# Prevention of Surgical Site Infection in Primary Total Joint Arthroplasty

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Prevention of Surgical Site Infection in Primary Total Joint Arthroplasty

## Abstract

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More than 900,000 total hip and knee replacement surgeries are performed in the United States annually. Of this number, it is estimated that 1 to 5% of total hip and knee arthroplasties will become infected. Such infections have costly consequences for the United States and for patients both financially and physically. Many methods for prevention of surgical site infection have been researched. Such methods include operative suite airflow and ultraviolet radiation, surgical personnel hygiene, barriers, and behaviors, as well as pre-operative preparation of the surgical client to include management of co-morbidities, antibiotic therapy and preparation of the surgical site. This paper explores these various methods for prevention of infection in total joint arthroplasty and more specifically of primary total knee and total hip arthroplasties and identifies the best practices.

*Key Words: Infection, Prevention, Total Joint, Arthroplasty, Hip, Knee*

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# Prevention of Surgical Site Infection in Primary Total Joint Arthroplasty

Infection is a common complication of surgery. In 2002, the Centers for Disease Control and Prevention placed surgical site infection (SSI) as the second most common healthcare-associated infection (HAI). One study found that out of approximately 100,000 HAI's reported in one year, SSI deaths occurred in over 8,000 cases (CDC, 2010). Surgical site infections are defined by the CDC as "an infection that occurs after surgery in the part of the body where the surgery took place" (CDC, 2010). According to the Agency for Healthcare Research and Quality (AHRQ) 555,800 total knee replacements and 383,500 total knee replacements were performed in 2005 (Merrill & Elixhauser, 2007). By 2030, projections anticipate that orthopedic surgeons will perform more than 571,000 primary total hip arthroplasties and 3.48 million total knee arthroplasties in the U.S. alone (Fiedler, 2006). From 2006 to 2026, the number of joint replacements is expected to double. If current infection rates are not decreased, the infection rate will proportionately double as well (Knobben, Van Horn, Van der Mei, & Busscher, 2006). It is estimated that 1 to 2% of hip implants and 2 to 4% of knee implants become infected (Knobben et al., 2006).

For the purposes of this paper, surgical arthroplasty is defined as plastic surgery to reshape or reconstruct a diseased joint, which may require use of an artificial joint ("Taber's Cyclopedic Medical Dictionary," 2001, p. 169). Surgical site infections lead to a large number of post-operative complications and morbidities due to extended hospital stays, additional surgeries, permanent loss of the implant with shortening of the affected limb, deformities, and death. This in turn costs patients both physically and financially. Procedures performed to attempt resolution of these infections cost between $40 and $80 million in the United States annually (Pinto, De Souza, Da Silva, Mimica, & Graziano, 2010). It is therefore, important to identify the best practices for prevention of SSIs in total knee and total hip arthroplasty. The purpose of this paper is to examine the literature for evidence of the best practices used in preventing surgical site infection in total hip and knee joint replacement surgery. This includes the evaluation of operative suite airflow and ultraviolet radiation, surgical personnel hygiene, barriers, and behaviors, as well as pre-operative preparation of the surgical client to include antibiotic prophylaxis, preoperative cleansing of the skin and surgical site and management of co-morbidities.

## Search Methods

The CINAHL and PubMed database search engines were used through the online library. Other databases used include Science Direct and Google Scholar. Initially, the key words of "surgery infection" were used to begin the search with CINAHL, Science Direct, and Google Scholar. This search was narrowed using the phrase "orthopedic surgery infection." This also produced many results not specifically relevant to arthroplasty; therefore the search was curtailed by using the phrases of "orthopedic implant infection" and "total joint surgery infection prevention." Over eighty articles were found using the CINAHL with full text database and the search query "total joint surgery infection prevention" and more than thirty were found using "orthopedic implant infection" as the search phrase. Science Direct and Google Scholar both produced results in the thousands using the search queries "total joint surgery infection prevention" and "orthopedic implant infection." The search using PubMed had a slight variation where the query was performed using the major search terms of "arthroplasty" and "replacement" along with the Medical Subject Heading (MeSH) of "surgical wound infection" and the limits set within the parameters of humans and English language. Using these criterions, over 200 articles were also found via PubMed. From these results, 5 articles were initially selected for inclusion based on their relevance, applicability and reliability. Only articles available in English were included in this review. Articles that specifically addressed recommendations for prevention of infection in total hip or total knee arthroplasty were originally selected for inclusion. Articles greater than 15 years old were not initially considered. Additional articles were later incorporated as a result of findings from the preliminary literature. Though there was much overlap of the articles in these categories, the recommendations were organized into 5 categories: reduction of operative suite air contamination, surgical personnel behaviors, as well as pre-operative preparation of the surgical client to include management of co-morbidities, antibiotic therapy and preparation of the surgical site. These 5 categories provide the organizational framework for the literature review.

