

PREVENTION OF PROSTHETIC JOINT INFECTION IN TOTAL HIP AND KNEE ARTHROPLASTIES: EVIDENCE BASED RECOMMENDATIONS.

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SUMMARY

Prosthetic joint infection is a dreaded complication of Total Joint Arthroplasty. Prevention, which is far more cost effective, should be of paramount importance to the arthroplasty surgeon. Proper patient selection and preparation as well as strict asepsis and antisepsis are the basic principles of prevention.

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INTRODUCTION

Prosthetic Joint infection (PJI) is a dreaded complication of total joint arthroplasty (TJA) that carries significant morbidity and mortality to patients. The reported incidence of PJI is 1-2% for total knee arthroplasty (TKA) and 0.3-1.3% for total hip arthroplasty (THA); following revision arthroplasty however, it is as high as 5-6% and 3-4% for TKA and THA respectively.¹ This complication leads to prolonged hospital stay, readmission, repeated surgeries, loss of work hours and sometimes death. Mortality following PJI has been reported in some series to be as high as 7% in patients undergoing two stage revisions.²

Worldwide, the cost of treatment of this condition is enormous. In Nigeria, treatment can be a huge burden on patients, as most times, they have to pay out of pocket for. The cost of primary TJA in Nigeria varies between 1-3 million Naira per joint, and the cost of revision TJA can be up to four times as high.

TJA is now increasingly offered to orthopedic patients in Nigeria many of whom are young patients with avascular necrosis (AVN) of femoral

head secondary to sickle cell haemoglobinopathy. The exact number of TJA done in Nigeria is unknown as there is no central database. The exact incidence of PJI in these patients is still unknown. However, in our centre, no case of PJI has been recorded among 71 joints operated so far in past three years. Of the two cases of PJI we have treated so far, one was performed in an Indian hospital while the other was performed in a Nigerian hospital.

As TJA is increasingly performed, it is imperative that orthopedic surgeons and indeed the entire orthopedic community are aware of the methods and protocols for prevention of prosthetic joint infection with emphasis on issues peculiar to our environment. There are various practices for prevention in the literature, with different levels of evidence for recommendation. We hereby review the best evidence for these practices and present our protocol at University College Hospital (UCH), Ibadan with the aim of providing safe and cost-effective recommendations.

CAUSATIVE ORGANISMS

The most commonly implicated organisms in PJI are *S. aureus*, *S. epidermidis* and coagulase negative staphylococcus (CNS) (35).+ At UCH, Ibadan the commonest organisms causing orthopedic implant related infections is *S. aureus*.

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Many of the organisms responsible for PJI are developing antibiotic resistance with methicillin resistant staphylococcus aureus (MRSA) being the most notable cause of PJI. Once the organisms form biofilms on the prosthetic surface, they become virtually unreachable by systemic antibiotics and the host immune system. This further underscore the need for prevention.

PATIENT FACTORS

Patient co-morbidities are among the most important risk factors for PJI. As TJA is an elective procedure, it is mandatory to identify these risk factors and optimize the patients before surgery. The evaluation of these patients includes a thorough history, a meticulous physical examination and laboratory investigations.

Screening for infection

The presence of a local infection such as in the skin, subcutaneous tissue or deep in the joint can lead to direct seeding of the prosthesis and is an absolute contraindication to total joint arthroplasty.⁶ Also, a systemic infection can lead to hematogenous seeding of the prosthesis and lead to a PJI.⁽⁷⁾ It is therefore recommended that TJA be delayed until all possible sources of infection are identified and treated. A 6 to 12-month interval between eradication of a septic arthritis and TJA is recommended.⁸

MRSA carriers are identified by screening and have nasal mupirocin and a five-day chlorhexidine wash for decolonization. Patients with athletes' foot on either limb are also identified and treated with an antifungal at least 3 weeks before surgery. A full blood count (FBC), C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR) may suggest an infection; so also, a urinalysis.

Urine cultures are only requested if a urinary tract infection (UTI) is suspected. Symptomatic UTI in association with urinary bacteria count greater than 1×10^3 /ml and leucocyte count greater than 1×10^4 /ml should be treated with appropriate antibiotics, and repeat culture should confirm eradication of infection before joint replacement is performed. Asymptomatic bacteriuria should not delay surgery but should be treated if bacteria count is greater than 1×10^3 /ml.⁹ Recurrent UTI in older men is likely due to underlying urinary outflow obstruction. If there are lower urinary tract symptoms, the patient should have a urology

review and appropriate treatment before TJA. Therefore, our patients routinely have a FBC, urinalysis and nasal swab culture.

