Functional Ability After Above-the-knee Amputation for Infected Total Knee Arthroplasty

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Abstract

Background Prosthetic joint infection is an uncommon but serious complication of total knee arthroplasty (TKA). Control of infection after TKA is not always possible, and the resolution of infection may require an above-knee amputation (AKA).

Questions/purposes The purpose of this study was to determine the etiology of AKA and the functional outcomes of AKA after infected TKA.

Methods We retrospectively reviewed 35 patients who underwent AKA after an infected TKA. The amputations

were performed an average of 6 years (range, 21 days to 24 years) after primary TKA. There were 19 females and 16 males with a mean age of 62 years (range, 26–88 years). Patient demographic information, comorbidities, surgical treatments, cultures, and culture sensitivities were recorded. Complications and functional status, including SF-12 and activities of daily living questionnaires, after AKA were also studied. The minimum followup was 7 months (mean, 39 months; range, 7–96 months).

Results Two patients died secondary to cardiac arrest and 13 more died during the followup period of unrelated causes. Nine patients required irrigation and débridement for nonhealing wounds after AKA and two patients had repeat AKA for bony overgrowth. Of the 14 patients fitted for prostheses, eight were functionally independent outside of the home. Patients fitted with a prosthesis had higher mean activities of daily living scores (58 versus 38) and also tended to be younger with fewer comorbidities than those who were not fitted with a prosthesis.

Conclusions We found low functional status in living patients with an AKA after infection with only half of the patients walking after AKA.

Level of Evidence Level IV, therapeutic study. See the Guidelines for Authors for a complete description of levels of evidence.

Each author certifies that he or she has no commercial associations (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements, etc) that might pose a conflict of interest in connection with the submitted article.

Each author certifies that his or her institution has approved the human protocol for this investigation, that all investigations were conducted with ethical principles of research, and that informed consent for participation in the study was obtained.

This work was performed at the University of Pittsburgh, Pittsburgh, PA, USA, and Thomas Jefferson University Hospital, Philadelphia, PA, USA.

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Introduction

Recurrent infection after two-stage exchange arthroplasty for infected TKA is a challenging problem. With persistent and recurrent infections, the surgeon is limited in treatment choices and may have to consider an above-the-knee amputation (AKA) to control the infection [2–5].

AKA is a definitive treatment to resolve infection in patients who have persistent infection after TKA who have exhausted all treatment options and/or are not suitable for a two-stage exchange arthroplasty or arthrodesis. The incidence of AKAs after primary TKAs is reportedly 0.10% [13]. Amputation after TKA is rare and our understanding of how these patients function is limited. Prior studies indicate patients undergoing AKA as a direct result of TKA had poor functional capabilities [7, 11, 13]. They reported less than 50% are ever fitted with a prosthesis and even fewer patients are ambulatory after AKA [7, 11, 13]. As a result of the rarity of AKA as a complication of TKA, these previous studies have included small patient populations and none to date have focused on AKA after septic TKA. Furthermore, the microbiology of the persistent infections that have failed all other treatment options leading to AKA has yet to be reported. Therefore, further data are needed to understand the factors leading to AKA and to confirm previously reported functional outcomes of AKA after infected TKA in a larger cohort.

Our goals were (1) to evaluate the causes for amputation, including the infecting microorganism; (2) to determine the complication rate after AKA; and (3) to assess the ambulatory status and ability to perform activities of daily living in infected TKAs treated with AKA.

Patients and Methods

We retrospectively reviewed 35 patients at two institutions who underwent an AKA for treatment of an infected TKA between 1994 and 2009. Before AKA, nine of the 35 patients lived independently; 5 could walk unlimited distance (two of which required an aid), 3 could walk less than 5 blocks outside of their home, and the other 27 were homebound. AKAs were performed on average 6 years (range, 6 months to 24 years) after primary TKA. There were 19 females and 16 males with a mean age of 62 years (range, 26–88 years). The mean body mass index was 33 kg/m² (range, 21–62 kg/m²). The average number of comorbidities at the time of AKA for this cohort was four (range, 1–8). Comorbidities included heart disease (21 patients), vascular disease (eight patients), diabetes (14 patients), chronic renal failure (eight patients), inflammatory arthritis (five patients), and malignant disease (eight patients). We used the American Society of Anesthesia score [1] to analyze the overall medical condition of the patient with a score of 4 (severe systemic disease that is a constant threat to life) in 14%, 3 (severe systemic disease) in 48%, and 2 (mild systemic disease) in 38% of patients. Patients had an average of five procedures (range, 1–10) between primary TKA and

