Better Function for Fusions Versus Above-the-knee Amputations for Recurrent Periprosthetic Knee Infection

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Abstract

Background Treatment of chronic periprosthetic joint infections (PJIs) after TKA is limited to fusions, above-the-knee amputations (AKAs), revision TKA, and antibiotic suppression and is often based on the patient's medical condition. However, when both fusion and AKA are options, it is important to compare these two procedures with regard to function.

Questions/purposes Do patients receiving a knee fusion for PJI after TKA have better function compared to patients receiving an AKA?

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

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Methods We retrospectively reviewed patients who were eligible for either fusion or AKA after PJI TKA. Thirty-seven patients underwent a fusion for PJIs after TKA between 1999 and 2010. Nine patients died postoperatively and eight patients were lost to followup, leaving 20 patients. Patients completed a specialized questionnaire about their fusion, and functional capability was assessed by the SF-12. We compared fusions to a previously published group of six patients who underwent AKA for recurrent PJI after TKA.

Results For patients with fusion, community ambulators increased from five to 10 and nonambulators decreased from three to one. For patients with AKA, nonambulatory patients increased from zero to two, and community ambulators decreased from four to one. The SF-12 physical component summary measurements were higher for fusions (51) than for AKAs (26). The mental component summary was also higher in fusions (60) than in AKAs (44). Seventy percent of patients indicated they would undergo a fusion again instead of undergoing an amputation if they were presented with both options after undergoing their operation.

Conclusions Patients receiving knee fusions for treating recurrent PJIs after TKA have better function and ambulatory status compared to patients receiving AKA.

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

Introduction

The treatment of periprosthetic joint infections (PJIs) after TKA commonly consists of antibiotic administration and one-stage reimplantation [5, 9, 20] or two-stage

reimplantation [21, 23, 24, 26, 39, 59]. The rate of recurrence ranges from 9% to 33% [21, 23, 26, 33, 39, 40, 49, 57, 59], and the treatment options for treating patients who have failed multiple revision TKAs are limited to revision TKA [52], long-term antibiotic suppression [44], fusion [2–4, 6, 10, 11, 13, 14, 22, 28, 34, 35, 42, 43, 47, 54], above-the-knee amputation (AKA) [17, 30, 41, 51], and resection arthroplasty [52]. Patients who undergo resection arthroplasty often do not have good function after surgery [50], and this surgery is usually performed for severely medically compromised patients [52]. When revision TKA fails, knee arthrodesis and AKA are the two remaining options [38].

Arthrodesis of the knee after PJI TKA is a reasonable option as it retains the leg and provides a stable and pain-free limb for ambulation. Fusions are performed using external fixators [11, 22, 53], intramedullary nailing [2, 3, 13, 14, 28, 42, 54], or plate and screw fixation [35]. Patients with knee fusions are able to perform strenuous physical tasks, but the loss of motion at the knee makes sitting difficult [25]. The amount of energy required to ambulate on an AKA is greater (0.20 mL/kg/minute) than that on a fused limb (0.16 mL/kg/minute) [10, 58]. Additionally, patients who undergo AKA often have reduced capacity to ambulate [10, 58].

Previous studies in patients with trauma have compared outcomes of amputations to fusions using various indexes, including Sickness Impact Profile [8], Limb Function Score [16], and Mangled Extremity Syndrome Index [36]. Older studies have demonstrated patients with trauma receiving fusion fare worse than those receiving amputation with regard to multiple factors, including more complications and operative procedures, longer hospital stays, worse limb function, and decreased quality of life [16, 18]. A recent study demonstrated patients with trauma undergoing lower-limb reconstruction had similar levels of health when compared to those undergoing amputation at 2-year followup, although patients undergoing fusions were more likely to be rehospitalized compared to those undergoing amputation [8]. Studies of patients with musculoskeletal tumors have also supported the use of limb salvage over amputation based on function and improved physical scores [1, 12, 19, 27, 45, 46]. These studies have laid a foundation for comparing patients with limb salvage to those with amputation, but studies have not been conducted in patients with arthroplasty directly comparing these two procedures. Several studies propose algorithms on whether to treat trauma patients with limb salvage or amputation [36, 37], but none compare patients with an infected TKA who are eligible for either an amputation or AKA.