Previous open joint surgery or previous joint trauma

Previous surgery or trauma involving the joint are associated with increased risk of PJI. This may be due to local wound healing concerns, difficulty with dissection and potential prior contamination, all of which may predispose to development of a PJI. The International Consensus Group (ICG) on prevention of PJI, recommends that the surgical history be documented, the local wound environment analyzed and the surgical approach and techniques be modified.⁷

Skin Problems

It is important that the skin is intact at surgery. Active skin lesions, psoriasis, chronic venous ulcers, eczema, increase bacteria joint infection and PJI.^(10,11) Psoriasis, eczema and other skin lesions may require dermatological review and treatment with surgery planned for when the skin condition is improved. Patients with chronic venous ulcers should be reviewed by a vascular surgeon and treated appropriately before surgery. There is a risk of recurrent ulceration following lower limb joint replacement, and advice on optimum perioperative management should be sought from a vascular surgeon.

Pre-morbid Medical Problems

Diabetes Mellitus

The incidence of type II diabetes is increasing worldwide. Nigeria is not exempt from this problem. Uncontrolled diabetes is linked with surgical site infections (SSI) including PJI.^{12,13} The ICG recommendation is to control diabetes before surgery (HbA1C of $<7\text{g/dl}$ or $\text{FBS} < 180\text{mg/dl}$).^{14,15} Therefore, all patients are screened with a fasting blood sugar (FBS) and two hours post prandial (2HPP) blood sugar, while only diabetic patients have glycated hemoglobin (HbA1C) checked. There is also evidence that perioperative hyperglycemia increases the risk of PJI and this should be monitored and controlled perioperatively.¹⁵ Chronic diseases such as chronic renal failure and liver disease increase the risk of PJI. These conditions could be associated with low platelets, malnutrition and anemia that may necessitate allogeneic blood transfusion and its attending risk.¹⁶

Rheumatoid arthritis and DMARDs

Earlier studies reported an increased risk of SSI and PJI with continual use of disease modifying anti rheumatic drugs (DMARDs) in patients with rheumatoid arthritis.¹⁷ However, a more recent study showed no increase in SSI in these patients.¹⁸ As a result, there are no clear recommendations; the ICG recommends cessation of DMARDs according to a schedule¹⁹, while the WHO does not recommend routine cessation.²⁰ It is best to work collaboratively with consultant rheumatologist to optimize patients perioperatively.

HIV Infection

The risk of PJI in patients with HIV is as high as 14%.²¹ However, to our knowledge, there are no recommendations on ideal CD4 count before surgery in these patients. It however seems prudent to obtain virologist input on the optimum timing of surgery and perioperative management of these cases.

Nutritional status

The problems of malnutrition include prolonged hospital stay,²² delayed wound healing,²³ persistent wound drainage and susceptibility to infection.^{24,25} Serum albumin, transferrin and prealbumin are some laboratory parameters for accessing malnutrition. However, only preoperative serum transferrin has been shown to correlate with delayed wound healing²³ while serum albumin <34g/L and total lymphocyte count of <1200cells/ml are predictors of post operative adverse outcomes.²² Clinical evidence of malnutrition is therefore sought in all patients and susceptible individuals are screened with albumin, transferrin or prealbumin.

Morbid Obesity

This carries an increased risk for all complications including PJI.^{26, 28} This may be due to longer operating time, larger incisions, difficult access, associated comorbidities and need for blood transfusion. A BMI of > 40kg/m² carries an unacceptable risk for PJI²⁹ and such patients should have weight reduction before TJA.

Depression

Patients with depression have an increased production of IL-6 which causes release of corticotropin releasing hormone (CRH) and then adrenocorticotrophic hormone (ACTH). ACTH causes release of cortisol which inhibits the

immune response.³⁰ It is recommended that TJA be delayed until the underlying cause is identified and addressed.³¹

Smoking

Smoking cessation prior to surgery has been shown to decrease the risk of wound complications and SSI.³² Although the optimal period of cessation is not well established, cessation 6-8 weeks before surgery has been suggested.³²

PERIOPERATIVE PRACTICES

Preoperative Showering

A systematic review on preoperative shower found no clear relationship between preoperative Chlorhexidine gluconate (CHG) shower and decrease in SSI.³³ Some other studies however, have shown it to decrease MRSA burden and subsequent SSI.^{34,35} The CDC and ICG endorse this practice at least 24 hours prior to surgery.^{36,37}

We recommend preoperative shower if patients are admitted earlier than the day before surgery and if they attend on the day, then antiseptic washing for a day before coming to hospital. Antiseptic soap may suffice.