## Theoretical Framework

The Health Belief Model (HBM) serves as the basis of this literature review. Kretzer and Larson (1998) identified several behavior theories that are relevant to infection control practices, one of which is the HBM. The five components of the HBM that are outlined by Kretzer and Larson (1998) include: the perceived susceptibility to a health threat; the perceived severity of the threat; health recommendations that must be beneficial without costly barriers or risk; cues to initiate behavior; self-efficacy (Kretzer & Larson, 1998). The HBM is most relevant to the infection control and prevention goals outlined in this paper, because the key to any of these proposed practices being successful is the belief that there is a problem and that acting on this problem will positively affect the outcomes. Healthcare workers generally strive for the best possible patient outcomes and therefore, should be open to carrying out best practice methods and initiating changes that benefit patients' health. Additionally, by reviewing the various methods of infection prevention, the best, most cost-effective measures can be identified, thus making the implementation of better infection prevention more attainable.

## Review of Literature

### Reduction of Operative Suite Air Contamination

In a review by Gosden, MacGowan and Bannister (1998) four key factors were identified as controllable ways to help prevent orthopedic implant infection. These factors include air quality, ultraviolet radiation, theater dress and antibiotics, with the latter two being discussed later in the review. In joint replacement surgery, studies have found that 98% of bacteria found in the patients' wound come directly or indirectly from the air (Gosden, MacGowan & Bannister, 1998). The amount of bacteria in the air is related to the number of personnel in the operating suite, as well as the amount of activity in the room. Air sampled within 300 mm of the surgical wound should contain less than 10 colony forming units per cubic meter (cfu/m$^{3}$) using conventional cotton clothing. Levels should be expected to be less than 1 cfu/m$^3$ when occlusive clothing or body exhaust systems are utilized. The perimeter of the surgical zone should contain less than 20 cfu/m$^3$ with conventional clothing, and less than 10 cfu/m$^3$ with occlusive clothing or body exhaust systems (Gosden, MacGowan, & Bannister, 1998).

Various types of ventilation systems impact how much bacterial contamination is in the air and how easily the organisms reach the surgical field. When assessing the various types of ventilation systems used in surgical suites, research suggests that laminar-flow ventilation results in less air contamination when compared to conventional plenum ventilation. Laminar airflow allows airborne particles to pass the operative field and prevents them from landing in the surgical site. In a study by Knobben, van Horn, van der Mei and Busscher (2006) laminar airflow was shown to be the best choice in ventilation systems, yet it must be monitored routinely to ensure that it is operating up to standard (Knobben et al., 2006). Other studies however, challenge the effectiveness of utilizing laminar airflow.

In a study by Miner, Losina, Katz, Fossel and Platt (2007), the relationship between risk of infection and use of laminar airflow and body exhaust suits was investigated. The incidence of deep infection was evaluated for the 90 day period following total knee replacement for 8,288 procedures performed in 256 hospitals. Of these 8,288, 28 infections were reported from 25 hospitals. The calculated risk ratios were 1.57 for use of laminar flow and 0.75 for use of body exhaust suits, suggesting that neither measure has significant effect on preventing deep wound infection (Miner, Losina, Katz, Fossel, & Platt, 2007). Based on these findings, it is suggested that further research needs to be performed in order to assess that either measure has a significant benefit in the operating room.

Use of ultraviolet radiation is another way to reduce airborne contamination in the operating room. It has been proven effective in reducing deep infection after orthopedic implant surgery. While ultraviolet radiation is less expensive than laminar airflow, it requires frequent maintenance. An advantage that ultraviolet radiation has over laminar-flow is that ultraviolet radiation may provide a bactericidal effect after wound contamination has occurred (Gosden, MacGowan, & Bannister, 1998). Consequently, use of ultraviolet radiation also requires that cumbersome protective attire be worn by patient and personnel.

Taylor, Bannister and Leeming (1995) conducted research aimed at analyzing bacterial counts in the air and wounds when using ultraviolet C (UVC) radiation in comparison to conventional air ventilation, as well as laminar airflow during primary total hip and knee arthroplasty. Four different operating room environments were tested to include combinations of clothing and air filtration or disinfection. The first was categorized as conventional, as it utilized plenum ventilation and balloon cotton clothing. The environment categorized as UVC was a combination of UVC clothing and the addition of UVC radiation at levels of 100 and 300 microwatts per square centimeter per second ($\mu W/cm^2/s$). The last environment, laminar flow, utilized high-efficiency particulate air (HEPA) filtered vertical linear down flow ultraclean air with cotton/polyester clothing. Bacteria in the air were measured within 30 cm of the wound using a Casella slit sampler. Bacteria from inside the wound were measured by imprinting with mixed cellulose acetate and nitrate membrane filters. For each separate environment assessment, a sterile control membrane was passed above the wound, and five other sterile membranes were pressed onto the exposed wound surface and removed after 10 to 30 seconds. These membranes were then processed to analyze the colony counts. Wounds samples were assessed, as soon as the fascia lata had been divided in total hip replacement and after patella dislocation in total knee replacement. Samples were again taken after 10 and 20 minute time frames (Taylor, Bannister, & Leeming, 1995).

