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Original Article

Outcome of Total Hip and Total Knee Revision Arthroplasty With Minor Infection Criteria: A Retrospective Matched-Pair Analysis

Kevin Staats, MD, BSc, Paul Kolbitsch, MD, Irene K. Sigmund, MD, Gerhard M. Hobusch, MD, Johannes Holinka, MD, Reinhard Windhager, MD *

Department of Orthopaedic Surgery, Medical University of Vienna, Vienna, Austria

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ABSTRACT

Background: Although diagnostic modalities for the detection of periprosthetic joint infection have improved, some infectious revision cases may still be diagnosed as aseptic complications.
We raised the question whether patients with positive Musculoskeletal Infection Society minor infection criteria differ in their outcome parameters (revision-free survival, revision rate) when compared to patients with "true" aseptic complications. Additionally, we asked whether the indication for revision surgery (eg, loosening) might have an influence on possible outcome discrepancies.
Methods: A retrospective matched-pair analysis was performed with 98 patients who had undergone revision surgery after total joint arthroplasty. Forty-nine patients showed less than 3 positive minor criteria (PMC), whereas 49 patients without any PMC were compared regarding re-revision rate and revision-free survival. Reasons for revisions were categorized according to loosening, liner wear, implant failure, and soft-tissue complication.
Results: In the group of patients with PMC, 30.6% (n = 15) had to undergo re-revision compared to 6.12% (n = 3) in the true aseptic complication control group. The long-term implant survival in the PMC group was 69.4% (95% confidence interval [CI], 47-69 months) and in the aseptic control group was 93.9% (95% CI, 82-94 months; $P = .001$). In patients with PMC and loosening of the implant, the long-term survival was 55.2% (95% CI survival time, 28.9-53.2 months) whereas in patients without PMC and loosening, the overall survival was 96.2% (95% CI survival time, 83.5-96 months; $P = .001$).
Conclusion: Our findings suggest that in the presence of prosthetic loosening, even a single positive minor criterion may have a negative impact on the outcome after total hip arthroplasty and total knee arthroplasty revision surgeries.

Aseptic complications and periprosthetic joint infections (PJI) represent the 2 main reasons for revision surgeries in total joint arthroplasty (TJA) [1]. In revision cases with suspected aseptic complications, ruling out a PJI is mandatory but still remains challenging [2,3]. Despite the continuous development of new tools [4-6], no diagnostic gold standard exists, and therefore many classification and definition systems have emerged to improve the detection of septic complications [3,7-9]. Hence, the Musculoskeletal Infection Society (MSIS) published a well-established and broadly used classification system [10]. When using this proposed system, the fulfilment of 1 of 2 major, or 3 of 5 minor, criteria is required to diagnose a PJI (Table 1). However, a subpopulation of patients, at the very minimum, with presumed aseptic complication may still be undiagnosed with a PJI [2]. In reference to this, the MSIS stated that PJI may be present even with fewer than 3 PMC identified [12,13].

One major complication after TJA in both aseptic and septic revision cases is prosthetic loosening [14]. Bacteria adhering to the prosthesis contribute to local inflammatory processes and lead to loosening by the induction of osteolytic processes [15]. It is a matter of current discussion whether the influence of bacteria in "aseptic" loosening may be underestimated [15,16].

Information about the outcome of patients with PMC is scarce and, to our knowledge, a matched-pair study design with "true" aseptic complications does not exist. Therefore, we have raised the

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* Reprint requests: Reinhard Windhager, MD, Department of Orthopaedic Surgery, Medical University of Vienna, Waehringer Guertel 18-20, A-1090 Vienna, Austria.

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Table 1
Definition of Periprosthetic Joint Infection (PJI) According to the International Consensus Group [12].

PJI is defined when 1 of the 2 major criteria or 3 of 5 minor criteria are present:	
Major criteria	Two positive periprosthetic cultures isolating the identical pathogen, OR A sinus tract communicating with the prosthesis, OR
Minor criteria	(1) Elevated serum erythrocyte sedimentation rate and serum C-reactive protein (2) Elevated synovial fluid white blood cell count or +++ change on leukocyte esterase test strip (3) Elevated synovial fluid polymorphonuclear neutrophil percentage (4) Positive histological analysis of periprosthetic tissue (5) A single positive culture

This definition system represents an adaptation of the Musculoskeletal Infection Society definition of PJI [13].

question as to whether patients with PMC differ in their outcome parameters (eg, revision rate and revision-free survival) when compared to patients without any positive infection criteria. Additionally, we have asked whether the indication for the index revision surgery (eg, loosening) plays an essential role in these potential outcome discrepancies.

