Review Article

Risk factors for periprosthetic joint infection following total hip and knee arthroplasty

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Abstract

Osteoarthritis is a common degenerative and progressive disease, involving the articular cartilage as well as the subchondral bone and the soft tissues in the hip and knee. The incidence of hip and knee osteoarthritis has increased over the last twenty years and is expected to increase even further. Approximately, 40% of men and 47% of women over 65 years old suffer from symptomatic osteoarthritis that eventually requires surgical treatment by an orthopedic surgeon. In 2010 around 2.5 million patients were operated for total hip replacement and around 4.7 people with knee osteoarthritis had a total knee replacement in the United States of America. Acute periprosthetic joint infection, with Staphylococcus aureus being the most common and aggressive pathogen is a very threatening complication for the whole health status of the patient. The need for revision procedures due to periprosthetic hip infection is expected to be doubled in 2026 and is already doubled due to periprosthetic knee infection in 2015. The risk factors for hip and knee periprosthetic joint infections appear in the preoperative period, as well as intraoperatively and continue to be harmful both in the postoperative period and after the patient’s discharge from the hospital. The aim of this article is to present the variety of risk factors, associated with periprosthetic infections after total hip and knee replacements. Many risk factors can be controlled with the use of specific preventive and therapeutic interventions by orthopedic surgeons.

Keywords: Osteoarthritis, Total hip replacement, Total knee replacement, Periprosthetic infections, Risk factors

Introduction

Osteoarthritis is the most common form of degenerative joint disease affecting several joints like the first carpometacarpal joint of the hand, the spine and the two major weight-bearing joints of the hip and knee. Patients suffering either from hip or knee osteoarthritis are referring to orthopedic departments due to symptoms of pain and stiffness and disability to perform simple clinical activities. The hip and knee osteoarthritis prevalence vary from 1.9% to 4.7% for men and 2.5% to 6.6% for women, respectively. The lifetime risk probability for symptomatic knee osteoarthritis is 40% in men and 47% in women population with normal body mass index (BMI). For overweight people with BMIs≥30%, the probability is elevated to 60%. In the Johnston County Osteoarthritis Project, the prevalence of symptomatic osteoarthritis was 16.7% for knees and 9% for hips among people over 45 years old.

The total annual number for total hip and knee replacement, for patients suffering from osteoarthritis is about 1,000,000 in the USA. About 2.5 million (1.4 million of women and 1.1 million of men) patients submitted for total hip replacement and 4.7 million (3 million of women and 1.7 million of men) for total knee replacement in USA in 2010. The prevalence for total joint replacement in USA is 5.26% for hips and 10.38% for knees.

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Periprosthetic joint infection remains a timeless and aggravating complication for some patients, operated for total hip and knee replacement. According to Shurman D, 9.1% of total knee replacements were infected and a revision surgical procedure needed, in 1981. Due to improvement of surgical techniques and targeted prophylactic antibiotic therapy, the prevalence of periprosthetic joint infection has minimized to 1-2% nowadays. In 2003, 202,500 and 402,000 primary total hip and knee replacements, respectively, were carried out in USA. During the same year, 36,000 revisions after total hip replacement and 32,700 revisions after total knee replacement were done. The need for revision surgery after primary total hip replacement is expected to be doubled in 2026 and is already doubled in 2015 after total knee replacement.

The factors that increase the risk for periprosthetic joint infection after hip and knee replacement are broadly inspected and have been the point of interest and research. We will analyze the presence of these risk factors that can lead to periprosthetic joint infections, at pre-operative, intra-operative and post-operative periods.

Method

Data sources

This study was performed as a systematic review of a series of articles exploring potential risk factors for periprosthetic hip and knee infections following arthroplasty as a treatment for osteoarthritis. We choose to study bibliography for both periprosthetic hip and knee infections as being the two major weight-bearing joints operated for osteoarthritis with the highest infection rates among the rest. Additionally, we found only few review studies referring to both hip and knee periprosthetic infections, even though many patients have both hip and knee replacement during lifetime.

Study selection and search strategy

The authors searched for published articles as original and review studies on PubMed. We searched the electronic database of PubMed for articles written in English, between 2000 and 2018. Moreover, we mentioned two older articles. The first by Shurman D published in 1981 to emphasize deterioration of infection rates with the passing of time. The second by Wilson MG published in 1991 to present racial differences in the use of total knee arthroplasty for osteoarthritis among older Americans. The quality of each study was also examined. Quality and risk of bias were assessed using Cochrane’s risk of bias tool (selection bias, performance bias, detection bias and reporting bias).

