The value of ring-fenced beds in elective lower limb arthroplasty

ABSTRACT

Background: Infection is a serious complication of prosthetic joint arthroplasty, associated with high rates of morbidity resulting in further surgical intervention and prolonged inpatient hospital admission. Rates of prosthetic joint infection have been reported as 1.5–2.5% following lower limb arthroplasty. This study compared infection rates in patients receiving primary hip and knee joint replacements before and after implementation of ring-fenced beds.

Methods: Retrospective study of all patients undergoing primary total hip replacement and total knee replacement from April 2013 to February 2014. Group 1 included pre-ring-fencing patients, group 2 included post-ring-fencing patients.

Results: The overall infection rate pre-ring-fencing was 6.3% (*n*=8). This reduced to 2.7% (*n*=3) post-ring-fencing. The mean inpatient length of stay for group 1 was 6 days *vs* 4 days for group 2.

Conclusions: Ring-fencing beds for patients undergoing elective lower limb arthroplasty significantly reduced rates of prosthetic joint infection and inpatient length of stay.

Infection is a serious complication following lower limb arthroplasty, associated with high rates of morbidity leading to extensive additional surgical interventions and prolonged inpatient hospital admission (Yin et al, 2013). Rates of prosthetic joint infection have been reported as 1.5–2.5% following lower limb arthroplasty and 2–20% following revision surgery; this risk increases with comorbidities such as diabetes mellitus, rheumatoid arthritis, obesity, cancer and immunosuppression (Hoekman et al, 1991; Berbari et al, 1998).

Ideally patients should not be admitted for elective arthroplasty before the day of surgery as prolonged preoperative hospitalization and subsequent longer delay to operation are associated with an increased risk of prosthetic joint infection (Pereira et al, 2015; Chuylán et al, 2017; Barnes et al, 2019). Surgical factors such as sterility, the use of antibiotic-impregnated cement and operative times also have an impact on subsequent risk of infection (Garibaldi et al, 1991; Kendall et al, 1996; Hanssen and Rand, 1999). Prosthetic joint infection can lead to devastating complications with mortality rates ranging from 2.7–18% (Sculco, 1993; Berbari et al, 1998; Lentino, 2003).

The causes of prosthetic joint infection are often multifactorial and can occur early or late after the initial surgery (Trampuz and Zimmerli, 2005). Commensal organisms of the skin most commonly infect implantable devices (Atkins et al, 1998), while their ability to form a biofilm plays an important role in prosthetic joint infection pathogenesis (Zimmerli et al, 2004). One major cause of hospital-acquired early infection is cross-contamination from other actively infectious patients in close proximity (Biant et al, 2004; Kelly et al, 2012). NHS hospitals are often under significant bed pressures, particularly during winter, and face challenges with high levels of acute admissions while attempting to maintain throughput of their elective services. This can compromise a bed ring-fencing policy and increase the risk of prosthetic joint infection in patients undergoing elective hip and knee joint replacements. This highlights the importance of strictly implementing such a policy in order to reduce the risk of prosthetic joint infection.

A common definition for prosthetic joint infection is yet to be established despite diagnostic criteria being widely accepted (Trampuz and Zimmerli, 2005; Müller et al, 2008). Prosthetic joint infections are generally classified into three phases: early-onset infection is defined as the appearance of the signs and symptoms of infection within 3 months post-arthroplasty while delayed-onset and late-onset infection occur within 3–24 months and >24 months respectively. Studies have demonstrated an almost equivalent distribution within each category (Zimmerli et al, 2004; Trampuz and Widmer, 2006). Public Health England (2013) defines criteria for superficial and deep surgical site infections (*Table 1*). However, these are limited to infections diagnosed within 12 months post-surgery.

The varying clinical presentation of prosthetic joint infection, from a chronic picture of progressive joint pain to sudden onset septic arthritis in addition to the numerous non-infectious causes of implant failure, often leads to difficulties in diagnosis (Del Pozo and Patel, 2009). With this in mind, further studies are usually required, with aspiration of joint synovial fluid proving useful for diagnosis (Del Pozo and Patel, 2009). In cases where the diagnosis is unable to be made before further surgical intervention, i.e. washout or revision surgery, intraoperative periprosthetic tissue cultures are important to establish the presence of prosthetic joint infection and tailor subsequent antibiotic therapy (Atkins et al, 1998). Improved long-term outcomes are achieved with optimal management.

Given the challenges of the diagnosis, management and prevention of prosthetic joint infection and the associated devastating complications as a result, this study compared infection rates in primary

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total hip and total knee joint replacements pre- and post-implementation of a bed ring-fencing policy.

