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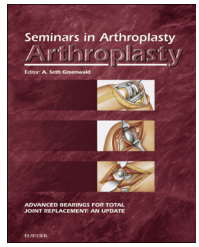

The two-stage standard: Res ipsa loquitur

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ARTICLE INFO

Keywords:
revision arthroplasty
total knee arthroplasty
periprosthetic joint infection
two-stage revision arthroplasty
revision knee arthroplasty

ABSTRACT

Periprosthetic joint infection is a morbid and costly complication of total knee arthroplasty. Treatment options vary depending on chronicity of the infection, causative organism, and host factors. Some authors advocate single-stage exchange arthroplasty to decrease patient morbidity and healthcare utilization costs. Due to its proven efficacy for infection eradication and soft tissue healing, however, two-stage exchange arthroplasty remains the gold standard for treatment of periprosthetic joint infection after total knee arthroplasty. In this review, we present the technique of two-stage exchange arthroplasty and evidence supporting its use.

1. Introduction

1.1. *Epidemiology and burden of periprosthetic joint infection*

Periprosthetic joint infection (PJI) is a morbid and costly complication of total knee arthroplasty (TKA). With contemporary prophylactic measures, the rate of PJI after TKA is 1–2% [1]. In the United States from 2005 to 2010, PJI was the most common indication for revision TKA. Moreover, PJI resulted in the longest length of hospital stay for any indication for revision TKA and was associated with an average hospitalization cost of $25,692 [2]. In addition to significant patient morbidity and resource utilization, revision for PJI is associated with a fivefold increase in mortality compared with revision for aseptic failure [3].

1.2. *Diagnosis of periprosthetic joint infection*

Diagnosis of PJI after TKA often poses a clinical challenge. In 2011, the Workgroup of the Musculoskeletal Infection Society (MSIS) produced the widely accepted definition of PJI (Fig. 1) [4]. There are no definitive thresholds for serum ESR, serum CRP, synovial leukocyte count, and synovial PMN% in the diagnosis of PJI. There is strong consensus among members of the International Consensus on Periprosthetic Joint Infection that serum ESR > 30 mm/h, serum CRP > 10 mg/L, synovial leukocyte count >3000 cells/μL, and synovial PMN% > 80%, if obtained more than 6 weeks postoperatively, may be consistent with PJI [5].

Novel biomarkers for the diagnosis of PJI are being tested but are not yet in widespread clinical practice. Synovial CRP was shown to be a more sensitive (84% versus 76%) and specific (97% versus 93%) marker of PJI compared to serum CRP [6]. A combination test of synovial fluid alpha-defensin and synovial CRP was found to have a sensitivity of 97% and specificity of 100% in the diagnosis of PJI [7]. In an extensive screening of synovial biomarker efficacy in the diagnosis of PJI, synovial alpha-defensin, neutrophil elastase 2 (ELA-2), bactericidal/permeability-increasing protein (BPI), lactoferrin, and neutrophil gelatinase-associated lipocalin (NGAL) each demonstrated both 100% sensitivity and specificity [8].

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http://dx.doi.org/10.1053/j.sart.2015.08.011
1045-4527/

MSIS Definition of Periprosthetic Joint Infection[4]

1) A pathogen is isolated by culture from at least two separate tissue or fluid samples obtained from the affected prosthetic joint; or
2) Four of the following six criteria exist:
   a. Elevated serum ESR and serum CRP,
   b. Elevated synovial leukocyte count,
   c. Elevated synovial neutrophil percentage (%PMN),
   d. Presence of purulence in the affected joint,
   e. Isolation of a microorganism in one culture of periprosthetic tissue or fluid, or
   f. Greater than five neutrophils per high-power field in five high-power fields observed from histologic analysis of periprosthetic tissue at x400 magnification

Figure 1 – Workgroup of the Musculoskeletal Infection Society definition of PJI.

Though promising, these biomarkers are currently investigational. The standard diagnostic evaluation for PJI remains a thorough history, physical examination, plain radiographs, serum inflammatory markers, and joint aspiration as suggested by both the MSIS and American Academy of Orthopaedic Surgeons [5,9].

