Periprosthetic joint infections at a teaching hospital in 1990–2007

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This work was presented at the *Journée de la recherche du Programme d'orthopédie Édouard-Samson* of Université de Montréal in 2009.

Accepted for publication June 7, 2012

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DOI: 10.1503/cjs.033610

Background: Periprosthetic joint infections (PJIs) are major complications associated with high costs and substantial morbidity. We sought to evaluate hip and knee arthroplasty infection rates at our hospital, compare them in periods before and after implementation of measures to reduce PJIs (1990–2002 and 2003–2007) and identify associated risk factors.

Methods: We retrospectively reviewed records of patients who received primary hip or knee total joint prostheses at our centre between Jan. 1, 1990, and Dec. 31, 2007, and were readmitted for the treatment of infection related to their surgery. We also reviewed data from a prospective surveillance protocol of total hip (THA) and knee arthroplasty (TKA) infections that started in November 2005. We ascertained the annual rates of deep, superficial and hematogenous infections.

Results: During the periods studied, 2403 THAs and 1220 TKAs were performed. For THA, the average rates of deep, superficial and hematogenous infections were 2.0%, 0.8% and 0.3%, respectively. For TKA, the rates were 1.6%, 0.7% and 0.2%, respectively. Of 106 infected joints, 84 (79.2%) presented risk factors for infection. Efforts to reduce the infection rate at our institution began in 2003. We achieved a 44% decrease in the deep infection rate for THA (2.5% v. 1.4%, $p = 0.06$) and a 45% decrease for TKA (2.0% v. 1.1%, $p = 0.20$) between the periods studied.

Conclusion: Knowing the actual infection rate associated with different procedures in specific settings is essential to identify unexpected problems and seek solutions to improve patient care. Although we do not know what specific improvements were successful, we were able to decrease our infection rates to levels comparable to those reported by similar care centres.

Contexte : L'infection au pourtour des prothèses articulaires constitue une complication majeure, associée à des coûts élevés et à une morbidité substantielle. Nous avons voulu évaluer les taux d'infection des arthroplasties de la hanche et du genou dans notre hôpital, en faire la comparaison avant et après l'application de mesures visant à contrer ces infections (1990–2002 et 2003–2007) et relever les facteurs de risque en cause.

Méthodes : Nous avons analysé de manière rétrospective les dossiers de patients qui ont subi des interventions pour prothèses primaires totales de la hanche ou du genou dans notre centre entre le 1 janvier 1990 et le 31 décembre 2007 et qui ont dû être réadmis pour le traitement d'une infection post-arthroplastie. Nous avons aussi passé en revue les données d'un protocole de surveillance prospective des infections associées à la prothèse totale de hanche (PTH) et du genou (PTG) mis en œuvre en novembre 2005. Nous avons vérifié les taux annuels d'infections profondes, superficielles et hématogènes.

Résultats : Au cours des périodes étudiées, 2403 PTH et 1220 PTG ont été implantées. Dans le cas des PTH, les taux moyens d'infections profondes, superficielles et hématogènes ont été de 2,0 %, 0,8 % et 0,3 %, respectivement. Dans le cas des PTG, les taux se sont situés respectivement à 1,6 %, 0,7 % et 0,2 %. Sur les 106 articulations infectées, 84 (79,2 %) présentaient des facteurs de risque d'infection. Les efforts visant à réduire le taux d'infection dans notre établissement ont débuté en 2003. Nous avons obtenu une diminution de 44 % du taux d'infections profondes dans les cas de PTH (2,5 % c. 1,4 %; $p = 0,06$) et une baisse de 45 % dans le cas des PTG (2,0 % c. 1,1 %, $p = 0,20$) entre les 2 périodes étudiées.

Conclusion : Afin de prévenir les problèmes imprévus et de trouver des solutions pour améliorer le soin des patients, il est essentiel de connaître le taux d'infections réel associé aux différentes interventions selon leur contexte spécifique. Même si nous ignorons quelles mesures de prévention spécifiques ont été couronnées de succès, nous avons réussi à ramener nos taux d'infections à des taux comparables à ceux qu'enregistrent des centres de soins similaires.

