



Human Immunodeficiency Virus Status Does Not Independently Predict 2-Year Complications Following Total Knee Arthroplasty

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Abstract

With improved treatment for human immunodeficiency virus (HIV), the demand for total knee arthroplasty (TKA) in this population has increased. Studying the relationship between HIV and postoperative complications following TKA will allow orthopaedic surgeons to accurately assess their patients' surgical risk and provide appropriate counseling. This study aims to understand how HIV impacts surgical and medical complications following TKA for osteoarthritis (OA). Patients identified in a national insurance database who underwent TKA for OA from 2010 to 2019 were divided into three cohorts: no HIV, asymptomatic HIV, and acquired immunodeficiency syndrome (AIDS). Univariate and multivariable regression analyses were performed to determine 90-day postoperative complications as well as 2-year surgical complications (revision surgery, prosthetic joint infection, aseptic loosening, and manipulation under anesthesia). A total of 855,373 patients were included, of whom 1,338 had asymptomatic HIV and 268 had AIDS. After multivariable regression analysis, patients with HIV had no difference in 2-year surgical complications relative to the control cohort. Within 90 days postoperatively, patients with asymptomatic HIV had increased odds of arrhythmia without atrial fibrillation and lower odds of anemia. Patients with AIDS had increased odds of anemia and renal failure. Patients with HIV and AIDS are at an increased risk for developing 90-day medical complications and 2-year surgical complications. However, after accounting for their comorbidities, the risk of 90-day complications was only mildly increased and the risk of 2-year surgical complications approximated the control cohort. Surgeons should pay particular attention to these patients' overall comorbidities, which appear to be more closely associated with postoperative risks than HIV status alone. Level of evidence: III.

Keywords

- ▶ total knee arthroplasty
- ▶ human immunodeficiency virus
- ▶ acquired immunodeficiency syndrome
- ▶ postoperative complications
- ▶ medical complications
- ▶ surgical complications

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With the average age of the United States population increasing, there is projected to be a large increase in arthritis cases to 67 million cases by 2030.¹ The most common cause of arthritis is osteoarthritis (OA), which currently affects 27 million adults.² The knee joint is the most affected joint; consequently,³ total knee arthroplasty (TKA) is one of the most frequently performed surgical procedures. Patients diagnosed with human immunodeficiency virus (HIV) may be at additional risk for developing postoperative complications following TKA.^{4,5} In the United States, over 1.1 million people are living with HIV, including an estimated 21% of whom are undiagnosed.⁶ With the advent of highly active antiretroviral therapies (HAARTs), HIV-positive patients are living much longer than they had historically. As the average age for this patient population increases, the demand for TKA will increase due to age-associated joint degeneration.⁷ This necessitates an understanding of how HIV affects perioperative and postoperative complications following TKA.

Multiple studies have attempted to analyze the postoperative complications of TKA in patients with HIV⁷⁻⁹; however, the literature is variable. Although some studies indicate that HIV-positive status alone is not a risk factor for increased complications following TKA,^{7,10,11} other studies report that individuals with HIV may be at increased risk for perioperative complications.^{4,5} Because some prior studies included subjects with both hemophilia and HIV, the data are subject to confounding.¹²⁻¹⁴ Prior studies have also been limited by short-term follow-up and lack of subject stratification into HIV and acquired immunodeficiency syndrome (AIDS) cohorts,¹⁵ which is an important distinction relative to the patient's immune status.

This study aimed to analyze the 90-day complications and 2-year postoperative surgical complications of patients with HIV who underwent TKA for OA. Our hypothesis was that patients with HIV, particularly patients with AIDS, would have significantly increased 90-day complication rates and higher risk of revision, particularly for prosthetic joint infection (PJI), at 2 years postoperatively.

Methods

Data Source and Collection

The PearlDiver Patient Records Database (www.pearliver-inc.com; Colorado Springs, CO) was used to perform a retrospective cohort analysis. Specifically, the Mariner dataset was utilized, including all-payer claim information for over 121 million patients from 2010 to 2019. Patients who underwent primary TKA were identified using International Classification of Diseases (ICD) procedure codes as well as Current Procedural Terminology (CPT) codes. Only patients with 2 years of follow up and who underwent primary TKA for knee OA were included in this study. The Mariner dataset provides active longitudinal follow-up based upon unique patient identifier codes that are not limited to changes in insurance status, minimizing loss to follow-up in the system. Therefore, patients with 2 years of follow up data included any patient with insurance continued coverage 2 years following TKA.