Preoperative factors

Hyperglycemia and diabetes management

Perioperative hyperglycemia is very common, up to 40%, for patients who undergo total hip or knee replacement during their hospitalization. A study by Mraovic B. et al. published in the Journal of Diabetes Science and Technology (JDST) in 2011, showed that patients with increased glucose in serum, above 200 mg/dl in the preoperative period, have a double risk for periprosthetic infection.

Patients suffering from diabetes mellitus must be controlled preoperatively with hemoglobin A1c (HbA1c) or with a fasting blood glucose test. Pre-existing diabetes mellitus is proven to be the most important risk factor for postoperative hyperglycemia that affects the immune defending system against infectious agents. The International Consensus Meeting Statement recommends glucose blood levels between 80 and 180 mg/dl and HbA1c<7% in the preoperative screening test to avoid periprosthetic infections.

Obesity and nutritional disorders

Obesity which is characterized by increase body mass index (BMI) is a skyrocketed phenomenon in western-industrial societies, and orthopedic surgeons deal with more obese patients. The rates of obese patients with joint osteoarthrosis referring to orthopedic clinics for total hip or knee replacement have increased from 30% to 52% from 1990 to 2005 in USA. Jamsen E et al. in a Finnish study investigated the risk for periprosthetic joint infection among 7,181 patients who underwent total hip or knee replacement. They recorded 52 patients who experienced periprosthetic joint infection after a year from the primary surgery. Patients with normal BMI (≤25 kg/m²) had a risk for periprosthetic joint infection approximately 0.37%, but adults with BMI greater or equal to 30 kg/m² had a risk around 4.66%. In the same study, it seemed that the risk for periprosthetic joint infection is much more elevated when obesity coexists with diabetes mellitus.

Additionally, malnourished patients who proceed with total hip or knee replacement have extremely high risk for infection after surgery. Serum markers that indicate establishment of malnutrition like leucocyte count less than 1500 cells/mm³, levels of transferrin less than 200 mg/dl and albumin levels below 3.5 g/dl must be checked preoperatively. According to Paul Het al, the presence of one or more markers that indicate malnutrition are independent risk factors for infection. Among 123 malnourished patients who had total hip or knee replacement, 9 patients (7%) had a periprosthetic joint infection which is statistically significant compared with 3 patients (1%) among 252 patients with normal BMI, in the same study.

Smoking

Patients who smoke have increased risk to develop an infection after total joint replacement due to vasoconstriction, insufficient blood and oxygen supply, and deterioration of circulating antimicrobial agents to the surgical site. Patients with osteoarthrosis must be advised to avoid smoking at least for 4 weeks prior surgery.
**Anemia**

Preexisting iron-deficiency anemia during preoperative period as well as excessive blood loss during intraoperative and postoperative periods, prolong hospital stay, increase the need for blood transfusion as well as the risk for periprosthetic joint infection\(^1^9\).

Greenky M et al., published their data from 15,222 patients who underwent total hip or knee replacement due to arthritis\(^1^9\). A significant ratio of patients approximately 19.6% referred to the hospital with preoperative anemia. Anemia determined as Hgb<12 g/dl in women and Hgb<13 g/dl in men\(^1^9\). About 4.3% of patients with anemia experience periprosthetic joint infection compared with 2% of people with normal hematocrit\(^1^9\). The need for blood transfusion was higher in the group of anemic patients (44%) compared to patients with normal hematocrit (13.4%)\(^1^9\). Additionally, the duration of hospital stay was extended in those with anemia (4.3 days) compared with normals (3.9 days), explaining the highest rates of postoperative infections\(^1^9\).

**Intra-articular steroid injection increases the risk for periprosthetic joint infection?**

Six clinical cohort studies were analyzed by Wang Q et al. describing the effect of preoperative intra-articular injection as a palliative therapy for osteoarthritis among 1,474 patients who were operated for total hip or knee replacement\(^2^0\). They found that 14 patients had deep and 72 patients superficial infections\(^2^0\). Another study by Jourdan M et al. found that the risk for periprosthetic joint infection was obviously elevated, only when the intra-articular injection was held in 3 months interval prior primary surgery\(^2^1\). Orthopedic surgeons must wait at least 6 months after the last intra-articular injection to proceed to joint replacement according to the same study\(^2^1\).

