RESEARCH PAPER

Periprosthetic Joint Infection after Endoprosthetic Reconstruction: Saving the Limb-Salvage

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Abstract

Background: This study evaluates mega-endoprosthetic survival after revision for periprosthetic joint infection (PJI) and two-staged reconstruction using a cement spacer. Mega-endoprosthetics offer patients an important treatment option for limb salvage. However, PJI is a devastating complication which affects between 2-10% of patients. It commonly results in revisions, amputation, and sometimes death. Literature in terms of success rates, limb salvage and Megaprostheses survival after revision for infection is limited. We present here our experience and the impact of length of the spacer in prostheses survival.

Methods: A retrospective chart review was implemented using Fisher's exact test for categorical data and the Kaplan-Meier method for prosthesis survival. Patient information was acquired through our institution's electronic medical records. Variables such as diagnosis, complications, length of cement spacer, and number of surgeries were recorded. We analyzed spacer length and prosthesis survival based on these variables.

Results: Fisher's Exact test showed no correlation between length of spacer and amount of repeat surgery ($P = 0.245$). After two-stage revision and mega-prosthesis insertion, there was a 63.2% chance of complication and a 26.3% chance of amputation. This indicates a 73.7% probability for limb salvage in this sample (Kaplan-Meier).

Conclusion: These data suggest long-term viability of mega-endoprostheses after two-stage revision despite a high complication rate.

Level of evidence: IV

Keywords: Limb salvage, Mega-endoprosthesis, Periprosthetic joint infection, Two-stage revision

Introduction

Before the implementation of limb salvage procedures, aggressive cancers and widespread infections in the extremities were treated with wide resections or amputation; this often resulted in poor functional outcomes for the patient (1, 2). Eventually, thanks to advances in imaging and surgical technology, surgeons were able to use prostheses to replace large bone defects and reconstruct the overlying soft-tissue with flaps and skin grafts. (2-4). While these procedures have limb-sparing potential, associated periprosthetic joint infections (PJI)—affecting between 2-10% of patients—remain a looming burden and can ultimately result in amputation and, in rare instances, death (5-7).

Chronic PJI's become even more challenging to treat due to the development of biofilm. Biofilm offers bacteria increased protection against detection and eradication efforts, which allows a PJI to develop over months to years, often times with few or no symptoms (8, 9). Despite

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the pesky repertoire of bacterial defense mechanisms, techniques such as one and two-stage revision surgeries with the use of antibiotic-loaded cement spacers have shown promising results (10, 11).

The purpose of the present study is to analyze patients that underwent a two-stage revision with cement spacer after a PJI and subsequently had a mega-endoprosthesis implanted—specifically, we attempted to assess the survivability of the mega-endoprosthesis at minimum one year follow-up. We hypothesize that this option will carry with it a high rate of complication, however, most patients will keep their limb and be able to ambulate independently at minimum one-year follow-up. Furthermore, we attempted to explore how the size of the bony defect would affect future complications. We suspect that as the size of the defect increases, the probability of requiring more surgeries and the amputation risk will also increase, likely due to bone loss and compromise of the soft-tissue envelope.

Materials and Methods

Between 2000 and 2016, 18 consecutive patients treated for PJI were reviewed retrospectively by Orthopedic Oncologic surgeons at a single tertiary care institution. Inclusion criteria consisted of any patient who had explantation of their original prosthesis followed by a two-stage revision with insertion of an antibiotic cement spacer and subsequent re-implantation with a mega-endoprosthesis—we did not set a cut off for how long after re-implantation an infection developed [Figures 1-3]. All patients treated with 2-stage revision were appropriately indicated for this treatment; by definition they had a PJI > 4 weeks after initial arthroplasty (12). The research protocol was approved the institutional review board and ethics committee from our institution. A waiver of consent was obtained due to the retrospective nature of this investigation.