Methods

A retrospective study was undertaken of all patients in the department of trauma and orthopaedics at the authors' institution undergoing primary total hip replacement and total knee replacement from April 2013 to February 2014. Ring-fencing of beds began in October 2013. Hospital bays on a general orthopaedic ward were subject to ring-fencing rather than the introduction of an entire elective ring-fenced ward. Data were collected from hospital notes, biochemistry, microbiology and imaging results with any infection, surgical site or otherwise, identified. Diagnosis of superficial and deep infection was as per Public Health England (2013) guidelines. In the event of a positive swab with clear documentation that there was no clinical concern for infection from the team overseeing the patient's care, colonisation was determined to be the cause. All procedures were undertaken in a laminar flow theatre.

Exclusion criteria were:

- Uni-compartmental knee or patello-femoral joint replacement
- Revision arthroplasty surgery
- Acute trauma patients, i.e. patients with a fractured neck of femur treated with a total hip replacement
- Patients whose hospital stay occurred during the transition period of implementing the ring-fencing policy or who were known to have breached this policy following its implementation.

Results

A total of 252 patients underwent lower limb arthroplasty during the study period. Twelve patients were subsequently excluded, resulting in a study population of 240 patients. The pre-ring-fencing group (group 1) had 128 patients while the post-ring-fencing group (group 2) had 112 patients who underwent primary lower limb arthroplasty. The patient demographics are shown in *Table 2*.

Table 3 demonstrates the distribution of superficial, deep and total infections in the study populations. There was a higher rate of both superficial and deep infection in group 1 patients who had undergone total hip replacement (2.3% and 4.5% respectively) culminating in a higher total infection rate (6.8% in group 1 *vs* 4.1% in group 2). This theme continued with patients who had undergone total knee replacement, with increased rates of both superficial and deep infection in group 1 (3.5% and 2.4% respectively) culminating in a higher total infection rate (5.9% in group 1 *vs* 1.6% in group 2). The overall infection rate in primary lower limb arthroplasty decreased from 6.3% to 2.7% following the implementation of a bed ring-fencing policy. There was a subsequent reduction in the average length of hospital stay following surgery from 6 days (range 1–49 days) for group 1 to 4 days (range 1–15 days) for group 2, giving a mean difference of 2 days.

Table 4 compares data on the infection rate from this study with the Surgical Site Infection Surveillance Service data from Public Health England. Although the

Table 1. Definitions of deep and superficial surgical site infections

	Superficial infection	Deep infection
Criteria	1. Purulent drainage from the superficial incision at <30 days 2. Positive culture with pus cells 3. Two or more of: ■ Pain or tenderness ■ Localised swelling ■ Redness ■ Heat and ■ The superficial incision is deliberately reopened by surgeon to treat the infection or ■ Clinician diagnosis of superficial incisional infection	Deep tissues infected at <1 year with any of: ■ Purulent discharge ■ Positive culture from the organ space with pus cells present ■ Spontaneous dehiscence with temperature >38°C or localized pain or tenderness ■ Abscess or other proof of deep infection confirmed by surgery, histology or radiology ■ Clinician diagnosis of deep infection

From Public Health England (2013)

Table 2. Patient demographics

	Group 1 (*n*=128)	Group 2 (*n*=112)
Mean age (range)	68.3 years (43–91 years)	68.4 years (39–88 years)
Gender (M:F)	56:72	44:68
Laterality (R:L)	61:67	62:50
Body mass index (mean)	29.6 kg/m^2	30.1 kg/m^2
American Society of Anesthesiologists score (mean)	2.2	2.2
Current smoker (%)	14.0	12.1
Total hip replacement:total knee replacement	43:85	48:64

Table 3. Number of infections in each group

		Superficial infection	Deep infection	Total infection
Total hip replacements	Group 1 (*n*=43)	1 (2.3%)	2 (4.5%)	3 (6.8%)
	Group 2 (*n*=48)	0 (0%)	2 (4.1%)	2 (4.1%)
Total knee replacements	Group 1 (*n*=85)	3 (3.5%)	2 (2.4%)	5 (5.9%)
	Group 2 (*n*=64)	1 (1.6%)	0 (0%)	1 (1.6%)
All patients	Group 1 (*n*=128)	4 (3.1%)	4 (3.1%)	8 (6.3%)
	Group 2 (*n*=112)	1 (0.9%)	2 (1.8%)	3 (2.7%)

Table 4. Comparison of infection rates, Public Health England *vs* study data

	Q2–Q3 2013	Q4 2013–Q1 2014
Public Health England – total hip replacement (%)	6.4	4.9
Public Health England – total knee replacement (%)	7.0	4.7
Group 1 – total hip replacement (%)	6.8	–
Group 1 – total knee replacement (%)	5.9	–
Group 2 – total hip replacement (%)	–	4.1
Group 2 – total knee replacement (%)	–	1.6

From Public Health England (2014)

