# Improved Detection Methods For Infected Hip Arthroplasty

Essay

Submitted for Partial Fulfillment of Master degree in Orthopaedic Surgery

By

**Mohamed Samir Safy Amr**
M.B.B.Ch.

Supervised by

**Prof. Dr. Amr Khairy Mahmoud**
Professor of Orthopaedic Surgery
Ain Shams University

**Dr .Sherif Mostafa Abd Eldayem**
Lecturer of Orthopaedic Surgery
Ain Shams University

Faculty of Medicine
Ain Shams University

٢٠١٢

بسم الله الرحمن الرحيم

قَالُوا سُبْحَانَكَ لاَ عِلْمَ لَنَا
إِلاَّ مَا عَلَّمْتَنَا إِنَّكَ أَنتَ الْعَلِيمُ الْحَكِيمُ

صدق الله العظيم

سورة البقرة الآية (٣٢)

# Acknowledgment

*First and foremost, praise and thanks be to the Almighty (ALLAH) for his limitless help and guidance and peace be upon his prophet.*

*I would like to express my deepest thanks, gratitude and profound respect to my honored professor, Prof. Dr. Amr Khairy Mahmoud ,Professor of Orthopedic Surgery, Faculty of Medicine, Ain Shams University, for his meticulous supervision. I consider myself fortunate to work under his supervision. His constant encouragement and constructive guidance were of paramount importance for the initiation, progress and completion of this work.*

*No words can describe the effort and help of Dr. Sherif Mostafa Abd Eldayem , lecturer of Orthopedic Surgery ,Faculty of Medicine, Ain Shams University, for his great support, facilities, careful supervision and continuous advice and guidance which were cornerstone for this work and helped me to overcome many difficulties.*

*Last but not least, I would like to express my endless gratitude to my family, especially my father and my mother and also my friends for their everlasting love, care and support.*

**Mohamed Samir Amr**

# List of Contents

# Table of Figures

# Tables



# Table of Abbreviations

| Abbreviation | Meaning |
|---|---|
| $^{111}$In | Indium-١١١ |
| AP | Antero-posterior |
| CRP | C-Reactive Protein |
| CT | Computed Tomography |
| DNA | DeoxyriboNucleic Acid |
| ESR | Erythrocyte Sedimentation Rate |
| FDG | Fluro-٢Deoxy-٢-D Glucose |
| Fig/s | Figure/s |
| FISH | Flurescence In Situ Hybridization |
| IFM | Immuno Fluorescence Microscopy |
| IgG | Immunoglobulin G |

| Abbreviation | Meaninig |
|---|---|
| IL-6 | Interleukin-٦ |
| J Arthroplasty | Journal of Arthroplasty |
| MRI | Magnetic Resonance Imaging |
| PCR | Polymerase Chain Reaction |
| PET | Positron Emission Tomography |
| PMA | PolyMethylMethAcrylate |
| rRNA | Ribosomal Ribonucleic Acid. |
| S. Aureus | Staphylococcus Aureus |
| S. Epidermidis | Staphylococcus Epidermidis |
| SCLM | Scanning Conofocal Laser Microscopy |
| THA | Total Hip Arthroplasty. |
| Tc99m | Technetium ٩٩Meta-staple |
| WBCs | White Blood Cells |

# INTRODUCTION

One of the most dreaded complications of total hip arthroplasty is infection. Although the prevalence of infected total hip replacement is only one percent ,the economic burden ,as well as the likelihood of significant morbidity ,and even mortality ,make this complication potentially devastating. Fortunately ,a number of diagnostic techniques are available to aid in determining the presence or absence of infection. Once an infection is confirmed, several treatment options are available to the treating surgeon . Knowledge of the proper indications for each technique ensures appropriate treatment and optimizes results.(١)

The aetiology of prosthetic joint infection is related to microorganisms growing in biofilms, rendering these infections difficult to diagnose and to eradicate A combination of preoperative and intraoperative tests are usually needed for an accurate diagnosis of infection of prosthetic joint infection . Successful treatment requires adequate surgical procedure combined with long – term antimicrobial therapy , ideally with an agent acting on adhering stationary phase microorganisms .(٢)

