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Outcomes of Total Knee Arthroplasty in Patients With a Prior Contralateral Above-Knee Amputation: A Retrospective Review of a Nationwide Database

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ABSTRACT

Background: Total knee arthroplasty (TKA) in patients with a prior contralateral above-knee amputation (AKA) is uncommon, with limited literature describing the outcomes. We used a national database to compare the outcomes of primary TKA in above-knee amputees and nonamputees.
Methods: A retrospective review of TKA recipients with prior contralateral AKA was performed using the PearlDiver database from 2010 to Q2 of 2019. Subjects and outcomes were identified using Current Procedural Terminology and International Classification of Diseases, Ninth and Tenth Revisions (ICD-9 and ICD-10). Patients were identified and matched at a 1-to-3 ratio with nonamputee (AKA group = 931; nonamputee group = 2792 patients). Perioperative outcomes and length of stay (LOS) were compared at 90 days, 6 months, 1 year, 3 years, and 5 years after TKA.
Results: The AKA group had a longer LOS (5.19 vs 3.00, $P < .001$) and higher overall complications rate (33.8% vs 11.8%). At all studied time intervals, the AKA group had higher periprosthetic infections, revisions, mechanical complications, and respiratory failure ($P < .001$), as well as surgical site infection, pneumonia, and blood transfusion ($P < .05$).
Conclusion: Our study revealed higher overall complications and longer LOS among TKAs in prior contralateral above-knee amputees. Surgeons should evaluate the risks and benefits of performing a TKA on patients with prior contralateral AKA.

Introduction

With more than 150,000 lower limb amputations being performed annually, more than 2 million individuals with lower extremity amputations are expected to be living in the United States by the year 2050 [1,2]. Lower limb amputations are performed for various reasons such as complications of peripheral vascular disease or diabetes, trauma, malignancy, congenital anomalies, or infections, including periprosthetic joint infection (PJI) [3]. Gait studies have proven that lower limb amputees have increased loading of the intact limb [4]. Accordingly, patients with above-knee amputation (AKA) have an increased risk for osteoarthritis (OA) in the nonamputated limb, thus increasing the risk for total knee arthroplasty (TKA) when compared to nonamputees [5,6].

Primary TKA in the setting of a prior contralateral lower limb amputation does not have a common occurrence [7-10]. When it comes to TKA in the setting of an AKA, the reported data in the literature are limited in terms of the prevalence of the procedure, outcomes, and perioperative complications. Few studies have emphasized the impact of AKA on TKA outcomes [7,8]. Given the limited data, it is difficult for surgeons to evaluate and counsel these patients about the risks and benefits of having a TKA with a prior contralateral AKA. Therefore, we performed a national database comparison using the PearlDiver database to report the prevalence and the outcomes of TKA in above-knee amputees in the United States. We specifically evaluated (1) patient characteristics and (2) complications of matched TKA recipients with and without a prior AKA in the United States from 2010 to the second quarter of 2019.

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Material and methods

Database selection

A retrospective review was performed using PearlDiver (PearlDiver Inc., Fort Wayne, IN), an inpatient, all-payer, national claims database. The PearlDiver data set contains 122 million distinct inpatient records from various provider groups throughout the United States. International Classification of Diseases, Ninth and Tenth Revisions (ICD-9 and ICD-10); Current Procedural Terminology codes; demographic, medical, and surgical information were analyzed [11]. This study was exempted from the institutional review board because the provided data were deidentified.

Patient selection and outcome variables

All patients undergoing primary TKA from 2010 to the second quarter of 2019 were identified (n = 1,393,357) using codes listed in Appendix A1. Patients with an established diagnosis of AKA who then underwent TKA were identified (n = 931) using the codes in Appendix A2. The AKA group was matched at a ratio of 1-to-3 by age, Charlson Comorbidity Index (CCI), gender, tobacco use, diabetes mellitus, and peripheral vascular disease to a control group of nonamputees who underwent TKA throughout the same period (Table 1). Demographics were not statistically significantly different between the two groups, indicating successful matching. Each group had a mean age of 62 years, CCI of 2, predominance of males (53%), nonsmokers (59%), diabetes (61%), and peripheral vascular disease (39%).