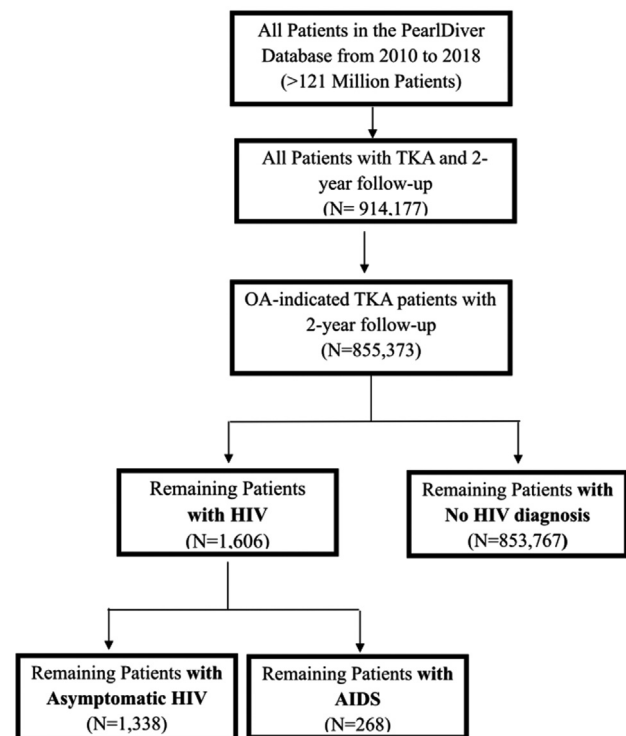


Fig. 1 Flow chart of PearlDiver patients included in the study.

Exclusion and Inclusion Criteria

Patients with a diagnosis of HIV were identified using ICD 9/10 diagnosis codes. These patients were further subcategorized as having AIDS (ICD-9-D-042 and ICD-10-D-V08) or asymptomatic HIV (AHIV; ICD-9-D-B20 and ICD-10-D-Z21). The control group consisted of patients who underwent TKA for OA with no known diagnosis of HIV. Patients who were less than 18 years of age or had a staged or simultaneous bilateral TKA were excluded. Staged/bilateral TKAs were excluded to confirm that revision outcomes were from the primary TKA since CPT modifier codes are not present in the PearlDiver database. The flow chart documenting which PearlDiver patients were included in the present study is shown in ►Fig. 1.

Demographics/Comorbidities and Outcome Variables

Patient demographic and comorbidities observed included age, gender, and Elixhauser Comorbidity Index comorbidities¹⁶ (congestive heart failure, arrhythmias, valvular disease, pulmonary circulatory disorders, peripheral vascular disease, hypertension, paralysis, other neuro disorders, chronic obstructive pulmonary disease, diabetes, hypothyroidism, chronic kidney disease, liver disease, peptic ulcer disease, lymphoma, metastatic cancer, nonmetastatic cancer, rheumatoid arthritis and cardiovascular disease, coagulopathy, fluid and electrolyte disorders, anemia due to blood loss, anemia due to deficiency, alcohol abuse, drug abuse, psychoses, depression, obesity, and smoking status). These were identified using ICD-9 and ICD-10 diagnosis codes. The primary outcomes of this study included 90-day postoperative complications: acute renal failure, surgical site infection (SSI), anemia, arrhythmia with and without atrial fibrillation,

blood transfusion, bleeding complications, deep vein thrombosis (DVT), pulmonary thrombosis, stroke, heart failure, respiratory complications, pneumonia, urinary tract infection, sepsis, and death. The secondary outcome of this study was the 2-year complication rate, which included manipulation under anesthesia (MUA), all-cause revision, revision for peri-PJI, and revision for aseptic loosening.

