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Original research

# Unicompartmental Knee Arthroplasty Is Associated With a Lower Rate of Periprosthetic Joint Infection Compared to Total Knee Arthroplasty

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ABSTRACT

*Background:* Several studies have reported lower perioperative complications with unicompartmental knee arthroplasty (UKA) than with total knee arthroplasty (TKA). However, there is a paucity of data analyzing the incidence of periprosthetic joint infection (PJI) in similar patients undergoing UKA and TKA. As such, we sought to analyze the incidence of UKA and TKA PJI in a large matched population.
*Material and Methods:* The Mariner data set of the PearlDiver database was queried for all patients undergoing UKA or TKA during 2010-2017. Included patients were required to have at least 2 years of database inclusion after surgery. Patients were then matched at a 1:3 ratio (UKA:TKA) on age, gender, Elixhauser Comorbidity Index, tobacco use, and obesity. Rates of PJI requiring operative intervention within 90 days and 1 year were calculated.
*Results:* In total, 5636 patients having undergone UKA were matched to 16,890 patients having undergone TKA. Fifteen (0.27%) after UKA and 79 (0.47%) after TKA had a PJI surgically managed within 90 days (risk ratio = 0.57, 95% confidence interval = 0.33-0.99, $P = .04$). Thirty (0.53%) after UKA and 136 (0.81%) after TKA had a PJI surgically managed within 1 year (risk ratio = 0.66, 95% confidence interval = 0.45-0.98, $P = .04$).
*Conclusions:* In a large group of rigorously matched patients, UKA was associated with a significantly lower rate of surgically managed PJI than TKA at 90 days and 1 year; however, the rate of PJI in both groups remained low at <1% at 90 days and 1 year.


## Introduction

Unicompartmental knee arthroplasty (UKA) remains a successful surgery to relieve pain and improve function in select patients with isolated compartment pathology [1-4]. While traditionally the criteria for UKA were strict [5], the indications and criteria have expanded [2,6-9], and the incidence of UKA has increased over the past decade [10,11]. Furthermore, the introduction of robotic and computer-assisted techniques has been shown to improve UKA alignment, component position, and potentially functional outcomes and revision rates [12-14]; as such, the wider adoption of robotic-assisted UKA may further increase the incidence of UKA [14,15].

While the long-term revision rates of UKA are higher than those of total knee arthroplasty (TKA) in most series in the literature [4,16-18], there are several reported advantages of a UKA compared with TKA. These include improvement in functional outcomes, higher activity level, quicker recovery, less pain and narcotic requirements postoperatively, and lower short-term complications [17-24]. Furthermore, UKA has been touted to have a lower rate of deep periprosthetic joint infection (PJI) than TKAs, although recent data show that treatment of UKA PJIs does not have better outcomes than TKA PJI treatment [25,26]. However, owing to the low incidence of UKA compared with TKA [10,11], the relatively low incidence of deep PJI in both UKA and TKA, and selection bias of younger and healthier patients toward UKA [15-27], there is a

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paucity of adequately powered data comparing UKA and TKA PJI rates in similar patient populations.

As such, the goal of the present study was to compare the incidence of reoperation for deep PJI at 90 days and 1 year in a large sample of patients from an administrative claims database undergoing UKA to a matched cohort of similar patients undergoing TKA. In addition, we sought to analyze how UKA PJIs were treated at both 90 days and 1 year. We hypothesize that the rate of surgically treated PJI at 90 days and 1 year will be lower for UKA than that for TKA.

## Material and methods

### *Data source*

The Mariner data set of the PearlDiver research database (PearlDiver Technologies, Colorado Springs, CO) was used to query deidentified, administrative claims data from patients covered by private insurance, Medicare Advantage, Medicaid, and/or claims paid with cash. It includes roughly 122 million total patients and spans the years of 2010 to 2018. The present study used Common Procedural Terminology (CPT), International Classification of Diseases (ICD)-9 and ICD-10 diagnosis and procedural codes included within the data set (Appendix). The data within this database are Health Insurance Portability and Accountability Act compliant and deemed exempt from institutional review board review.

