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Clinical Outcome of Massive Endoprostheses Used for Managing Periprosthetic Joint Infections of the Hip and Knee

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ABSTRACT

Background: Endoprosthetic replacement (EPR) is an option for management of massive bone loss resulting from infection around failed lower limb implants. The aim of this study is to determine the mid-term outcome of EPRs performed in the treatment of periprosthetic joint infection (PJI) and infected failed osteosyntheses around the hip and knee joint and identify factors that influence it.
Methods: We retrospectively reviewed all hip and knee EPRs performed between 2007 and 2014 for the management of chronic infection following complex arthroplasty or fracture fixation. Data recorded included indication for EPR, number of previous surgeries, comorbidities, and organism identified. Outcome measures included PJI eradication rate, complications, implant survival, mortality, and functional outcome (Oxford Hip or Knee Score).
Results: Sixty-nine EPRs (29 knees and 40 hips) were performed with a mean age of 68 years (43-92). Polymicrobial growth was detected in 36% of cases, followed by coagulase-negative staphylococci (28%) and *Staphylococcus aureus* (10%). Recurrence of infection occurred in 19 patients (28%): 5 were treated with irrigation and debridement, 5 with revision, 1 with above-knee amputation, and 8 remain on long-term antibiotics. PJI eradication was achieved in 50 patients (72%); the chance of PJI eradication was greater in hips (83%) than in knees (59%) ($P = .038$). The 5-year implant survivorship was 81% (95% confidence interval 74-88). The mean Oxford Hip Score and Oxford Knee Score were 22 (4-39) and 21 (6-43), respectively.
Conclusion: This study supports the use of EPRs for eradication of PJI in complex, multiply revised cases. We describe PJI eradication rate of 72% with acceptable functional outcome.

Periprosthetic joint infection (PJI) following hip and knee surgery is a potentially catastrophic complication that is associated with a significant increase in patient morbidity and mortality [1,2]. In addition, this infection burden is likely to increase in prevalence based on the projected increase in the number of hip and knee arthroplasties and associated PJIs in the near future [3–6].

The optimum management options in PJI remain surgical; a surgical treatment algorithm exists with the following common options: debridement antibiotics and implant retention, implant revision (either 1 or 2 stage), arthrodesis, resection arthroplasty, or amputation [7,8]. Debate remains as to the optimum treatment modality but good results (80%-100%) have been reported with all the above in specialized units. Despite the advances made, not all PJIs are resolved with the initial surgical management and further treatment may be necessary.

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Table 1
Commonly Used Antibiotic Algorithms Based on the Organisms Identified.

Organism	Initial Therapy	Adjunctive Therapy	Follow-On Oral Therapy	Alternative Oral Therapy Options (Depending on Sensitivities, Interactions, and Tolerance)
Methicillin-susceptible *Staphylococcus aureus*	IV flucloxacillin (ceftriaxone if discharged to OPAT)	Oral rifampicin	Ciprofloxacin + rifampicin	Doxycycline, cotrimoxazole, clindamycin, fusidic acid, flucloxacillin
Methicillin-resistant *S aureus*	IV glycopeptide (vancomycin as inpatient and teicoplanin on discharge with OPAT)	Oral rifampicin	Doxycycline + rifampicin	Fusidic acid, cotrimoxazole, linezolid, doxycycline monotherapy
Coagulase-negative staphylococci	IV glycopeptide	Oral rifampicin	Ciprofloxacin + rifampicin	Doxycycline, cotrimoxazole, clindamycin, fusidic acid
Streptococci	IV amoxicillin (ceftriaxone if discharged with OPAT)	–	Amoxicillin	Clindamycin, doxycycline
Enterococci	IV amoxicillin (daptomycin if required)	–	Amoxicillin	Linezolid
Enterobacteriaceae	IV amoxicillin (ceftriaxone or ertapenem if required)	–	Amoxicillin, cotrimoxazole, or ciprofloxacin	Amoxicillin clavulanate, ciprofloxacin, cotrimoxazole
Pseudomonas	IV meropenem	–	Ciprofloxacin	–
Culture negative	IV glycopeptide	Oral rifampicin	Ciprofloxacin + rifampicin	Doxycycline, cotrimoxazole, clindamycin, fusidic acid

IV, intravenous; OPAT, outpatient parenteral antimicrobial therapy.