There were 13 patients assessed in the conventional operating environment, 18 with UVC radiation at 100 $\mu W/cm^2/s$, 13 with UVC at 300 $\mu W/cm^2/s$ and 13 with laminar flow. The conventional environment had a mean air count of 58 $cfu/m^3$ and laminar flow had a count of 4.5 $cfu/m^3$, both with insignificant differences between the first and second samples. UVC clothing worn in the plenum room reduced the air count to 36 $cfu/m^3$. With the addition of UVC radiation at UVC at $100\mu W/cm^2/s$, counts decreased to 11 $cfu/m^3$. With UVC radiation at $300\mu W\ cm^2\ s$, air bacterial counts further decreased to 5.4 $cfu/m^3$. Additionally, there were more colonies per membrane filter used to pass over wounds in the conventional environment, as compared to laminar flow (Taylor et al., 1995).

In the conventional environment, wound bacterial counts were similar to control values, yet increased after 10 minutes and did not change after 20 minutes. In the laminar flow environment, with the system running throughout the experiment, wound counts at the start of the surgery were the same as control counts and did not demonstrate an increase at the 10 or 20 minute assessment points. When compared to the conventional environment, wound bacterial colony counts were 75% lower at the beginning of surgery, 93% lower after 10 minutes and 94% lower after 20 minutes. In the same environment with conventional plenum ventilation, the addition of UVC clothing decreased wound counts by 66%. In the 100 $\mu W/cm^2$/ s UVC radiation environment, wound counts were similar to controls at the start of the surgery, but by 10 minutes increased. After irradiation with UVC at 100 $\mu W/cm^2$ /s, wound counts were 52.9% less than at 10 minutes and similar to control values. In the 300 $\mu W/cm^2$ /s environment, wound counts were again, comparable to controls at the start of surgery and increased by 10 minutes. However following irradiation, the counts decreased by 73%. The difference between UVC intensities of 100 $\mu W/cm^2$ /s and 300 $\mu W/cm^2$ /s did not yield significant differences (Taylor et al., 1995).

The researchers felt that laminar flow had favored bias due to the fact that laminar flow ran throughout the first 10 minute period, which kept bacterial counts from accumulating in the wound. Additionally, the control wound counts were 58% higher when the membrane filters were opened outside the laminar flow area. It was concluded that statistically, there was not a significant difference between the use of laminar flow and UVC at either 100 or 300 $\mu W/cm^2$/ s. The cost of UVC was estimated to be one-tenth of laminar airflow. UVC also has the ability to provide disinfection of a wound, whereas laminar airflow cannot. However, in order to protect operating room staff from UVC radiation, protective clothing was worn that was thick, hot and uncomfortable and generally felt to be unacceptable for routine wear (Taylor et al., 1995).

**Operating Room Personnel**

Many studies have shown that microorganisms are shed from the hair, skin and mucous membranes of operating room personnel. The attire worn by operating room staff can affect airborne bacterial contamination of the surgical site. The review by Gosden et. al. (1998) discussed that wearing an occlusive type of clothing, instead of typical cotton clothing reduces the amount of bacterial dispersion. The average sized desquamated skin cell is about 20 micrometers, whereas the pore size of the cotton fabric that is normally used in hospital attire is significantly larger (Gosden et al., 1998). In the 1999 executive summary of recommendations from the CDC for prevention of surgical site infection, Mangram Horan, Pearson, Silver, & Jarvis (1999) recommended that scrub suits, impermeable surgical gowns, masks and caps be worn by operating room staff to reduce the number of bacteria in the air of the operating room. It is still unclear however, due to lack of controlled studies, whether specific kinds of surgical attire affect postoperative infections (Mangram, Horan, Pearson, Silver, & Jarvis, 1999). The review concluded that personnel still need to adhere to these hygiene practices, as they are considered reasonably prudent based on research thus far. In a review by Jamsen et. al. (2010) the practice of double-gloving and use of indicator gloves was recommended, as it likely reduces the risk of hand contact between the surgeon and patient (Jamsen et al., 2010).