AKA (Table 1). Fifteen patients died during the postoperative followup period. Twelve of the 20 remaining patients were available for followup by telephone to evaluate functional outcomes after AKA. Seven patients had sufficient data in their chart for inclusion and the remainder of the cohort was considered lost to followup with regard to functional outcomes secondary to death ($n = 15$) or inability to contact ($n = 1$). The average time from amputation to final followup or death was 35 months (range, 20 days to 95 months). Patients were followed for a minimum of 7 months or until death. Minimum followup was 7 months (average, 39 months; range, 7–96 months). Only one patient who had an AKA as a result of a septic TKA between 1994 and April 2009 was followed for less than 12 months, but that patient had already been fitted with a prosthesis at the last followup visit at 7 months and was therefore included. No patients were recalled specifically for this study; data were obtained from the medical records in 21 of the 35 patients and by telephone in 14.

AKA was performed by several different surgeons at two large centers over a long time period and we did not use any standard technique although certain principles were respected. The surgeon in all cases attempted to maintain adequate femoral length for a well-fitted prosthesis. Length was determined by the remaining healthy bone and soft tissue coverage. The soft tissues also dictated the timing for fitting of the prostheses. Many of the chronic knee infections that resulted in AKA had poor tissues, and the wounds healed slowly. Healing the stump was our first priority and therefore early and accelerated rehabilitation for this group was impossible.

We collected intraoperative culture results, joint aspirations, and culture sensitivities from all patients at the time of AKA. Resistant Gram-positive organisms (methicillin-resistant *Staphylococcus aureus*/methicillin-resistant *Staphylococcus epidermidis*) were cultured in 39%, Gram-negative organisms in 27%, and methicillin-susceptible *S. aureus*/methicillin-susceptible *S. epidermidis* in 16% of knees resulting in AKA (Table 1).

Chart review was completed on all 35 patients for details of complications, whether or not the patient had been fitted with a prosthesis, and functional independence post-AKA. We assessed functional capabilities and independence with the use of the SF-12, which has been used to document the overall well-being of the patient [14, 15], and the activities of daily living score (ADLS) to evaluate the ability of the patient to function [6, 10]. In addition, patients were asked questions regarding the amputation itself, including whether they were fitted with a prosthesis, their ambulatory status, the use of aids for ambulation, transfer status, and level of independence both pre- and postamputation (Appendix 1). All questionnaires were read

Table 1. Patients with above-the-knee amputation for infected TKA

Case number	Gender	Age at AKA	Number of previous surgeries	ASA	Microbiology	Died	SF-12 PCS/MCS	ADLS	Fitted for prosthesis?	Ambulation status last followup	Housing
1	M	52	9	3	MSSE				Y	Unlimited without aids	Independent
2	M	59	1	4	MRSA	Y (2 months)					
3	F	61	3	4	MRSA; Escherichia coli		28.1/48.9	67.1	Y	Housebound with walker	House with assistance
4	M	56	9	3	MRSA				Y	Housebound without aids	House with assistance
5	F	75	5	3	MRSA		24.7/35.4	24.3	N (patient choice)	Nonambulatory	House with assistance
6	F	77	5	3	E. coli	Y (33 months)			Y	< 5 blocks with walker	
7	F	66	7	3	Klebsiella; Pseudomonas		21.0/36.1	45.7	N		House with assistance
8	F	75	6	3	MRSA; Enterobacter		31.7/43.4	44.2	N		Nursing home
9	F	77	5	4	MRSE; Proteus; Serratia	Y (4 months)					
10	M	26	6	2	E. coli; Enterococcus; MRSE				Y	< 5 blocks with crutches	House with assistance
11	M	82	8	3	No growth		37.5/25.9	55.7	Y	Transfers only with walker	House with assistance
12	F	81	4	4	Pseudomonas	Y (3 months)					
13	F	43	4	2	No growth		25.7/55.8	32.9	Y	Transfers only with walker	Independent
14	M	56	9	2	MRSE		52.8/27.3	48.6	Y	Nonambulatory	Assisted living facility
15	F	67	10	2	MRSE	Y (48 months)					
16	M	30	5	2	No growth		31.8/62.9	57.1	Y	< 5 blocks without aids	Independent
17	M	44	4	2	MSSA						
18	F	79	2	3	MSSE	Y (48 months)					
19	F	31	5	2	S. pneumoniae; MSSA						
20	M	75	2	3	MRSE		37.7/56.7	75.7	Y	< 5 blocks with walker	House with assistance
21	F	42	5	2	MSSA; MSSE				Y	Unlimited without aids	Unknown
22	M	48	7	2	MRSA	Y (81 months)					
23	M	75	5	2	S. lugdunensis	Y (54 months)					
24	M	74	9	3	MRSA	Y (44 months)					
25	F	74	8	2	MRSA		25.0/53.3	45.7	Y	Unlimited with walker	House with assistance
26	F	48	3	3	Serratia; Candida				N	Nonambulatory	Unknown