Infection at the site of a total joint arthroplasty can be classified into four basic categories : Type I ( early prostoperative ) , Type II ( late chronic ) , Type III ( acute hematogenous ) , and Type IV ( positive intraoperative cultures with clinically unapparent infection )on which depend methods of detection &treatment. (٣)

The reported infection rates are probably underestimated, since many cases of presumed aseptic failure may be due to unrecognized infection . In addition, infection rates after surgical revision are usually considerably higher than after primary replacement. (٤)

Todays , molecular biological identification procedures such as the polymerase chain reaction (PCR) Combined with cloning , Immunofluorescence microscopy (IFM) and fluorescence in situ hybridization ( FISH ) have also provided new insights into the diagnosis of biofilm (٥ ,٦ , ٧ , ٨ ) . These techniques have in some cases – especially following sonication of the test material – increased bacterial detection rate in revision arthroplasty with up to ٧٣ % (٧) , as opposed to standard culture techniques which only identify bacteria in ٤-١٥٪ of infected cases. (٧ , ٩)

The use of preoperative antimicrobial prophylaxis has substantially decreased the frequency of implant associated infection. In patients with primary joint replacement, the infection rate in the first two years is lowered after perioperative antibiotics .(٢)

Importantly, prosthetic joints remain susceptible to haematogenous seeding during their entire lifetime and some perioperative infections may have a latency period longer than two years. Therefore, for accurate comparisons, the frequency of infection should be reported as incidence rate ( per prosthesis – years ) rather than as risk ( without specified denominator ) . In the future, it is expected that the incidence of revision of prosthetic joint infections will further increase(٤) .

Finally, proper and early diagnosis together with careful selection of the treatment option gives the patient best chance for complete recovery and better life style.

# Aim of the work

This work aims at illustrating importance of improved detection methods compared to classic methods for diagnosis of infected hip joint prostheses and reviewing of measures of prophylaxis from infection of hip prostheses.

# EPIDEMIOLOGY

The use of perioperative antimicrobial prophylaxis has substantially decreased the frequency of implant associated infection. In patients with primary joint replacement, the infection rate in the first two years is usually <١٪ in hip and shoulder prostheses, < ٢٪ in knee prostheses, and <٩٪ in elbow prostheses. (٢)

The reported infection rates are probably underestimated, since many cases of presumed aseptic failure may be due to unrecognized infection . In addition, infection rates after surgical revision are usually considerably higher than after primary replacement . (٤)

Importantly, prosthetic joints remain susceptible to haematogenous seeding during their entire lifetime and some perioperative infection may have a latency period longer than two years. Therefore, for accurate comparisons the frequency of infection should be reported as incidence rate (per prosthesis – years) rather than as risk (without specified denominator). In a study involving hip and knee prosthesis, the incidence of infection was ٥,٩ per ١٠٠٠ prosthesis – years during the following the first ٢ years after implantation and ٢,٣ per ١٠٠٠ prosthesis – years during the following ٨ years. In the future, it is expected that the incidence of revision of prosthetic joint infection will further increase due to :

١. Better detection methods for microbial biofilms involved in prosthetic joint infections.
٢. The growing number of implanted prostheses in the ageing population
٣. The increasing residency time of prostheses,which are at continous risk for infections during their implanted lifetime.(٤)

## Epidemiology of infecting organisms:

A variety of different bacterial species can cause deep periprorsthetic infection. Staphylococcus aureus and Staphylococcus epidermidis are the most common organisms, although a wide range of gram-positive and gram-negative organisms as well as anaerobic organisms have also been identified.

Table (١) shows the most common organisms identified and incidence for each species.(٢)

The timing of infection varies by species : S. aureus predominate in early infections, and bacteria from normal skin flora such as S. epidermidis, propionbacterium acnes and peptostreptococci present later in delayed infections . There have also been occasional reports of infection caused by rare organisms and fungus such as Candida albicans, and Actinomyces israelii.