In the aforementioned study by Knobben, van Horn, van der Mei and Busscher (2006) emphasis was placed on two main sources of contamination including the patient's skin and airborne particles from operating room staff. The study focused on reducing airborne particles in the operative theater by implementing staff disciplinary measures, as well as proper use of laminar airflow systems over a two-phase implementation. Intra-operative bacterial cultures were taken during 207 random primary total hip and knee replacements over a two and a half year period (Knobben et al., 2006). During the first phase only the use of the laminar airflow was altered by having sterile instrumentation unpacked and handled inside the plenum (surgical field area inside laminar airflow). The second phase incorporated major behavioral changes along with a systemic change. These included: patient preparation outside the operating suite, proper utilization of staff body, face and hair coverage, limiting conversations and staff movements or changes that are unnecessary, and replacing the conventional airflow with a new laminar airflow system. The new system increased airflow from 2700 $m^3/h$ to 8100 $m^3/h$, increased speed of air inflow from 10 cm/s to 20 cm/s and the total number of air changes from 22/h to 60/h. Additionally, glass panels extending from the ceiling were placed, that along with the newly increased airflow, increased the airflow at the surgical table to a total number of air changes of 240 per hour. The plenum size was increased from 3 $m^2$ to 10.2 $m^2$ (Knobben et al., 2006). To evaluate effectiveness, culture samples were taken at different stages of the operation. Two were taken from instruments used for the case, two were taken from unused instruments and two more were from removed bone. The results found that contamination occurred in 32.9% of cases in the control group, 34.3% of cases in the first phase group and only 8.6% in the second phase group (Knobben et al., 2006). It is therefore suggested that the combination of staff behavior and operating room ventilation system changes can greatly decrease the amount of intra-operative bacterial contamination.

**Antibiotic Prophylaxis**

AlBuhairan, Hind and Hutchinson (2008) performed a systematic review that cited the most prevalent organisms causing periprosthetic infections as *Staphylococcus aureus* and

*Staphylococcus epidermis* (AlBuhairan et al., 2008). These organisms, which are present in normal skin flora, are able to adhere to implants and multiply in polymers. The use of systemic intravenous antibiotics reduces the risk of postoperative infections. It is therefore recommended that systemic antibiotic prophylaxis be used in orthopedic implant surgery.

In the summary of recommendations, Mangram et. al. (1999), suggested that cephalosporins be commonly used due to their efficacy against staphylococcus pathogens, their low cost, availability, safety, and desired pharmacokinetics (Mangram et al., 1999). Cefazolin is commonly used and accepted as the antibiotic of choice in clean operations. Van Kasteren et. al. (2007) stated that cefazolin and cefuroxime are considered to be equally effective in reducing SSI. It is recommended that vancomycin be used for high-risk patients that are carriers of methicillin-resistant *Staphylococcus aureus* (MRSA) (Jamsen et al., 2010). In the case of beta-lactam allergy, clindamycin or vancomycin are preferred alternatives (Jamsen et al., 2010). The timing of the administration of preoperative antibiotic is another important factor to be considered with antibiotic prophylaxis. A higher risk of infection is associated with the administration of the antibiotic both before and after the optimal time frames.

In a prospective, multisite intervention study by van Kasteren, Mannien, Ott, Kullberg, de Boer and Gyssens (2007) data was collected for 1922 patient who underwent elective total hip arthroplasty in 11 Dutch hospitals that participated in the project, Surgical Prophylaxis and Surveillance. The purpose of the study was to analyze various parameters of antibiotic prophylaxis that influence the risk of SSI after total hip replacement. The parameters analyzed included duration of prophylaxis, timing of prophylaxis, sex, age, American Society of Anesthesiology (ASA) score, wound class, duration of surgery >75$^{th}$ percentile, National Nosocomial Infections Surveillance score, and duration of preoperative hospital stay. The highest odds ratios for SSI were found to be patients who received antibiotic prophylaxis after incision (2.8), had an ASA score >2 (2.8), and had a duration of surgery > 75$^{th}$ percentile (2.5). It was therefore suggested by the study's contributors that further research be directed at specifically the timing of antibiotic prophylaxis as this was the only modifiable factor of statistical significance (Van Kasteren et al., 2007).

Weber et al. (2008) performed a prospective observational cohort study, in which the optimal timing for antimicrobial prophylaxis was researched at Basel University Hospital. The incidence of surgical site infections was analyzed in regards to the timing of prophylactic antibiotics in 3836 surgical procedures in the Visceral, Vascular and Traumatology Divisions of the General Surgery Department at Basel University Hospital. The standard antibiotic used was 1.5 gm cefuroxime (plus an additional 500 mg of metronidazole in colorectal surgery) as single-shot administration of a first- or second-generation cephalosporin is considered to be the up to date method of antimicrobial prophylaxis. The researchers hypothesized that the risk of SSI would be lower when cefuroxime was administered between 2 hours and 30 minutes before surgery, than when administered in the final half hour prior to incision. The study's overall SSI rate was 4.7%. Multivariable logistic regression analyses showed an increase in the odds of SSI when antibiotic prophylaxis was given at less than 30 minutes (adjusted odds ratio = 1.95), and at 120 to 60 minutes (adjusted odds ratio = 1.74), as compared to the reference time frame of 59 to 30 minutes prior to incision (odds ration = 1.0). The study therefore found that antibiotic prophylaxis, specifically cefuroxime, was more effective when administered between 30 to 59 minutes prior to surgery, rather than in the final half hour. Furthermore, the lowest rate of SSI was found when antibiotics were infused between 74 and 30 minutes prior to incision (Weber et al., 2008).