We therefore compared patients with PJI after TKA who were eligible for either an AKA or fusion in regard to the following parameters: (1) preoperative and postoperative

ambulatory status and (2) physical and mental status after AKA or fusion.

Patients and Methods

We performed a retrospective cohort study examining all 74 patients who underwent a fusion or AKA for recurrent PJI after TKA between 1999 and 2010. All but six patients were candidates for either a fusion or AKA, and all patients had failed suppressive antibiotic therapy; this left 68 eligible patients. Of these 68 patients, 39 had a fusion and 29 an AKA. The indications for fusion were (1) patient preference, (2) adequate bone stock for reconstruction, (3) and extensor mechanism disruption. The indications for AKA were (1) patient preference, (2) excessive loss of bone, (3) previous below-the-knee amputation, (4) failed distal femoral replacement, (5) previous failed fusion, (6) contralateral limb fusion, and (7) the need to remove the nidus for infection for other surgical interventions (ie, aortic valve replacement). The indications of undergoing either of these procedures were (1) patient preference, (2) adequate bone stock, (3) adequate soft tissue envelope, and (4) surgical resolution of PJI after TKA. The contraindications for these two procedures were (1) no medical clearance to undergo a surgical procedure and (2) patient preference to not perform either an AKA or fusion. Among the 68 patients, we included only those who filled out the SF-12 self-assessment form and patient questionnaires specific to their method of treatment and who had a minimum of 1-year followup; these criteria resulted in the exclusion of six of the 68 patients. Since all 68 patients were contacted to participate in this study, there was selection bias present as only those who chose to respond were included. Of the remaining 62 patients, there were 37 patients receiving fusion (15 men, 22 women; 18 right, 19 left) with an average $\pm$ SD age of 63.2 ± 11.0 years at the time of fusion (Fig. 1). However, of these 37 patients, nine patients died postoperatively (all from causes unrelated to their fusion) and eight patients were lost to followup,

Fig. 1 A flowchart illustrates the study design for patients undergoing fusion versus AKA for treatment of PJI after TKA.

leaving 20 patients receiving fusion (eight men, 12 women; nine left, 11 right) available for analysis (Table 1). The average age was 63.1 ± 10.5 years, the average BMI was 37.2 ± 8.3 kg/m², and the number of comorbidities ranged

from two to 12. For American Society of Anesthesia (ASA) score [48], three patients were Class II, 15 were Class III, and two were Class IV. The average time to fusion after TKA was 3.9 ± 4.9 years. The average followup was 54.1 months

Table 1. Comparison of demographics and outcomes of patients undergoing knee fusion or AKA as treatment for periprosthetic joint infections after TKA

Variable	Fusion	AKA	p value
Number of patients	20	6	
Sex			0.132
Male	8 (40%)	0 (0%)	
Female	12 (60%)	6 (100.0%)	
Laterality			0.612
Right	11 (55.0%)	4 (66.7%)	
Left	9 (45.0%)	2 (33.3%)	
Age (years)*	63.1 ± 10.5	67.2 ± 12.2	0.224
BMI (kg/m ²)*	37.2 ± 8.3	35.4 ± 10.7	0.497
Number of comorbidities			0.418
1	0	0	
2	2	0	
3	2	0	
4	4	1	
5	2	1	
6	2	3	
7	4	0	
8	0	0	
9	1	1	
10	2	0	
11	0	0	
12	1	0	
ASA class			0.484
1	0 (0%)	0 (0%)	
2	3 (15.0%)	2 (33.3%)	
3	15 (75.0%)	4 (66.7%)	
4	2 (10.0%)	0 (0%)	
Time after primary surgery (years)*	3.9 ± 4.9	8.1 ± 7.1	0.352
Number of surgeries	4.4 ± 2.7	6.5 ± 2.1	0.036
Length of followup (months) [†]	54.1 (12.3–134.3)	37.5 (7–95)	0.224
Complications of surgery			
Irrigation and débridement	8 (40.0%)	1 (16.7%)	0.292
Revision	6 (30.0%)	0 (0%)	0.126
Preoperative ambulatory status			
Out of home	5 (25.0%)	4 (66.7%)	0.060
At home	12 (60.0%)	2 (33.3%)	0.250
Nonambulatory or transfers	3 (15.0%)	0 (0%)	0.313
Postoperative ambulatory status			
Out of home	10 (50.0%)	1 (16.7%)	0.147
At home	9 (45.0%)	3 (50.0%)	0.829
Nonambulatory or transfers	1 (5.0%)	2 (33.3%)	0.057