Univariate/Multivariable Analysis

Patient data on demographics, comorbidities, and postoperative complications were analyzed using univariate and multivariable analysis via R software (<https://www.R-project.org/>, R Foundation for Statistical Computing, Vienna, Austria) provided by PearlDiver. Univariate analysis was conducted using Chi-squared and Student's *t*-tests where appropriate. Demographics and comorbidities with a *p*-value less than 0.2 on univariate analysis were included as independent variables in multivariable regression for postoperative complications. Results from the multivariable analysis were reported as odds ratios (ORs) and 95% confidence intervals (CIs). A *p*-value of 0.05 was used as the threshold level for significance.

Results

Study Cohort

In total, 855,373 patients who underwent TKA for a primary diagnosis of OA were included in this study. A total of 1,606 patients (0.19%) undergoing TKA for OA had a diagnosis of HIV at the time of their procedure. Of those, 1,338 patients (83.3%) had a diagnosis of AHIV at the time of TKA and 268 patients (16.68%) had a diagnosis of AIDS at the time of TKA. Demographics and comorbidities are detailed in ►Table 1.

Two-Year Surgical Complications

A total of 2.9% of patients with HIV (46 patients), of whom 85% (39 patients) had AHIV and 15% (7 patients) had AIDS, underwent revision TKA within 2 years of the initial procedure. This was significant compared with 1.8% of patients in the non-HIV cohort who required revision at this time point ($p=0.002$). Patients with AHIV had a higher risk of PJI ($p<0.001$), aseptic loosening ($p=0.011$), and MUA ($p<0.001$) than patients without HIV. Patients with AIDS were only at an increased risk for PJI ($p=0.002$) compared with the control group. The breakdown of patients who had surgical complications is displayed in ►Table 2.

However, on multivariable analysis, neither the AHIV nor the AIDS group was found to be at greater or lesser odds of 2-year revision surgery, PJI, aseptic loosening, or MUA compared with the control cohort. The ORs and CIs for all cohorts are shown in ►Table 3.

Ninety-Day Medical Complications

On univariate analysis, patients with AHIV were found to be at an increased risk of several minor 90-day complications such as SSIs ($p<0.001$), arrhythmia without atrial fibrillation ($p=0.002$), and pneumonia ($p=0.004$) as well as major 90-day complications such as renal failure ($p=0.024$) and sepsis

($p<0.001$). Patients with AIDS were also at an increased risk of several 90-day complications including SSI ($p=0.007$), anemia ($p<0.001$), arrhythmia without atrial fibrillation ($p<0.001$), bleeding complications ($p=0.024$), DVT ($p=0.111$), and pneumonia ($p<0.001$). This cohort of patients was also at an increased risk of renal failure ($p<0.001$) and sepsis ($p=0.187$) within 90 days following TKA (►Table 4).

On multivariable analysis, AHIV patients were found to have lower odds of anemia (OR: 0.697; 95% CI: 0.587–0.821; $p<0.001$) compared with the control cohort while AIDS patients were found to have greater odds of anemia (OR: 1.516; 95% CI: 1.123–2.018; $p=0.005$) relative to the control group. Additionally, AIDS patients were found to have greater odds of renal failure (OR: 2.129; 95% CI: 1.239–3.451; $p=0.004$) within 90 days of TKA compared with the control group.

Discussion

It is imperative to understand the relationship between HIV/AIDS and postoperative complications following TKA given the increased life expectancy and rising incidence of TKA in this population. This study aimed to determine the 90-day complication rates and 2-year postoperative surgical complications in patients with a diagnosis of HIV who underwent TKA for OA. To our knowledge, no prior study has utilized a large administrative database to study the outcomes of HIV-positive patients who underwent OA-indicated TKA.

Patients with a diagnosis of HIV, both symptomatic and asymptomatic, had significantly increased odds of certain complications, including arrhythmia without atrial fibrillation and decreased odds of other complications, such as anemia, following TKA. However, patients with a diagnosis of AIDS had significantly increased odds of several 90-day postoperative complications including renal failure, anemia, and pneumonia ($p=0.004$, $p=0.005$, and $p=0.003$, respectively). We were surprised to find that there were no significant differences in 2-year postoperative surgical complications between HIV-positive and HIV-negative TKA patients after multivariable regression analysis was performed (►Table 3).