**Colonization by Staphylococcus Aureus**

Staphylococcus Aureus (SA) is the most usual isolated pathogen in periprosthetic joint infections along with coagulase-negative staphylococci\(^2^2\). SA colonizes anterior nares, axilla, inguinal and other body sites\(^2^2\). According to Hacek et al., the nasal cavity must be screened for SA and a 5-day mupirocin decolonization protocol has to be demonstrated preoperatively for positive tests, as the risk for periprosthetic joint infection can be decreased by 4-folds\(^2^2\).

Due to the highly aggressive behavior of SA a full body decolonization especially at axilla and inguinal it is recommended to use an at home protocol with chlorhexidine body wash the night before and the morning of the surgery day\(^2^3\).

**Preoperative infections at distal sites**

Preoperative infections affecting other body parts like the oral cavity, urinary tract and skin could be misdiagnosed if they are not inspected carefully and can lead to periprosthetic joint infections postoperatively\(^2^4\).

Preoperative bacteremia due to poor oral hygiene can threaten joint prostheses with oral pathogens leading to infection\(^2^5\). Total joint replacement following tooth extraction sometimes needs prophylactic antibiotic therapy although recent evidence doesn’t support it\(^2^5\). Certainly, major orthopedic surgeries like total hip and knee replacement must delay at least one week after dental procedure to give the appropriate period for oral mucus to be replaced as it is the most important barrier for pathogens to penetrate local vessels and cause bacteremia\(^2^5\).

According to Cordero-Ampuero J et al., the risk for periprosthetic joint infection in patients with asymptomatic bacteriuria is negligible so there is no need for prophylactic antibiotic therapy\(^2^6\). Among 228 patients who submitted total hip replacement, 8 persons had asymptomatic bacteriuria diagnosed from urine cultures\(^2^6\). Only one person developed periprosthetic joint infection, but cultures from the surgical site showed different pathogens between the joint and urinary tract\(^2^6\).

The skin of people that are going to be treated with joint replacement due to symptomatic osteoarthritis has to be inspected by orthopedic surgeons for the presence of atrophy, ulceration and lymphedema\(^2^6\). Absolute contraindications to proceed in total joint replacement are cellulitis, erysipelas and skin folliculitis\(^2^6\). Total hip or knee replacement with existing local eczema or atopic dermatitis is not prohibited if the skin is maintained clean and dry\(^2^6\).

**Anticoagulant agents for prophylaxis from Deep vein thrombosis (DVT) prior surgery**

Patients with past medical history of artificial biological heart valve replacement, deep vein thrombosis, cardiac arrythmias e.g. atrial fibrillation, stroke, thrombophilia and other circulation illnesses receive anticoagulant therapy at home in the preoperative period\(^2^9\). Anticoagulant agents increase the risk for blood loosening, anemia, the formation of hematoma, insufficient closure and split of surgical wound, making ideal environment for excessive microbial contamination and spread of pathogens\(^2^5\).

According to McDougall C et al, the incidence of superficial and deep infections among patients who have total hip replacement is higher in those who received Warfarin postoperatively compared to those they didn’t\(^2^8\). The study group was composed by 89 patients who were under warfarin therapy and the control group included 179 patients who received aspirin 300 mg, 1 dose daily for 6 weeks\(^2^8\). The risk for superficial infection appeared to be significant higher in study group (13.5% in Warfarin group compared to 2.2% in aspirin group), as well as the risk of hematoma formation (28% in warfarin group compared with 4% in aspirin group)\(^2^8\). During the 5-year follow-up patients from the warfarin group had 9% danger to experience a deep infection compared to patients from the aspirin group who had only 2.2% risk\(^2^8\). When patients had to take Warfarin...
alongside with Low Molecular Weight Heparin (LMWH) the risk for periprosthetic infection was elevated cumulatively28. The effectiveness in thromboprophylaxis after total hip and knee replacement, as well as the ratio of postoperative complications between Warfarin and LMWH were studied in a retrospective study from the Global Orthopedic Registry (GLORY) among 3,755 patients in USA29. The results of this study showed that patients who received LMWH were more susceptible in postoperative complications compared with Warfarin group (6.2% bleeding in LMWH group compared with 2.1% in Warfarin group), (29.4% need for blood transfusion in LMWH group compared with 22% in Warfarin group)39. Postoperative periprosthetic infection found to be more common in LMWH group (1.6%), compared with Warfarin group (0.6%), and revision rates due to infection were higher in LMWH (2.4%) compared with Warfarin group (1.3%), too28.