Guidelines published by the American Academy of Orthopaedic Surgeons [AAOS] (2004) advised that three major recommendations for antibiotic prophylaxis be considered. The first recommendation is that the selection of antibiotics for surgical prophylaxis should be chosen based on current recommendations from the literature and takes into account individual variables, including resistance and allergies. Cefazolin and cefuroxime remain the antibiotics of choice. Clindamycin or vancomycin may be used for patients with a beta-lactam allergy. Vancomycin should be used for patients with known MRSA or in facilities with known MRSA outbreaks. The next recommendation states that the timing and dosage of antibiotics should optimize their efficacy. AAOS recommends administration of antibiotic prophylaxis within one hour prior to incision. Vancomycin should be infused two hours prior to incision. When proximal tourniquets are used, prophylactic antibiotics must be infused in their entirety prior to inflation of the tourniquet. Dosing of antibiotics should also be weight based. Additionally, intraoperative doses of antibiotics should be administered, if either the duration of surgery exceeds one to two times the antibiotic's half-life or if there is substantial blood loss. The final recommendation from AAOS states that the duration of antibiotic prophylaxis should not exceed the 24-hour post-operative period.

**Preoperative Skin and Surgical Site Cleansing**

Johnson, Daley, Zywiel, Delanois and Mont (2010) conducted research that focused on the effectiveness of patients using a 2% chlorhexidine gluconate impregnated cloth at home prior to total hip arthroplasty (THA) surgery in order to decrease the incidence of deep periprosthetic infection. The researchers wanted to assess whether using a more effective delivery method of topical chlorhexidine by means of a no-rinse cloth at home would decrease SSI rates following total hip arthroplasty. Between January 2007 and December 2009, 1134 patients who had THAs at the senior author's institution were included in this study (Johnson et. al., 2010). All surgeons performing total hip arthroplasties were instructed to provide their patients with directions and chlorhexidine cloths prior to their surgery. Patients were given detailed instructions to perform full body skin cleansing, along with separate surgical site application once the night before surgery and once the morning of surgery (Johnson et al., 2010). To verify that they had performed the appropriate cleansing, the patients were asked to place the stickered label from each of the cleansing cloths on a sheet to bring back in. On the day of surgery, all patients received the same preparation in the hospital. The researchers found that the group of 157 patients who fully complied with the at-home chlorhexidine regimen had no surgical site infections. In comparison, of the 897 patients who did not comply by completing the at-home pre-operative skin preparation, 14 had infections. Additionally, of the 80 patients who were only partially compliant (did not 100% comply with the regimen) no SSIs occurred (Johnson et al., 2010). These findings are significant, because this pre-operative regimen is a low-cost and simple method to help further decrease the rate of SSIs in THA surgery.

A similar study was conducted by Zywiel et al. (2011) in regards to total knee arthroplasty. This study had similar yields with the same recommendations as an outcome. At a single institution over a two-year period, all arthroplasty surgeons were asked to provide their patients undergoing total knee replacement with no rinse 2% chlorhexidine cloths and specific instructions for use the night before and the morning of surgery. There were 912 patients identified in the study of which only 65 partially complied leaving 835 patients involved in the study. As with the previous study, patients were asked to remove the labels from the cloths at the time of use and affix them to a sheet that they would bring in to the hospital in order to demonstrate their compliance. Once at the hospital, all patients underwent the same perioperative skin disinfection procedure. Of the 136 patients who completed the at-home skin cleansing protocol, there were no surgical site infections. Of the 711 patients who received in-hospital preparation only, there were 21 infections. The rate of infections for those who were only partially compliant was 1 in 65 patients (Zywiel et al., 2011).

No rinse chlorhexidine cloths appear to help decrease surgical site infection when appropriately used once the evening before, and once the morning of, both total hip and knee replacement. While topical chlorhexidine has been shown to be effective as a long-lasting antiseptic, at-home rinses have not provided adequate delivery in comparison to no-rinse cloths (Johnson et al., 2010). Additional studies with larger patient populations are still needed to further prove efficacy. The 1999 CDC guidelines for prevention of SSI, recommend pre-hospital cleansing with chlorhexidine in order to reduce the microbial colony counts on patients' skin (Mangram et al., 1999).

