Different infecting organisms by time to infection, and overall frequency of infecting organisms

Organism*	0 to 3 months	3 to 24 months	Over 24 months	Overall frequency (%)
Coag -ve staph.	5	15	7	36
Staph aureus	7	10	2	25
Enterococcus	1	6	0	9
Streptococci	1	3	1	7
MRSA	1	2	0	4
E. coli	1	1	1	4
Pseudomonas	2	1	0	4
Klebsiella	2	0	0	3
Acinetobacter	1	0	0	1
Aerococcus viridans	1	0	0	1
Corynebacterium	0	1	0	1
Diphtheroids	0	0	1	1
Propionobacterium	0	0	1	1
Salmonella	0	0	1	1

* Coag -ve staph, coagulase-negative staphylococcus; Staph aureus, staphylococcus aureus; MRSA, methicillin-resistant staphylococcus aureus; E. coli, escherichia coli

tion or from tissue taken at the time of revision. In four cases the infection was identified only at the time of revision surgery for what was thought to be aseptic loosening. In 23 (31%) cases more than one organism was grown, but in 52 (69%) only one organism was identified. The most common infecting organisms were coagulase-negative staphylococcus in 27 cases (36%) and *Staphylococcus aureus* in 19 (25%). There were seven infections (9%) with enterococci and three (4%) each of methicillin-resistant *Staphylococcus aureus* (MRSA), *Escherichia coli* and *Pseudomonas aeruginosa*. Table I shows the different infecting organisms by both time to infection and frequency.

In 46 (60%) cases there was no obvious cause for infection other than the original operation, but in 29 (39%) there were other potential aetiological factors including post-operative urinary tract infection, catheterisation for post-operative retention of urine (despite the use of antibiotic cover at the time of insertion and removal), cellulitis at a site distant from the surgical scar, septicaemia, and angiography.

A superficial wound infection treated with antibiotics before the deep infection developed occurred in 31 (41%) patients. In three of these the same organism was isolated from both sites, and in seven a different organism was found. In the other 21 cases the diagnosis of superficial infection was made on clinical grounds, swabs either unexpectedly failing to produce an organism or showing mixed growth. The mean time to proven deep infection in these cases was eight months (0 to 33), compared to 22 months (0 to 138) in those without a previous superficial infection.

Of the patients who developed deep infection, 22 (29%) were found to have micro-organisms that were resistant to the antibiotics used for prophylaxis. This included all of the MRSA and *Pseudomonas aeruginosa* infections as well as 11 of the 27 (41%) coagulase-negative staphylococci, which were methicillin and cefuroxime resistant.

No specific treatment policy was used over the period of this study, but in general, acute infections were treated with antibiotics and lavage or debridement, whereas chronic infections tended to be treated with one or two-stage revisions. All but three of the patients were cured of their infection and none required amputation. However, 11 (15%) patients required removal of their prosthesis, resulting in a pseudarthrosis in six cases (54%) and an arthrodesis in three (27%). Of these 11 patients, two (18%) had undergone the

first stage of their revision with resolution of the infection, but were still awaiting the second-stage procedure. The overall success rate in curing deep infection was 96%, whereas the success rate for having an implant *in situ* was 85%. This was the same for both hip and knee replacements.

Debridement and antibiotics succeeded in eradicating infection in 41% of patients (12 of 29) in which this management was used. One-stage revision was successful in all of the seven patients who had this treatment. Four of the patients had early acute infection and three had late infections, the only common feature being that all seven had infections with just one organism, six being staphylococcal and one pseudomonas. Two-stage revision was used in 40 patients (53%) and was eventually successful in eradicating infection in 38 (95%). There was one patient from this group (3%) who required repeated two-stage procedures to eradicate the infection successfully. Excision arthroplasty was eventually needed in ten patients (13%). In one patient the infection persisted despite removal of the prosthesis.

Discussion

This paper examines the risk of infection of primary hip and knee replacements at a specialist orthopaedic hospital. There has been a Control of Infection Committee for 17 years with the same team members, which has documented all infections arising in hip and knee replacements based on microbiological and clinical findings. Although our committee predates the definition of deep prosthetic infection proposed by Atkins et al¹⁹ a similar definition of infection applied throughout the study period. We excluded patients with clinical features of infection but negative microbiology, and those with superficial wound infections that did not progress to deep infection. It is possible that we overlooked a limited number of patients who went elsewhere for treatment of an infected prosthesis. However, our hospital is a regional referral centre for complex joint replacement problems, making it probable that any patient with a late infection would have been referred back for treatment.

Our figures include all patients who presented with microbiologically-proven infection who developed associated joint sepsis at any time since the operation. Only 29% of all infections arose within three months of surgery, and only 64% within one year. Because we have included all infections, our rates will be higher than those reporting only infection manifesting early.

With 10 735 primary lower limb replacements and a minimum three-year follow-up, we believe that our results are reliable and may be used as a benchmark for the incidence of early and late deep infection in primary hip and knee replacements.

The patients included in this study were under the care of 20 different consultants, all of whom had trainees. Of the infections, 47% arose in arthroplasties performed by trainees reflecting the proportion of operations conducted by trainees, most of whom were in the latter stages of their training.