Periprosthetic joint infection (PJI), a devastating complication of joint arthroplasty, causes substantial morbidity, as it exposes patients to multiple surgical procedures and compels mid- to long-term antibiotic use. Infection rates reported in regional studies vary from 0.3% to 1.8% for primary total hip arthroplasty (THA)[1–4] and from 0.39% to 1.1% for primary total knee arthroplasty (TKA).[1,3–8] On the other hand, investigations involving national data have revealed higher infection rates ranging from 0.88% to 2.22% for THA[9,10] and from 0.92% to 2.01% for TKA.[9,11,12]

Considerable progress has been made over the last few decades in reducing deep PJI rates, largely owing to the implementation of antibiotic prophylaxis and the optimization of aseptic protocols. Even if the importance of antibiotic prophylaxis and the timing of its administration are supported by scientific evidence, their use remains suboptimal in orthopedic surgery. A national study[13] disclosed that only 61.2% of patients undergoing THA or TKA received prophylactic antimicrobials within 1 hour before surgical incision, and the antibiotic regimen was discontinued within 24 hours after surgery in only 36.3% of patients. Many aseptic measures are efficient in preventing infections. Aseptic surgical solutions combining chlorhexidine gluconate and isopropyl alcohol have been found to reduce surgical site infections in an orthopedic joint replacement population[14] and after clean–contaminated surgery.[15] Other aseptic measures demonstrated to be effective in decreasing bacterial contamination include waterproof gowns[16–18] and double-gloving with outer glove changes after draping and at regular intervals during surgery.[19,20] Moreover, longer duration of surgery[21] and a larger number of personnel in the operating room (OR) or circulating in and out of the room[21–24] are associated with higher contamination rates during arthroplasty.

Periprosthetic joint infections have known modifiable and nonmodifiable risk factors. Established modifiable risk factors include allogenic blood transfusion,[1,25] excessive anticoagulation treatment,[26,27] obesity,[1,2,28–32] malnutrition,[28,29,33,34] simultaneous bilateral surgery,[1] alcoholism,[29] surgical drain[27,35] and long postoperative urinary catheterization.[36] Interventions to prevent or correct these modifiable risk factors have the potential to lower the PJI rate.

As part of an internal quality assessment that started in 2002, we decided to review our infection rate for the period 1990–2000. High rates of deep infection (2.8% for THA and 1.9% for TKA) prompted us to modify several aspects of patient preparation before surgery and of our surgical procedures. In 2003, we implemented a preoperative medical work-up program to optimize the medical preparation of patients before surgery. As part of a surgical safety checklist before skin incision, we implemented a policy to ensure that antibiotics were given within 60 minutes before the incisions. We replaced iodine solution with 2% chlorhexidine plus 70% alcohol and started using antibiotic-loaded cement in cemented joints (Simplex P bone cement with tobramycin; Stryker), waterproof paper drapes and waterproof gowns. Skin blades were discarded after opening, and new blades were used for deep dissection. The number of personnel and their circulation in the OR were restricted as much as possible; the front door was locked before opening/unpacking surgical instruments, and a clear notice was posted on the second door: “Do not enter: total joint surgery in progress.” We stopped routine bladder catheters and surgical drains. Efforts were made to decrease the transfusion rate with preoperative ferrous supplements (intravenous or oral) or erythropoietin injections to achieve a hemoglobin level of 120–130 g/L presurgery. The first dressing was not removed before 48 hours, and continuous education for sterile protocol implementation was undertaken among the nursing staff caring for patients. The present study reports on our institutional THA and TKA infection rate evolution over the last 17 years. We sought to identify the risk factors linked with infection.