* Values are expressed as mean $\pm$ SD; [†] values are expressed as mean, with range in parentheses; the remaining values are expressed as number of patients, with percentage in parentheses; AKA = above-the knee amputation; ASA = American Society of Anesthesiologists.

(range, 12.3–134.3 months). Of the remaining 62 patients, there were 25 patients receiving AKAs (10 men, 15 women; 15 right, 10 left) with an average age of 64.1 ± 15.3 years at the time of AKA (Fig. 1). Twelve patients died (two secondary to cardiac arrest in the immediate postoperative period, 10 secondary to causes unrelated to their surgery) and seven were lost to followup, leaving six patients receiving AKA (six women; four right, two left) available for analysis (Table 1). The average age was 67.2 ± 12.2 years, the average BMI was 35.4 ± 10.7 , and the number of comorbidities ranged from four to 9. For ASA score, two patients were Class II and four were Class III. The average time to AKA after TKA was 8.1 ± 7.1 years. The average followup was 37.5 months (range, 7–95 months). Two of the six patients received prostheses. In both groups, we excluded a total of 21 deceased patients and 15 patients lost to followup between 2.9 and 68.2 months postoperatively. This study was conducted with institutional review board approval (PRO08080139) and all persons gave their informed consent.

The two groups were similar with regard to age, sex, laterality of the procedure, and medical condition, including BMI, ASA score, and number of comorbidities (Table 1). However, the average number of surgeries was lower ($p = 0.036$) from TKA to fusion (4.4 ± 2.7) than from TKA to AKA (6.5 ± 2.1). There was no difference in revision rates after fusion or AKA, although one patient with fusion did subsequently undergo an AKA.

Fusions were performed by two-column plating (two) and intramedullary nailing (18). The patients with fusion and with AKA completed specialized questionnaires about their fusion (Appendix 1; supplemental materials are available with the online version of CORR) and their AKA [17], respectively. Both questionnaires assessed a patient's ability to walk, use of walking aids, and a patient's living situation both before and after surgery. A community ambulator was defined as someone who could ambulate independently outside of the house. A household ambulator was someone who could ambulate around the home, and a nonambulator was someone who transferred short distances or was bedbound. The specialized fusion questionnaire also ascertained a patient's pain score, whether subsequent surgeries were performed, and whether they would undergo a fusion again if given the opportunity. Similar questions in the questionnaires allowed for direct comparisons between the two groups.

There were multiple organisms present in these patients with recurrent PJI. The majority of patients were affected by gram-positive organisms. Of the patients with fusion, seven were infected with methicillin-resistant *Staphylococcus aureus* (MRSA), four with coagulase-negative *S aureus* (CNS), two with methicillin-sensitive *S aureus* (MSSA), two with *Pseudomonas aeruginosa*, and three

with mixed organisms (MRSA/*Streptococcus/Klebsiella*, MRSA/vancomycin-resistant *Enterococcus/Candida glabrata*, and Group B *Streptococcus/Klebsiella/Citrobacter freundii*). Two of the patients were culture negative. Of the patients with AKA, there was one culture-negative patient, two with MRSA, and three with mixed organisms (MRSE/*Escherichia coli/Enterobacter*, MRSA/*Enterobacter*, and *Klebsiella/P aeruginosa*).