Cefuroxime was the standard prophylactic antibiotic administered during the study.^{20,21} In 51 of the 75 patients (68%) with deep infection, the primary infecting organism was sensitive to cefuroxime. However, in 22 cases (29%) the organism was cefuroxime resistant. In two cases (3%), no information about the antibiotic sensitivities of the infecting organisms could be found. There was no evidence that using a broader-spectrum antibiotic (e.g. vancomycin) would reduce the infection rate.

No data were available for the number of patients receiving cement loaded with antibiotic (usually gentamicin), but there has been a gradual increase in its use, from no use at all at the start of the study to use in every case today. Interestingly, this change has not resulted in a decrease in overall infection rates.

In 1975 Coventry¹⁶ proposed a classification system for peri-prosthetic infections of the hip. This was refined by Fitzgerald et al¹⁷ who considered that infection occurring within three months of surgery was acute, that arising within three months to two years was delayed, and that occurring after two years was haematogenous in origin. This system remains in regular use.²² We dispute the suggestion that infection arising later than two years after surgery is necessarily haematogenous in nature, and agree with others that although haematogenous spread into the joint can occur, infections may still arise from bacterial contamination at the time of surgery, even though the effects of the infection may not be apparent until much later.^{1,23} Our study found seven of 27 (26%) cases of infection due to coagulase-negative staphylococci first manifesting more than two years after surgery. The incidence of infection manifesting more than two years after surgery in this study was 0.13%, which is similar to the 0.19% recorded in a series of 3204 consecutive total hip replacements by Nolan et al.⁷

In common with other reports,^{22,24-27} our results illustrate the importance of elevated inflammatory markers in suggesting a diagnosis of deep infection. All the patients reviewed in this study had either raised CRP or raised ESR, suggesting that if both these parameters are normal, infection is unlikely.²⁴⁻²⁷ As noted in a recent review,²² the white blood cell count was less useful in the diagnosis of infection.

The difficulty of diagnosing wound infection accurately has been noted by others.^{28,29} Various definitions have been applied, but it is generally accepted that it can be diagnosed on clinical grounds, even if no pathogenic organism is isolated. We found that when deep infection was preceded by a superficial infection, in 30% of cases with a positive wound culture the same organism was implicated. This is rather lower than that noted in the MRC trial.²⁸

We found coagulase-negative staphylococci to be the most common infecting organism, followed by *Staph aureus*, enterococci and streptococci. These figures are similar to those published in 2001,³⁰ and by Elson in 1993.³¹ They tend to confirm the observation that after joint replacement

the organisms responsible for infection are often bacteria with low virulence in the absence of implanted material.²³ The relative importance of *S. epidermidis* (or coagulase-negative staphylococci) as an infecting organism was also noted by Mohanty and Kay.³² They found that, of 312 *S. epidermidis* cultures obtained during primary or revision hip or knee replacement, 55.1% were methicillin resistant. Kilgus, Howe and Strang,³³ in their series of 70 infected hip and knee replacements, grew *S. epidermidis* in bacterial culture from 24 joints (34%). Of these, 15 (62.5%) were methicillin resistant. Of our cultures of coagulase-negative staphylococci 42% were methicillin resistant.

The three MRSA isolates were found in patients who underwent their index surgery in 1993, 1996 and 2000, respectively, and whose infections became manifest respectively at eight months, six months and immediately post-operatively. This low rate of MRSA infection may be due to our hospital functioning as an elective orthopaedic unit with no other specialties on site. Patients infected with MRSA who require admission are placed in side rooms and strict infection control measures are followed. All three MRSA infections were successfully eradicated, one by excision arthroplasty and two by two-stage revision. Hirakawa et al³⁴ reported only 67% success in eradicating MRSA infection in their small series. The importance of isolating patients with MRSA has been shown by Biant et al,³⁵ who showed that ring fencing of elective orthopaedic beds in a general hospital resulted in a significant decrease in all infections and eradication of infection by MRSA.

Following the recent Nosocomial Infection National Surveillance Service results,³⁶ the current Surgical Site Infection (SSI) surveillance (which in April 2004 became mandatory for orthopaedics at all NHS hospitals in the United Kingdom) aims to document infection rates in order to identify actions to improve them. The definition of deep incisional infection being applied is infection involving the deep tissues occurring within a year if an implant is in place and that the infection appears to be related to the surgical procedure.³⁷ However, data collection is limited to the period in hospital, with the early results indicating an incidence of deep prosthetic infection of 0.68%.³⁷ Using the same data set from our hospital, we have previously shown that the incidence of superficial infection is 1.3%, and that only 10.2% (i.e. 0.13% overall) will progress to deep infection.¹⁵ Concerns have been raised that small changes in the definition or interpretation of the Centre for Disease Control definition of wound infection, upon which the SSI figures are based, can lead to large variations in the estimated percentage of wound infections.³⁸

Using the SSI definitions of infection proven during hospital admission, the incidence of deep infection in our patient group would be 0.10%. This would actually only represent 15% of the total deep infections.

Our results confirm the premise that a specialist orthopaedic hospital can have a very low rate of infection, sup-

porting the work of Biant et al³⁵ that ring fencing elective orthopaedic beds is helpful in infection control.

Monitoring the outcome of total joint replacement is important. We believe that our decision to monitor infection following all total joint replacements, taken over 20 years ago, was justified on the evidence of our results presented here.

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