## Management of Co-morbidities

Co-morbid conditions may play a significant role in increasing the risk for surgical site infections. In an instructional course lecture for the American Academy of Orthopaedic Surgeons (AAOS) by Garvin and Konigsberg (2011) alcohol abuse, smoking, malnutrition, urinary tract infection and obesity were identified as some of the primary factors that may increase the incidence of periprosthetic infection (Garvin & Konigsberg, 2011). Matar et. al. (2010) named significant co-morbidities including rheumatoid arthritis, myocardial infarction, atrial fibrillation and obesity (Matar et al., 2010). Konttinen, Seitsalo, Lehto and Santavirta (2005) acknowledged that patients with rheumatic arthritis are at an increased risk of infections due to bone and joint inflammation and injury. Furthermore, the use of biological anti-rheumatic drugs may further predispose a patient to wound infections and delayed healing. The authors recommend that biological anti-rheumatic medications be stopped before total joint arthroplasty and rheumatoid related surgery and not be started again until initial repair has occurred after surgery. The exact timelines for starting and stopping are not known for certain at this time, but recommendations are currently based on the anti-rheumatic drug half-lives (Konttinen, Seitsalo, Lehto, & Santavirta, 2005).

Garvin and Konigsberg (2011) cited obesity and morbid obesity as significant risk factors for periprosthetic infection following total knee arthroplasty. In a prospective study of 1214 primary total knee arthroplasties, Dowsey and Choong (2009) compared the rate of deep prosthetic infection between obese and non-obese patients for 12- months post-operatively. Obesity was classified according to CDC guidelines with a BMI < $30kg/m^2$ being non-obese, $30kg/m^2$ to $39kg/m^2$ being obese and $40kg/m^2$ or greater being morbidly obese. The authors had previously conducted a study that identified obesity as an independent risk factor for developing prosthetic infection after total hip arthroplasty. As a result of their findings, the authors decided to conduct similar research with total knee arthroplasty. Periprosthetic infection developed in 18 of the 1214 patients who underwent total knee arthroplasty in the observed study population. Of this number, 10 were morbidly obese and 4 were obese, while 4 were non-obese (Dowsey & Choong, 2009). The overall prosthetic infection rate was 1.5% and the odds for developing a deep prosthetic infection were greater with morbid obesity (odds ratio 8.96) and diabetes (odds ratio 6.87). It is therefore recommended that obese patients be counseled about their increased risk for infection and ways to reduce this risk prior to undergoing joint replacement surgery (Garvin & Konigsberg, 2011). Nutritional status of obese patients also needs to be assessed prior to surgery by obtaining serum albumin and transferrin levels, as well as total lymphocyte count. If their nutritional status is found to be inadequate (as evidenced by transferrin level <200mg/dL, albumin <3.5g/dL, or total lymphocyte count <1500 cells/$mm^3$) obese patients should be referred to a nutritionist or primary care provider prior to surgery or surgery should be delayed until their overall nutritional status is improved (Matar et al., 2010; Garvin & Konigsberg, 2011). While wound healing problems are common in obese patients, frequently associated conditions of diabetes and peripheral vascular disease further exacerbate their risk for infection. Diabetic patients are 3.1 times more likely to develop a deep infection, than those without diabetes mellitus (Garvin & Konigsberg, 2011). It has therefore been recommended to establish and maintain strict glycemic control throughout the perioperative period.

## Discussion

### Indications for Nurse Practitioners

Having an enhanced knowledge about potential periprosthetic infection and an understanding about what can be done to help prevent such a complication is beneficial for any primary care provider. Several of the operating environment specific recommendations in this study may not directly apply to the practice of many nurse practitioners. A small number of nurse practitioners may work in the orthopedic setting in which the findings of this review would be very relevant to consider in daily practice. Nurse practitioners employed in this role must be cognizant of their facility's total joint arthroplasty protocol and take all necessary steps to adhere to it. Additionally, nurse practitioners participating in the surgical care of clients receiving total hip or knee replacements should continue to review the most current and relevant evidence based guidelines. Furthermore, it would be prudent for nurse practitioners to educate and ensure that surgeons, staff, and facilities are appropriately implementing these practices.

For the vast number of nurse practitioners who serve as primary care providers, it is important to be aware of the desired management of co-morbidities and risk factors for infection before a client undergoes total hip or knee arthroplasty. The management of these factors is not only important in reducing the risk of infection preoperatively, but in the intraoperative and postoperative periods, as well. Optimal glycemic control has a significant role in post-operative healing. Smoking cessation and alcohol abuse counseling are also key factors in achieving the desired outcome. Cardiovascular and respiratory status assessments are also crucial in determining whether a patient qualifies as a surgical candidate. Attention to detail of the results of preoperative urinalysis is also an important factor in preventing infection. Obese clients should be counseled on reduction of BMI prior to elective arthroplasty and their nutritional status should be assessed. If needed, obese clients should be referred to a nutritionist. Patients on anti-rheumatic drugs that are immunosuppressive need to have a plan for stopping and restarting their medications coordinated with their primary care provider and orthopedic surgeon. Additionally, these co-morbidities need to be monitored and efficiently managed in the postoperative period to prevent later development of infection.