Postoperative visits were conducted at 2 weeks, 6 weeks, 3 months, 6 months, and 1 year and on a yearly basis thereafter. AP and lateral radiographs of the knee or amputation site were obtained at each postoperative visit. Ambulatory and neurologic function was assessed at each clinic visit, in addition to complications that required further surgery (irrigation and débridement or revision surgery). Along with the treatment-specific questionnaires, we further assessed patients' functional capabilities using the SF-12. Previous validation studies determined the SF-12 is comparable to the SF-36 for assessing patients' physical and mental states [31, 32, 55, 56]. The physical component summary (PCS) and mental component summary (MCS) scores from the SF-12 were used to compare patient outcomes between groups. Other questionnaires were considered, such as the Activities of Daily Living questionnaire [29] and the WOMAC Osteoarthritis Index. We believed these other questionnaires were not appropriate for assessing outcomes after AKAs or fusions, based on questions such as stiffness, giving way, buckling, or shifting of the affected knee.

We compared continuous demographic variables, such as age, BMI, time after surgery, length of followup, and number of surgeries, between the fusion and AKA cohorts using Mann-Whitney U tests. Nominal variables, such as sex, laterality, ASA score, comorbidities, and complications of surgery, were compared between both groups using Fisher exact test. We determined the differences in preoperative and postoperative ambulatory status between the two groups using the Fisher exact test. We determined the difference in PCS and MCS between the two groups using the Mann-Whitney U test. All statistical analyses were performed using PASW® Version 18.0 (SPSS, Inc, Chicago, IL, USA).

Results

The ambulatory status of patients differed before and after surgery and between groups (Fig. 2). Before fusion, three were nonambulatory, 12 were household ambulators, and five were community ambulators. After fusion, one was nonambulatory, nine were household ambulators, and 10 were community ambulators. In comparison, in the AKA group, there were only ambulatory patients before

surgery (four community ambulators, two household ambulators). After surgery, two were nonambulatory, three were household ambulators, and one was a community ambulator. Postoperative nonambulatory status differed between the two cohorts, as there were more ($p = 0.057$) nonambulators after AKA than after fusion.

The SF-12 results also differed between groups. The SF-12 PCS scores were higher ($p < 0.001$) for patients with fusion (51.4 ± 1.9) than for patients with AKA (26.0 ± 3.6). The SF-12 MCS scores were also higher ($p < 0.001$) for patients with fusion (60.4 ± 0.6) than for patients with AKA (44.4 ± 8.5) (Fig. 3). Fourteen of

20 patients who underwent fusions (70%) indicated they would undergo a fusion again instead of undergoing an amputation if they were presented with both options after undergoing their operation.

Discussion

Recurrent infections after TKA are devastating complications and are difficult to treat. When chronic antibiotic suppression and reimplantation do not work, knee arthrodesis, AKA, and resection are the only remaining options. Klinger et al. [34] reported a series of 20 patients who underwent arthrodesis as a treatment for failed infected TKA and found arthrodesis provided a stable and painless extremity for ambulation after failed infected TKA. On the other hand, older trauma studies demonstrated patients receiving fusions do worse than those receiving amputations, as they have worse limb function, decreased quality of life, and more complications [16, 18]. However, more recent studies have demonstrated patients with trauma undergoing lower limb reconstruction have similar levels of health when compared to those undergoing amputation at 2-year followup [8]. Tumor studies also support the role of limb salvage over amputations [1, 12, 19, 27, 45, 46]. While trauma and tumor studies have compared patients receiving AKA and fusion, these patients were younger than those who have sustained a PJI after TKA and these patients were not undergoing elective surgical procedures (Table 2). Additionally, arthrodeses in trauma were compared to a population of patients undergoing early amputation, while amputation is often a delayed surgical choice in patients with tumors and with PJI after TKA. Therefore, we compared (1) preoperative and postoperative ambulatory status and (2) postoperative SF-12 PCS and MCS scores in patients who underwent a modality of end-stage surgical treatment for PJI after TKA (fusion or AKA).