Methods

We retrospectively analyzed the medical records of patients who underwent primary THA or TKA at our university hospital between Jan. 1, 1990, and Dec. 31, 2007, and were readmitted for treatment of PJI (minimum follow-up of 8 mo). After a patient was admitted to hospital for PJI, the surgeon filled out a summary sheet with the diagnosis. A code was then attributed to the diagnosis and recorded in the archives. In this study, it was therefore possible for the archivists to search for medical records corresponding to specific PJI codes and verify if they were available for review. The charts were then analyzed, and only primary THA and TKA infections were selected. Data from a prospective surveillance protocol of THA and TKA infections that started in November 2005 were also included. We ascertained the annual rate of superficial wounds, early deep (< 4 wk after primary arthroplasty), late deep (> 4 wk after primary arthroplasty) and hematogenous infections.[37] The diagnosis of superficial wound infection was made in the presence of purulent wound discharge and/or positive wound culture. Deep PJIs were diagnosed on evidence of infection during subsequent surgery and/or positive joint aspiration culture or positive intraoperative culture. The risk factors for infection considered in this study are described in Box 1.

As mentioned in the introduction, our centre implemented multiple actions to reduce its infection rate in 2003.

Statistical analysis

All statistical analyses were performed with the SPSS 17.0 package. Categorical variables were reported as frequencies and percentages and compared using the Pearson χ^2 test. We considered results to be significant at $p < 0.05$.

Results

Overall, the combination of research in the archives and data from the prospective surveillance protocol identified 107 patients with deep, hematogenous or superficial infections. From Jan. 1, 1990, to Dec. 31, 2007, 2403 primary THAs were performed at our institution, including 224 hip resurfacing surgeries done between April 2003 and December 2007. There were 1351 THAs performed during the 1990–2002 period (average 103.9 THAs/yr) and 1052 during the 2003–2007 period (average 210.4 THAs/yr). In all, 49 patients were found to have deep THA infections (2.0%). Of these, 28 had early infections (mean 20.5, range 9–29 d), whereas 17 had late infections (mean 295.7, range 31–1734 d). For 4 patients, a clear classification of early versus late infection was impossible because information was unavailable. There were 7 hematogenous (mean 1409.6, range 8–3465 d) and 20 superficial (mean 16.6, range 7–30 d) wound infections, amounting to infection rates of 0.3% and 0.8%, respectively. Among the 7 hematogenous infections, 2 occurred within the first postoperative year, at 8 and 14 days after the primary THA, respectively. Both were secondary to a postoperative urosepsis with urinary and joint cultures positive for *Escherichia coli*. This group of THA patients consisted of 41 men and 35 women, and their mean age was 56.4 (range 19–81) years. The preoperative diagnoses were osteoarthritis in 54 patients, rheumatoid arthritis in 11, avascular necrosis in 5, posttraumatic ankylosis in 4 and hip fracture in 2 patients.

During the same total period, 1220 primary TKAs were performed. There were 659 TKAs performed during the 1990–2002 period (average 50.7 TKAs/yr) and 561 during the 2003–2007 period (average 112.2 TKAs/yr). In all, 19 patients had deep infections, amounting to an infection rate of 1.6%. Early infections occurred in 7 patients (mean 16.5, range 8–23 d), whereas late infections occurred in 11 patients (mean 621, range 48–2282 d). For 1 patient, a clear classification of early versus late infection was impossible because information was unavailable. We noted 2 hematogenous infections at 25 and 606 days after primary TKA and 9 superficial infections (mean 24.1, range 7–50 d), amounting to rates of 0.2% and 0.7%, respectively. The early TKA hematogenous infection was also secondary to a postoperative urosepsis with urinary and joint cultures positive for *E. coli*. This group of TKA patients consisted of 13 men and 17 women, and their mean age was 67.4 (range 41–80) years. The preoperative diagnoses were osteoarthritis in 27 patients, rheumatoid arthritis in 2 and avascular necrosis in 1.