Individualized treatment in patients who are submitted in orthopedic departments for total joint replacement, taking into consideration the pros and cons among all medications for thromboprophylaxis will certainly minimize complication especially the risk for periprosthetic infections.

### Intraoperative factors

#### Factors that originate from patients’ profile

Many studies support that the gender of the patients is a reasonable factor for the different ratio of postoperative complications between men and women30. Differences in skin characteristics, like skin pH, subcutaneous fat distribution, skin thickness, and circulating hormones are the more obvious reasons30. Skin normal flora differs between the two genders, as cultures from skin samples show that men are more prone in Staphylococcus Aureus colonization compared with women, and decolonization stills more difficult in men31. Lübbeke A et al., supported that periprosthetic joint infection is most common in non-obese men compared with non-obese women, 16.1-folds more common in obese women, but comparing obese with non-obese men, the infectious ratio were the same32.

Patient’s age seems to be another significant factor for infection following total hip or knee replacement. According to Soohoo et al., in a population study among 138,399 patients who submitted total hip arthroplasty in California from 1995 to 2005, patients between 55 to 74 years old are at greater risk to develop periprosthetic infection33. They supported that the reason for that is due to higher BMI of African Americans, intraoperatively compared with Caucasians34. Collins TC et al., support that higher risk for postoperative infections among African Americans is relevant to the prolonged duration of stay in hospital postoperatively35.

The socioeconomic status of patients is another risk factor for periprosthetic joint infection after primary surgery36. It is believed that patients with poor socioeconomic status, follow unhealthy lifestyle, and are hospitalized in poorer hygiene circumstances sometimes in hospitals with lack of antiseptic protocols in developing countries36.

#### Genetic susceptibility

A very interesting and pioneer research study by Zhou X et al., supports that the presence of C allele and C/C genotype for the MBL-550 Single-Nucleotide-Polymorphism (SNP), A/A genotype for the MBL-54 SNP, as well as G allele for MBL-221 SNP, increase the risk for periprosthetic infections among Caucasians37. On the other hand, the presence of G allele and G/G genotype for MBL-550 SNP decreases the risk for infections among Caucasians with total hip or knee replacement37.

### The parameter of high qualified orthopedic surgeons in well experienced medical centers

The incidence of periprosthetic infections is directly dependent on the level of specialization of the health center and high experience of the medical staff in total hip and knee replacements. Early symptoms and signs of infections are diagnosed easier from well qualified doctors and nursing staff who are familiar with large number of patients operated for osteoarthritis38,39. According to Kutz JN et al., the risk for periprosthetic infections is 50% lower between orthopedic surgeons who handle more than 50 total joint replacements annually, in hospitals with over 100 operated patients per year38,39.

#### Risk factors for infections associated with circumstances under the patient is operated

In a retrospective study by Chang C et al., among 3,081 patients who had total hip or knee replacement in Taiwan between 2002 and 2006, showed that general anesthesia is associated with higher risk for periprosthetic infection compared with epidural or spinal anesthesia40. General anesthesia causes peripheral vasodilatation diminishing blood and oxygen supply to the surgical site40. Additionally, opioids and drugs used in general anesthesia suppress the defending mechanisms of immune system42. On the other hand, epidural and spinal anesthesia maintain postoperative angesia that bans peripheral vasodilatation and keep enough supply of antimicrobial agents in the operated joint40.

The role of duration of the surgical procedure in total hip and knee replacement studied from Dicks K et al., in a retrospective study from 43 hospitals in USA41. Among 42,187 total knee replacements, Dicks K et al, found that when the duration of operation was up to 1 hour the possibility for infection was 50% lower compared with operations ranged between 64 to 106 minutes (median
time 83 minutes)\textsuperscript{41}. In the same study, among 25,531 total hip replacements the risk for periprosthetic joint infection was 1.11\% higher in patients who operated between 61 to 105 minutes (median time 80 minutes) compared to operations that exceeded more than 105 minutes\textsuperscript{41}. Obviously, the duration of operation is a more decisive factor for infections in total knee replacements compared with total hip replacements\textsuperscript{41}.