Hair removal

There is no proven benefit of shaving to decreasing SSI.³⁸ If this is carried out in hairy individuals especially during THA, it should be done just before skin preparation, preferably in the induction room with a surgical hair clipper with disposable clipper head.³⁹ We do not practice or recommend routine shaving for reducing infection risk. However, we shave the surgical field if necessary, to ensure an adherent wound dressing and secure wound seal.

Operating room environment

Various studies have demonstrated the importance of decreasing airborne bacteria in theatre.^{40, 43} This can be achieved by ventilation systems, limiting operating room (OR) traffic and personnel, theatre behavior and adequate terminal cleaning of the operating room.⁴⁴

Dedicated Orthopaedic Theatres

TJA involves the implantation of large metal and plastic implants into bone and tissues a process that can increase the virulence of bacteria more than 100 thousand times.⁴⁵ It clearly cannot be

done in any theatre. The orthopaedic theatre used for TJA should not be shared with ENT, obstetrics and gynaecology, general surgery or urology where dirty surgery is the norm and unacceptable contamination is almost inevitable. The theatre should be large enough to accommodate all staff and equipment required for TJA. It should be adequately ventilated and well-lit. Equipment not required should be removed to reduce crowding as well as reduce generation of bacteria carrying particles. There should be running tap water in the scrub area for hand skin prep.

There should ideally be an anesthetic induction room adjoining the main theatre area where patients are set up and activities such as shaving can be carried out before the patient is moved into theatre. Patient positioning and application of supports to maintain the position can be done at this stage as can the application of plastic exclusion drape and preliminary skin preparation before proceeding into theatre.

Team Huddle and WHO Safety Checklist

All staff should come together to discuss the list before the start of surgery. The list is reviewed, and each case is discussed using the WHO safety checklist. This ensures patient safety, maximizes efficiency while reducing the risk of complications including PJI.

Operating Room Traffic

The most commonly implicated bacteria in SSI are derived from skin flora, both patient and theatre staff. Studies have correlated the number of personnel in OR with bacterial count.²⁶ Increased traffic in and out of the OR also increases turbulence, particle and bacteria count.⁴⁶ However, there is no evidence on the optimal number of staff or door openings. The ICG recommendations are to limit the OR traffic, have all implants in the OR before start of surgery, use telephone to obtain information instead of entering the OR and avoid exchange of scrubbed personnel during surgery.⁴⁴ **We recommend one surgeon with a maximum of three assistants, two anesthetists, two scrub nurses and one circulating nurse.**

Laminar Flow

The premise of the laminar flow system is that it filters the air coming into theatre of bacteria carrying particles thereby reducing the likelihood

of joint infection from seeding of the wound by these bacteria carrying particles. This has been routine practice for many decades in many countries in the world where TJA practice is well established.

Recently evidence is emerging that challenges this presumed benefit of laminar flow ventilation systems over conventional ones. Some studies have shown an increase in rate of SSI while others have shown a decrease; depending on whether vertical or horizontal, placement of personnel and the study design.^{40,47,50} A review of the New Zealand TJA registry in 2011 even showed an increase in rate of early deep infection in hip arthroplasty.⁵¹ Furthermore a well-designed study has failed to show any difference in the incidence of infection with the use of laminar flow systems when compared with conventional systems.⁵²

We use a conventional ventilation system and a High Efficiency Particulate Air(HEPA) filter.

Operating room humidity and temperature is important in our environment as a tropical country. The temperature should be kept at 20 degrees centigrade and low humidity.

Terminal Cleaning

The ICG recommends that the theatre floor, surfaces and furniture, operating lamp and any portable equipment in the OR be cleaned after every surgery.⁴⁴

Antibiotic Prophylaxis

First generation cephalosporins e.g cefazolin or second generation cephalosporin e.g Cefuroxime are the recommended prophylactic antibiotics.^{53,54} This is because of the good gram positive bacteria coverage, cost effectiveness and excellent distribution.⁵³ The AAOS and ICG recommendation on vancomycin use is in MRSA carriers, penicillin anaphylaxis, institutionalized patients and healthcare workers.⁵³ The administration is within 1 hour of incision; however, extended infusion time antibiotics such as fluoroquinolones and vancomycin should be started sooner.⁵⁵ If the surgery lasts more than 3 hours, a further dose should be given. Multiple guidelines recommend stoppage within 24hours.^{55,56} It is paramount to observe all these precautions in preventing infection rather than continuing antibiotics beyond 24 hours as this confers no further gains in preventing infection and instead increases the risk of generating resistant organisms.⁵⁵

Skin preparation and gowning – Surgical staff.