The outcomes studied included length of stay (LOS), PJI, mechanical complications, revision, surgical site infection (SSI), periprosthetic fractures, blood transfusion, deep venous thrombosis, pulmonary embolism, cerebrovascular accidents, cardiac arrest, myocardial infarction, pneumonia, and respiratory failure (RS) (The mechanical complications codes used are listed in Appendix A3). Length of hospital stay was defined as the stay from admission till discharge. These outcomes were compared between both groups at 90 days, 6 months, 1 year, 3 years, and 5 years after TKA.

Statistical analysis

A descriptive and statistical analysis was performed using the programming language R (University of Auckland, New Zealand) integrated within PearlDiver to analyze odds ratios with their respective 95% confidence interval and *P* values. Student's t-test was used to determine significance in continuous outcomes between the two cohorts. A *P* value less than 0.05 was considered statistically significant.

Table 1
Demographics in above-knee amputees and nonamputees groups undergoing primary TKA.

Demographic variables	TKA in AKAs (n = 931) n(%)	TKA in nonamputees (n = 2792), n (%)	*P*
Age (SD)	62 ± 9.7	62 ± 9.7	.824
CCI ± SD	2 ± 2	2 ± 2	.978
Female, n (%)	434 (46.6)	1302 (46.6)	.999
Specific comorbidities, n (%)			
Tobacco use	378 (40.6)	1134 (40.6)	.998
Diabetes mellitus	567 (60.9)	1701 (60.9)	.998
Peripheral vascular disease	370 (39.7)	1110 (39.8)	.998

AKA, above-knee amputation, CCI, Charlson Comorbidity Index; SD, standard deviation; TKA, total knee arthroplasty.

Results

The total number of patients with AKA who underwent primary TKA represented less than 0.07% (n = 931) of the total number of patients who underwent primary TKA through the same period (2010 to Q2 of 2019) (Fig. 1). Patients with AKA undergoing TKA had a longer hospital LOS (5.19 vs 3.00, $P < .001$) (Table 2). At 90 days, the AKA group had higher rates of periprosthetic infections (14.3% vs 1.9%, $P < .001$), revisions (3.4% vs 1%, $P < .001$), RS (2.5% vs 0.9%, $P < .001$), mechanical complications (1.9% vs *, $P < .001$ [in accordance to the PearlDiver Data Use Agreement Suppression Policy, patient populations/cohorts comprised of ≤11 patients cannot be displayed in printing to maintain patient confidentiality]), blood transfusions (1.7% vs 0.6%, $P = .003$), pneumonia (3.1% vs 1.7%, $P = .13$), and SSIs (1.3% vs 0.5%, $P = .015$). The 90-day overall complication rate for primary TKA in patients with prior contralateral AKA was more than double of that for primary TKA in nonamputees (33.8% vs 11.8%) (Table 3). PJIs, revisions, mechanical complications, and RS remained elevated at 90 days, 6 months, 1 year, 3 years, and 5 years ($P < .001$). More than 68% of the PJIs occurred within 90 days of surgery for the AKA group vs 38.8% in the nonamputee group. SSIs, pneumonia, and blood transfusions were also increased at all time intervals ($P < .05$). Myocardial infarction showed an increase from 6 months and onwards ($P < .05$), and periprosthetic joint fractures were increased at 1, 3, and 5 years ($P < .05$). Table 4 shows the outcomes at 90 days, 6 months, 1 year, 3 years, and 5 years. Readmissions at 90 days were significantly higher in the AKA group (35.1% vs 4.5%, $P = .02$) (Table 5).