**Table (١)**

| **Microorganism** | **Frequency (%)** |
|---|---|
| Staphyloccus aureus | ٣٢-٦٣ |
| Streptococci | ٩-١٠ |
| Enterococci | ٣-٧ |
| Gram-negative bacilli | ٣-٦ |
| Anaerobes | ٢-٤ |
| Polymicrobial | ١٠-١٢ |
| Mixed | ١٠-١١ |

Commonly identified microorganisms causing prosthetic joint infection .(٢)

# PATHOGENESIS

**Routes of infection**

There are four routes by which infecting organisms can reach periprothetic space :

**I) Contamination at the time of surgery :**

It is a well – recognized factor. Lidwell et al, showed progressive decrease in the incidence of joint infection with reduction of air contamination.(١٠)

Salvati et al, investigated the effect of ultraclean air laminar flow and found a statistically significant decrease in infection rates for hip replacement from ١,٤٪ to ٠,٩٪.(١١)

**II) Contiguous spread :**

It's more common in joint close to surface as knee and elbow than in hip arthroplasty . The organism may migrate to the hip from superficial infection. Schmalzried et al, reported on ٤٧ deep infection in a series of ٣،٠٥١ THAs. Two of these patients had infection from direct or contiguous spread. One of them had urethral strictures that were complicated by a deep perineal abscess that drained into the hip.(١٢)

Surin et al , reviewed ٣٤ deep infection in a consecutive series of ٨٠٣ hip replacements. They found a ٣,٢ fold increased risk of deep infection (١١ hips) in the ١١٥ hips with postoperative wound complication after a minimum follow up Of ٣ years(١٣).

However, this finding was not supported by the work of Gaine et al, who reported on ٣٠١ THAs at a mean follow up of ٢٦ months. There was no increase in deep wound infection in the subgroup of ٥٦ patients with a superficial infection, compared with those who had no wound complication. Four of the ٣٠١ arthroplasties (١,٣%) resulted in early deep infection: The infection rate subsequently decreased with installation of a laminar airflow system.(١٤)

**III) Haemtogenous spread:**

Haematogenous seeding of bacteria that originated in a remote infection in the periprosthetic tissues. In the study of David and Verahas on ٦٧ infected THAs, the most common source of infection was skin infection in ٣١ of ٦٧ (٤٦٪), followed by dental infection or dental manipulation in ١٠ of ٦٧ (١٥٪) and also reported with urinary tact infection in ٩ of ٦٧ (١٣٪) .(١٥)

**IV) Reactivation of infection in a previously infected hip :**

The fourth mode of infection is reactivation of infection in a previously infected hip. This was the mechanism of infeaction in ١٣ of ٤٧ infected hips previously mentioned in the study of Schamlzried et al.(١٢)

**Role of Microbial Biofilms:**

Implant – associated infections are typically caused by microorganisms growing in structure known as bio films (fig ١&٢) (١٦)

These microorganisms live clustered together in highly hydrated extracellular matrix called slim attached to a surface. Depletion of metabolic substances or waste product accumulation in biofilms causes microbes to enter a slow or non-growing (stationary) state.

Therefore, biofilm microorganisms are up to ١،٠٠٠ times more resistant to growth – dependent antimicrobial agents than their free- living (planktonic) counterpats.(١٧)

Biofilms contain interstitial voids (water channels) in which nutrients can circulate between microbial cells. Within biofilms, Bacterial cells develop into organized and complex communities with structural and functional heterogeneity resembling multicellular organisms in which water channels serve as rudimentary circulatory system. (١٨)

Release of cell-to-cell signaling molecules (quorum sensing) induces bacteria in a population to respond in concern by changing patterns of gene expression involved in biofilm differentiation.(١٩)

Programmed cell death of damaged cell may play an important role in bacterial biofilms, similar to multicellular organisms. (٢٠)

In summary, existence within a biofilm represents a basic survival mechanism by which microbes resist external and internal environmental factors, such as antimicrobial agents and the host immune system.(٢١)

**Role of Foreign Body**

The pathogenesis of implant-associated infection involves interaction between the microorganisms, the implant and the host.(٢٢)

Adherence of S. epidermidis to the surface of the device involves rapid attachment to the surface of the implant mediated by nonspecific factors such as( surface tension, hydrophobia, and electrostatic forces), or by specific adhesions factors ( specific protein called fibronectin -binding protein ). This initial phase of adherence is followed by an accumulative phase during which S epidermidis bacterial cell adhere to each other and form a biofilm.(٢٣)