The head should be covered with the hair tucked in. There should be no fringes showing. Disposable face mask should be worn and both nose and mouth should be covered. The face mask should be changed for each procedure.

Surgical hand and forearm scrub by the scrub staff is an essential part of the surgical routine that has been shown to reduce the risk of SSI and has strong recommendation from all major guidelines generating institutes and orthopedic consensus groups.⁵⁷ The aim is to clear the skin of transient flora as well as reduce the volume of resident flora. The skin preparation should involve both hands, forearms, and elbows. It requires running tap water for effective skin preparation. The use of large basins of stagnant water for surgical hand skin prep is not acceptable and TJA should not be carried out in theatres without running tap water. Recommendation for hand prep is aqueous antiseptic soap. Chlorhexidine gluconate or Povidone iodine are commonly used.

The skin should be prepared using antiseptic soap and soft disposable brush, paying attention to the nails and interdigital clefts. It is advisable that surgical staff should not keep nails and artificial nails need to be removed as should finger and wrist jewelry. The area under the fingernail should be cleaned using a nail cleaner or a brush to ensure that there is no dirt. The skin cleansing should carry on past the elbow with the hand and forearm flexed and under the tap and elbows dependent. There is evidence that skin prep as described for 3 minutes or more results in eradication of transient bacteria and reduces resident bacteria by >90%. The hand and forearms are dried with the arms in the aforementioned positions and sterile disposable gowns are next worn with strict aseptic precautions followed by double gloving. Subsequent hand preparation can be carried out using this process each time or alcohol-based antiseptic hand rub can be used. The addition of alcohol to the antiseptic appears to increase its efficacy and this combination is recommended.

Changing of gloves should be considered after surgical site skin prep and draping but before application of plastic drape and at key stages of the surgery including reaming and rasping, handing implants and wound closure.⁵⁸ Glove should also be changed when indicator inner gloves reveal

perforation has occurred. Gloves should be changed when surgery lasts more than 2 and half hours.⁵⁹

Skin Preparation and Draping-Patient

CHG and povidone iodine are acceptable antiseptics for skin preparation as there is no evidence for one agent over another for prevention of SSI.^{37,60} While CHG in alcohol is superior to povidone iodine alone⁶¹, there is no difference between the two when each is combined with alcohol.⁶¹ Therefore the CDC and ICG recommend that irrespective of which of the 2 agents is used, alcohol must be added.^{36,37}

In our practice, after positioning the patient, we wash the entire limb and adjoining areas with a sterile gauze soaked in CHG. **Our recommendation is to prepare the whole limb including the foot⁶³.**

After the surgical team are gowned, the whole limb is again prepared twice with 10% povidone iodine in alcohol starting with the operation field and ending with the foot. The draping is done with strict aseptic precautions to expose the operation field with the leg draped free. An iodine impregnated incise drape is also used over the operation site to prevent contamination. Although a systematic review had found no evidence that plastic adhesive drapes reduce rate of SSI³³, a large comparative study recently showed iodine impregnated incise drapes to have a cost effective benefit in reducing SSI compared to the non-iodine impregnated ones.⁶² *Considering that many theatres in Nigeria do not meet strict aseptic standards, we recommend the routine use of iodine impregnated incise drapes.*

Surgeon arthroplasty volume and Surgical Duration

Several studies have clearly demonstrated that decreasing surgical duration decreases the rate of SSI.^{8,31,63,64} The number of TJA done by a hospital and the number done by the surgeon per annum have a bearing on infection rates with low volume hospitals and low volume surgeons having higher rates of PJI.⁶⁵ **It is recommended that solitary surgeons carrying out low volume occasional joint replacement, should be encouraged to visit larger volume centers to ensure that both their surgical skill and surgical volume are improved.**

Blood conservation

Because perioperative allogenic blood transfusion is a risk for SSI and PJI^{19,66}, it is important to maximize blood conservation. Interventions may include identifying and treating the cause of anaemia, meticulous haemostasis during surgery and use of intravenous or topical tranexamic acid.^{67,68} In our practice, we administer 1g of i.v tranexamic acid routinely unless contraindicated one hour before incision. While closed drains are important to prevent hematoma collection, suction drains have been shown to increase transfusion rate⁶⁹ which may increase the risk of SSI. Therefore, the ICG recommendation is to remove drains if used, 24 hours after.⁷⁰ **We tend to avoid drains, preferring to achieve meticulous haemostasis and close the wound in layers without drainage.**

