Arthroplasty Today 6 (2020) 475–479

Contents lists available at ScienceDirect

Arthroplasty Today

journal homepage: http://www.arthroplastytoday.org/

Original Research

# Survivorship of Megaprostheses in Revision Hip and Knee Arthroplasty for Septic and Aseptic Indications: A Retrospective, Multicenter Study With Minimum 2-Year Follow-Up

Eric L. Smith, MD [a, *], Akash Shah, MD [b], Sung Jun Son, MS [c], Ruijia Niu, MPH [b], Carl T. Talmo, MD [a], Ayesha Abdeen, MD [d], The Boston Arthroplasty Collaborative Megaprosthesis Writing Committee, Muzna Ali, BS [e], John Pinski, MD [f], Matthew Gordon, MD [f], Santiago Lozano-Calderon, MD, PhD [g], Hany S. Bedair, MD [g]

[a] Department of Orthopaedics, New England Baptist Hospital, Boston, MA, USA
[b] Department of Orthopaedic Surgery, Boston Medical Center, Boston, MA, USA
[c] Boston University School of Medicine, Boston, MA, USA
[d] Beth Israel Deaconess Medical Center, Boston, MA, USA
[e] Beth Israel Deaconess Medical Center, Boston, MA, USA
[f] Tufts Medical Center, Boston, MA, USA
[g] Massachusetts General Hospital, Boston, MA, USA

ARTICLE INFO

*Article history:*
Received 31 December 2019
Received in revised form
10 April 2020
Accepted 2 May 2020
Available online xxx

*Keywords:*
Megaprosthesis
Revision arthroplasty
Infection

ABSTRACT

*Background:* The use of megaprostheses in nononcologic patients has been associated with complication rates greater than 50%. In patients with prior periprosthetic joint infection (PJI) with subsequent two-stage reimplantation, this complication rate may be even higher. This study was to investigate the outcomes of megaprostheses in nononcologic patients undergoing revision hip/knee arthroplasty.
*Methods:* We retrospectively studied patients who underwent megaprosthesis replacements from 1999 to 2017 at 5 hospitals with minimum 24 months of follow-up. Patients were stratified based on history of prior PJI (septic vs aseptic) and location of the megaprosthesis (the hip or knee). Postoperative complications were classified as soft-tissue failure, aseptic loosening, structural failure, and infection.
*Results:* Of the 42 patients, 19 were in the septic cohort and 23 were in the aseptic cohort. The overall complication rate was 28.6%. Complication rates for the septic and aseptic cohorts were 32% and 26%, respectively ($P = .74$). By anatomic location, there were 2 of 13 (15%) and 10 of 29 (34%) complications in the hip and knee groups, respectively ($P = .28$). In the septic cohort, there were no (0%) complications in the hip group and 6 of 14 (43%) complications in the knee group ($P = .13$), all due to infection. In the aseptic cohort, there were 2 of 8 (25%) and 4 of 15 (27%) complications in the hip and knee groups, respectively ($P = 1.0$).
*Conclusions:* There is no difference in the postoperative complication rates between the septic or aseptic cohorts undergoing revision hip or knee megaprosthesis replacements. In patients with prior PJI, proximal femoral replacements have improved short-term survivorship compared with distal femoral or proximal tibial replacements.


## Introduction

Massive bone loss in the setting of periprosthetic fracture, prosthetic joint infection, and failed total joint replacement can pose a significant challenge. Initially designed for use in patients with primary and metastatic bone tumors, proximal and distal femoral replacements have become powerful reconstructive tools in patients with large skeletal defects due to fracture, infection, or osteolysis [1,2]. Over time, surgeons have expanded the application of these devices to nononcologic patients with good success [3].