Providers should have a heightened level of suspicion for potential infection in an artificial joint. Any postoperative total hip or knee arthroplasty patient who presents with changes in the joint that include swelling, redness, warmth, decreased range of motion, pain or fever should be suspected of infection and needs to be vigorously treated ("Antibiotic prophylaxis for bacteremia," 2010). In the case of suspected periprosthetic joint infection, the orthopedic surgeon who performed the joint replacement should be consulted.

The American Academy of Orthopaedic Surgeons (2010) recommendations regarding antibiotic prophylaxis for prevention of bacteremia were addressed in an information statement. AAOS feels that late implant infection can be caused by seeding from bacteria of the oral cavity, skin, respiratory, gastrointestinal or genitourinary tracts. Patients with total joints who are having invasive procedures or who have other infections are at an increased risk for infection in their prosthesis ("Antibiotic prophylaxis for bacteremia," 2010). Given the significant costs and adverse outcomes of periprosthetic infection, the AAOS recommends that providers consider antibiotic prophylaxis, prior to invasive procedures that may cause bacteremia for joint replacement patients with one or more of the following risk factors: all patients with prosthetic joint replacement, immunocompromised or immunosuppressed patients, inflammatory arthropathies, co-morbidities, previous prosthetic joint infections, malnourishment, hemophilia, HIV, insulin dependent diabetes, malignancy or megaprostheses ("Antibiotic prophylaxis for bacteremia," 2010). The antibiotic chosen for prophylaxis should be chosen based on its effectiveness against endogenous flora of the site of invasive procedure. As with any antibiotic consideration, perceived potential benefits must outweigh the risks. The AAOS encourages any clinician caring for a patient with a joint replacement to consult with the orthopedic provider, if there is any concern about adherence to these recommendations for antibiotic prophylaxis to prevent bacteremia ("Antibiotic prophylaxis for bacteremia," 2010).

## Summary

Due to the devastating adverse health and financial effects that periprosthetic infection can lead to, diligent infection prevention practices are crucial for both total hip and knee arthroplasties. Many recommendations for the prevention of infection in total hip and knee arthroplasty have been analyzed and discussed in this review. In addition to these findings, there are numerous other variables that may warrant additional discussion and research. These specific interventions were selected however for their relevance and common themes throughout the literature.

The reduction of operating room air contamination may be benefited by efficient, properly maintained laminar airflow systems. The greatest benefit is provided when laminar airflow is augmented by staff behavior modifications. Ultraviolet systems may be less favored due to the nature of protective attire and the need for frequent system maintenance. Surgical personnel must also maintain personal hygiene and appropriate wear of protective attire to reduce contamination. Body exhaust suits are typically worn by scrubbed members and are generally viewed as a good barrier for both the staff and patient.

Antibiotic prophylaxis should routinely be administered prior to any total joint arthroplasty. Cephalosporins are typically the first line drug of choice. The timing has some variability, but most recommendations agree that at a minimum, the antibiotic needs to be infused prior to incision. Antibiotic prophylaxis should also be considered for any patient with a history of total joint arthroplasty prior to undergoing an invasive procedure. Additionally, at home chlorhexidine impregnated cloths have shown to be beneficial in reducing surgical site infections, when patients demonstrate compliance. Finally, the management of co-morbidities throughout all surgical phases including preoperative, intraoperative and postoperative periods is a crucial component of preventing periprosthetic infection. Management of co-morbidities often requires a coordinated team approach in order to reduce as many risk factors as possible, prior to undergoing surgery.

The purpose of this review was to identify the best practices for prevention of infection in total hip and knee arthroplasty. Preventative measures occur during all phases of the operative period and therefore require adherence by all those involved in the care of the patient. The aim of this paper is to hopefully raise awareness to the critical roles that providers and staff assume in ensuring the best outcomes for the patient receiving a total hip or knee arthroplasty.

## References

AlBuhairan, B., Hind, D., & Hutchinson, A. (2008). Antibiotic prophylaxis for wound infection in total joint arthroplasty. *The Journal of Bone and Joint Surgery (Br)*, *90-B*(7), 915-919.

Antibiotic prophylaxis for bacteremia in patients with joint replacements. (2010). Retrieved from http://www.aaos.org/about/papers/advistmt/1033.asp

Arthroplasty. (2001). In *Taber's Cyclopedic Medical Dictionary* (19 ed., p. 169). Philadelphia, PA: F. A. Davis.