Table 5. Causative organisms and treatment

		Group 1 (*n*=8)	Group 2 (*n*=3)
Organism	Polymicrobial	3	3
	Staphylococcus aureus	5	0
Treatment	Washout (surgery)	2	1
	Revision (surgery)	2	1
	Antibiotics (no surgery)	4	1
Mean length of stay (range)		11 days (1–49)	7 days (2–15)

Table 6. Characteristics of infection and total populations in both groups

	Group 1		Group 2	
	Infection (*n*=8)	Total (*n*=128)	Infection (*n*=3)	Total (*n*=112)
Age (years)	65.8	68.3	66.7	68.4
Mean body mass index (kg/m^2)	30.8	29.6	38.4	30.1
Gender (M:F)	7:1	56:72	2:1	44:68
Type 2 diabetes mellitus	2 (25.0%)	23 (18.0%)	1 (33.3%)	23 (20.5%)
Immunosuppression	0	11 (8.6%)	1 (33.3%)	14 (12.5%)
Catheterised	5 (62.5%)	49 (38.3%)	1 (33.3%)	43 (38.4%)
Drain	4 (50%)	46 (35.9%)	0	36 (32.1%)
Blood transfusion	2 (25%)	23 (18.0%)	1 (33.3%)	18 (16.1%)
Theatre time (minutes)	90	80.2	120.5	83.8

infection data from Public Health England are recorded quarterly, the data within this study were obtained during a similar time period allowing comparison to be made.

Infection sub-group analysis

The average length of stay remained reduced in group 2 compared to group 1 when considering the infection population (*Table 5*). In group 1, there was an equal distribution among total hip replacement and total knee replacement procedures that subsequently proceeded to further intervention via washout or revision surgery, while the primary procedure in group 2 was total hip replacement.

Table 6 compares characteristics between both infection and total populations within group 1 and 2, demonstrating that those developing an infection in either group were more likely to be male, have a higher body mass index, type 2 diabetes mellitus and have had a blood transfusion in addition to a longer operation time.

Discussion

The main finding in this study was a reduction in total infection rate post-primary lower limb arthroplasty upon implementation of a bed ring-fencing policy. This contributed to a significant reduction in average length of stay as a result.

Superficial wound infection rates have been reported to be as high as 14.3% (Gaine et al, 2000), much higher than the figures in this study, which demonstrated a decrease from 3.1% to 0.9%. Deep infection rates also decreased from 3.1% to 1.8% upon implementation of bed ring-fencing, falling within the reported rates of 1.5–2.5% (Sculco, 1993; Lentino, 2003). The total infection rate decreased from 6.3% to 2.7% as a result. The findings in this study compare favourably to the data obtained by Surgical Site Infection Surveillance Service with Public Health England during similar time periods.

Superficial infections were included as contiguous spread from an adjacent site can result in a superficial surgical site infection progressing to involve the prosthesis, thereby becoming a deep infection (Tande and Patel, 2014).

Prosthetic joint infection post-primary lower limb arthroplasty is a devastating complication, associated with substantial morbidity and cost, which presents a considerable challenge to clinicians (Yin et al, 2013). Eradicating infection, preventing recurrence and preserving mechanical joint function are all aspects that need to be considered in the management of prosthetic joint infection, encompassing decisions regarding implant retention, surgical strategies and antimicrobial therapy (Laffer et al, 2006; Moran et al, 2007). Longer hospital stays, prolonged courses of intravenous antibiotics and further surgical intervention such as washouts and revision surgery, even leading to amputation, are associated with prosthetic joint infection, with mortality rates of between 2.7% and 18% reported (Berbari et al, 1998).

The complications that can ensue secondary to infection post-arthroplasty are reinforced in this study, with four of the eight patients in group 1 in addition

KEY POINTS

- Infection is a serious and devastating complication following elective lower limb arthroplasty associated with significant morbidity leading to extensive further surgical and medical therapy and longer inpatient hospital admissions.
- The causes of prosthetic joint infection are often multifactorial and can occur early or late after surgery.
- The varying clinical presentation of prosthetic joint infections can make diagnosis and therefore subsequent management difficult.
- Implementing a bed ring-fencing policy contributes to decreased rates of prosthetic joint infection and shorter length of inpatient hospital stay.

to two of the three patients in group 2, developing an infection requiring further surgical intervention in the form of washout or total revision joint replacement surgery. The four remaining patients in group 1 were treated appropriately with antibiotics alone (without further surgical intervention) as per microbiology sensitivity results for a superficial wound infection as was the other patient in group 2.