With the advent of HAARTs, HIV-positive patients are making significant improvements in survivorship,¹⁷ which is expected to result in increased demand for total joint arthroplasties (TJAs) among HIV-positive patients.¹⁸ There is currently no consensus in the literature regarding perioperative complications in HIV-positive patients undergoing TKA. Some studies report that HIV-positive patients are not at a significantly increased risk compared with the general population.^{7,10,11} Other studies report that HIV-positive patients may be at a significantly increased risk for postoperative complications compared with their HIV-negative cohort.^{4,5} O'Neill et al conducted a systematic review of 19 studies with a subgroup analysis of 4 studies.⁹ The authors found that HIV-positive patients were at a significantly increased risk of infection and revision (risk ratio of 3.31

Table 1 Demographics and comorbidities of patients undergoing total knee arthroplasty

	HIV			AHIV			AIDS			Control		
	Number	Percent (%)	p-Value	Number	Percent (%)	p-Value	Number	Percent (%)	p-Value	Number	Percent (%)	p-Value
Total	1,606			1,338			268			853,767		
Age (y)	58.76		<0.001	59.04		<0.001	57.31		<0.001	65.75		<0.001
Gender			<0.001			<0.001			<0.001			<0.001
Male	767	47.76%		627	46.86%		140	52.24%		312,607	36.62%	
Female	839	52.24%		711	53.14%		128	47.76%		541,160	63.38%	
CHF	359	22.35%	<0.001	310	23.17%	<0.001	49	18.28%	0.326	135,780	15.90%	
Arrhythmias	730	45.45%	<0.001	606	45.29%	<0.001	124	46.27%	0.008	325,760	38.16%	
Valvular disease	415	25.84%	<0.001	365	27.28%	<0.001	50	18.66%	0.159	191,524	22.43%	
Pulmonary disorders	172	10.71%	<0.001	148	11.06%	<0.001	24	8.96%	0.562	66,743	7.82%	
PVD	532	33.13%	<0.001	460	34.38%	<0.001	72	26.87%	0.109	192,772	22.58%	
HTN	1,227	76.40%	<0.001	1,040	77.73%	<0.001	187	69.78%	0.501	613,115	71.81%	
Paralysis	60	3.74%	<0.001	49	3.66%	<0.001	11	4.10%	0.041	18,108	2.12%	
Other neuro disorders	206	12.83%	<0.001	170	12.71%	<0.001	36	13.43%	<0.001	62,413	7.31%	
CPD	845	52.62%	<0.001	704	52.62%	<0.001	141	52.61%	<0.001	285,665	33.46%	
Diabetes mellitus	791	49.25%	<0.001	690	51.57%	<0.001	101	37.69%	0.577	306,206	35.87%	
Hypothyroidism	398	24.78%	0.019	345	25.78%	0.019	53	19.78%	0.002	245,347	28.74%	
CKD	396	24.66%	<0.001	331	24.74%	<0.001	65	24.25%	0.012	154,788	18.13%	
Liver disease	635	39.54%	<0.001	538	40.21%	<0.001	97	36.19%	<0.001	114,618	13.42%	
PUD	58	3.61%	<0.001	49	3.66%	<0.001	9	3.36%	0.194	17,483	2.05%	
Rheumatoid arthritis and CVD	365	22.73%	<0.001	317	23.69%	<0.001	48	17.91%	0.872	148,146	17.35%	
Coagulopathy	243	15.13%	<0.001	198	14.80%	<0.001	45	16.79%	<0.001	63,431	7.43%	
Fluid and electrolyte disorders	712	44.33%	<0.001	579	43.27%	<0.001	133	49.63%	<0.001	262,490	30.74%	
Blood loss anemia	121	7.53%	<0.001	100	7.47%	<0.001	21	7.84%	0.065	43,999	5.15%	
Deficiency anemia	442	27.52%	<0.001	382	28.55%	<0.001	60	22.39%	0.023	144,937	16.98%	
Alcohol abuse	70	4.36%	<0.001	63	4.71%	<0.001	7	2.61%	0.011	8,000	0.94%	
Drug abuse	484	30.14%	<0.001	396	29.60%	<0.001	88	32.84%	<0.001	50,616	5.93%	
Psychoses	179	11.15%	<0.001	153	11.43%	<0.001	26	9.70%	<0.001	28,216	3.30%	
Depression	886	55.17%	<0.001	717	53.59%	<0.001	169	63.06%	<0.001	285,586	33.45%	
Obesity	678	42.22%	<0.001	563	42.08%	<0.001	115	42.91%	<0.001	252,169	29.54%	
Smoking	629	39.17%	<0.001	509	38.04%	<0.001	120	44.78%	<0.001	108,159	12.67%	

Abbreviations: BMI, body mass index; CHF, congestive heart failure; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disorder; CVD, collagen vascular disease; HTN, hypertension; PUD, peptic ulcer disease; PVD, peripheral vascular disease.