Arthroplasty surgeons must counsel patients on the risks and benefits of megaprosthesis implantation. Revision hip and knee

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.
* Corresponding author. New England Baptist Hospital, 125 Parker Hill Avenue, Boston, MA 02120, USA. Tel.: +1 617 754 5526.
*E-mail address:* esmith@nebh.org

https://doi.org/10.1016/j.artd.2020.05.004

**Table 1**
Patient demographics of the septic and aseptic cohorts.

| Demographics | Total | Septic cohort (n = 19) | Aseptic cohort (n = 23) | *P*-value |
|---|---|---|---|---|
| Age (mean ± SD) | 60.0 ± 17.7 | 52.5 ± 18.5 | 66.1 ± 14.8 | .01 |
| Female (n) | 26 | 10 | 16 | .34 |
| ASA | | 2.6 | 2.7 | .52 |
| Patients with comorbidities (n) | | | | |
| Smoker | 10 | 3 | 7 | .30 |
| Diabetes | 9 | 4 | 5 | 1 |
| Hypertension | 25 | 11 | 14 | 1 |
| Coronary artery disease | 6 | 2 | 4 | .67 |
| Myocardial infarction | 3 | 1 | 2 | 1 |
| Chronic obstructive pulmonary disease (COPD) | 2 | 0 | 2 | .49 |
| Chronic kidney disease (CKD) | 4 | 3 | 1 | .31 |
| Estimated blood loss (mL) (mean ± SD) | 611 ± 628 | 614 ± 522 | 609 ± 715 | .98 |
| Average follow-up in months (mean ± SD) | 60.3 ± 43.5 | 67.0 ± 42.8 | 54.7 ± 44.2 | .37 |

arthroplasty with proximal and distal femoral replacements can allow for early mobilization and quicker return of function in comparison with cases where internal fixation or bulk allograft reconstruction may require protected postoperative weight-bearing [4-7]. However, megaprosthesis failure rates are significant and have been reported higher than 50%, with infection being the leading cause [4,5,8-10]. Henderson et al. classified failure of these implants in nononcologic patients into 4 main types: (1) soft-tissue failure, (2) aseptic loosening, (3) structural failure, and (4) infection [11].

Recent studies have shown that oncologic patients undergoing revision to megaprosthesis with a history of periprosthetic joint infection (PJI) experienced higher postoperative complication rates than for aseptic indications [8,11]. To our knowledge, no previous study has determined the complication rates for megaprostheses around the hip and knee in nononcologic patients. The purpose of the present study was to compare the postoperative outcomes of megaprostheses in nononcologic patients undergoing revision hip or knee arthroplasty in septic and aseptic cohorts.

## Material and methods

### *Patient selection*

A retrospective, multicenter review was performed on a consecutive series of patients who underwent revision arthroplasty with proximal femoral, distal femoral, or proximal tibial replacement megaprosthesis by 1 of 6 surgeons at 5 academic medical centers between January 1999 and December 2017. Inclusion criteria were age greater than or equal to 18 years; failed total hip or knee arthroplasty due to osteolysis, fracture, joint instability, or PJI; and minimum follow-up of at least 24 months. PJI was defined based on the 2018 Musculoskeletal Infection Society criteria. Patients with a prior history of PJI in the operative joint were stratified to the septic cohort, and those without any prior infection were stratified to the aseptic cohort. In the septic cohort, all patients underwent a two-stage revision. Reimplantation was performed in all cases after inflammatory markers normalized and after a negative aspiration while off antibiotics for a minimum of 2 weeks. Exclusion criteria were total femur replacements and oncologic cases. Institutional review board approval was obtained at each of the 5 institutions.

