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Incidence and safety profile of outpatient unicompartmental knee arthroplasty☆

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ABSTRACT

Background: Outpatient surgery is an increasingly attractive option for patients undergoing procedures with established, acceptable risk profiles. Benefits of outpatient surgery include cost savings, enhanced patient experience and improved resource allocation at busy hospitals. The purpose of this study was to compare 90-day complication and readmission rates for patients undergoing unicompartmental knee arthroplasty (UKA) in the outpatient as opposed to the inpatient setting.

Methods: Patients who underwent UKA (CPT code 27446) between 2007 and 2016 were retrospectively selected from a national private insurance database. Patients were defined as ambulatory if their coded location of procedure was in an ambulatory surgery center or as an in-hospital outpatient. Postoperative complications were identified using the Reportable Center for Medicare Services (CMS) Complication Measures. Risks of complications were compared between the inpatient and outpatient cohorts using multivariate logistic regression controlling for age, gender, and comorbidities.

Results: 2600 patients undergoing ambulatory UKA and 5084 patients undergoing inpatient UKA were identified. The percentage of UKA procedures performed on an outpatient basis significantly increased over the course of the study (14.5% to 58.1%, $p < 0.001$). After adjusting for age, gender, and comorbidities, ambulatory surgery was found to be associated with a decreased risk of postoperative transfusion (OR 0.28; $p < 0.001$) and pneumonia (OR 0.23; $p = 0.008$) and there was a trend towards decreased 90-day readmission risk (OR = 0.83; $p = 0.062$).

Conclusion: Ambulatory discharge following UKA is increasing in popularity, does not increase risk for perioperative complications or readmission, and may even portend a safer post-operative course.

1. Introduction

As demand for hip and knee arthroplasty continues to increase, significant resources and research have focused on improving clinical outcomes and decreasing complication rates, while decreasing costs and healthcare resource utilization [1]. Streamlined clinical pathways have been developed as a result of hospital-wide multidisciplinary collaboration efforts to facilitate expedient and safe discharge [2–4]. Outpatient surgery represents an attractive frontier for surgeons, health care administrators, and even patients. Patients report improved experience [5], and cost savings of outpatient surgery are well documented [1,6,7]. Additionally, outpatient surgery reduces provider burden, bed occupancy, and allows for better resource allocation at busy hospitals.

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Despite the perceived benefits of outpatient surgery, a thorough understanding of the postoperative adverse event profile and patient risk factors must exist in order to facilitate safe, effective implementation of these pathways. Recently, the safety of outpatient total knee arthroplasty (TKA) was brought into question by a large, nationwide database study [2]. Meanwhile, unicompartmental knee arthroplasty (UKA) is an increasingly popular surgical option for treatment of isolated medial or lateral compartment osteoarthritis, and has a favorable short-term adverse event profile compared to TKA [8–12]. UKA is associated with decreased morbidity and postoperative pain compared to total knee arthroplasty, an advantageous profile for ambulatory surgery [13,14]. A number of small scale, single institution studies have promoted the feasibility, efficacy, and safety of outpatient UKA [5,13–16]. Additionally, a recent study using a nationwide, hospital reported database demonstrated no difference in 30-day readmission or complication rates when comparing outpatient to inpatient UKA [9]. To our knowledge, no large study has investigated the 90-day risk profile of outpatient UKA.

This study queried data from a large, nationwide insurance data base to determine seven, 30 and 90-day complication rates for patients undergoing UKA. Our study hypothesis was that there would be no significant difference in postoperative adverse events for patients undergoing outpatient versus inpatient unicompartmental knee arthroplasty, despite an increase in outpatient procedures.

2. Materials and methods

A retrospective review was conducted of patients identified through the Pearl Diver Patient Records Database (www.pearldiverinc.com, Fort Wayne, IN), a nationwide health insurance derived database. The Humana insurance records database was queried, representing over 20.9 million patients.

Current Procedure Terminology (CPT) code 27446 was utilized to identify patients who underwent UKR between the first quarter of 2007 and the second quarter of 2016 as the primary procedure and were active in the insurance plan for at least 90 days following the procedure. Patients were defined as ambulatory if their coded location of procedure was either ambulatory surgery center or as an in-hospital outpatient using associated service location codes.

Demographic data including sex, age (reported in 10-year increments), and year of the procedure were available. Preoperative comorbidity data was identified for 30 domains as previously described by Elixhauser et al. [17]. Due to Pearl Diver patient privacy rules, patient values less than 11 are not reported in the results tables, although analysis is performed on the correct data number.

Inferential statistics were utilized to compare preoperative demographic and comorbidity data between the inpatient and outpatient cohorts using chi-square analysis or Fisher's exact test with significance defined as $p < 0.05$.