Centers for Disease Control and Prevention website. (2010). http://www.cdc.gov/

Dowsey, M. M., & Choong, P. F. (2009). Obese patients are at substantial risk for deep infection after primary TKA. *Clinical Orthopaedics and Related Research*, *467*, 1577-1581.

Fiedler, E. (2006, March 22-25). Primary, revision THA, TKA expected to surge by 2030. *Academy News: The Annual Meeting Edition of the AAOS Bulletin*. Retrieved from http://www2.aaos.org/aaos/archives/acadnews/2006News/sat/c25_2.htm

Garvin, K. L., & Konigsberg, B. S. (2011, June 15). Infection following total knee arthroplasty. *The Journal of Bone and Joint Surgery*, *93*, 1167-1175.

Gosden, P. E., MacGowan, A. P., & Bannister, G. C. (1998). Importance of air quality and related factors in the prevention of infection in orthopaedic implant surgery. *Journal of Hospital Infection*, *39*, 173-180.

Jamsen, E., Furnes, O., Engesaeter, L. B., Konttinen, Y. T., Odgaard, A., Stefansdottir, A., & Lidgren, L. (2010). Prevention of deep infection in joint replacement surgery. *Acta Orthopaedica*, *81*, 660-666.

Johnson, A. J., Daley, J. A., Zywiel, M. G., Delanois, R. E., & Mont, M. A. (2010). Preoperative chlorhexidine preparation and the incidence of surgical site infections after hip arthroplasty. *The Journal of Arthroplasty*, *25*(6), 98-102.

Knobben, B. A., van Horn, J. R., van der Mei, H. C., & Busscher, H. J. (2006). Evaluation of measures to decrease intra-operative bacterial contamination in orthopaedic implant surgery. *Journal of Hospital Infection*, *62*, 174-180.

Konttinen, Y. T., Seitsalo, S., Lehto, M., & Santavirta, S. (2005). Management of rheumatic diseases in the era of biological anti-rheumatic drugs. *Acta Orthopaedica*, *76*(5), 614-619.

Kretzer, E. K., & Larson, E. L. (1998). Behavioral interventions to improve infection control practices. *American Journal of Infection Control*, *26*, 245-253.

Mangram, A. J., Horan, T. C., Pearson, M. L., Silver, L. C., & Jarvis, W. R. (1999). Guideline for prevention of surgical site infection, 1999. *American Journal of Infection Control*, *27*(2), 97-134.

Matar, W. Y., Jafari, S. M., Restrepo, C., Austin, M., Purtill, J. J., & Parvizi, J. (2010). Preventing infection in total joint arthroplasty. *The Journal of Bone and Joint Surgery*, *92* (Suppl 2), 36-46.

Merrill, C., & Elixhauser, A. (2007). *Hospital stays involving musculoskeletal procedures, 1997-2005* (Statistical Brief Healthcare Cost and Utilization Project Statistical Brief #34). Retrieved from Agency for Healthcare Research and Quality website: http://www.hcup-us.ahrq.gov

Miner, A. L., Losina, E., Katz, J. N., Fossel, A. H., & Platt, R. (2007). Deep infection after total knee replacement: impact of laminar airflow systems and body exhaust suits in the modern operating room. *Infection Control and Hospital Epidemiology*, *28*(2), 222-226.

Pinto, F. M., De Souza, R. Q., Da Silva, C. B., Mimica, L. M., & Graziano, K. U. (2010). Analysis of the microbial load in instruments used in orthopedic surgeries. *American Journal of Infection Control*, *38*, 229-33.

Recommendations for the use of intravenous antibiotic prophylaxis in primary total joint arthroplasty. (2004). Retrieved from http://www.aaos.org/about/papers/advistmt/1027.asp

Taylor, G. J., Bannister, G. C., & Leeming, J. P. (1995). Wound disinfection with ultraviolet radiation. *Journal of Hospital Infection*, *30*, 85-93.

Van Kasteren, M. E., Mannien, J., Ott, A., Kullberg, B., Der Boer, A. S., & Gyssens, I. C. (2007, 1 April). Antibiotic prophylaxis and the risk of surgical site infections following total hip arthroplasty: timely administration is the most important factor. *Clinical Infectious Diseases*.

Weber, W. P., Marti, W. R., Zwahlen, M., Misteli, H., Rosenthal, R., Reck, S.,...Widmer, A. F. (2008). The timing of surgical antimicrobial prophylaxis. *Annals of Surgery*, *247*(6), 918-926.

Zywiel, M. G., Daley, J. A., Delanois, R. E., Naziri, Q., Johnson, A. J., & Mont, M. A. (2011). Advance pre-operative chlorhexidine reduces the incidence of surgical site infections in knee arthroplasty. *International Orthopaedics*, *35*, 1001-1006.