Chronic, multiply revised, infected prosthetic hip and knee joints are a particular challenge for the arthroplasty surgeon. These cases pose specific difficulties due to issues relating to the poor quality of the soft tissues, the associated bone loss, biofilm formation, and the need to revise the prosthesis. Following infected soft tissue debridement and excision of necrotic bone, the extent of bone loss may be so great that the joint may not be reconstructible with revision implants. In such extreme cases, endoprosthetic replacement (EPR) may be the only option for limb salvage. These modular megaprostheses have traditionally been used in tumor surgery with a well-documented track record of success [9–13]. The promising results have instigated the wider utilization of EPRs in treating non-neoplastic conditions such as PJIs affecting revision arthroplasties and failed osteosynthesis with significant bone loss [14–19].

The purpose of this study is to determine the mid-term clinical outcome of EPRs performed in the treatment of PJI and infected failed osteosyntheses around the hip and knee joint, and to identify factors that influence it.

Patients and Methods

This Institutional Review Board approved study is a retrospective consecutive case series of hip and knee EPRs performed between January 2007 and December 2014 for the treatment of PJI, ensuring a minimum 2-year follow-up period. All cases in this multisurgeon (n = 9) series were performed with a multidisciplinary team (MDT) approach in a dedicated Bone Infection Unit consisting of experienced arthroplasty surgeons, infectious disease physicians, plastic surgeons, physiotherapists, occupational therapists, and outpatient parenteral antimicrobial therapy specialist nurses. In our tertiary referral center, which includes a tumor service, approximately 50 EPRs are performed annually for all indications. Two-thirds of these cases are performed for nontumor indications, half of which are performed for PJI.

All EPRs performed for the treatment of PJI following complex arthroplasty or fracture fixation were retrieved from our institution's joint replacement database. The medical records of all the patients were reviewed for clinical and microbiological data, details of the initial prosthesis implantation and subsequent debridement surgery, antibiotic therapy along with its duration, and follow-up results. Data recorded included patient demographics, indication for EPR, number of previous surgeries, microbiological organisms identified, antibiotic therapy (along with its duration), and subsequent follow-up results. Patient comorbidities were recorded using the American Society of Anesthesiologists (ASA) score and Charlson comorbidity index score [20]. Definition of infection was based on the modified Musculoskeletal Infection Society criteria, which were recommended at the 2013 International Consensus Meeting [21].

Intraoperatively, following removal of the previous implants, a comprehensive debridement and excision of infected and nonviable bone or soft tissues was carried out. Tissue sampling for microbiological and histological analysis was performed based on an established protocol that has been previously described [22]. Due to the complexity of these cases, subsequent treatment algorithms, including antibiotic protocols, were based on an individual case-by-case basis defined by the MDT. In general, staphylococcal and culture-negative infections would usually have received intravenous therapy for 4-6 weeks (most commonly a glycopeptide or anti-staphylococcal penicillin) with the addition of adjunctive rifampicin once the surgical wound had healed, followed by combination oral therapy (most commonly ciprofloxacin and rifampicin) to complete at least 3 months of therapy in total. Table 1 summarizes the commonly used antibiotic regimes in our unit.

The EPR implant system used for all procedures was the Stanmore METS® (Modular Endoprosthetic Tumour System) (Stanmore Implants Worldwide, Elstree, United Kingdom). This is a modular cemented prosthesis made of titanium alloy, which provides a range of different sized modular components in addition to a hydroxyapatite-coated collar for the bone-prosthesis junction for osseointegration (Fig. 1). This prosthesis has recently been made available with the option of a silver coating in order to provide additional bactericidal properties (Agluna; Stanmore Implants Worldwide). The EPRs used in the latter part of the study had this silver coating and consisted of 9 hips and 5 knees.

Provided patients had a minimum follow-up of 2 years, and treatment success of PJI was determined based on the International Consensus Meeting Delphi criteria [23]. All complications and reoperations were confirmed from medical records, postal questionnaires, and Family Practitioner records. Infection status for deceased patients was established from hospital records at the time of death. Mortality data were collected from the hospital and