### *Patient selection and outcomes*

Patients who underwent UKA and primary TKA were identified using codes CPT-27,446 and CPT-27,447, respectively, to preliminarily create 2 cohorts (Fig. 1). All patients were limited to analysis of their first UKA or TKA if they underwent more than one UKA or TKA in the database. Patients who were included in both groups, with an index procedural code for TKA occurring after index UKA, were included in the UKA cohort and eliminated from the TKA cohort so that the patient could not be matched to himself/herself. Patients were then limited to only those who had continuous database inclusion for at least 2 years. In order to minimize potential bias in patient selection criteria, patients with morbid obesity (body mass index [BMI] > 40 kg.m$^2$) were excluded as many surgeons consider morbid obesity a contraindication for UKA. Patients in each cohort were then matched on a patient to patient basis in a 1:3 ratio (UKA:TKA) on age, sex, Elixhauser Comorbidity Index, obesity (BMI > 30 kg/m$^2$), and tobacco use, and final demographic information was reported for each matched cohort (Table 1). Outcome of infection within 90 days and 1 year of index procedure was reported for each cohort using ICD-9 and ICD-10 diagnosis codes for PJI (Table 2). In addition, the treatment modality used to address PJI in the UKA cohort was reported by stratification into explantation or treatment with debridement, antibiotics, and implant retention (DAIR) using CPT, ICD-9, and ICD-10 procedural codes (Table 2). Diagnosis codes of PJI had to be linked to the same record as the procedural code identified as the mode of treatment.

### *Statistical analysis*

Descriptive statistics were used to describe the demographic and clinical characteristics of the matched groups. Descriptive statistics were also used to present the rates of PJI at both 90 days and 1 year in the UKA and TKA groups. The association between surgical type and PJI at both 90 days and 1 year was expressed using the relative risk of PJI in the UKA group compared with the TKA group with 95% confidence intervals (C.I.) used to assess the statistical significance of this association. Even though there was

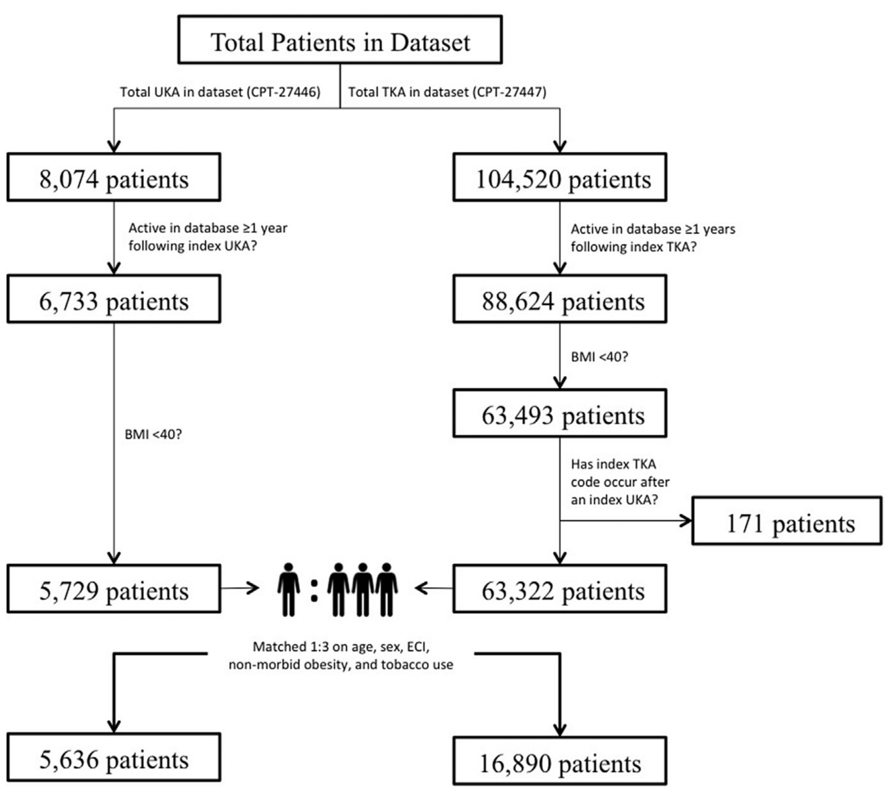


**Figure 1.** Flowchart representing the total number of patients in the database and those excluded due to inadequate follow-up or exclusion criteria. ECI, Elixhauser comorbidity index.