There was no significant difference between the two groups for cardiac arrests, cerebrovascular accidents, deep venous thrombosis, nor pulmonary embolisms. In accordance to the PearlDiver Data Use Agreement Suppression Policy, patient populations/cohorts comprised of 11 patients or less cannot be displayed in printing to maintain patient confidentiality.

Discussion

TKA in patients with prior contralateral AKA is quite challenging. To our knowledge, TKA in patients with prior contralateral AKA is not commonly reported in the literature, and no studies specifically comparing the outcomes in this patient group to nonamputees exist [7,8]. In this study, we used the PearlDiver database to identify the characteristics of this patient population and compare their outcomes to the outcomes of TKA in the general population. This present study demonstrates that patients with AKA undergoing TKA had more than double the overall complications rate at 90 days

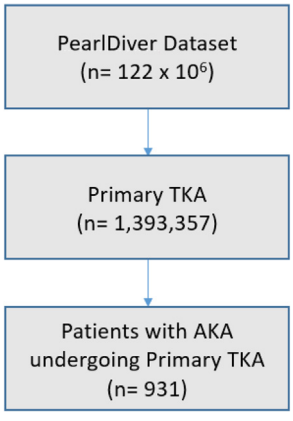

Figure 1. Flow diagram of the patients included in the study. AKA, above-knee amputation; TKA, total knee arthroplasty.

Table 2
Showing hospital length of stay for each group.

Length of stay			
	TKA in AKAs (n = 931)	TKA in nonamputees (n = 2792)	*P*
LOS, mean ± SD	5.19 ± 3.79	3.00 ± 1.69	<.001

AKA, above-knee amputation; LOS, length of stay; TKA, total knee arthroplasty.

compared with TKA in nonamputees. Amputees also had higher rates of PJIs, revisions, mechanical complications, and RS at 90 days, 6 months, 1 year, 3 years, and 5 years. More than 68% of the PJIs occurred within 90 days of surgery for the AKA group vs 39% in the nonamputee group. These findings shall raise the attention that having an AKA can worsen the outcomes of primary TKA.

Gait studies have shown an increased loading of the intact limb in patients with lower limb amputation to compensate for the functional loss of the amputated limb [6]. Thus, these patients usually have an increased prevalence of OA of the knee [5,12]. According to Melzer et al. [4], patients with lower limb amputations had a significantly higher rate of OA than the nonamputees. They demonstrated that with the knee center of gravity being medial to the knee joint, the medial compartment of the knee tends to be more affected with excess loading during both standing and asymmetrical walking [4]. Even with the usage of the prosthesis, analysis of the force plate records showed that the normal leg bears more load than the prosthetic leg, thus more time is spent standing on the normal leg [13].

The largest case series reported in the literature was represented by Visser and Mason [8], who reported the outcomes of TKA in ten cases with prior contralateral AKA. Only six patients reported no pain or improved pain with weight-bearing. The ambulatory status was improved only in two patients, worsened in five patients, and remained unchanged in three patients. Five patients suffered significant postoperative complications. They concluded that even though AKA is not a contraindication to TKA, patient counseling is essential because these patients are considered a high-risk population. They also suggested aggressive preoperative patient medical condition optimization and modified postoperative recovery protocols [8].

The overall incidence of primary TKA in prior contralateral AKA population within the United States represented less than 0.07% of the total number of primary TKA performed from 2010 to 2019, with more than 57% of these patients younger than 65 years. Younger patients undergoing TKA have an increased risk for early revisions [14,15]. Walker-Santiago et al. reported increased rates of early revisions for primary TKA in younger patients [15]. Meehan et al. [14] showed that young patients have an increased risk for PJI and aseptic

Table 3
Ninety-day complications for TKA in above-knee amputees and nonamputees.