All patients in the study were treated with an antibiotic containing cement spacer of variable length (recorded off of radiographs) to reconstruct the limb defect; these cement spacers included Tobramycin (2.4 grams), Vancomycin (2 grams), or both (2 grams of Vancomycin and 2.4 grams of Tobramycin)—these doses are standard protocol at the aforementioned institution and their use was taken from operative reports. Additionally, the patients received IV antibiotics for 6 to 8 weeks based on culture sensitivity data. To minimize the variability of spacer length measurements from patient to patient, spacer size was recorded in the binary format in centimeters (cm): "> 10cm" and "< 10 cm." Based on the distribution of the spacer length data, a cut-off length of 10 cm was chosen. Variables including pre-operative diagnosis, perioperative complications (including "infection", "revision", or "amputation"), the number of times a patient was operated on following two-stage revision and subsequent implantation of the mega-prosthesis, and the length of the antibiotic cement spacer used for reconstruction were recorded. Patients were followed for at least 1 year post-operatively. Among the outcome measures recorded were retention of the mega-endoprosthesis, limb amputation, and ambulatory status at latest follow-up. We analyzed the correlation between spacer length and number of surgeries. After obtaining the information and de-identifying the patient data, we organized it into a database for statistical analysis.

The indications for two-stage revision were (1) patients

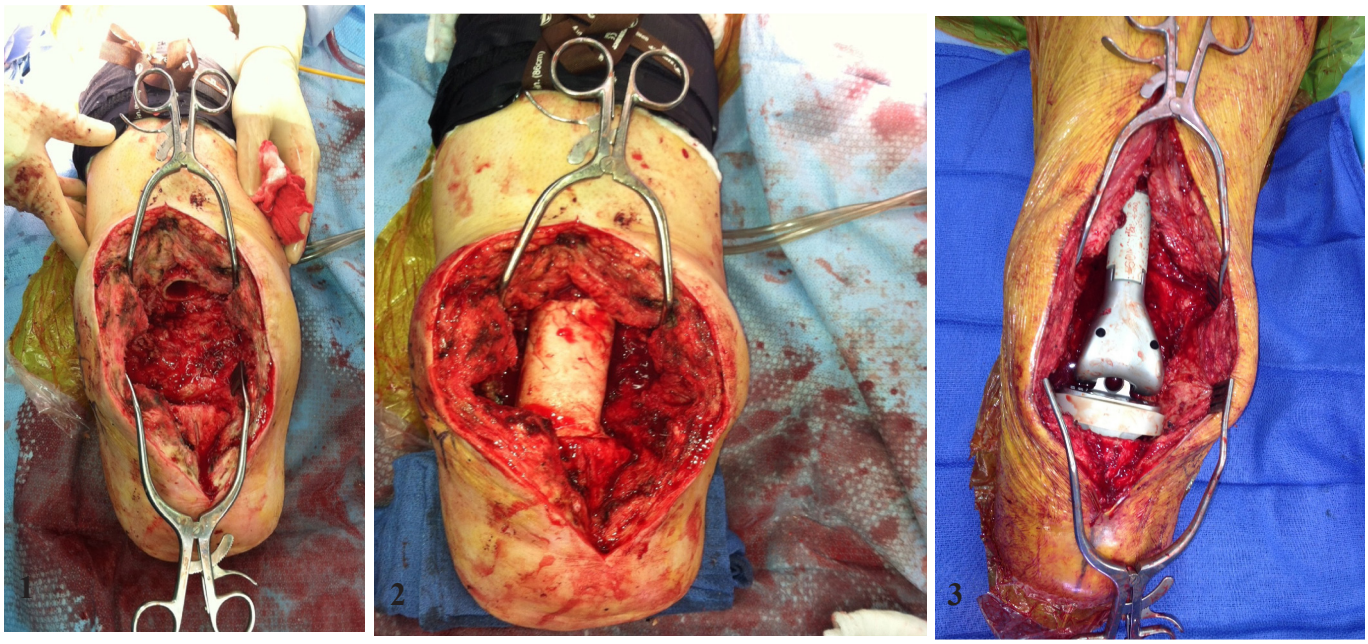

Figure 1-3. 1)Patient with history of below-knee amputation before insertion of the antibiotic cement spacer that will replace resected femoral segment. 2) After insertion of the antibiotic cement spacer that has replaced resected femoral segment. 3) After insertion of a mega-endoprosthesis.

with systemic manifestations of infection (sepsis), (2) obvious clinical signs of infection but no organism identified, (3) difficult to treat/antibiotic resistant organisms identified by pre-operative cultures, (4) presence of a sinus tract, or (5) inadequate/non-viable soft tissue coverage (3). There were no age, sex, or diagnostic requirements. The exclusion criteria consisted of patients who did not complete the full two-stage revision and those that were lost to follow-up before the minimum one-year period. Two patients that did not make it to statistical analysis went directly from their cement spacer to an amputation, whereas the other 19 limbs finished the course of a two-stage reconstruction and continued to various outcomes; this is what we were specifically attempting to study.