Note: All p-Value comparisons made between group of interest and control group; statistically significant p-values (p < 0.05) are indicated in bold.

Table 2 Two-year surgical complications following total knee arthroplasty

	HIV			AHIV			AIDS			Control		
	Number	Percent (%)	p-Value	Number	Percent (%)	p-Value	Number	Percent (%)	p-Value	Number	Percent (%)	p-Value
Total	1,606			1,338			268			853,767		
Revision	46	2.86%	0.002	39	2.91%	0.004	7 ^a	2.61%	0.460	15,552	1.82%	
PJI	25	1.56%	< 0.001	19	1.42%	< 0.001	6 ^a	2.24%	0.002	5,038	0.59%	
Loosening	10 ^a	0.62%	0.050	10 ^a	0.75%	0.011	0	0.00%	0.705	2,704	0.32%	
MUA	103	6.41%	< 0.001	86	6.43%	< 0.001	17	6.34%	0.084	34,748	4.07%	

Abbreviations: MUA, manipulation under anesthesia; PJI, prosthetic joint infection. Note: Groups were analyzed with chi-squared analysis compared with the control group. Statistically significant p-Values ($p < 0.05$) are indicated in bold. ^aPer HIPAA requirements, <11 cohort sizes are not reportable.

and 2.25, respectively). However, the authors caution that the quality of evidence was low and that there was heterogeneity between the studies. Parvizi et al report a significantly increased rate of early procedural failures among a cohort of HIV-positive patients undergoing TJA (13 knee procedures and 8 hip procedures).⁴ Of the 21 total procedures, 12 were not successful due to loosening (average time of 9.5 years) and early repeat surgeries due to a decreased range of motion, hematoma of the knee, and other reasons. Six of the 12 procedural failures were due to infections, which had an average time to revision of 3.5 years. This study was limited due to its retrospective nature and small sample size. Olson et al conducted a multicenter retrospective cohort analysis of 110 HIV-positive patients and 240 control patients who underwent TJAs (85 total hip arthroplasties [THAs] and 25 TKAs).¹⁹ The authors found a statistically significantly increased risk for venous thromboembolism in the HIV-positive TKA group compared with the control group (8.0 vs. 1.7% ; $p = 0.046$). Accordingly, they recommended that stronger prophylactic anticoagulation and a longer duration of prophylaxis be considered for HIV-positive patients undergoing TKA.

Boylan et al conducted a nationwide retrospective review and found that HIV-positive individuals undergoing TKA did not have significantly higher surgical complications overall compared with controls, but they were found to be at a significantly higher risk for developing infections.²⁰ Falakassa et al conducted a retrospective cohort analysis of 24 HIV-positive patients (31 THAs and one TKA).⁷ In this study, there was one instance of aseptic loosening but no PJIs. The authors concluded that HIV-positive status did not place patients at an increased risk for postoperative PJIs and that patients with CD4 counts >200 on HAART therapy were at a similar risk to HIV-negative individuals.⁷ Capogna et al reported no significant differences in infection, survivorship, or revision after TJA comparing 69 HIV-positive patients to 138 controls.²¹

Lin et al analyzed the Nationwide Inpatient Sample and identified 5,681,024 patients who were admitted for THAs and TKAs (0.14% were HIV-positive).¹⁰ The authors found no significant increase in total complications between the HIV-positive and control group for TKA patients. While there were some increased complications (acute renal failure, wound infection, and increased indication for postoperative debridement and irrigation) identified in THA patients, it could not be concluded that HIV-positive status alone was a risk factor for increased complications after TJA. Roof et al conducted a multicenter retrospective study that analyzed discrepancies between 25 HIV-negative and 25 HIV-positive patients who underwent TKA.⁸ The authors found that HIV-positive patients had an acceptable complication risk compared with HIV-negative patients (not statistically significant); however, HIV-positive patients who underwent TKA had significantly increased length of stay (3.8 vs. 2.28 days, $p = 0.004$).