Table 1. continued

Case number	Gender	Age at AKA	Number of previous surgeries	ASA	Microbiology	Died	SF-12 PCS/MCS	ADLS	Fitted for prosthesis?	Ambulation status last followup	Housing
27	F	65	4	3	MRSA; Enterococcus	Y (51 months)			N	Transfers only	Unknown
28	M	57	2	3	MRSE						
29	F	85	2	3	MSSE	Y (0.6 months)					
30	M	69	5		VREF; Proteus; E. coli	Y (29 months)					
31	F	42	2		No growth	Y (32 months)			Y	Unknown	Unknown
32	F	67	3		No growth						
33	M	49	6		Streptococcus		55.6/51.1	78.6	Y	Unlimited with cane	Independent
34	M	88	8		MRSA	Y (9 months)					
35	F	77	1		No growth	Y (38 months)					

AKA = above-the-knee amputation; ASA = American Society of Anesthesiologists; PCS/MCS = physical component score/mental component score; ADLS = activities of daily living score; M = male; F = female; MSSE = methicillin-susceptible *Staphylococcus epidermidis*; MRSA = methicillin-resistant *Staphylococcus aureus*; MRSE = methicillin-resistant *Staphylococcus epidermidis*; MSSA = methicillin-susceptible *S. aureus*; VREF = vancomycin-resistant *Enterococcus faecalis*; Y = yes; N = no.

over the phone to the patient and the answers were recorded by one of the authors.

Results

Two patients died in the immediate postoperative period secondary to cardiac arrest and 13 more patients died of causes seemingly unrelated to their septic joint during the followup period at an average of 40 months post-AKA (range, 3.7–81 months); two patients died within 6 months of their AKA and another one within a year (Table 1). Nine patients required irrigation and débridement (I&D) after their AKA and two patients required an AKA stump revision for nonhealing stumps. One patient had removal of their ipsilateral hip implant at the same time as their AKA and had to have a branch of their superior gluteal artery ligated as a direct complication of the hip explantation.

After AKA, 14 patients were fitted with a prosthesis. Of these, nine actually wore the prosthesis with seven wearing it more than 1 hour a day. Three patients only used the prosthesis for transfers, whereas one patient never used his prosthesis and was wheelchair-bound (Table 1). Eight of the 14 were able to walk outside of the home but only four were able to ambulate unlimited distances. Of these four patients, two were able to walk independently without the use of aids, one required a cane, and one required a walker. Four patients could walk outside less than five blocks at a time; one used no aids, one required crutches, and two used walkers. Two more patients were household ambulators. Twelve patients were able to remain in their own homes but 8 required assistance. One patient lived in an assisted living facility, whereas another patient required full assistance in a nursing home. The living situation of the remaining six patients was unknown. However, a higher percentage of patients fitted with a prosthesis were able to remain in their own houses either independently or with some assistance (91% versus 67%). Only patients fitted with a prosthesis were able to live independently (Table 1). Those fitted with a prosthesis had a higher mean ADLS score than those who were not: 58 ± 14 versus 38 ± 12 , respectively. The patients who were fitted with a prosthesis tended to be younger (55 ± 17 versus 66 ± 10 years) with fewer comorbid conditions (3 ± 2 versus 5 ± 1) compared with those who were never fitted. They also tended to have higher average mental component (47 ± 14 versus 38 ± 4) and physical component (36 ± 11 versus 25 ± 5) SF-12 scores. Body mass index (BMI) and American Society of Anesthesiologists (ASA) scores were similar between groups (Table 2). The patients fitted with a prosthesis who were community ambulators also tended to be younger with less comorbid conditions

Table 2. Patients fitted for a prosthesis after AKA versus those not fitted

Fitted for a prosthesis	Age (years)	BMI (kg/m ²)	ASA	Number of comorbidities	ADLS	SF-12 PCS	SF-12 MCS
Yes (n = 14)	53 ± 16	35 ± 10	2.5 ± 0.7	3.8 ± 1.9	58.2 ± 14.6	37 ± 12	48 ± 14
No (n = 5)	66 ± 11 (p = 0.1)	38 ± 11 (p = 0.5)	3.0 ± 0.0 (p = 0.2)	5.4 ± 1.1 (p = 0.1)	38.1 ± 12.0 (p < 0.05)	26 ± 5 (p = 0.1)	38 ± 4 (p = 0.2)

AKA = above-the-knee amputation; BMI = body mass index; ASA = American Society of Anesthesiologists; ADLS = activities of daily living score; PCS = physical component score; MCS = mental component score.