**Table 1**
Characteristics of matched UKA and TKA patients.

| Characteristic | UKA, N = 5636 | TKA, N = 16,890 |
|---|---|---|
| Sex | | |
| Male | 2670 (47.4%) | 7993 (47.3%) |
| Female | 2966 (52.6%) | 8897 (52.7%) |
| Age | | |
| 30-39 | 20 (0.4%) | 51 (0.3%) |
| 40-49 | 357 (6.3%) | 1063 (6.3%) |
| 50-59 | 1488 (26.4%) | 4463 (26.4%) |
| 60-69 | 1929 (34.2%) | 5786 (34.3%) |
| 70-79 | 1842 (32.7%) | 5527 (32.7%) |
| ECI | | |
| Mean ± SD | 4.84 ± 3.23 | 4.84 ± 3.22 |
| Tobacco use | | |
| Yes | 1090 (19.3%) | 3259 (19.3%) |
| No | 4546 (80.7%) | 13,631 (80.7%) |
| Obesity | | |
| Yes | 1574 (27.9%) | 4711 (27.9%) |
| No | 4062 (72.1%) | 12,179 (72.1%) |
| Service location | | |
| Hospital inpatient | 3442 (61.1%) | 16,307 (96.5%) |
| Hospital outpatient | 2194 (38.9%) | 583 (3.5%) |

ECI, Elixhauser comorbidity index.

dependency structure within the data created by matching, this could not be incorporated into the statistical analysis given the manner in which data are output from the PearlDiver platform. We elected to match 1:3 UKAs to TKAs given the rarity of UKA PJIs and the significantly higher number of TKAs in the database. Descriptive statistics were also used to describe the treatment characteristics of UKA patients with PJI. No adjustment was made for multiple hypothesis testing, and an alpha threshold of 0.05 was used to assess the statistical significance of associations as reflected by the 95% level for the C.I. All analyses were performed using Stata 16.1 (StataCorp, College Station, TX).

## Results

### *Patient matching and demographics*

In total, 5636 patients having undergone UKA were matched to 16,890 patients having undergone TKA (Table 1). As would be expected based on matching, the groups were evenly matched based on demographic and clinical characteristics but not by service location, which was not included in matching. Patients undergoing UKA were more frequently treated as outpatient.

### *Incidence of PJI in UKA and TKA*

Of patients undergoing UKA, 15 (0.27%) had a PJI surgically managed within 90 days (Table 2). Of patients undergoing TKA, 79 (0.47%) had a PJI surgically managed within 90 days. UKA was associated with a significantly lower risk of PJI within 90 days with a risk ratio of 0.57 and 95% C.I. from 0.33 to 0.99 ($P = .04$).

Of patients undergoing UKA, 30 (0.53%) had a PJI surgically managed within 1 year. Of patients undergoing TKA, 136 (0.81%) had a PJI surgically managed within 1 year. UKA was associated with a statistically significant lower risk of PJI within 1 year, with a risk ratio of 0.66 and 95% CI from 0.45 to 0.98 ($P = .04$).

**Table 2**
Association of UKA compared to TKA with infection.

| | UKA, N = 5636 | TKA, N = 16,890 |
|---|---|---|
| PJI in 90 d | | |
| N (%) | 15 (0.27%) | 79 (0.47%) |
| RR (95% C.I.) | 0.57 (0.33-0.99) | 0.00 (Ref) |
| PJI in 1 y | | |
| N (%) | 30 (0.53%) | 136 (0.81%) |
| RR (95% C.I.) | 0.66 (0.45-0.98) | 0.00 (Ref) |

### *UKA PJI treatment*

Of the 15 patients who underwent surgical management of their UKA infection within 90 days, 10 (67%) initially underwent a DAIR. Of the 15 patients who underwent surgical management of their UKA between 91 days and 1 year of UKA, 6 (40%) initially underwent a DAIR (Table 3).