Complications	AKA group (n = 931)	Nonamputee group (n = 2792)	*P* value
Periprosthetic joint infection	133 (14.3)	52 (1.9)	<.001
Mechanical complications	18 (1.9)	[a]	<.001
Blood transfusion	16 (1.7)	17 (0.6)	.003
Deep venous thrombosis	38 (4.1)	110 (3.9)	.924
Pulmonary embolism	14 (1.5)	37 (1.3)	.807
Pneumonia	29 (3.1)	48 (1.7)	.013
Respiratory failure	23 (2.5)	24 (0.9)	<.001
Surgical site infection	12 (1.3)	13 (0.5)	.015
Revision	32 (3.4)	27 (1.0)	<.001

AKA, above-knee amputation; TKA, total knee arthroplasty.
[a] In accordance to the PearlDiver Data Use Agreement Suppression Policy, patient populations/cohorts comprised of 11 patients or less cannot be displayed in printing to maintain patient confidentiality.

Table 4
Comparison of primary TKA complications in patients with above-knee amputation vs nonamputees at 90-day, 6-month, 1-year, 3-year, and 5-year periods.

Complication/period	AKA group (n = 931) n (%)	Nonamputee group (n = 2792), n (%)	*P* value
Prosthetic joint infection			
90 d	133 (14.3)	52 (1.9)	<.001
6 mo	150 (16.1)	53 (1.9)	<.001
1 y	168 (18.0)	64 (2.3)	<.001
3 y	186 (20.0)	99 (3.5)	<.001
5 y	195 (21.0)	115 (4.1)	<.001
Prosthetic revision			
90 d	32 (3.4)	27 (1.0)	<.001
6 mo	40 (4.3)	34 (1.2)	<.001
1 y	52 (5.6)	53 (1.9)	<.001
3 y	69 (7.4)	109 (3.9)	<.001
5 y	74 (8.0)	134 (4.8)	<.001
Mechanical complication			
90 d	18 (1.9)	[a]	<.001
6 mo	22 (2.4)	16 (0.6)	<.001
1 y	34 (3.7)	32 (1.1)	<.001
3 y	54 (5.8)	83 (3.0)	<.001
5 y	61 (5.6)	95 (3.4)	<.001
Respiratory failure			
90 d	23 (2.5)	24 (0.9)	<.001
6 mo	30 (3.2)	27 (1.0)	<.001
1 y	41 (4.4)	47 (1.7)	<.001
3 y	77 (8.3)	134 (4.8)	<.001
5 y	99 (10.6)	195 (7.0)	<.001
Surgical site infection			
90 d	12 (1.3)	13 (0.5)	.015
6 mo	16 (1.7)	17 (0.6)	.003
1 y	20 (2.1)	30 (1.1)	.021
3 y	47 (5.0)	70 (2.5)	<.001
5 y	53 (5.7)	95 (3.4)	.003
Pneumonia			
90 d	29 (3.1)	48 (1.7)	.013
6 mo	39 (4.2)	62 (2.2)	.002
1 y	64 (6.9)	104 (3.7)	<.001
3 y	125 (13.4)	268 (9.6)	.001
5 y	159 (17.1)	378 (13.5)	.009
Blood transfusion			
90 d	16 (1.7)	17 (0.6)	.003
6 mo	17 (1.8)	21 (0.8)	.008
1 y	26 (2.8)	30 (1.1)	<.001
3 y	43 (4.6)	58 (2.1)	<.001
5 y	49 (5.3)	88 (3.2)	.004
Myocardial infarction			
90 d	[b]		
6 mo	11 (1.2)	14 (0.50)	.048
1 y	18 (1.9)	22 (0.8)	.006
3 y	40 (4.3)	56 (2.0)	<.001
5 y	52 (5.6)	80 (2.9)	<.001
Periprosthetic joint fracture			
90 d	[b]		
6 mo	[b]		
1 y	12 (1.3)	[a]	<.001
3 y	14 (1.5)	13 (0.5)	.003
5 y	14 (1.5)	16 (0.6)	.011