Diagnosing Infection

Four attending Orthopaedic surgeons at our institution, using the American Academy of Orthopaedic Surgeons diagnosis of PJI, gave the diagnosis of infection. Criteria used to diagnose periprosthetic joint infection included: (1) a communicating sinus tract with the prosthesis, (2) isolation of a pathogen in culture from two separate fluid or tissue samples surrounding the prosthesis, or (3) four of the following six criteria exist: (a) elevated ESR or CRP, (b) elevated synovial WBC count, (c) elevated synovial neutrophil percentage, (d) presence of purulence in the affected joint, or (e) isolation of a microorganism in one culture of the periprosthetic fluid or tissue.

Technique

Patients in this study group were treated with a two-stage revision surgery which involved: 1) removal of the infected prosthesis and replacement with the antibiotic cement spacer for at least four to six weeks and 2) definitive replacement of said spacer with a mega-endoprosthesis.

Statistical Analysis

Baseline data were analyzed by descriptive statistics. Fisher's Exact test was performed for categorical data. The standard Kaplan-Meier method was used to analyze infection-free survival, revision-free survival, amputation-free survival, and overall free survival in the study population. Factors with a p-value < 0.05 were considered significant. STATA version 15.1 (StatCorp, College Station) was used for all statistical analyses.

Follow-up

All patients included had a minimum follow-up of 1-year. The current functional status of all participants was obtained using the last available clinic note from the treating Orthopedic surgeon. Functional status included ambulatory capacity, use of an assistive device, and associated limitations.

Results

Patient Population

A total of 23 patients and 24 limbs (cases) were eligible for inclusion. Five patients were excluded based on inadequate follow up. The included 18 patients (19 limbs) had a mean age of 42 years old (± 16.7) and eight patients (44.4%) were female. An overview of the population in terms of age, diagnosis, and number of post-operative complications is presented in table 1. Tumor was the most common indication for limb reconstruction in this population (12 patients [10 Osteosarcoma, 1 Synovial Sarcoma, and 1 Giant Cell Tumor]), two patients had osteoarthritis, two patients sustained significant trauma (two from vehicle crashes one from a fall down stairs), one patient developed a pathologic fracture secondary to multiple myeloma, and one patient had two unrelated procedures on her knees – one secondary to severe rheumatoid arthritis, and one spontaneous joint infection which developed from an abscess [Table 1]. The included patients all had lower extremity pathology and were treated with either one or a combination of proximal femoral replacement, distal femoral replacement, total femoral replacement, or proximal tibial replacement.

Mean follow-up time was 85.9 months following re-implantation of the mega-prosthesis after 2-stage revision. Prosthesis survival was measured over a 10-year period. 10 years was chosen because this was the furthest time point at which an event occurred during the data acquisition phase. Of note, one of the patients who was event-free leading up to the completion of this manuscript developed a PJI and was subsequently revised with a 1-stage revision. This was not included in the Kaplan-Meier Analysis, as it occurred after data analysis.

Prosthesis Survival

After a 10-year period, it was seen that 12 of the 19 re-implanted mega-prostheses (63.2%) had complications, 10 (~52.6%) of which were associated with an infection, and five (26.3%) associated with revisions (one fracture, two aseptic loosening, one with multiple dislocations, and one with soft-tissue failure). Five of our patients (26.3%) ultimately ended up with an amputation. Overall event-free survival was 56.477 months ± 10.179 [± indicates standard deviation] [Table 2; Figure 4].