Caution to traffic control in the operating room is another parameter that can affect the infectious risk\textsuperscript{42}. Unnecessary overcrowded rooms by staff that moves inside and outside the room, with frequent opening and closing of the doors, may increase the inoculation of airborne microbes in the surgical site\textsuperscript{42}.

The type of air circulation and ventilation in orthopedic theaters for prevention of postoperative infections, was examined by Gastmeier P et al.\textsuperscript{43}. Among 75,000 total knee replacements and 120,000 total hip replacements in four countries (Germany, New Zealand, UK, USA) they found that Laminar flow system (air moves in a single direction along parallel flow lines) is not superior in prevention of postoperative infections compared with Plencent system (pressure greater inside than outside room) and Ex-flow system (air moves down and outwards the room)\textsuperscript{43}.

The type of prostheses used and how they impact on infectious rates

The bearing surface of the selected prosthesis in total hip replacements is crucial for complications like increased levels of serum metal ion, aseptic lymphocyte-dominated vasculitis-associated lesions and periprosthetic infections\textsuperscript{44}. A very recent study by Huang P et al. presented data from the Australian Orthopaedic Association National Joint Replacement Registry, comparing infection rates between Metal on Metal (MOM) and other bearing surfaces like Metal on Polyethylene (MOP), Ceramic on Metal (COM), Ceramic on Polyethylene (COP) and Ceramic on Ceramic (COM)\textsuperscript{44}. Among 200,076,879 patients, editors found that, revision for infection of MoM surfaces in primary hip replacement was 2.5\%, compared to 0.8\% for other type of prostheses\textsuperscript{44}. This is one of the reasons MOM bearing surfaces are rarely used nowadays\textsuperscript{44}. According to Huang P et al., the lowest risk for periprosthetic infections appears in Ceramicized Metal on Polyethylene and COP prostheses, with MOP and COC having an intermediate risk between MOM and COM\textsuperscript{44}.

Ever since, unicompartmental knee replacement versus tricompartmental total knee replacement was another matter of issue between orthopedic surgeons. Furnes O et al., studied the 10 -year survival probability between the two techniques from 1994 to 2004 in Norway\textsuperscript{45}. They found that unicompartmental knee replacements have significant lower risk for infections compared with tricompartmental knee replacement (relative risk was 0.28 with 95\% confidence interval, 0.10 to 0.74) $p=0.01$\textsuperscript{45}. The risk for infection may be one third in unicompartmental compared with tricompartmental knee replacements\textsuperscript{46}. However, unicompartmental knee replacements are not preferred due to higher risk for other complications, like pain which needs revision, aseptic loosening of the tibial and femoral components and periprosthetic fractures\textsuperscript{45}.

An article by Poultsides LA et al., showed that when either unilateral or staged bilateral within one-year knee replacement was preferred, the infection risk for in-hospital infection was higher compared with one day bilateral total knee arthroplasty\textsuperscript{47}.

Engesæter L et al., collected data from the Norwegian Arthroplasty Register for the period between 1987 and 2003, investigating the role of cementation of total hip arthroplasties in infection rates\textsuperscript{48}. Among 56,275 patients with osteoarthritis who had total hip replacement, 252 revisions due to infection were recorded\textsuperscript{48}. Comparing risk of infection between uncemented and cemented arthroplasties with antibiotic-loaded cement, no differences were observed\textsuperscript{48}. On the other hand, cemented total hip arthroplasties without antibiotic had 1.8 times much more danger for infection\textsuperscript{50}. Every time that total hip arthroplasties are chosen to be cemented, orthopedic surgeons must ensure that they use antibiotic-loaded cement\textsuperscript{48}.

Perioperative antibiotic coverage

Perioperative antimicrobial prophylaxis consists of preoperative, intraoperative and postoperative prevention strategies against periprosthetic infections\textsuperscript{49}. Current data support the use of cefazolin (or cefuroxime) at a dose of 2 g/day (3 g for obese patients), between 30 to 60 minutes before the surgical incision. Intraoperative redosing is essential when the operation exceeds more than 4 hours and blood loss is over 2 liters\textsuperscript{49}. Administration of cefazolin stops with the end of first postoperative day\textsuperscript{49}. In the case there is known allergic reaction (type 1) beta-lactams or Methicillin-resistant Staphylococcus aureus colonization the recommended alternatives are clindamycin and vancomycin\textsuperscript{49}.