Pulsatile Lavage

A systematic review found pulsatile lavage to reduce SSI compared to standard irrigation.⁷¹ We routinely use pulsatile lavage before placement of prosthesis and before wound closure in both THA and TKA. There is low quality evidence that intra-operative irrigation with dilute antiseptic solution (Povidone iodine 0.35% or chlorhexidine 0.05 %) can reduce the risk of PJI.⁷² This may be considered in addition to saline jet lavage irrigation in patients at high risk of infection such as Haemoglobinopathy, patients with inflammatory arthritis and patients with diabetes.

Antibiotic loaded cement

Most, including all cement in our practice are already loaded with gentamicin. There are studies that suggest these may be effective.^{73,74} However routine use may lead to resistance.^{75,76}

POSTOPERATIVE CARE

Wound Management

There is no evidence to support one closure technique over another. The ICG recommends monofilament non-absorbable sutures be used for skin closure.⁷⁷ It is important to eliminate dead space by closing the wound in layers. We use skin staples in our practice. The choice of wound dressing has an influence on wound healing.⁷⁸ Various studies have shown hydrofibre or hydrocolloid dressings especially alginate hydrofibres to decrease blister formation which may decrease SSI and PJI when compared to routine gauze and adhesive dressings.^{77,79}

Application of wound dressing under stretch can cause shearing of the skin layers thus predisposing to blister formation around the wound. This can increase the risk of wound and joint infection. **The dressing should be sterile, absorbent, impermeable and should be gently applied without stretch.**

Prolonged hospitalization increase the risk of SSI including nosocomial infections with antibiotic resistant organisms.⁸⁰ Efforts should be made to reduce the length of stay in hospital by pre-operative optimization of co-morbidities, pre-operative education and early mobilization by physiotherapy and adequate pain control using enhanced recovery protocols. Length of stay following uncomplicated surgery should not be longer than 4 days.

Management of the draining wound

Drainage from the wound lasting more than 24 hours should be managed with any of reinforced dressings, compressive wraps, negative pressure wound therapy, immobilization or absorbent dressing. Anticoagulants should also be stopped. If the drainage persists for more than 5 days, the wound should be reopened, irrigated, debrided and closed.⁷⁷

Patients with joint replacement undergoing procedures known to generate transient bacteremia such as dental or urologic surgery should be given prophylactic antibiotic to protect the joint from hematogenous seeding. Also if they have any active local or systemic infection in this should be promptly treated for the same reason.⁴³

INFECTION SURVEILLANCE

PJI Infection surveillance is important and any case of PJI particularly in the early post-operative period should be thoroughly investigated as this is likely to arise from inoculation intraoperatively. Adherence to these infection prevention guidelines should be monitored through regular audit of adherence to the guidelines.

CONCLUSION

A prosthetic joint infection is a nightmare. The entire surgical staff should be aware of the various methods at prevention, the most important being proper patient selection/optimization and asepsis/antiseptis.

TAKE HOME MESSAGE

- Prevention of PJI infection is far better than attempts at its treatment and it is everyone's responsibility.
- Adoption of these recommendations does not involve significant expense but a change of attitude.
- Greater Collaboration with other specialist colleagues is needed to optimize patients undergoing arthroplasty.
- Theatre team practice and behavior is one of the most important factors in reducing infection risk.
- Active peri-operative management including pre-operative optimization, optimum pain management and early mobilization is important in ensuring patients do not stay longer than necessary in hospital.
- Regular Audit and surveillance to reduce PJI infection should be instituted.

ABBREVIATIONS:

FBC: Full Blood Count

CRP: C-Reactive Protein

ESR: Erythrocyte Sedimentation Rate

ICG: International Consensus Group

HbA1C: Glycated Hemoglobin

DMARDs: Disease Modifying Anti Rheumatic Drugs

HIV: Human Immunodeficiency Virus

CD4: Colony of Differentiation 4

BMI: Body Mass Index

CRH: Corticotropin Releasing Hormone

ACTH: Adrenocorticotropic Hormone

CDC: Centre for Disease Control (America)

ENT: Ear, Nose and Throat (surgery)

WHO: World Health organization

AAOS: American Academy of Orthopedic Surgeons

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