In line with this study, the value of ring-fencing beds is highlighted in other studies, with Biant et al (2004) demonstrating that rates of all infections, including prosthetic joint infection, decreased significantly following implementation of a bed ring-fencing policy, with a 70% drop in prosthetic joint infection and no new cases of meticillin-resistant *Staphylococcus aureus*. This resulted in a shorter length of stay as well as a 14% increase in the number of patients being treated as a result of improved planning with regards to bed occupancy. Kelly et al (2012) demonstrated a significant decrease in not only meticillin-resistant *S. aureus* infections but also deep wound infections upon implementation of a bed ring-fencing policy. However, patients perceived to be at low-risk of acquiring meticillin-resistant *S. aureus*, as identified by inadequate risk assessments, can compromise the effectiveness of ring-fencing elective patients in the event of being allowed onto a ring-fenced area (Schmidt et al, 2012).

Various patient- and surgery-related risk factors for developing prosthetic joint infection have been identified (Kendall et al, 1996; Berbari et al, 1998; Hanssen and Rand, 1999). While patients having revision procedures were eight times more likely to develop a prosthetic joint infection than those undergoing primary joint arthroplasty, studies suggest that factors such as comorbidities, longer operative time or blood transfusions may have a contributing role (Ahnfelt et al, 1990; Wymenga et al, 1992), while there is conflicting evidence surrounding the effect of urinary catheterisation (Wroblewski and del Sel, 1980; Lindsay et al, 2011). One study demonstrated an increased risk of infection from 2.6% in procedures lasting up to 1 hour to 8.5% in procedures lasting over 3 hours (Pavel et al, 1974). Indeed, longer operation times were evident in both group 1 and group 2 patients developing an infection, as was a higher rate of type 2 diabetes mellitus and a higher mean body mass index when compared to the baseline data within their respective populations.

In this study, the causative agent in 45.5% of cases was *S. aureus* while 54.5% of cases were polymicrobial in nature. Both values are significantly higher than those quoted in the literature, with *S. aureus* identified as causing prosthetic joint infection in 12–23% of cases while 10–19% of cases involved more than one organism (Berbari et al, 1998; Zimmerli et al, 2004). In the current study, one patient developed a polymicrobial deep infection following chest sepsis, highlighting the role of haematogenous spread in prosthetic joint infection pathogenesis (Berbari et al, 1998; Uçkay et al, 2009).

The current study has a number of limitations. It is retrospective, so is reliant on correct clinical coding and accurate documentation. Unlike other studies where entire wards were ring-fenced, 4–6-bedded bays or side-rooms were ring-fenced in this study, for elective patients undergoing primary lower limb arthroplasty. While the ring-fencing policy in this study applied only to bays rather than the introduction of an entire elective ring-fenced ward, a decreased infection rate was demonstrated. The data also compared favourably with Public Health England (2014) data during the same time period. Diagnosis of superficial and deep infection was as per Public Health England (2013) guidelines whereas definitions of surgical site infections vary in other studies. With several acute hospitals within the geographic region, patients may have presented or been referred to another hospital with complications, in which case these complications could have been missed unless correspondence was sent to the original consultant. Given that prosthetic joint infections can occur via haematogenous spread at any point during the lifetime of the implant (Murdoch et al, 2001), late-onset infections which were not detected in this study remain a possibility.

The ultimate goal of prosthetic joint infection treatment is to restore functional and pain-free joint status through a combination of both medical and surgical therapies. However, in the context of prosthetic joint infection, prevention is better than cure. Increasing numbers of lower limb arthroplasties are expected to be performed in the future (Kurtz et al, 2007), emphasizing the importance of minimizing the number of prosthetic joint infections and their associated complications and substantial cost while improving long-term outcomes. An elective ring-fenced ward is an important cost-saving measure, as a result of reduced length of stay in primary hip and knee arthroplasty. Soler et al (2013) demonstrated a significantly increased length of stay of 1.89 days on losing a ring-fenced ward to non-elective admissions as a result of adverse weather conditions and the subsequent increased demand for beds. This equated to an estimated 6.82% loss of revenue per case. Three surgical site infections were noted in a general orthopaedic ward subjected to ring-fenced bays compared to zero in a dedicated elective ring-fenced ward (Barlow et al, 2013), highlighting the significance of adopting such ring-fencing policies. Contingency plans should be in place for situations that could potentially lead to a breach in bed ring-fencing.

Although the benefits of dedicated elective ring-fenced wards have been outlined above, the value of implementing a ring-fencing policy limited to specific ward bays only for patients undergoing elective primary lower limb arthroplasty has been demonstrated in this study. The reduction in the infection rate on implementing such a policy has practical implications for other hospitals. Despite the improvements in recent years, further research is required to ascertain the most effective approach to the diagnosis, management and prevention of prosthetic joint infections.

Conclusions

This study demonstrated the effectiveness of adopting a ring-fencing policy with a subsequent reduction in infection rate from 6.3% to 2.7%. This culminated in a shorter average length of stay. **BJHM**

Conflict of interest: none.

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