There are several limitations to this study. First, we did not include an analysis of limb length discrepancy between the two populations, which can negatively affect function in patients with fused limbs. Accurately assessing limb lengths requires radiographs and physical examination of patients, which was prohibitory in our retrospective study. Second, we did not conduct a cost-analysis comparison between the treatment groups. We believed this would be too variable, as the initial cost comparison would be between the hardware used for arthrodesis and the prosthesis of amputation patients. Subsequent costs would be difficult to determine, especially given the variability of maintaining a prosthesis. Third, this study is subject to recall bias since patients completed surveys by mail and may have undergone their operations many years before.

Fig. 2 A graph shows ambulatory status for patients receiving fusion or AKA before and after surgery. Patients were stratified according to their ability to ambulate outside of the home (community ambulator), ambulate only within the home (household ambulator), or not ambulate (nonambulator). For patients with fusion, community ambulators increased from five to 10 and nonambulators decreased from three to one. For patients with AKA, nonambulatory patients increased from zero to two, and community ambulators decreased from four to one. Preop = preoperative; Postop = postoperative.

Fig. 3 A graph compares SF-12 PCS and MCS scores between patients receiving fusion and those receiving AKA. Both the PCS and MCS measurements were higher ($p < 0.001$) for fusions than for AKAs.

Table 2. Comparison of amputation and arthrodesis studies within literature

Study	Category	Surgical intervention	Number of knees	Age (years)*	Followup (months)*	Findings
Aksnes et al. [1]	Tumor	Limb salvage or amputation	118	31 (15–57)	156 (72–264)	Amputees had lower MSTs scores and lower SF-36 PCS scores, but similar TESS scores compared to patients with limb salvage
Davis et al. [12]	Tumor	Limb salvage or amputation	36	Amputation: 34.4 ± 1.6 Limb salvage: 30.4 ± 11.7	Amputation: 28.5 ± 15.1 Limb salvage: 30.5 ± 25	Amputees had decreased SF-36 PCS scores and an increased trend toward disability compared to patients with limb salvage
Ginsberg et al. [19]	Tumor	Limb salvage or amputation	91	20.1 ± 5.7	Amputation: 9.6 ± 6.4 Limb salvage: 4.3 ± 3.0	Patients with limb salvage performed better in functional mobility assessment compared to amputees
Hopyan et al. [27]	Tumor	Limb salvage or amputation	45	26 ± 7	167 (60–312)	Amputees had lower MSTs and TESS scores compared to patients with limb salvage; SF-36 scores were similar between groups
Renard et al. [45]	Tumor	Limb salvage or ablative surgery (AKA or hip/knee disarticulation)	77	30 (median) (2–70)	Ablative: 112 (42–267) Limb salvage: 97 (28–271)	Patients with limb salvage had better functional results but had more complications compared to patients with ablative surgery
Rougraff et al. [46]	Tumor	Limb salvage or amputation	227	16	132	Amputees had decreased MSTs and Knee Society scores compared to patients with limb salvage; the two groups had similar quality-of-life assessments
Bosse et al. [8]	Trauma	Limb reconstruction or amputation	545	Amputation: 35.2 Reconstruction: 35.8	24	The two groups had similar Sickness Impact Profile scores at 2-year followup
Fairhurst [16]	Trauma	Limb salvage or early amputation	24	25 (14–45)	12+	Amputees had higher quality of life, higher functionality, and fewer operations than patients with limb salvage for Grade III tibia fractures
Georgiadis et al. [18]	Trauma	Limb salvage with free flap or early amputation	34	Amputation: 32 (16–56) Limb salvage: 33 (19–51)	Amputation: 44 (19–90) Limb salvage: 35 (20–96)	Patients with limb salvage had more complications, more operative procedures, and longer hospital stays; took longer to achieve full weightbearing; and were less likely to return to work