Infection

After the 10-year period, 10 extremities (52.6%) developed an infection, of which six cases were within

Table 1. Study Population

	Number	Details
Total Number of Cases	N = 19	Males: 10 Females: 8
Average Age	42.3	Range: 18-68
Average Follow Up (mo)	85.9	Range: 12-191
Diagnosis		Oncologic: 12 Degenerative: 2 Inflammatory: 1 Trauma: 3 Infection: 1

Details of the study population. The population was diverse in terms of age, diagnosis, and number of post-op complications. Average age determined at time of mega-endoprosthetic reconstructive surgery. For diagnosis, oncologic refers to a cancer diagnosis and degenerative refers to degenerative arthritis

Table 2. Patient Timeline

Case	Sex	Age (y)	Initial Diagnosis	Implant	Follow-up (mo)	Revision (mo)	Infection (mo)	Amputation (mo)	Overall event	Implant Status	Functional Status
1	F	20	Osteosarcoma	GMRS PTR, MRH knee	79	0	0	0	Sarcoma mets to brain and c-spine s/p occipitocervical fusion	Retained	Ambulating w/ out issues
2	M	36	Osteosarcoma	GMRS DFR	67	0	0	0	6 weeks s/p final mega-recon, had a fall and sustained bimal ankle fx. Presented 5 weeks later for ORIF	Retained	Ambulating w/ out issues
3	M	23	Osteosarcoma	Biomet DFR + PTR	89	0	0	0	None	Retained	Ambulating well but cannot sustain for long periods
4	M	37	Trauma	GMRS DFR	72	0	0	0	None	Retained	Ambulating w/ out issues.
5	M	33	Osteosarcoma	GMRS DFR + PTR	173	0	66	0	5 years post-op, had MI s/p triple bypass. 2 months after CABG, developed infection of R knee (diagnosed via arthrocentesis)—underwent 1-stage revision	Revised	Ambulating w/ out issues.
6	F	46	Trauma	GMRS DFR w/ all poly tibia	52	6	3, 13	53	3 months after mega recon, developed an infection (unremarkable aspirate but grew alpha-hem. Strep—I&D + liner exchange. Loose tibial component noted 3 months after—revised. Persistent knee effusions, no obvious source—I&D + liner exchange at 7 months. AKA for chronically swollen + painful leg.	Explanted w/ amputation	Lost to f/u
7	M	31	Osteosarcoma	GMRS PFR	139	0	0	0	None	Retained	Ambulating without issues.
8	M	48	Multiple Myeloma	GMRS PFR	58	0	1, 2, 10, 13	14	Wound dehiscence w/ chronic infection lead to tibial turn-up. Passed away although our records do not indicate when or why.	Explanted w/ amputation	Deceased: Was ambulating w/ prosthetic
9	M	21	Osteosarcoma	GMRS TFR	122	0	69, 105	0	6 years after mega recon, developed acute leukemia w/ PJI and underwent 1-stage revision. 3 years later, developed myelodysplastic syndrome and PJI and underwent I&D.	Revised	Able to walk short distances w/ some chronic pain.
10	F	46	Osteosarcoma	GMRS DFR w/ all poly tibia	97	61	0	0	About 5 years after recon, she fractured her prosthesis and underwent revision ORIF.	Retained	No motor function distally, wheelchair bound.
11	F	60	Rheumatoid Arthritis	GMRS DFR w/ all poly tibia	143	0	146	0	12 years after mega recon, underwent 1-stage revision for PJI	Revised	Ambulates with rolling walker w/out issues
12	F	63	Rheumatoid Arthritis	GMRS DFR + PTR	123	0	6, 47, 104, 122		2-stage revision at 6 months post op due to recurrent infection. At 46 months underwent I&D + liner exchange for PJI. About 4 years later underwent 1-stage revision due to PJI. About a year later, she underwent 2-stage revision for PJI.	Multiply Revised	Ambulates with rolling walker w/out issues