According to Sewick A et al., vancomycin can’t be the first line perioperative antimicrobial prophylaxis in colonized patients who are not MRSA resistant\textsuperscript{50}. Vancomycin is less effective compared with beta- lactams, needs more time to diffuse in tissues\textsuperscript{50}. Co-administration with cefazolin showed poor results in periprosthetic infections, but reduced infection rates by MRSA\textsuperscript{50}.

Skin preparation and draping

Current data support the use of chlorhexidine for skin preparation in the orthopedic theatre to sterilize the incision site\textsuperscript{51}. Bosco JA et al. showed that chlorhexidine is a superior antimicrobial agent compared with iodine (Bedatine) and alcohol-based solutions\textsuperscript{51}.

Draping of surgical site with antiseptic agents can further deteriorate the risk for superficial and deep infections. A systematic review by Webster J et al., showed that adhesive
plastic skin drapes, do not reduce infection rates. On the contrary they seem to be less protective against pathogens according to new evidence, disputing previous studies\(^{52}\).

**Postoperative risk factors**

**Persistent drainage from surgical wound**

Persistent wound drainage, especially more than 48 hours postoperatively, must be monitored and make medical staff suspicious for complications like periprosthetic infection\(^{53}\). Surgical sites that continue to drain between 5 to 7 days after operation, are 12.5 times more susceptible to develop periprosthetic infection, compared to clean and dry sites\(^{54}\). Every next day the wound continues to drain, the risk for periprosthetic hip infection can reach 42% and 29% for periprosthetic knee infection\(^{55}\).

Medical conditions that delay wound healing and exceed wound drainage are diabetes mellitus, rheumatoid arthritis, smoking, old age, obesity, malnutrition and hypoalbuminemia\(^{56}\). The use of LMWH, for postoperative anticoagulation prophylaxis also increases the risk for delay drainage compared with aspirin and warfarin\(^{57}\).

**Postoperative distant infections**

According to Pulido L et al, among 9,245 persons who submitted total hip or knee arthroplasty, patients with postoperative urinary tract infection had 5-folds more risk to develop periprosthetic joint infection\(^{57}\), Iorio R et al., found increased risk for urinary tract infection and postoperative knee infection after primary arthroplasty in patients who were catheterized with indwelling catheters compared with straight catheters\(^{58}\). Urinary catheter removal is another significant factor for infections and must no delay\(^{58}\).

Postoperative nosocomial pneumonia is another complication that may lead to periprosthetic joint infection. According to Parvizi J and Pulido L, the incidence of nosocomial pneumonia after total hip and knee arthroplasty is 0.1% and 0.15%, respectively\(^{59,60}\). Streptococcus pneumonia being the most common pathogen isolated in pneumonia, can settle on hip or knee prostheses and cause infection\(^{61}\). Early signs and symptoms of postoperative pneumonia must early recognized by clinical and imaging examination and treated with appropriate medications\(^{51}\).

During immediate postoperative period, the anatomic skin barrier is disturbed. Postoperative subcutaneous hematoma formation creates ideal circumstances for pathogens to develop. Skin over surgical incision has to be clean and dry until sutures removal\(^{62}\).

Urinary tract infection, postoperative pneumonia, skin infections and non-well sterilized catheters for intravenous drug administration, can be the reason for postoperative bacteremia\(^{63}\). Murdoch Dr et al., defined periprosthetic joint infection due to postoperative bacteremia in those cases that happened 1 year after implantation\(^{64}\). Staphylococcus aureus is the most common pathogen found in postoperative bacteremia\(^{64}\). However, hospital-acquired is less aggressive compared with community-acquired staphylococcus aureus and difficult to distinguish whether joint site is the primary or secondary source of infection\(^{64}\).

**Postoperative cardiac complications**

Cardiovascular system consists of the pump and vascular network that transports blood, oxygen, nutrients, antimicrobial cells and molecules in the hole body, increasing the risk for periprosthetic infection when it functions insufficiently\(^{57}\). According to Pulido L et al., atrial fibrillation and infarction of the myocardium have 6.2 and 20.4 odds ratio, respectively, as independent predictors for periprosthetic infection\(^{57}\).

**Length of hospital stay and early readmissions due to infection**

The extended length of hospital stay increases patient’s exposure in nosocomial microbes and the risk for periprosthetic joint infection after total hip or knee replacement.