While some 90-day complications were more prevalent in our HIV-positive cohort, there were no significant increases in 2-year postoperative surgical complications on

Table 3 Multivariable analysis of 2-year complications and 90-day complications following total knee arthroplasty

	HIV				AHIV				AIDS			
	Odds ratio	25%	75%	p-Value	Odds ratio	25%	75%	p-Value	Odds ratio	25%	75%	p-Value
2-year complications												
Revision	0.842	0.618	1.119	0.257	0.872	0.622	1.186	0.405	-	-	-	-
PJI	1.237	0.807	1.805	0.298	1.139	0.695	1.748	0.578	1.639	0.643	3.397	0.236
Loosening	1.013	0.505	1.790	0.968	1.240	0.618	2.192	0.502	1.146	0.672	1.823	0.590
MUA	1.220	0.991	1.486	0.054	1.234	0.982	1.530	0.063	-	-	-	-
90-day complications												
SSI	1.113	0.828	1.461	0.459	1.076	0.773	1.455	0.648	1.257	0.620	2.254	0.483
Renal failure	1.153	0.876	1.491	0.292	0.958	0.691	1.292	0.786	2.129	1.239	3.451	0.004
Anemia	-	-	-	-	0.697	0.587	0.821	<0.001	1.516	1.123	2.018	0.005
Arrhythmia w/ atrial fibrillation	0.814	0.668	0.984	0.037	0.813	0.655	1.000	0.055	-	-	-	-
Arrhythmia w/o atrial fibrillation	1.304	1.068	1.579	0.008	1.257	1.006	1.553	0.039	1.541	0.964	2.367	0.058
Bleeding complication	-	-	-	-	-	-	-	-	1.666	0.591	3.651	0.262
Blood transfusion	0.931	0.726	1.175	0.559	0.855	0.645	1.111	0.259	1.302	0.746	2.112	0.317
Pneumonia	1.318	0.946	1.783	0.087	1.094	0.736	1.559	0.638	2.473	1.299	4.265	0.003
Stroke	-	-	-	-	-	-	-	-	-	-	-	-
Death	1.179	0.466	2.415	0.689	1.151	0.410	2.500	0.755	-	-	-	-
DVT	1.085	0.813	1.416	0.563	1.054	0.765	1.413	0.736	1.210	0.596	2.176	0.561
Heart failure	0.912	0.689	1.188	0.505	0.885	0.652	1.178	0.416	-	-	-	-
Pulmonary embolism	1.232	0.832	1.757	0.273	1.173	0.756	1.737	0.450	-	-	-	-
Respiratory complication	-	-	-	-	-	-	-	-	-	-	-	-
Sepsis	1.294	0.843	1.891	0.209	1.301	0.813	1.962	0.239	1.206	0.370	2.863	0.713
UTI	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations: DVT, deep vein thrombosis; MUA, manipulation under anesthesia; PJI, prosthetic joint infection; SSI, surgical site infection; UTI, urinary tract infection; w/ atrial fibrillation, with atrial fibrillation; w/o atrial fibrillation, without atrial fibrillation.
 Note: Groups were analyzed with chi-squared analysis compared with control group. Statistically significant p-Values ($p < 0.05$) are indicated in bold.