### *Outcome assessment*

We compared the demographics and surgical outcomes between 2 patient groups characterized by the location of their megaprosthesis: the hip group included proximal femoral replacements, and the knee group included distal femoral and proximal tibial replacements. Patient characteristics (age, sex, comorbidities, and estimate blood loss during surgery) were evaluated. Postoperative complications were identified based on follow-up clinic visits, unexpected readmissions, and reoperations. We classified postoperative complications into 4 types

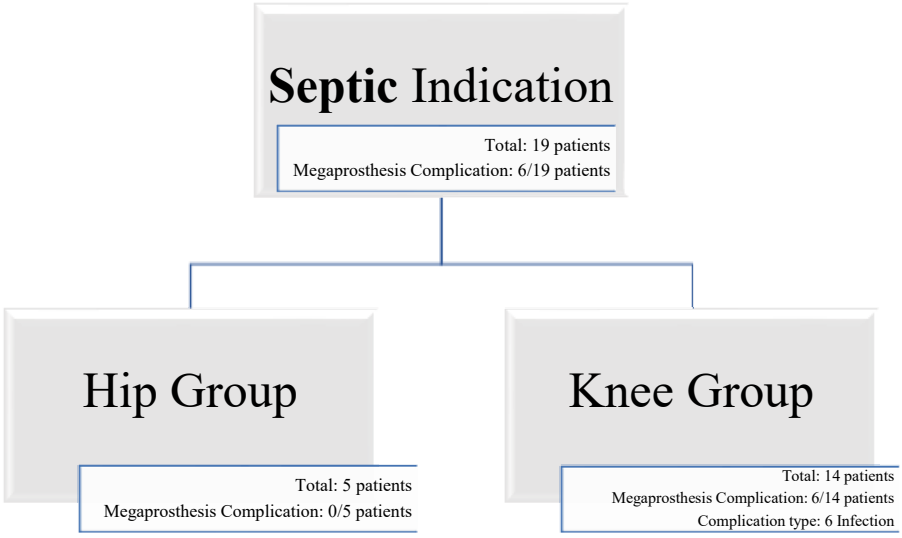


**Figure 1..** Stratification of the Septic Cohort.

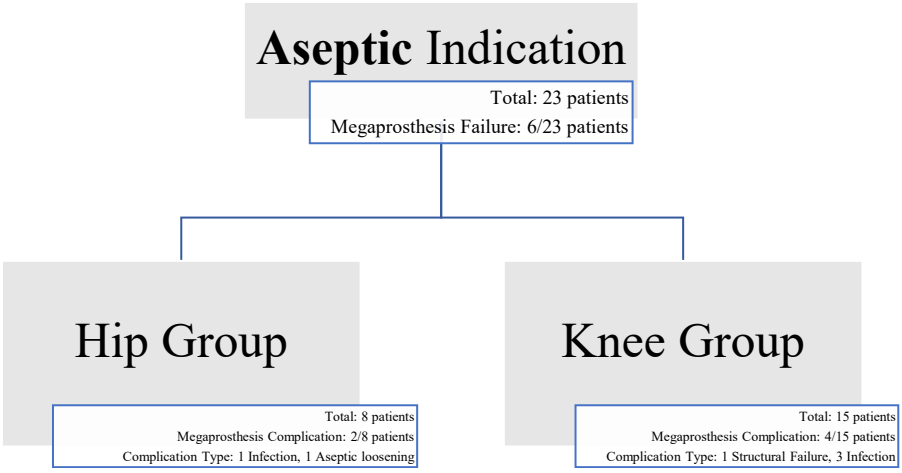


**Figure 2..** Stratification of the Aseptic Cohort.

based on the Henderson classification: (1) soft-tissue failure (instability, tendon rupture, and wound dehiscence), (2) aseptic loosening (determined by clinical and radiographic evidence), (3) structural failure (periprosthetic fractures), and (4) infection (requiring removal of device) [11].

*Statistical analysis*

Proportions and percentages were used to determine complication rates. Fisher's exact test was used to detect if a statistically significant difference was present in the complications rates in the subgroup analysis ($\alpha = 0.05$).