1.3. *Treatment options*

Once the diagnosis of PJI has been made, treatment options vary depending on chronicity of the infection, causative organism, and host factors. Two-stage exchange, single-stage exchange, irrigation and debridement with retention of components, and prolonged antibiotic suppression alone are all feasible options. Irrigation and debridement with antibiotic suppression or antibiotic suppression alone are not recommended for the vast majority of patients. These options are reserved for patients with poor functional status or for those who refuse prosthesis removal [10]. Knee arthrodesis, resection arthroplasty, and above-knee amputation are options when salvage is not possible. Arthrodesis after failure to eradicate PJI can be difficult to achieve [11]. One- and two-stage exchange arthroplasty will be discussed in detail in the current review.

1.4. *History of exchange arthroplasty*

The management of PJI after TKA has evolved over time, but the principles of treatment have remained unchanged. In 1983, Insall et al. [12] described the results of 11 two-stage exchange TKAs after infection. The staged procedures included removal of all components and cement, thorough soft tissue and bony debridement, 6 weeks of parenteral antibiotic therapy, and reimplantation of components. At an average 34-month follow-up, there was no recurrence of the original infection. One knee was infected with a different organism, thought to be due to hematogenous seeding from a peripheral source. After Insall published this series, other investigators confirmed the efficacy of two-stage exchange arthroplasty as a reliable procedure for eradication of infection and preservation of knee function [13–16].

1.5. *One- versus two-stage revision*

In order to decrease patient morbidity and hospital utilization costs, some authors have advocated single-stage exchange arthroplasty for the treatment of PJI after TKA. The indications for one-stage exchange are not well established. There is strong consensus among members of the International Consensus on Periprosthetic Joint Infection that a definitive contraindication to single-stage exchange is systemic manifestation of infection. Relative contraindications include infection with resistant organisms, presence of a sinus tract, and tenuous soft tissue coverage [5].

With restrictive selection criteria, some authors have reported reliable infection eradication with single-stage exchange arthroplasty. Early experience with this technique by von Foerster et al. [17] yielded an infection control rate of 73.1% with recurrence of infection in 20 of 104 TKAs. Goksan and Freeman reported an 89% rate of infection control after 5-year follow-up of one-stage exchange arthroplasty in 18 patients. All patients were infected with susceptible gram-positive organisms and none had systemic signs of toxicity [18]. Buechel et al. [19] reported a 90.9% rate of infection control with one-stage exchange arthroplasty in 22 patients infected with susceptible organisms with an average follow-up of 10.2 years. Singer et al. [20] retrospectively reviewed their experience with one-stage exchange in PJI after TKA. The indications for one-stage exchange in this cohort were the identification of microorganism with an antibiotic susceptibility profile and wounds that could be closed during surgery. Patients with resistant organisms were excluded. With this highly selected cohort of 63 patients, the infection control rate was 95% with three recurrences and an average follow-up of 35.9 months.

Zahar et al. [21] described the recent results of one-stage exchange to a rotating hinge device at the Helios ENDO Klinik in Hamburg, Germany, a high-volume center that pioneered the one-stage exchange technique. A total of 59 patients with an average follow-up of 10 years were included in the analysis. Indication for one-stage exchange was diagnosis of PJI after TKA with a known causative organism. No patients were excluded based on comorbid conditions. Patients with resistant organisms were included. The 10-year infection-free implant survival was 93%.

Since Insall first described the two-stage exchange procedure, new implant designs, surgical techniques, and antibiotic therapies have been developed. With the goal of limiting patient morbidity and resource utilization, some surgeons are advocating one-stage exchange arthroplasty in selected patients [17–23]. If a single-stage method for treatment and reconstruction of PJI with long, cemented stems fails; however, the bone loss can be massive and not amenable to reconstruction. Additionally, there is no opportunity for host modification or optimization of comorbid conditions as there is with a two-stage approach. Due to its proven clinical efficacy for infection eradication and soft tissue healing, two-stage exchange arthroplasty remains the best option for surgeons who are only occasionally confronted with PJI or those hospitals that cannot adequately manage the intensive support services needed for one-stage treatment.

2. Two-stage exchange arthroplasty: technique

2.1. *Preoperative evaluation and patient optimization*

The host classification system developed by Cierny and Mader for treatment of osteomyelitis is an effective method