Table 4 90-Day complications following total knee arthroplasty

	HIV			AHIV			AIDS			Control		
	Number	Percent (%)	p-Value	Number	Percent (%)	p-Value	Number	Percent (%)	p-Value	Number	Percent (%)	p-Value
Total	1,606			1,338			268			853,767		
SSI	51	3.18%	<0.001	41	3.06%	<0.001	10	3.73%	0.007	13,056	1.53%	
Renal failure	62	3.86%	<0.001	44	3.29%	0.024	18	6.72%	<0.001	19,808	2.32%	
Anemia	222	13.82%	0.886	161	12.03%	0.089	61	22.76%	<0.001	116,699	13.67%	
Arrhythmia with atrial fibrillation	130	8.09%	0.029	109	8.15%	0.055	21	7.84%	0.343	83,173	9.74%	
Arrhythmia without atrial fibrillation	123	7.66%	<0.001	99	7.40%	0.002	24	8.96%	0.016	46,304	5.42%	
Bleeding complication	14	0.87%	0.227	9 ^a	0.67%	0.891	5 ^a	1.87%	0.024	5,174	0.61%	
Blood transfusion	73	4.55%	0.070	57	4.26%	0.277	16	5.97%	0.065	31,279	3.66%	
Pneumonia	41	2.55%	<0.001	29	2.17%	0.004	12	4.48%	<0.001	10,749	1.26%	
Stroke	18	1.12%	0.247	14	1.05%	0.464	4 ^a	1.49%	0.387	7,064	0.83%	
Death	6 ^a	0.37%	0.088	5 ^a	0.37%	0.133	1 ^a	0.37%	0.941	1,434	0.17%	
DVT	54	3.36%	0.001	44	3.29%	0.005	10 ^a	3.73%	0.111	18,248	2.14%	
Heart failure	64	3.99%	0.086	54	4.04%	0.097	10 ^a	3.73%	0.748	27,316	3.20%	
Pulmonary embolism	31	1.93%	0.014	25	1.87%	0.044	6 ^a	2.24%	0.218	10,457	1.22%	
Respiratory complication	10 ^a	0.62%	0.930	9 ^a	0.67%	1.000	1 ^a	0.37%	0.822	5,736	0.67%	
Sepsis	25	1.56%	<0.001	21	1.57%	<0.001	4 ^a	1.49%	0.187	5,594	0.66%	
UTI	100	6.23%	0.515	87	6.50%	0.310	13	4.85%	0.587	49,642	5.81%	
Readmission	152	9.46%	<0.001	123	9.19%	<0.001	29	10.82%	<0.001	48,961	5.73%	
LOS	2.80		<0.001	2.77		<0.001	4.60		<0.001	2.39		

Abbreviations: DVT, deep vein thrombosis; LOS, length of stay; SSI, surgical site infection; UTI, urinary tract infection.
 Note: Groups were analyzed with chi-squared analysis compared with control group. Statistically significant p-Values (p < 0.05) are indicated in bold.
^aPer HIPAA requirements, <11 cohort sizes are not reportable.

multivariable linear regression analysis. Similar findings were seen in the study by Issa et al where no significant postoperative complications were seen with HIV-positive individuals who underwent TKA.¹¹ Knee implant survivorship between the HIV-positive and control groups was also comparable with no significant differences.

The significant heterogeneity in the literature indicates that HIV-positive status should not necessarily prevent patients from receiving TKAs. If proper preoperative and perioperative precautions are taken (use of antibiotics, anticoagulants, etc.), then HIV-positive patients may be successful TKA candidates. However, it is imperative that surgeons carefully weigh the risks and benefits of operating since some studies do report increased complications and infection risks for HIV-positive patients. Surgeons must assess each patient's individual risk factors, including comorbidities and past medical/surgical history, before deciding to move forward with TKA.

There are numerous strengths to this study. This study is unique in that it analyzes the 2-year postoperative surgical complications of patients with and without a diagnosis of HIV who underwent TKA for OA of the knee. The additional analysis comparing AHIV and AIDS is also novel. Study power was facilitated by using a large nationwide database, allowing the results to be more generalizable due to its inclusion of patient data from numerous institutions. However, the authors also recognize the limitations of this study. As with any retrospective database study, coding errors might have affected the results. Furthermore, we did not have access to the CD4 count or antiretroviral regimen each patient was taking, which may have influenced how the cohorts were identified. Further, revisions or other complications outside the 2-year study window were not captured. As such, it is likely that our study underestimates revision rates, and longer term studies are needed to better define the longitudinal risks of TKA in HIV-positive patients to guide patient counseling and shared decision-making.

Conclusion

After multivariable analysis, we found that patients with a diagnosis of HIV or AIDS are not at increased risk for developing surgical complications within 2 years of undergoing TKA. We recommend patient optimization focusing on the overall comorbidities rather than the patient's HIV status when considering TKA in HIV-positive patients.