## Results

Of the 42 patients in the study, 16 (38%) were male and 26 (62%) were female. The mean age at time of revision surgery was 60 years (standard deviation: 17.7). Patients were operated on at 1 of the 5 academic medical centers, including Boston Medical Center (n = 3), Beth Israel Deaconess Medical Center (n = 16), Massachusetts General Hospital (n = 12), New England Baptist Hospital (n = 3), and Tufts Medical Center (n = 8). The average time to final follow-up was 60 months. Table 1 compares patient demographics between the septic and aseptic cohorts. Besides age, there was no statistically significant difference between the groups with respect to the gender; American Society of Anesthesiologists (ASA) class; smoking status; diabetes; or cardiac, respiratory, or renal disease.

There were 19 (45%) patients in the septic cohort and 23 (55%) patients in the aseptic cohort. Causes for revision in the aseptic cohort were fracture (13), joint instability (6), and osteolysis (4). Within the septic cohort, 5 (26%) patients and 14 (74%) patients received megaprosthesis replacements of the hip and knee, respectively (Fig. 1). Within the aseptic cohort, 8 (35%) patients and 15 (65%) patients received megaprosthesis replacements of the hip and knee, respectively (Fig. 2).

Table 2 shows the overall complication rates in the study cohort. Tables 3-5 show the complication rates within each cohort and based on the anatomic location of the implant. There was no statistically significant difference between overall complication rates in the septic and aseptic cohorts ($P = .74$). In the subgroup analysis, 100% (6/6) and 67% (4/6) of septic and aseptic cohort complications were due to infection, respectively. In addition, 50% (1/2) and 90% (9/10) of the hip and knee group complications were due to infection, respectively. All 6 complications in the septic cohort knee group were due to infection. There were no complications in the septic cohort hip group. The difference in the complication rates between the septic cohort hip and knee groups was trending toward significance ($P = .13$) (Table 4).

The aseptic cohort had 2 complications (1 infection and 1 aseptic loosening) in the hip group and 4 complications (3 infections and 1 structural failure) in the knee group. The difference in complication rates between the aseptic cohort hip and knee groups was not statistically significant ($P = 1.0$) (Table 5). Furthermore, an analysis based on the anatomic location of the megaprosthesis showed no statistical difference in the complication rates when subdivided into septic or aseptic indications (Tables 6-8).

**Table 2**
Complication rates subdivided based on the Henderson classification.

| Presence of infection or the location of the implant (the number of cases) | Type 1 (soft-tissue failure) | Type 2 (aseptic loosening) | Type 3 (structural failure) | Type 4 (infection) | All types (risk) |
|---|---|---|---|---|---|
| Septic (19) | - | - | - | 6 (100%) | 6 (31.6%) |
| Aseptic (23) | - | 1 (16.7%) | 1 (16.7%) | 4 (66.7%) | 6 (26.1%) |
| Hip (13) | - | 1 (50%) | - | 1 (50%) | 2 (15.4%) |
| Knee (29) | - | - | 1 (10%) | 9 (90%) | 10 (34.5%) |
| Overall (42) | - | 1 (8.3%) | 1 (8.3%) | 10 (83.3%) | 12 (28.6%) |

## Discussion

In our retrospective series of 42 lower extremity megaprosthesis replacements for nononcologic conditions, patients with a prior history of PJI demonstrated equivalent short-term survivorship to their aseptic counterparts. In addition, hip megaprostheses had a lower complication rate than knee megaprostheses in patients with a prior PJI, although this did not reach statistical significance. The leading cause of complication in the septic cohort was infection, whereas aseptic loosening, structural failure, and infection were predominant causes in the aseptic cohort.