**Table 3**
Surgical management of infection for UKA.

| | UKA, N = 5636 |
|---|---|
| PJI in 90 d | |
| Explant | 5 (33%) |
| DAIR | 10 (67%) |
| PJI at 91 d to 1 y | |
| Explant | 6 (40%) |
| DAIR | 9 (60%) |

## Discussion

The overall incidence of UKA is steadily increasing and expected to continue to increase in the next decade [6-11], especially with the introduction of computer navigated and robotic techniques [12-15]. Numerous studies have reported lower perioperative and short-term complications of UKA compared to TKA [4,17-24]. The low incidence of UKA compared to TKA and biased selection of younger and potentially healthier patients for UKA over TKA render such comparisons, especially for complications with a low incidence such as PJI, and lead to studies being often underpowered and biased. As such, we sought to rigorously match patients undergoing UKA to those undergoing TKA in a large non-Medicare population to compare the incidence of PJI in each cohort. We found that UKA conferred a significantly lower rate of PJI than TKA at 90 days (RR = 0.57) and 1 year (RR = 0.66).

Several studies have reported lower perioperative complication rates of UKA, including lower medical complication rates [4,18], reduced rates of venous thromboembolism [4,18], lower readmission rates [4,18], as well as decreased LOS, lower opioid requirements, and improved functional outcomes [17,19,22] compared with TKA. However, no studies to the authors' knowledge directly compare the incidence of UKA and TKA PJI in the US population. Reported rates of UKA and TKA PJI vary significantly depending on the institution and patient population, ranging from 0% to 2.5% [4,18-23,27,28–30] at early time points. Lum et al. [29] reported a 0% UKA PJI rate in 650 patients with a BMI > 35 kg/m$^2$ at a mean follow-up of 2.3 years; conversely, Nettrour et al. [28] reported a 2.2% rate of UKA PJI in patients with a BMI > 40 kg/m$^2$ at a mean follow-up of 3.4 years. While the reported rates of PJI vary, most US cohort studies report the rate of UKA PJI from 0.5% to 1% [4,27,28–30].

While there have been very few studies comparing UKA and TKA PJI rates in the United States, a few studies of European patient populations have directly or indirectly compared their rates. In a 1:3 matched cohort of 101,330 patients undergoing 25,334 UKAs and 75,996 TKAs in the National Joint Registry for England and Wales analyzing adverse outcomes as a whole, Liddle et al. [18] found a 2-fold increased risk of revision for UKA at 8 years but significantly reduced perioperative complications, length of stay, and rate of readmission. While not a major outcome measure, they did also find that the incidence of PJI in UKA was significantly lower than that in TKA (HR = 0.5, $P < .001$) and accounted for just ~5% of all revision UKAs compared with 25% of all revision TKAs [18]. In an unmatched observational cohort study of 679,010 knee arthroplasties from the England and Wales registry, Poisson and piecewise exponential multilevel regression models used to analyze several risk factors for PJI; cemented UKA also conferred a lower rate of PJI (RR = 0.5) compared to cemented TKA [23]. Finally, in an older study of roughly 5000 knee arthroplasties in the Norwegian registry performed between 1994 and 2004, the overall risk of revision was 2-fold higher for UKA than that for TKA, but UKAs were associated with a lower (RR = 0.28, $P = .01$) risk of PJI than TKA [31]. The results of these registry-based studies are similar to those of the present study, in which UKA conferred a lower risk of PJI in a matched patient cohort at 90 days and 1 year.

As expected, most UKA PJIs in the present study within 90 days were treated with a DAIR (67%), while 60% of UKA PJIs treated beyond 90 days were treated with a DAIR. Recent studies have shown that DAIR has equally poor, if not worse, outcomes for UKA than for TKA, even in relatively young and healthy patient populations. In the largest study on UKA PJI treatment outcomes, DAIR for acute postoperative PJI had a survivorship free from all-cause reoperation of 55% at 2 years, including a 31% failure for PJI [25]. Similarly, Hernandez et al. [26] reported that 6 of 11 (55%) patients with UKA PJI treated with DAIR underwent septic (n = 4) or aseptic (m = 2) reoperation by 5 years. In comparison, Weston et al [32] reported a 33% rate of reinfection within 5 years in patients with acute postoperative TKA PJIs treated with DAIR. As such, while UKA may be associated with slightly lower rates of deep PJI, the outcomes of PJI treatment do not appear to be superior to those of TKA; however, there is a paucity of data on their outcomes.