In California (from 2009 to 2011), 4.29% of patients were readmitted with 33.02% recorded readmissions due to infection\(^{65}\). In Florida (from 2009 to 2013), 4.7% of patients were readmitted with 33.39% of patients diagnosed with septic arthritis\(^{55}\). In Massachusetts (from 2010 to 2012), 3.92% of patients were readmitted with 35.2% for periprosthetic joint infection\(^{65}\). Staphylococcus Aureus was the most usual cultivated pathogen from septic samples\(^{65}\). According to Barad SJ et al., the average hospital stays between 2009 and 2014 shortened from 2.0 to 1.3 days per year\(^{66}\). More patients are discharged directly at home with outpatient physical rehabilitation (from 9% to 53%) and less patients choose to move in a rehabilitation facility (from 41% to 1%)\(^{68}\). Postoperative readmission rates after 30 days still the same and savings were improved to $3,245 per patient\(^{66}\).

**Post-discharge factors**

**Postoperative dental procedures**

Daily dental manipulations like brushing and flossing as well as bad oral hygiene, cause transient bacteremia by oral microbes of the flora\(^{67}\). Dental procedures following total hip or knee replacement has been a long-standing issue between the American Academy of Orthopedic Surgeons (AAOS) and the American Dental Association (ADA) for being a risk factor for postoperative infections. The use of antibiotic prophylaxis prior hip and knee arthroplasties stills controversial in several case studies\(^{67}\). Berbari EF et al., found among 339 patients with total hip or knee replacement, that administration of antibiotic prophylaxis does not decrease the risk for postoperative infection prior a high-risk or low-risk dental procedure and must give only to specific patients\(^{68}\).
Orthopedic surgeons, dentists and infectious disease specialists recommended that “antibiotic prophylaxis is not indicated for most dental patients with total joint replacements”, but AAOS redefined that “…clinicians have to consider antibiotic prophylaxis for all total joint replacement patients prior to any invasive procedure that may cause bacteremia”.

Orthopedic surgeons must encourage their patients to keep high quality oral hygiene. Meanwhile, more case studies have to be accomplished to define safe postoperative period for dental procedures as well as the necessity of antibiotic prophylaxis, due to the lack of evidence.

**Total hip or knee arthroplasty in patients with history of periprosthetic joint infection**

Hip and knee osteoarthrosis being a degenerative and progressive disease is often detrimental for more than two joints at the same time in a single patient. People with multiple joint arthroplasties may have elevated risk for infection after a subsequent joint replacement. Patients with past medical history of periprosthetic joint infection have 19-20% more risk to develop a new infection in a future joint replacement. Abblitt W et al., in a retrospective study, reviewed 167 patients treated with revision surgery due to periprosthetic joint infection, from 2003 to 2014. Among these patients, 76 had multiple joint arthroplasties due to osteoarthrosis. A significant number of this group (10/76), approximately 13%, operated for periprosthetic joint infection in a second location. Abblitt W et al., found a close association between positive blood cultures before joint replacement and the risk for future periprosthetic infection. In bacteremic patient the risk was 20% and in non-bacteremic patients 5.2%. Patients with multiple arthroplasties planned for future joint replacement, must thoroughly be checked for septic loosening of their prostheses and positive blood cultures prior operation, especially if they have medical history of joint infection.

**Conclusion**

Every patient submitted for total hip or knee arthroplasty is exposed in various independent risk factors for postoperative joint infection. Some of them are patient-based factors being irreversible like the gender and race. Other ones are under the sphere of comorbidities that follow the patient like cardiovascular diseases and obesity which could be controlled. Improvement of the quality of antiseptic prophylaxis like adequate antibiotic prophylaxis and preferred type of prosthesis can also impact the risk for infection. A wide spectrum of factors, that have been analyzed above, affect the health of the patient from prior, during and after a total hip or knee joint replacement. We suggest that orthopedic surgeons in cooperation with infectious practitioners have to design population-based cohorts in order to develop evaluating infection scores. Tools like FRAX score for osteoporosis and Framingham Score for Heart disease risk, are excellent paradigms for a new tool for periprosthetic joint infections estimating the significance of each risk factor in a total risk score. Patients may benefit from such a pioneer tool as they will be categorized in high and low risk groups for periprosthetic infections and improve their score under medical advice.

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