Patients and Methods

This study was approved by the local ethics committee (No. 1071/2016). Medical records from patients who underwent a 1-stage revision surgery due to an aseptic complication after total hip arthroplasty (THA) or total knee arthroplasty (TKA) between 2008 and 2015 were evaluated. Their medical histories were reviewed concerning PMC without fulfilling the diagnostic requirements for a manifest PJI in regard to the modified MSIS definition (Table 1) [10,12]. We therefore included patients with less than 3 PMC. Patients with 3 or more PMC were excluded from the study, because these cases were considered to be infectious and thus treated according to a different therapeutic approach. From 60 patients with 1-3 PMC, 11 patients were lost to follow-up, of which 4 patients died from causes unrelated to the revision surgery and 4 patients did not attend regular control examinations. Because single positive cultures of virulent microorganisms like *Staphylococcus aureus* can predict a PJI, we excluded 3 patients who had an infection with *Staphylococcus aureus*. All other patients with single positive culture were eligible for inclusion. Table 2 shows the pathogens found in patients with single positive culture. Forty-nine patients with a mean follow-up of 36 months (±24 months; min/max, 12-84 months) were therefore included in this study. The aseptic control (AC) cohort consisted of patients who underwent revision surgery without the detection of any PMC. Due to considerable differences in basic demographics compared to the PMC cohort (age, 63 ± 17 years [AC] vs 69 ± 13 years [PMC], $P = .006$; follow-up time, 22 ± 17 months [AC] vs 36 ± 24 months [PMC], $P < .001$), we aimed for a more homogenous setting for the comparison of outcome parameters (revision-free survival, revision rate). We thus performed a matched-pair analysis with 49 patients of the PMC cohort and 49 patients of the AC cohort. Compromising host factors were classified from all included patients using the classification system by McPherson et al [11] (Table 3). Patients with no compromising factors were classified as systemic host grade A, patients with 1 or 2 compromising factors were assigned to systemic host grade B, and patients with more than 2 compromising factors were classified as systemic host grade C (Table 3). In order to balance the study groups, propensity score matching (ratio 1:1) was performed where patients were matched according to their sex, age, joint, and comorbidities (Table 4). Indications for 1-stage revisions were classified into loosening, liner wear (without loosening), prosthetic failure (bearing dislocation, component breakage), and soft-tissue complication (eg, contracture, tendon-rupture, instability).

Table 2
Distribution of Pathogens Found Through Single Positive Culture in Total Hip Arthroplasty (THA) and Total Knee Arthroplasty (TKA) During Revision Surgery.

Pathogen	THA	TKA	Total
Candida parapsilosis	1	0	1
Corynebacterium species	1	0	1
Enterococcus species	0	1	1
Micrococcus luteus	2	0	2
Propionibacterium acnes	3	3	6
Staphylococcus epidermidis	5	3	8
Staphylococcus hominis	4	0	4
Staphylococcus lugdunensis	0	1	0
Staphylococcus warneri	1	0	1
Streptococcus mitis	3	2	5
Total	20	10	30

Table 3
Systemic Host Compromising Factors Taken From the Study by McPherson et al [11].

- Age ≥80 y
- Alcoholism
- Chronic active dermatitis or cellulitis
- Chronic indwelling catheter
- Chronic malnutrition (albumin ≤3.0 g/dL)
- Current nicotine use (inhalational or oral)
- Diabetes (requiring oral agents and/or insulin)
- Hepatic insufficiency (cirrhosis)
- Immunosuppressive drugs (methotrexate, prednisone, cyclosporine)
- Malignancy (history of, or active)
- Pulmonary insufficiency (room air arterial blood gas <60%)
- Renal failure requiring dialysis
- Systemic inflammatory disease (rheumatoid arthritis, systemic lupus erythematosus)
- Systemic immune compromise from infection or disease (human immunodeficiency virus, acquired immunodeficiency virus)

Patients with <1 factor = systemic host grade A.
Patients with 1-2 factors = systemic host grade B.
Patients with >2 factors = systemic host grade C.

Statistical Analysis

In order to evaluate the differences in potentially confounding parameters between the study group and the control group, the Mann-Whitney *U* test and chi-square test were applied. The chi-square was used to compare the revision rate and the infection rate between the study group and the control group. Additionally, revision-free survival and cumulative survival were calculated using a Kaplan-Meier survival analysis, including a 95% confidence interval (CI), and a log-rank test was applied to detect differences between the observed groups. End points were defined as re-revision for any cases. *P* values <.05 were considered as statistically significant, and these statistical analyses were performed using SPSS software, version 23.0 (SPSS Inc, Chicago, IL).

Results

Ninety-eight patients who underwent revision surgery after THA or TKA were included in this study. Of them, 49 patients showed less than 3 PMC, and 49 patients with no signs of infection regarding MSIS criteria represent the AC group. Figures 1 and 2 summarize the information regarding implant type of primary implantation and the type of revision surgery performed in the