**Table 3**
Complications in the septic and aseptic cohorts.

| Sepsis | Septic | Aseptic | Fisher's exact test |
|---|---|---|---|
| Complication | 6 | 6 | $P = .74$ |
| No complication | 13 | 17 | |

**Table 4**
Complications in the septic cohorts by the location.

| Joint | Septic hip | Septic knee | Fisher's exact test |
|---|---|---|---|
| Complication | 0 | 6 | $P = .13$ |
| No complication | 5 | 8 | |

There have been several reports on clinical outcomes of megaprosthesis implantation in nononcologic patients [5,12-16]. Parvizi et al. studied 48 patients who underwent revision arthroplasty with proximal femoral replacement for nononcologic conditions [16]. Approximately 21% patients underwent revision because of complication with survivorship of the implant at 87% at 1 year and 73% at 5 years [16]. Korim et al. performed a review of 14 similar studies, with an average follow-up of 3.8 years in 356 proximal femoral replacements [15]. In their review, there was a 23.8% reoperation rate, and the most common complications were dislocation (15.7%) and infection (7.6%) [15]. The present study has a similar overall complication rate to the current literature. In addition, a strength of this study is the subgroup analysis of patients with history of prior PJI and aseptic causes, representing one of the largest series to date.

High complication rates for distal femoral replacement have been demonstrated in several studies [5,12,13]. Despite this, authors highlight the benefits of improved patient-reported outcomes, earlier mobilization, and limb salvage as reasons to consider a megaprosthesis in appropriately selected patients. In a study by Vertesich et al., 43% patients required revision surgery with more than 25% due to infection [12]. Revision-free survival was 74.8%, 62.5%, and 40.9% at 1, 3, and 10 years, respectively [12]. Toepfer et al. had a 64.6% complication rate in a cohort of distal femur replacements, most commonly due to mechanical failure, soft-tissue failure, and aseptic loosening [13]. Holl et al. reported a 52% complication rate in their cohort of distal femur and proximal tibia replacements [5]. Most importantly, all these studies showed a statistically significant improvement in patient-reported outcomes after distal femoral replacement [5,12,13]. Comparatively, the present study has a lower complication rate (34%) in the distal femoral replacement group, inclusive of septic and aseptic indications. Our hypothesis is that improved tissue handling, modern prosthesis design, and improved Musculoskeletal Infection Society criteria to rule out infection before reimplantation may explain the lower complication rate. Specifically, implants with improved component modularity allowing better reproduction of native patient anatomy, polyethylene design, and improved metallurgy have shown promising outcomes in midterm studies [17-19]. However, prospective studies and long-term follow-up are needed to confirm this trend.

There are several limitations to this study. First, its retrospective nature may not have captured all the differences between the septic and aseptic cohorts. Second, given the relatively uncommon occurrence of hip and knee megaprostheses, our sample size was small. However, this is comparable to cohort sizes in prior studies. Moreover, our data are pooled from multiple academic institutions, which increases the generalizability. Finally, patient-related functional outcomes assessed by questionnaires were not measured.

**Table 5**
Complications in the aseptic cohorts by the location.

| Joint | Aseptic hip | Aseptic knee | Fisher's exact test |
|---|---|---|---|
| Complication | 2 | 4 | $P = 1$ |
| No complication | 6 | 11 | |

**Table 6**
Complications in the hip megaprostheses.

| | Septic hip | Aseptic hip |
|---|---|---|
| Complication | 0 | 2 |
| No complication | 5 | 6 |

Fisher's exact test, *P*-value = .49.

**Table 7**
Complications in the knee megaprostheses.

| | Septic knee | Aseptic knee |
|---|---|---|
| Complication | 6 | 4 |
| No complication | 8 | 11 |

Fisher's exact test, *P*-value = .45.

**Table 8**
Complications in the hip and knee megaprostheses.

| | Hip | Knee |
|---|---|---|
| Complication | 2 | 10 |
| No complication | 11 | 19 |

Fisher's exact test, *P*-value = .28.

## Conflict of interest

The authors declare there are no conflicts of interest.

## Conclusions

In conclusion, there is no difference in postoperative complication rates between the nononcologic septic or aseptic cohorts undergoing revision hip or knee arthroplasty with megaprostheses. For patients with prior PJI, proximal femoral replacements have improved short-term survivorship compared with distal femoral or proximal tibial replacements.

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