Of the 106 patients with a diagnosis of deep, superficial or

Box 1. Risk factors for periprosthetic joint infection

Patient comorbidities

- History of joint surgery (arthroscopy, osteotomy)[38]
- Rheumatoid arthritis[28,29,39]
- Malnutrition (serum albumin < 35 g/L)[28,29,33,34]
- Psoriasis[41]
- Diabetes[28,29,42]
- Hemophilia[44]
- Neoplasm[28]
- Alcoholism[29]
- Obesity (body mass index ≥ 35)[1,2,28–32]
- American Society of Anesthesiologists score > 2[1,5]
- Post-trauma[39]
- Avascular necrosis
- Immunosuppression (drugs, human immunodeficiency virus)[28,29,43]
- Osteopetrosis

Postoperative complications

- Hematoma[29,39]
- Allogenic transfusion[1,25]
- Wound drainage > 5 days[31,33,40]
- Atrial fibrillation[1]
- Myocardial infarction[1]
- Urinary tract infection[1,28,29]
- Cutaneous infection[29]
- Hospital stay > 5 days[1]

Other factors

- Simultaneous bilateral arthroplasty[1]
- Surgical drain > 24 hours[27,35]
- Urinary catheterization > 48 hours[36]

Table 1. Risk factors for periprosthetic joint infections in total hip arthroplasty patients with deep infections, $n = 34$

Risk factor	No. patients
Patient comorbidities	
Rheumatoid arthritis	7
ASA score > 2	6
Obesity (BMI > 35)	5
Diabetes	5
Neoplasm	4
History of joint surgery	3
Osteopetrosis	1
Post-trauma	1
Avascular necrosis	1
Psoriasis	1
Alcoholism	1
Immunosupression	1
Malnutrition	1
Postoperative complications	
Hospital stay > 5 days	13
Wound drainage > 5 days	12
Hematoma	9
Allogenic transfusion	7
Myocardial infarction	1
Urinary tract infection	1
Other factors	
Surgical drain > 24 hours	6
Urinary catheterization > 48 hours	4

ASA = American Society of Anesthesiologists; BMI = body mass index.

hematogenous infection, 84 (79.2%) presented risk factors for PJI. In all, 34 of 49 (69.4%) patients with deep THA infections and 15 of 19 (78.9%) with deep TKA infections had risk factors; they are summarized in Tables 1 and 2.

We calculated deep infection rates for the periods before and after the implementation of PJI reduction measures (1990–2002 and 2003–2007). The THA deep infection rate was 2.5% for the period 1990–2002 and 1.4% for the period 2003–2007, accounting for a decrease of 44% in the rate of infection ($p = 0.06$). The TKA deep infection rate was 2.0% for 1990–2002 and 1.1% for 2003–2007, accounting for a decrease of 45% in the rate of infection ($p = 0.20$). Table 3 provides details of THA and TKA deep infection rates in each time cohort.

Even if the THA deep infection rate was higher than that for TKA for each period, there was no statistical difference for the complete period (2.0% v. 1.6%, $p = 0.31$) and in each time cohort (1990–2002: 2.5% v. 2.0%, $p = 0.45$; 2003–2007: 1.4% v. 1.1%, $p = 0.55$).

Discussion

Periprosthetic joint infections remain a challenge for orthopedic surgeons and microbiologists. The consequences for patients and society are so substantial that professionals must review their practices to ensure optimal prevention and management of this complication. In the present study, we retrospectively evaluated our institutional infection rate after THA and TKA over a period of 17 years, paying specific attention to periods before and after the implementation of an infection prevention program. Although no significant difference was found when comparing THA ($p = 0.06$) and TKA ($p = 0.20$) deep infection rates for each time cohort, reductions of 44% (2.5% v. 1.4%) and 45% (2.0% v. 1.1%) in deep infection rates were observed for THAs and TKAs, respectively. Those improvements are clinically important in relation to the changes made in 2003.

When comparing the surgical volume between the 1990–2002 and 2003–2007 periods, we found that it was twice as high in the latter period for both primary THAs and TKAs. As surgical volume increased, the ease of surgery may have improved, resulting in shorter average duration of surgery. No objective data comparing the average duration of surgery for both periods were available. The likely shorter average surgical duration for the 2003–2007 period may have been a confounding variable. Hip resurfacing procedures were started at our institution in April 2003, and a total of 224 procedures were performed between April 2003 and December 2007. Among those patients, we noted 2 superficial and 2 deep infections for a deep infection rate of 0.89%. It is possible that this may have contributed to the lower infection rate for the 2003–2007 period.