Table 2. continued

Study	Category	Surgical intervention	Number of knees	Age (years)*	Followup (months)*	Findings
Fedorka et al. [17]	Arthroplasty	AKA	35	62 (26–88)	39 (7–96)	Amputees had low functional status
Klinger et al. [34]	Arthroplasty	Fusion	20	67 (47–81)	54 (24–132)	Arthrodesis is a good treatment option after failed infected TKA based on SF-36 scores and minimal pain based on VAS
Current study	Arthroplasty	Fusion or AKA	32	Amputation: 61.4 ± 18.5 Fusion: 63.1 ± 10.5	Amputation: 46.1 (7–95) Fusion: 54.1 (12.3–134.3)	Patients with fusions had higher SF-12 scores (PCS and MCS) and postoperative ambulatory status compared to amputees

* Values are expressed as mean, with range in parentheses, or mean ± SD, except as noted; AKA = above-the-knee amputation; MSTS = Musculoskeletal Tumor Society; PCS = physical component summary; TESS = Toronto Extremity Salvage Score; MCS = mental component summary.

Finally, the sample size for both populations is small, but given the rarity of performing either procedure for recurrent PJIs after TKA, the number is comparable to other studies.

We compared the ambulatory function of patients receiving AKA and fusion for PJI after TKA. From a physical perspective, the amount of energy expenditure needed for ambulating on an AKA fitted with a prosthesis is higher than ambulating on a fused leg [10]. This is reflected in our findings with regard to ambulatory status after surgery. Patients who underwent fusions had a greater number of community ambulators and fewer nonambulators postoperatively. In comparison, patients who underwent AKAs had more nonambulators and fewer community ambulators postoperatively. These findings are supported in the literature, as multiple studies have found patients with fusion returned to work after surgery and many ambulated without assistive devices [2, 11, 47]. Rud and Jensen [47] found 18 of 23 patients returned to work after undergoing knee arthrodesis. Another study found 15 of 20 patients returned to their previous occupation, and 16 of 20 ambulated without an assistive device [15]. On the other hand, studies have demonstrated patients with AKA are less ambulatory after surgery. Pring et al. [41] followed 23 patients with AKA for 13 years and found only 10 were able to ambulate for at least 2 years during the followup period. Isiklar et al. [30] reported only two of eight patients were able to ambulate after an AKA for a failed TKA. Fedorka et al. [17] reported patients treated with AKA for PJI after TKA had low functional status, as eight of 14 patients fitted with prostheses were ambulating outside of the home.

We also found patients receiving fusion had higher PCS and MCS scores than patients receiving AKA. SF-12 measurements in our patients with fusion are comparable to other patients with fusion in the literature [6, 34]. Of note, the finding that the MCS scores were lower in patients undergoing AKA compared to patients undergoing fusion is different from the findings in the tumor literature [1, 12]. Mentally, patients with fusion may be less self-conscious since they preserve their leg, as compared to patients with AKA. In addition, patients with fusion also underwent fewer surgical procedures compared to patients with AKA. Fourteen of our 20 patients with fusion would repeat the procedure as a treatment for recurrent PJI after TKA. When questioned, most patients stated they would undergo a fusion again instead of undergoing an amputation if they were presented with both options after undergoing their operation. Another benefit of performing a knee arthrodesis is that conversion to an AKA is possible in the future, as evidenced by one patient in our study population.

Our findings that patients undergoing fusion function mentally and physically better on the SF-12 than patients

undergoing AKA strengthen current findings in the orthopaedic trauma [7, 8] and tumor [1, 12] literature. Additionally, our study demonstrates ambulatory status is more likely to improve after an arthrodesis than after AKA. When counseling patients who are eligible for either option, it is important to note performing an arthrodesis as treatment for recalcitrant PJI after TKA may have better functional outcomes compared to the alternative of performing an AKA.

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