Table 3. Community ambulators versus homebound patients

Variable	Community ambulators*	Homebound	p Value
Age (years)	50 ± 19	60 ± 14	0.2
BMI (kg/m ²)	36 ± 4	34 ± 15	0.1
ASA	2.3 ± 0.5	2.8 ± 0.8	0.3
Number of comorbidities	3 ± 1	4 ± 2	0.3
ADLS	64.0 ± 13.5	51.0 ± 14.4	0.1
SF-12 PCS	37 ± 13	36 ± 12	0.8
SF-12 MCS	56 ± 5	39 ± 15	0.08

* Able to walk outside of the home; BMI = body mass index; ASA = American Society of Anesthesiologists; ADLS = activities of daily living score; PCS = physical component score; MCS = mental component score.

compared with those who were fitted with a prosthesis but were homebound. Community ambulators also tended to have higher mean ADLS scores along with higher mean physical and mental component scores on the SF-12. BMI and ASA scores were similar in both groups (Table 3).

Discussion

Prosthetic joint infection can be a devastating complication after TKA. Modern surgical treatments and medications are unable to control all of these infections. If an infection from a TKA cannot be controlled, a definitive and last resort treatment that can be used is AKA. Three previous studies have reported patients undergoing AKA as a direct result of TKA had poor ambulatory and functional capabilities [7, 11, 13]. However, these reports studied smaller patient cohorts and none focused only on AKA after infected TKA. We therefore (1) evaluated the causes for amputation, including the infecting microorganism; (2) determined the complication rate after AKA; and (3) assessed the ambulatory status and ability to perform activities of daily living in infected TKAs treated with AKA.

There are several limitations to this study. First, we did not compare our patients with a matched group of patients

who underwent AKA for reasons not related to TKA. This may have allowed us to compare the functional capabilities of the two groups to determine if patients undergoing AKA for septic TKA were worse off than those undergoing AKA for other reasons. Developing a matched group was not possible at these two institutions. Second, the retrospective nature of our study may introduce recall bias both by the physician and patient. Because much of our data was collected by telephone surveys, the patient may not have answered accurately because many of these operations happened years ago, and the majority of this patient population is elderly. Patients may also have not accurately answered questions about their living status, because some are reluctant to admit they require help to perform their activities of daily living. Third, a large number of the patient population died during the followup period and were therefore not available for evaluation with outcome questionnaires. The high death rate reflects the poor health in this group of patients. Finally, although the numbers are larger than that previously reported in the literature, the sample size is too small for meaningful statistical analysis to determine the role of comorbidities in the development of infection leading to AKA or the role of comorbidities in the functional outcome post-TKA. The sample size was also too small to determine the potential risk factors for AKA after TKA. However, this sample size is relatively large considering how rare AKA is after TKA; data were pulled from two large tertiary care institutions over 15 years.

Amputations are a last resort treatment for difficult to control TKA infections. It therefore correlates that two-thirds of the infections in this cohort came from resistant Gram-positive (39%) and Gram-negative organisms (27%), which are the most difficult to cure [8, 9, 12]. Parvizi et al. [9] and Mittal et al. [8], respectively, demonstrated a 40% and 24% reinfection rate after two-stage exchange arthroplasty in methicillin-resistant *S. aureus*/methicillin-resistant *S. epidermidis* prosthetic joint infections. These patients required further surgery in an attempt to control the infection. The majority of the patients in our study also had multiple failed surgical procedures (average, 5; range, 1–10) in an effort to eliminate their infections before their AKA. Patients continued to have

complications postoperatively with nine requiring an I&D after their AKA and two undergoing stump revision for a nonhealing wound. Two postoperative deaths occurred secondary to cardiac arrest and two more patients died within the first 6 months after AKA. These complications are not surprising in this group of patients with multiple medical conditions (62% had an ASA of 3 or 4) leading to wound healing problems and complicated postoperative courses. Sierra and Trousdale also demonstrated a high mortality rate during their followup period with 10 of 25 patients dead at final followup [13].

