In Brief

Biofilm Related Total Knee Arthroplasty Infection: Prevention, Diagnosis and Treatment

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Abstract

Biofilm related implant infection is undoubtedly a relevant challenge in total knee arthroplasty (TKA) with our comprehension steadily progressing and novel management approaches being developed. The aim of this article was to review the most important advances in approaches to combat infections due to biofilm-forming bacteria in TKA. The main conclusions were the following: 1) Fundamental management techniques for infected TKA include open DAIR (debridement, antibiotics, and implant retention), and one and two-stage revision TKA; 2) Continuous local antibiotic perfusion (CLAP) appears to diminish the risk of periprosthetic joint infection (PJI); 3) Restraint of quorum sensing seems to avert PJI after TKA; 4) A recent in vitro study showed promising results in the prevention and management of PJI after TKA using PMMA [poly(methyl methacrylate)] loaded with up to 100 mg of rifampin.

Level of evidence: III

Keywords: Biofilms, Diagnosis, Periprosthetic joint infection, Prevention, Total knee arthroplasty, Treatment

Introduction

Total knee arthroplasty (TKA) is the treatment of choice for individuals with severe osteoarthritis of the knee and intense pain. Over one million TKAs are carried out every year globally with up to 143% growth by year 2050 forecast.[1] A recent clinical study showed that knee periprosthetic joint infections (PJIs) were principally attributed to infection with ST59 methicillin-resistant Staphylococcus aureus (MRSA) and rising trends for infection with ST8 and other ST types of MRSAs in PJI individuals were found from 2016 to 2019. The identification of MRSA genotypes in PJIs might be useful for the treatment of PJIs.[2]

For the purposes of this review, on 1 January 2024 a bibliographic search was performed on PubMed utilizing the search string: [biofilm total knee arthroplasty], resulting in 123 articles, of which 20 papers were finally analyzed because they were directly related to novel strategies to prevent and treat biofilm-forming bacteria on TKA and were published in 2022, 2023 and 2024.

Main body

Current Diagnostic and Treatment Methods

Recent publications on the diagnosis of PJI in TKA are shown in [Table 1].[3-11] in a computer tomography (CT)-based cadaver study it was shown that cement removal of polymethyl methacrylate (PMMA) using ultrasounds was nearly full.[12]

Open DAIR (debridement antibiotic implant retention)

A recent study has suggested that debridement antibiotic pearls and retention of the implant (DAPRI) could be a good alternative to the DAIR technique.[13]

One-stage revision TKA (rTKA)

According to Ji et al (2022) one-stage rTKA using intraarticular infusion of antibiotics can diminish biofilm formation.[14]

Two-stage rTKA

In 2023 Shichman et al analyzed the characteristics of 90 individuals who have had recurrent infection after two-stage rTKA for PJI. The most frequent pathogen detected was coagulase-negative Staphylococci. Persistence of bacteria was seen in 14 (22.2%) of recurrent PJIs. Almost one third of the individuals attained infection control after treatment of a failed two-stage rTKA due to PJI.[15]

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Table 1. Recent publications on the diagnosis of periprosthetic joint infection (PJI) in total knee arthroplasty (TKA)