AKA, above-knee amputation; TKA, total knee arthroplasty.
[a] In accordance to the PearlDiver Data Use Agreement Suppression Policy, patient populations/cohorts comprised of 11 patients or less cannot be displayed in printing to maintain patient confidentiality.
[b] No statistically significant difference at the given time interval.

mechanical failure by 1.8 and 4.7 times, respectively, compared with patients older than 65 years [14]. It is not a surprise that TKA in patients with prior contralateral AKA has more complications than TKA in nonamputees. Our results have shown that TKA in a patient with prior contralateral AKA has the risk of 14.4% for PJI, 1.9% for mechanical complications, and 3.4% for revisions at 90 days and 18.1%, 3.6%, and 5.6%, respectively, at 1 year. More than 25% of the AKA had at least one readmission at 90 days; this is 6 times more than that in the nonamputees group, a fact that should raise the attention to the importance of separating this nonamputee patient group from the

Table 5
Readmissions at 90 d.

Number of readmissions	Patients in AKA group (%) (n = 931)	Patients in nonamputee group (%) (n = 2792)	*P* value
1	235 (25.2)	108 (3.9)	
≥2	92 (9.9)	17 (0.6)	
Total	327 (35.1)	125 (4.5)	.02011

AKA, above-knee arthroplasty.

normal population undergoing TKA. Although the two groups were matched by age and CCI, we can see a significant difference in the outcomes at different time intervals. We believe that increased joint loading of the nonamputated limb and the young age together can have a synergistic effect that can promote failure.

This study has several limitations starting with its retrospective nature. Furthermore, there exists a possibility of coding bias with the manual entry of the codes used for diagnosis and procedures in this study. In addition to that, the transition period from ICD-9 to ICD-10 medical coding systems occurred during the study period. This may have inadvertently caused miscoding of the outcomes studied, which might have produced inconsistency with the incidence of the outcome. The PearlDiver database cannot identify the type of anesthesia received (general, spinal, or epidural), which might affect the LOS [16]. In addition, the PearlDiver database does not collect functional status, discharge destination, LOS date ranges, disposition or mortality data, or information based on race or socioeconomic factors beyond gender and age. Although the patients' age, CCI, smoking status, and percent of patients diagnosed with diabetes mellitus and peripheral vascular disease are similar in both groups, there might be a variation in the preoperative level of function (wheelchair dependant vs walking with prosthesis) and the degree of severity/control of diabetes mellitus and peripheral vascular disease, which could act as confounding factors. Finally, although veterans are included in the retrieved data, we could not specify their exact percentage. This encourages the interest in a focused study of the military population with amputations who may require TKA for the treatment of knee OA. We also encourage further multi-institutional collaborations with a more detailed analysis of the associated risk factors and, more specifically, if amputation is an independent risk factor for increased complications after TKA.

The question we are trying to find an answer to is, "What to expect with a knee replacement surgery when the patient has a prior contralateral above-knee amputation?" In our study, we highlighted the prevalence and expected outcomes of primary TKA in patients with prior contralateral AKA in the US population. Although this procedure may have an uncommon occurrence in the United States according to our database study, those patients had more than double the overall complications rate at 90 days. Complications including periprosthetic infections, revisions, mechanical complications, and RS are higher than those with TKA in nonamputees at 90 days, 6 months, 1 year, 3 years, and 5 years. Surgeons must set realistic expectations and deliver effective counseling for these patients before surgery.

Conclusions

The present study revealed increased overall complication rates, revisions, LOS duration, and readmission rates at 90 days among patients with AKA undergoing TKA compared with matched nonamputees undergoing TKA. Further multi-institutional collaboration is encouraged with more analysis of the preoperative risk factors and the outcomes to verify specifically whether amputation is an independent indicator of worse complications in this specific population. Surgeons should thoroughly evaluate the risks and benefits of performing a TKA on patients with prior contralateral AKA.

Conflicts of interest

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.artd.2021.10.022.

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