Table 2. Continued

13	M	48	Osteosarcoma	GMRS PTR, MRH knee	31	0	2	2	2 months after mega recon, developed PJI and had lack of soft tissue coverage so opted for AKA	Explanted w/ amputation	Phantom limb pain + poor gait and ill-fitting prosthesis.
14	F	18	Osteosarcoma	GMRS PTR, MRH knee	155	86, 146	0	0	7 years after mega recon, underwent revision for implant loosening. Underwent another revision 5 years later for a fractured femoral component.	Revised	Ambulating w/ out issues
15	M	25	Osteosarcoma	GMRS PTR, MRH knee	191	0	106	108	9 years after mega recon, developed PJI after a splenectomy. 2 weeks later, noted to be persistently draing so underwent 1-stage revision. 2 months later, developed another infection w/ exposed hardware so opted for AKA	Explanted w/ amputation	Ambulates with crutches w/ out issues
16	F	65	Osteoarthritis	GMRS DFR	16	0	4	4	Before mega recon, had multiple attempts at flap coverage. 4 weeks after mega recon, exposed hardware through flap which necessitated AKA	Explanted w/ amputation	Wheelchair bound due to AKA and progressive Multiple Sclerosis
17	F	68	Osteoarthritis	GMRS TFR	12	5	9	0	5 months after mega recon, had revision due to dislocations. Coded at the end of the case. 4 months later had PJI—underwent I&D + liner exchange	Revised	Ambulating w/ walker without issues
18	M	55	Synovial Sarcoma	GMRS DFR w/ prox tibia APC	15	15	6	0	Patient had multiple I&D of flap—at 6 months developed wound infection and underwent I&D + liner exchange. 9 months later developed PJI and underwent 1-stage revision	Revised	Progressing w/ PT, beggining to ambulate
19	F	61	Giant Cell Tumor	Stryker custom DHR APC	13	0	0	0	Doing well	Retained	Progressing w/ PT, struggling with mobility

Patient's treatment course including diagnosis, implant information, adverse events, and functional status. PTR = Proximal Tibia Replacement, MRH = Modular Rotating Hinge, DFR = Distal Femoral Replacement, PFR = Proximal Femoral Replacement, TFR = Total Femoral Replacement, APC = Allograft Prosthetic Composite

the first year follow-up postoperatively. The median time to infection was 106 months (95% CI 6 to not reached). The infection-free survival rate is 68.4% (95% CI 42.8 to 84.4) at two years after initial reimplantation. Nine years after initial reimplantation, infection-free survival rate was 42.1% (95% CI 15.4 to 67.1) [Table 2; Figure 5].

Revision

Five cases (26.3%) required revision surgery after maximum follow-up for each patient. In two of these cases (10.5%) aseptic loosening was the mode of failure, for which these cases received a distal femoral replacement/total femoral replacement. In one case (5.3%) there were multiple dislocations of a prosthesis without evidence to suggestion infection, for which this case underwent a revision total femoral replacement with conversion of the femoral head from a modular bipolar head to a regular head and a polyethylene liner with a posterior 10-degree rim. In one case (5.3%) there was a fracture of the prosthesis, which was treated with a distal femoral replacement and on a later stage with an arthrodesis. One case (5.3%) developed an infection a year from surgery and was revised—five months following this revision and flap coverage, there was failure of the distal aspect of the flap which necessitated flap revision. During this flap revision, the plastic components of the prosthesis were revised. Cultures obtained and infectious markers showed no evidence of infection. Two of the five cases required revision surgery within the first year of follow-up. The revision-free survival rate is 83.9% (95% CI 57.9 to 94.5) at two years after initial reimplantation. Ten years after initial reimplantation, revision-free survival rate was

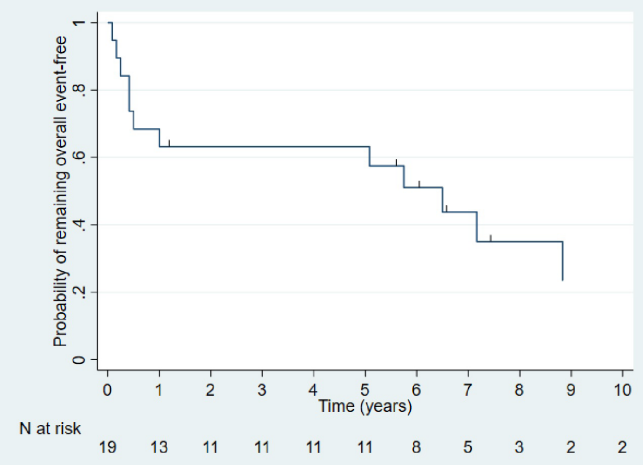

Figure 4. Kaplan-Meier survival analysis for Overall-free survival.