AUTHORS [REFERENCE]	YEAR	FINDINGS
Tsikopoulos et al [3]	2022	In this meta-analysis no difference was found between the sonication and chemical-based biofilm dislodgment methods.
Rodriguez-Merchan [4]	2022	The sonication technique proved to be reliable. Its sensitivity and specificity were greater than conventional cultures of the periprosthetic tissue. Polyethylene liners sonication has been published to be enough for diagnosis of PJI
Fisher et al [5]	2022	Proteomic profiling utilizing a small protein panel was able to make a distinction between PJI and non-infectious arthroplasty failure sonicate samples and rendered a better comprehension of the immune response during TKA failure.
Azad et al [6]	2022	This study showed that the clinical sensitivity of the Investigational Use Only (IUO) BioFire Joint Infection (JI) Panel was excellent for on-panel bacteria. However, overall sensitivity for PJI diagnosis was low due to the absence of Staphylococcus epidermidis.
Flurin et al [7]	2022	This study analyzed the accuracy of a 16S rRNA (rRNA) gene-based PCR followed by Sanger sequencing and/or targeted metagenomic sequencing approach (tMGS) carried out on synovial fluid for PJI diagnosis. It was found that the sequencing-based method was not better that culture for diagnosis of PJI, but produced positive results in some culture-negative samples.
Hong et al [8]	2023	The 16S ribosomal RNA (rRNA) gene-based targeted metagenomic sequencing (tNGS) method has shown similar performance characteristics than shotgun metagenomic sequencing (sNGS) for PJI bacteria recognition in sonicate fluid from failed TKAs in culture-negative cases.
Brooks et al [9]	2023	Implant surface culture (ISC) successfully recognized bacterial growth with high sensitivity while also disclosing that biofilm growth was usually localized to particular locations.
Drago et al [10]	2023	The antibiofilm pre-treatment of synovial fluids with dithiotreitol (DTT) demonstrated the capacity to raise the sensitivity of microbiological examination in the synovial fluid of individuals with PJI.
Fisher et al [11]	2023	In a pilot study proteomic profiling of sonicate fluid utilizing liquid chromatography-tandem mass spectrometry (LC-MS/MS) was able to distinguish between S. aureus PJI and non-infected arthroplasty failure.

Strategies to Reduce Risk of Infection

How to decrease the risk of PJI before, during and after surgery is shown in [Table 2]. In a study, eight individuals accomplished resolution of the infection using continuous local antibiotic perfusion (CLAP) and intravenous antibiotics. The study suggested that CLAP can be a useful management alternative for PJI after TKA.[16]

Table 2. Facts to keep in mind to reduce the risk of periprosthetic joint infection (PJI) before, during and after total knee arthroplasty (TKA)

PREOPERATIVE PHASE
Body mass index (BMI) of less than 35
Optimization of diet
Good levels of hemoglobin and fructosamine
Stop smoking
MRSA (methicillin-resistant Staphylococcus aureus) nasal screening
INTRAOPERATIVE PHASE
Appropriate antibiotic prophylaxis
Adequate fluid resuscitation

Table 2. Continued

Skin preparation with betadine and chlorhexidine
Irrigation with diluted povidone iodine solution
Administration of tranexamic acid
Utilization of monofilament barbed triclosan-coated sutures for the closure of soft tissues
POSTOPERATIVE PHASE
Early PJI infection must be suspected when erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), D-dimer, and interleukin (IL)-6 are not normal 6 weeks after the procedure

Novel Techniques to Prevent and Treat PJI

Quorum sensing (QS) can reduce bacterial virulence. In fact, inhibition of bacterial communication with sodium salicylate (NaSa) has shown to be effective.[17] A systematic review and meta-analysis stated that rifampin seemed to confer a protective effect. This management effect was particularly pronounced in the context of rTKA.[18] A recent in vitro study showed promising results in the prevention and management of PJI after TKA using PMMA loaded with up to 100 mg of rifampin.[19] In a clinical study on PJI with coagulase-negative Staphylococcus aureus it was found that the success rate was 47% at 1-year follow-up. Open DAIR had the higher failure rate (60%). Two-stage rTKA had a 46.7% failure rate.[20]

Conclusion

Essential treatment approaches for infected TKA include Open DAIR and one and two-stage rTKA; continuous local antibiotic perfusion (CLAP) seems to reduce the risk of PJI; restraint of QS (imstead of quorum sensing) appears to avert PJI after TKA; a recent in vitro study has shown promising results in the prevention and treatment of PJI after TKA using PMMA loaded with up to 100 mg of rifampin.

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