Several changes aimed at reducing PJIs were made in our clinical practice in 2003. These modifications may have been responsible for the lower infection rate observed after 2003. One of these changes was the use of antibiotic-loaded cement for cemented joints. The effectiveness of antibiotic-loaded cement in the prevention of deep infections has been reported in prospective randomized trials and in national joint registries[39,47,48] around the world. However, we observed similar deep infection rate reductions for TKAs and THAs despite TKAs being cemented without antibiotics before 2002 and with antibiotics thereafter, whereas THAs were mostly uncemented during the whole observation period (1990–2007). Another modification was the implementation of a policy to ensure that antibiotics were given within 60 minutes before skin incision as part of a surgical safety checklist. However, it was impossible to compare whether there was

Table 2. Risk factors for periprosthetic joint infections in total knee arthroplasty patients with deep infections, *n* = 15

Risk factor	No. patients
Patient comorbidities	
History of joint surgery	4
Diabetes	3
Immunosuppression	3
ASA score > 2	2
Obesity (BMI > 35)	1
Rheumatoid arthritis	1
Postoperative complications	
Hospital stay > 5 days	7
Wound drainage > 5 days	4
Allogenic transfusion	2
Hematoma	2
Other factors	
Surgical drain > 24 hours	3
Urinary catheterization > 48 hours	2

ASA = American Society of Anesthesiologists; BMI = body mass index.

Table 3. Deep infections in total hip and knee arthroplasty

Procedure	Period 1990–2002	Period 2003–2007	Total	*p* value
Primary total hip arthroplasty, no.	1351	1052	2403	
Deep infection, no. (%)	34 (2.5)	15 (1.5)	49 (2.0)	0.06
Primary total knee arthroplasty, no.	659	561	1220	
Deep infection, no. (%)	13 (2.0)	6 (1.1)	19 (1.6)	0.20

a significant change in the number of patients who received their antibiotics within 60 minutes between the 2 periods. Such information was not available for the 1990–2002 period.

The rates of deep THA and TKA infections between 2003 and 2007 were 1.4% and 1.1%, respectively. These rates are within the range of reported infection rates in similar centres for THA (0.3%–1.8%)[1–4] and TKA (0.39%–1.1%).[1,3–8] Our study is not the first to report a decreased infection rate after implementation of a specific program aimed at preventing PJIs. Knobben and colleagues[49] reported that a combination of systemic and behavioural changes in the OR significantly diminished intraoperative contamination, subsequent wound discharge and superficial wound site infection, although the rate of deep PJIs was not reduced significantly. It has been demonstrated that established principles for infection prevention in the OR should be followed rigorously as new aseptic measures, such as prophylactic antibiotics and laminar systems, might lead to relaxation of asepsis standards.[24]

We found that 84 of 106 (79.2%) patients who experienced deep, hematogenous or superficial infections for THAs or TKAs presented known risk factors for PJIs. In all, 34 of 49 (69.4%) patients with deep THA infections and 15 of 19 (78.9%) patients with deep TKA infections had risk factors. The vast majority of patients also had at least 1 associated medical condition, many of which are known to have a cumulative effect on the risk for PJI, since each additional medical condition increases the baseline risk of infection by 35%.[42] This confirms the importance of identifying patients with risk factors for infection to establish adequate measures for preventing modifiable infections whenever possible. On the other hand, we also observed that one-fifth of patients with infections did not have risk factors. This demonstrates that prosthetic joint infections can occur in a low-risk population and reinforces the necessity and importance of applying strict aseptic measures in the OR.