66.4% (95% CI 34.8 to 85.3) [Table 2; Figure 6].

Amputation

Five cases (26.3%) received an amputation after maximum follow-up for each patient. The majority of the cases (n = 3) with an amputation (15.6%) occurred within the first 14 months. In total, five amputations were performed—four (80%) due to infection and one (20%) due to a chronically swollen and painful leg. At two years after initial reimplantation, amputation-free survival rate was 82.8% (95% CI 55.5 to 94.1). Amputation-free survival rate was 65.5% (95% CI 33.4 to 84.9) at 10 years after initial reimplantation [Table 2; Figure 7].

Spacer Length

Spacers greater than 10 cm were used in 15 of the 19

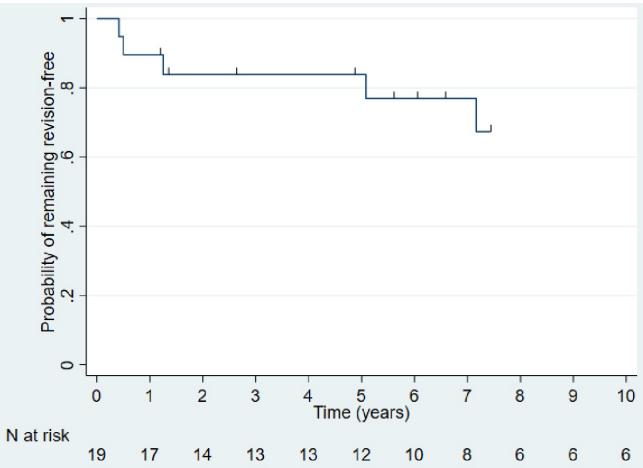

Figure 6. Kaplan Meier curve for probability of remaining revision-free.

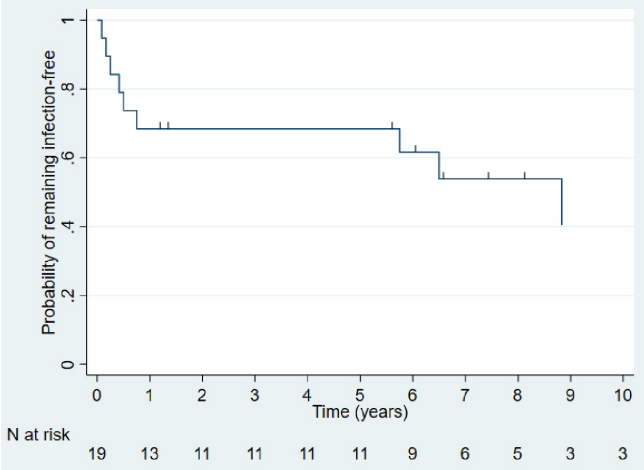

Figure 5. Kaplan Meier curve for probability of remaining infection-free.

cases—one of our patients did not have films at the time of cement spacer insertion and spacer length could not be determined. In three of these cases, spacers of less than 10 cm were used. Multiple surgeries (> 1 surgical procedures) were present in eight observations (53.3%) with spacers greater than 10 cm, compared to three observations (100%) with spacers less than 10 cm. Fisher's Exact test showed no correlation between length of spacer and amount of repeat surgery ($p = 0.245$).

Discussion

Our study investigated the survivability of mega-endoprosthetics following a two-stage revision and attempted to explore how the size of the bony defect would impact the lifespan of these prostheses. The data showed no correlation between size of the bony defect and subsequent surgeries. Theoretically, as the patient undergoes more surgical events, they are more

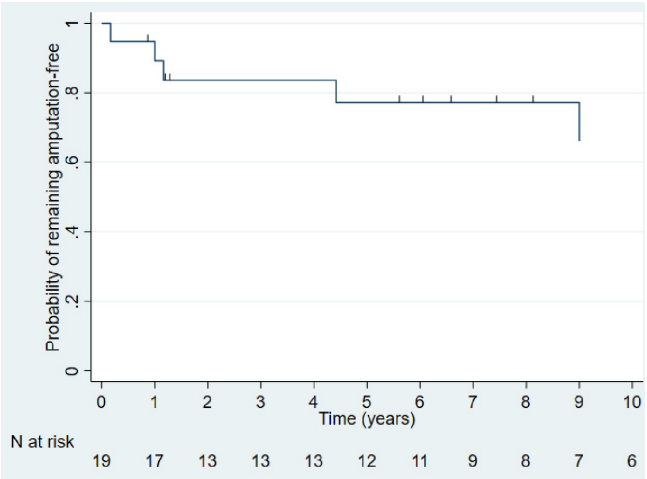

Figure 7. Kaplan Meier curve for probability of remaining amputation-free.