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Conflict of Interest

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References

- Hootman JM, Helmick CG. Projections of US prevalence of arthritis and associated activity limitations. *Arthritis Rheum* 2006;54(01):226–229
- Lawrence RC, Felson DT, Helmick CG, et al; National Arthritis Data Workgroup. Estimates of the prevalence of arthritis and other rheumatic conditions in the United States. Part II. *Arthritis Rheum* 2008;58(01):26–35
- Takacs J, Carpenter MG, Garland SJ, Hunt MA. The role of neuromuscular changes in aging and knee osteoarthritis on dynamic postural control. *Aging Dis* 2013;4(02):84–99
- Parvizi J, Sullivan TA, Pagnano MW, Trousdale RT, Bolander ME. Total joint arthroplasty in human immunodeficiency virus-positive patients: an alarming rate of early failure. *J Arthroplasty* 2003;18(03):259–264
- Chalmers BP, Abdel MP, Taunton MJ, Trousdale RT, Pagnano MW. Mid-term results of total hip and total knee arthroplasty in patients with human immunodeficiency virus. *Orthopedics* 2017;40(04):e699–e702
- Moore RD. Epidemiology of HIV infection in the United States: implications for linkage to care. *Clin Infect Dis* 2011;52(Suppl 2):S208–S213
- Falakassa J, Diaz A, Schneiderbauer M. Outcomes of total joint arthroplasty in HIV patients. *Iowa Orthop J* 2014;34:102–106
- Roof MA, Anoushiravani AA, Chen KK, et al. Outcomes of total knee arthroplasty in human immunodeficiency virus-positive patients. *J Knee Surg* 2020;33(08):754–761
- O'Neill SC, Queally JM, Hickey A, Mulhall KJ. Outcome of total hip and knee arthroplasty in HIV-infected patients: a systematic review. *Orthop Rev (Pavia)* 2019;11(01):8020
- Lin CA, Kuo AC, Takemoto S. Comorbidities and perioperative complications in HIV-positive patients undergoing primary total hip and knee arthroplasty. *J Bone Joint Surg Am* 2013;95(11):1028–1036
- Issa K, Pierce TP, Harwin SF, Scillia AJ, Festa A, Mont MA. No decrease in knee survivorship or outcomes scores for patients with HIV infection who undergo TKA. *Clin Orthop Relat Res* 2017;475(02):465–471
- Rodriguez-Merchan EC, Wiedel JD. Total knee arthroplasty in HIV-positive haemophilic patients. *Haemophilia* 2002;8(03):387–392
- Rodriguez-Merchan EC. Total knee arthroplasty in patients with haemophilia who are HIV-positive. *J Bone Joint Surg Br* 2002;84(02):170–172
- Trieb K, Panotopoulos J, Wanivenhaus A. Risk of infection after total knee arthroplasty in HIV-positive hemophilic patients. *J Bone Joint Surg Am* 2003;85(05):969–970, author reply 969–970
- Cms.gov. 2018. ICD-10-CM Official Guidelines for Coding and Reporting FY 2019. Accessed July 27, 2021 at: <https://www.cms.gov/Medicare/Coding/ICD10/Downloads/2019-ICD10-Coding-Guidelines-.pdf>
- Elixhauser A, Steiner C, Harris DR, Coffey RM. Comorbidity measures for use with administrative data. *Med Care* 1998;36(01):8–27
- Burgoyne RW, Tan DH. Prolongation and quality of life for HIV-infected adults treated with highly active antiretroviral therapy (HAART): a balancing act. *J Antimicrob Chemother* 2008;61(03):469–473

- 18 Enayatollahi MA, Murphy D, Maltenfort MG, Parvizi J. Human immunodeficiency virus and total joint arthroplasty: the risk for infection is reduced. *J Arthroplasty* 2016;31(10):2146–2151
- 19 Olson JJ, Schwab PE, Jackson J, Lange JK, Bedair HS, Abdeen A. HIV-positive patients are at increased risk of venous thromboembolism after total joint replacement. *J Am Acad Orthop Surg* 2021;29(11):479–485
- 20 Boylan MR, Basu N, Naziri Q, Issa K, Maheshwari AV, Mont MA. Does HIV infection increase the risk of short-term adverse outcomes following total knee arthroplasty? *J Arthroplasty* 2015;30(09):1629–1632
- 21 Capogna BM, Lovy A, Blum Y, Kim SJ, Felsen UR, Geller DS. Infection rate following total joint arthroplasty in the HIV population. *J Arthroplasty* 2013;28(08):1254–1258