Limitations

Our study had some limitations. First, our power analysis showed that with the current total number of patients in the THA group (2403), we obtained a study power of 54% with the difference of 1.1% found in deep infection rate between the periods (2.5% in 1990–2002 v. 1.4% in 2003–2007). To obtain a power of 80% with the same infection rate in each group, we would have needed a total of 5000 patients. For the TKA group, the study power was 26% for a total of 1220 patients and a difference of 0.9% between the groups (2.0% in 1990–2002 v. 1.1% in 2003–2007). To obtain a power of 80% with the same infection rate in each group, a total number of 5900 patients would have been necessary. Another limitation was the retrospective nature of the study, with the addition of a prospective part only for the last 2 years. For this reason, the true incidence of PJI might have been underestimated. Looking at information sources for the period in which both data from the archives and prospective lists were available (November 2005 to December 2007), 10 patients with deep infections (4 for TKA and 6 for THA) were included in both the chart review and prospective follow-up, whereas 4 patients (1 for THA and 3 for TKA) were included only in the prospective follow-up. However, these infections being recent, data entry was probably not yet completed by the archivists for this period at the time of our chart review. All medical records corresponding to patients who were included only in the prospective surveillance protocol were then reviewed. Each chart contained a summary sheet with a diagnosis of PJI, and all patients had been treated at our institution. This confirms that the lag in data entry by the archivists was most likely responsible for the disparity between prospective data and the archives list for deep infections. In the same period, 15 patients with superficial infections (5 for TKAs and 10 for THAs) were also included only on the prospective list. The same lag in data entry could explain the difference, along with the possibility that superficial infections were managed on an out-patient basis and would, therefore, not have appeared in the archived medical records of patients readmitted for treatment of PJIs. Most superficial infections included in the archives list occurred during hospital admission for the primary arthroplasty. Thus, it is likely that the rates of superficial infection were underestimated compared with those for deep and hematogenous infections.

Because the study was retrospective and covered a long period, some data were lost. The archives could not retrieve 8 old medical records that were previously analyzed as part of the internal quality assessment in 2002 (4 deep infections for THAs, 2 superficial infections for THAs, 1 hematogenous infection for THA and 1 deep infection for TKA). The type of infection and the risk factors were recorded at that time, and this information was used for the present study. The only information that was not analyzed in 2002 was the timing of deep infection (early v. late). This explains why a clear classification was impossible for 4 patients with deep THA infection and 1 patient with deep TKA infection. These patients were included in the calculation of the infection rate. Another weakness of our study was that some patients had only a few months of follow-up after primary surgery (minimum of 8 mo). This might have led to the underestimation of the infection rate. Also, it is possible that some patients sought treatment for their infection at another institution. Finally, the anticoagulation protocol was changed from warfarin to low-molecular-weight heparin in 1995 at our centre. It is possible that this change could have led to an increased incidence of wound drainage and subsequent superficial or deep infections after 1995.

Conclusion

Our results add to the evidence that the implementation of a specific program is effective to reduce PJIs. Such measures should be the standard for all arthroplasty patients. Double gloving with outer glove changes should occur at least after draping and before implant insertion. There is also literature to support glove changing at regular intervals during arthroplasty surgery,[19] but, to our knowledge, no specific time interval is yet established as a standard. The standard recommendations for high-risk patients would be the same as those for low-risk patients, except it might be necessary to widen the antimicrobial prophylaxis coverage if a known source of infection cannot be eradicated before surgery or to cover specific germs associated with a concomitant disease,[50] as for diabetes, psoriasis, sickle cell anemia or HIV. The duration of prophylactic antimicrobials is still controversial, but most literature supports that prophylaxis end within 24 hours after the surgery,[13,50–52] or after the drain is removed.

Although we cannot determine the individual impact of each factor implemented in our infection prevention program, this strategy was able to reduce our THA and TKA infection rates to an acceptable level for a teaching hospital. Additional efforts must be made to diminish the incidence of these infections to limit patient morbidity and lessen the economic impact of PJIs. The poor success rate of treatment and its associated potential mechanical complications confirm the need to invest more resources in decreasing modifiable risk factors.

Competing interests: None declared.

Contributors: All authors participated in study design, data acquisition and analysis, article writing and review, and they each approved its publication.

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