Table 3. Treatment Strategies

Case	PJI Organism	Antibiotic Plan	Implant	Subsequent Infection?	Megaendo Organism	Antibiotic Plan	Long term antibiotic
1	CoNS	IV Vanc x 8 weeks (unknown dosing), PO Clinda x 6 weeks (unknown dosing)	GMRS PTR, MRH knee	No			No
2	MSSA + Klebsiella	IV Vanc (1.75 g IV q12) x 6 weeks 6 weeks then PO Doxycycline (100 mg BID) + Rifampin (300 mg BID) x 6 weeks	GMRS DFR	No			Rifampin (300 mg BID) for 2 years + Doxycycline (100 mg BID) for life
3	MRSA + P. acnes	Vanc (1 g IV q12) + Rifampin (300 mg PO BID) x 6 weeks	Biomet DFR + PTR	No			No
4	MDR Enterobacter	Tigecycline (50 mg IV q12), Gentamycin (100 mg IV q8) x 6 weeks	GMRS DFR	No			No
5	CoNS	Nafcillin (2 g IV q4) + Rifampin (600 mg PO BID) x 8 weeks then Levofloxacin (500 mg PO qD) + Rifampin (300 mg PO BID) x 8 weeks	GMRS DFR + PTR	Yes	Strep mitis	Ceftriaxone (2 g qD) x 6 weeks	No
6	Alpha hemolytic strep	Daptomycin (6 mg IV qD) + Ertapenem (IV dose unknown) x 6 weeks	GMRS DFR w/ all poly tibia	Yes	Alpha hemolytic strep	Cefrriaxone (2 g qD) x 6 weeks	Doxycycline (100 mg BID) until amputation
7	CoNS + P acnes	Vancomycin (1 g IV q12) x 6 weeks	GMRS PFR	No			Doxycycline (100 mg BID) 3 years
8	CoNS	Vancomycin (1g IV q12) + Rifampin (300mg PO BID) x 8 weeks	GMRS PFR	Yes	CoNS + Serratia	Vancomycin (1g q12), Rifampin (300 mg PO TID), Zosyn (3.375 g IV q6) x 6 weeks	No
9	Klebsiella	Vancomycin (1 g IV q8) x 5 weeks d/c 2/2 hepatotoxicity then Ceftriaxone (2 g IV qD) x 3 weeks d/c 2/2 tape dermatitis then Ciprofloxacin (750 mg PO q12) x 6 months	GMRS TFR	Yes	Culture negative	Vancomycin (1.5 g IV q12) + Meropenem (1 g IV q8) x 6 weeks	No
10	Strep mutans	Ceftriaxone (1 g IV qD) x 10 weeks	GMRS DFR w/ all poly tibia	No			No
11	MSSA + GBS	Daptomycin (260 mg IV qD) + Levaquin (500 mg PO qd) x 6 weeks then subsequent infection --> Linezolid (600 mg PO BID) + then Flagyl (500 mg IV q8) Levaquin (500 mg PO qd) x 6 weeks then Fluconazole (100 mg PO qD) x 2 weeks	GMRS DFR w/ all poly tibia	No			No
12	Culture negative	Linezolid (600 mg PO q12) + Aztreonam (1g IV q8) x 6 weeks	GMRS DFR + PTR	Yes	multiple I&D's: culture neg infections and x1 infection with alpha hemolytic strep	(unknown) broad spectrum abx for ~ 6 weeks x 4 events, AHS tx w/ Penicillin (3mU IV q4) x 6 weeks	Doxycycline (100 mg PO qD) + Amoxicillin (875 mg PO BID)
13	Ureaplasma	Vancomycin (1.25 g IV q12) + Levofloxacin (500 mg PO qD) x 6 weeks	GMRS PTR, MRH knee	Yes	Polymicrobial: Pseudomonas, Dermatobacter, Finegoldia, Peptoniphilus	Vancomycin (1.5 g IV q8) + Ciprofloxacin (750 mg PO BID) + Flagyl (500 mg PO BID) x 6 weeks then Augmentin (500 mg PO BID) x 4 weeks + Doxycycline (100 mg PO BID) + Ciprofloxacin (500 mg PO BID) 6 months	No
14	CoNS	Unknown	GMRS PTR, MRH knee	No			No
15	CoNS	Unknown	GMRS PTR, MRH knee	Yes	MSSA + Enterobacter	Penicillin (4 mU IV q4) + Ciprofloxacin (750 mg PO BID) until amp 2 months later	No
16	Culture negative	Vancomycin (500 mg IV q12) x 4 weeks	GMRS DFR	No			No
17	CoNS	Vancomycin (1 g IV q12) x 6 weeks	GMRS TFR	Yes	P. acnes	Vancomycin (1 g IV q12) + Rifampin (300 mg qD) x 6 weeks	Doxycycline (100 mg PO BID) for life
18	Staph epi, Corynebacterium, Finegoldia	Cefazolin (2 g IV q8) x 6 weeks	GMRS DFR w/ prox tibia APC	Yes	Staph epi + Candida	Vancomycin (1500 mg IV q8) + Ciprofloxacin (500 mg PO BID) + Fluconazole (400 mg PO qD) x 6 weeks	Remains on Fluconazole (400 mg PO qD)
19	CoNS	Daptomycin (500 mg IV q24) + Ciprofloxacin (500 mg PO BID) x 6 weeks	Stryker custom DHR APC	No			No