We acknowledge several limitations to the present study. First, it is a large database study with inherent limitations and biases. However, given the lower incidence of UKA and even lower incidence of UKA PJI, with less than 50 UKA PJIs specifically analyzed in the literature [25,26], a large database study is likely the most resource-efficient method to address this question. Furthermore, while databases rely on accurate coding of procedures and diagnoses, the main goal of this study was to compare UKA and TKA PJI, so the potential of PJI being miscoded should not bias this association differently in one group more than the other. Furthermore, it is possible despite matching on several key demographics that the study populations were not equivalent and that patient selection bias on other nonmatched factors may have occurred. Finally, we did not analyze risk factors for UKA PJI as the overall number of patients who developed a UKA PJI, even in this large database sample, was low.

## Conclusions

In this large non-Medicare population study of rigorously matched cohorts of patients undergoing either UKA or TKA, UKA conferred a significantly lower risk of PJI at 90 days (RR = 0.57) and 1 year (RR = 0.66) than TKA. However, the overall incidence of PJI in both UKA and TKA patients at 90 days and 1 year was overall low at <1%. As such, surgeons should continue to balance the short-term benefits and lower perioperative complications of UKA for patients compared to the improved long-term durability of TKA when counseling patients on knee arthroplasty options.

## Conflicts of interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Edwin P. Su designed and receives royalties for a cementless unicompartmental knee arthroplasty.

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## Appendix

**Supplementary Table 1**
Codes used.

| Description | Codes used |
| --- | --- |
| Unicompartmental arthroplasty | CPT-27446 |
| Total knee arthroplasty | CPT-27447 |
| Periprosthetic joint infection | ICD-9-D-99669, ICD-10-D-T8450XA, ICD-10-D-T8450XD, ICD-10-D-T8450XS, ICD-10-D-T8459XA, ICD-10-D-T8459XD, ICD-10-D-T8459XS, ICD-10-D-T8453XA, ICD-10-D-T8453XD, ICD-10-D-T8453XS, ICD-10-D-T8454XA, ICD-10-D-T8454XD, ICD-10-D-T8454XS, ICD-9-D-99660, ICD-9-D-99666, ICD-9-D-99667 |
| Explantation | CPT-27486, CPT-27487, CPT-27488, ICD-9-P-0080, ICD-9-P-0081, ICD-9-P-0082, ICD-9-P-0083, ICD-9-P-8006, ICD-9-P-8155, ICD-10-P-0SPC0JC, ICD-10-P-0SPC0JZ, ICD-10-P-0SPD0JC, ICD-10-P-0SPD0JZ, ICD-10-P-0SPT0JZ, ICD-10-P-0SPU0JZ, ICD-10-P-0SPV0JZ, ICD-10-P-0SPW0JZ, ICD-10-P-0SWC0JC, ICD-10-P-0SWC0JZ, ICD-10-P-0SWD0JC, ICD-10-P-0SWD0JZ, ICD-10-P-0SWT0JZ, ICD-10-P-0SWU0JZ, ICD-10-P-0SWV0JZ, ICD-10-P-0SWW0JZ |
| Debridement, antibiotics, and implant retention | CPT-27486, CPT-27487, CPT-27488, ICD-9-P-0080, ICD-9-P-0081, ICD-9-P-0082, ICD-9-P-0083, ICD-9-P-8006, ICD-9-P-8155, ICD-10-P-0SPC0JC, ICD-10-P-0SPC0JZ, ICD-10-P-0SPD0JC, ICD-10-P-0SPD0JZ, ICD-10-P-0SPT0JZ, ICD-10-P-0SPU0JZ, ICD-10-P-0SPV0JZ, ICD-10-P-0SPW0JZ, ICD-10-P-0SWC0JC, ICD-10-P-0SWC0JZ, ICD-10-P-0SWD0JC, ICD-10-P-0SWD0JZ, ICD-10-P-0SWT0JZ, ICD-10-P-0SWU0JZ, ICD-10-P-0SWV0JZ, ICD-10-P-0SWW0JZ |