Our data confirmed the overall low ambulatory status and functional capabilities seen in other studies. Of the 19 patients who had complete medical records to review, 14 were fitted with a prosthesis and only eight were able to become community ambulators at any level. Three previous studies report followup of AKA after infected TKA. Pring et al. studied 23 AKAs for unsuccessful TKA and found only seven patients were regular daily walkers and 12 patients were confined to a wheelchair at final followup [11]. Isiklar et al. reported only three of eight (35%) patients were ambulatory (two with walkers and one with a prosthetic device) [7]. More recently, Sierra and Trousdale studied 25 patients who had AKAs as a direct result of TKA complications. Eighteen of these AKAs were performed for infection. They found only six of the 18 (33%) patients were fitted with a prosthesis and of those six, only three were ambulatory (two for less than five blocks and one housebound ambulator). One more of the 18 patients was not fitted with a prosthesis but was a household ambulator with two crutches [13]. We found more patients were fitted with a prosthesis after AKA for infected TKA compared with Sierra and Trousdale (13 of 19 versus six of 18 patients). Also, a larger number of patients were able to ambulate unlimited distances (four of 13 versus zero of six) or at least ambulate outside of the home (four of 13 versus two of six). There may be

explanations for the differences in the outcomes in the two studies. The cohort reported by Sierra and Trousdale was collected over a much longer period of time (1970–2000 versus 1994–2009), and prosthetic devices evolved during this time period. Patients undergoing an AKA in more recent years have more options for custom-made devices that may make it easier to ambulate. Also, the average age of patients in our study was almost 10 years younger than that of Sierra and Trousdale (62 versus 71 years) [13]. The lower age may suggest a more active and healthy patient population allowing for easier ambulation either with a prosthesis or ambulatory aid. No other study of AKAs for infected TKAs has looked at functional outcomes using ADLS or SF-12 questionnaires. We found patients who were fitted with a prosthesis had higher ADLS scores than patients who were never fitted with a prosthesis. We also demonstrated a trend toward higher SF-12 mental and physical scores in the patients who were fitted with a prosthesis. More importantly, our data suggest patients who were fitted with a prosthesis and were able to ambulate outside the home tended to have higher outcomes scores (SF-12 and ADLS). Further research with a larger cohort may solidify these trends. This may require a multicenter study.

Our study demonstrated a higher percentage of patients fitted with a prosthesis compared with the literature (68% versus 33%) and a higher percentage were ambulatory at last followup (53% versus 22%) [12]. Regardless of these comparisons, functional outcomes in this study are still poor with only half of the patients ambulating after AKA. AKA should therefore be reserved for the most severe cases of recurrent or persistent infection. AKA should only be used as a last resort treatment.

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Appendix 1: Above-The-Knee Amputation Functional Ability Questionnaire

Patient name: _____ Date: _____ Time: _____
Number called: _____

Question 1a: Just before above-the-knee amputation, how would you characterize your ability to walk?

1. Able to walk outside of the house, unlimited distance
2. Able to walk outside the house, < 5 blocks
3. Able to walk around the house only
4. Only use your legs to get in and out of bed, out of a chair, or the bathroom
5. Not able to walk at all

Question 1b: If you were able to walk before your amputation, do you need assistance from a device:

1. No ambulatory aid
2. Cane
3. Crutches
4. Walker

Question 2: Before your amputation, where did you live?

1. In your own house, without assistance
2. In your house, with outside assistance (from family or home care nurses, etc)
3. In an assisted living facility
4. In a nursing home

Question 3a: After your amputation, were you ever fitted for a prosthesis?

1. Yes
2. No

Question 3b: How often did you wear your prosthesis?

1. Never
2. Less than 1 hour a day
3. More than 1 hour a day

Question 3c: With you prosthesis, how well were you able to walk?

1. Able to walk outside of the house, unlimited distance
2. Able to walk outside the house, < 5 blocks
3. Able to walk around the house only
4. Only use your legs to get in and out of bed, out of a chair, or the bathroom
5. Not able to walk at all

Question 3d: With your prosthesis, did you require an aid to get around?

1. No ambulatory aid
2. Cane
3. Crutches
4. Walker

Question 3e: If you were not fitted for a prosthesis, what was the reason?

1. Surgeon choice
2. Patient choice

Question 4: After your above-the-knee amputation where did you live?

1. In your own house, without assistance
2. In your house, with outside assistance (from family or home care nurses, etc)
3. In an assisted living facility
4. In a nursing home

Question 5: Did you have to have any additional surgeries on your amputation leg after your amputation?

1. No
2. Yes—washout of the wound
3. Revision amputation

Question 6: Do you have any problems with your nonamputation leg that inhibit you from walking around?

1. Yes
2. No

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