Infecting organisms and associated treatment strategies.

susceptible to losing their prosthesis to infection and/or loss of the soft tissue envelope (10). It is probable that this lack of statistical significance is due to the small number of patients included in the study. Furthermore, the data showed that although there was a complication rate of 63.2% there was a 73.7% chance of retaining the prosthetic after a two-stage revision at a minimum follow-up of one year. This data shows a much higher complication rate and a higher amputation rate than with two-stage revisions for non-mega-endoprosthetics in the current literature (11, 13-15). The follow-up data showed that 15 out of 18 patients (83.3%) were ambulating without issues at minimum one year follow up (four using either a walker or crutches but denying pain) despite the severity and invasiveness of limb salvage surgery. This information leads us to believe that a PJI treated with a two-stage revision and ultimately reimplantation with a mega-endoprosthesis can be successful, but the surgeon must be mindful of a high complication rate.

Due to the possible surgical morbidities, the use of mega-endoprosthetic reconstruction is not for everyone. It will become a serious commitment for both patient and surgeon; limb salvage may end up requiring multiple surgeries and antibiotic treatments which may end up increasing the time and cost required to restore function [Table 3]. Some people will not be able to tolerate or simply may not want to put themselves through multiple invasive surgeries. In these cases, amputation may be the best treatment option. However, it is important to understand that the bony deformity is not a death sentence for the limb. A mega-endoprosthetic can correct this deformity and save what otherwise would be a completely healthy distal leg and foot.

The biggest weakness of our study was the small sample size. Because this is a very rare problem, it was difficult to match patients with our criteria. During the course of recruitment, we had to exclude several patients due to follow-up issues and small inconsistencies. This small sample size took away from the power of our statistical tests and caused our data to lose significance in a standard t-test. The Mann-Whitney-Wilcoxon test allowed us to analyze this small and slightly unbalanced data and came up with correlations at 95% confidence. Another weakness was functional status evaluation; given our loss to follow-up and the retrospective nature of this study, it was not possible to reach a large majority of these patients for administration of functional status questionnaires. Instead, we relied on the subjective nature of the surgeon's clinic visit assessment. Because this study was retrospective, it will allow us to continue adding to our data set. Over time, this sample size can be increased, and we will be able to use the more reliable t-test for statistical correlation. This study suggests that use of a mega-endoprosthetic following two-stage revision for megaprostheses PJI can be a successful treatment option.

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