Postoperative surgical and medical complications were identified for each cohort using 2016 Centers for Medicare & Medicaid Services' (CMS) Complication Measures. Complication categories included seven-day occurrence of myocardial infarction, pneumonia, and sepsis, 30-day occurrence of surgical site bleeding and pulmonary embolism, and 90-day occurrence of mechanical complications (which includes periprosthetic fractures and dislocation) and periprosthetic or surgical site infection. Death was not used as an outcome as it is not reliably reported in the database. Additional complications were identified via appropriate International Classification of Diseases (ICD)-9 or ICD-10 codes, including 30-day occurrence of deep-venous thrombosis (DVT) and blood transfusion and 90-day all cause readmission. Differences in individual complications were assessed using chi-square analysis or Fisher's exact test. Finally, using the Pearl-Diver statistical analysis software, multivariate logistic regression was performed for each complication controlling for age, gender, and comorbidities. Odds ratios were obtained for each complication with inpatient surgery as the baseline.

3. Results

Seven thousand six hundred eighty-four UKRs were identified over the study period. Two thousand six hundred cases were performed on an outpatient basis, with 2098 (80.7%) as hospital outpatient and 502 (19.3%) at ambulatory surgery centers. The amount of UKRs performed in total and the percentage performed on an outpatient basis significantly increased over the course of the study. (Table 1, Figure 1). 20.0% of these procedures were performed at ambulatory surgery centers. 53.6% of the patients

Table 1
Yearly incidence of unicompartmental knee arthroplasty.

Year	All UKA		Ambulatory		Inpatient		% performed as ambulatory	p
	n	%	n	%	n	%		
2007	344	4.5	50	1.9	294	5.8	14.5	
2008	551	7.2	75	2.9	476	9.4	13.6	
2009	589	7.7	104	4.0	485	9.5	17.7	
2010	626	8.1	124	4.8	502	9.9	19.8	
2011	588	7.7	128	4.9	460	9.0	21.8	
2012	762	9.9	178	6.8	584	11.5	23.4	
2013	846	11.0	261	10.0	585	11.5	30.9	
2014	1108	14.4	473	18.2	635	12.5	42.7	
2015	1348	17.5	671	25.8	677	13.3	49.8	
2016	922	12.0	536	20.6	386	7.6	58.1	<0.001

UKA = unicompartmental knee arthroplasty.

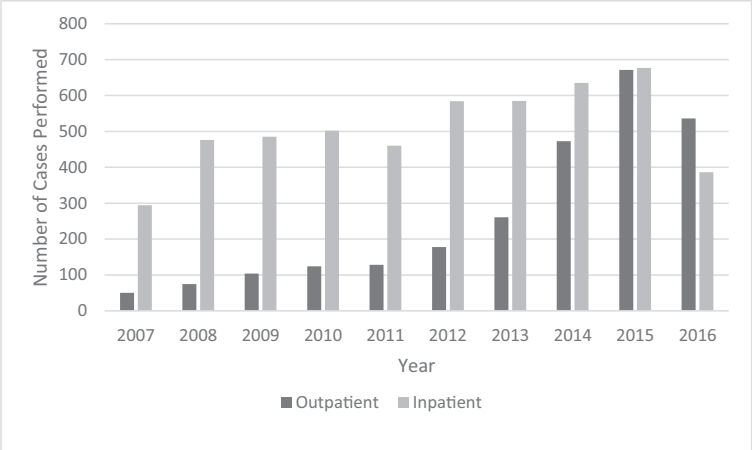

Figure 1. *Outpatient* versus *Inpatient Unicompartmental Knee Arthroplasties Performed.* Number of unicompartmental knee arthroplasties performed on an outpatient (dark gray) versus inpatient (light gray) basis by year. Numbers represent full year data from 2007 to 2015, and mid-year data in 2016.

were female and 83.3% were at least 60 years old. Baseline demographics demonstrated no difference between outpatient and inpatient cohorts (Table 2). Patients with renal failure ($p < 0.001$), obesity ($p < 0.001$), alcohol abuse ($p = 0.01$) or drug abuse ($p < 0.001$) were statistically more likely to be performed on an outpatient basis. Patients with hypertension ($p < 0.001$) were more likely to have surgery on an inpatient basis (Table 3).

The total 90-day postoperative complication rate was 5.7% (Table 4). On univariate analysis, ambulatory patients had a significantly decreased rate of overall complications as compared to inpatients (3.7% vs. 6.5%, $p < 0.001$). Ambulatory patients were less likely to suffer from postoperative complications such as requiring a blood transfusion (0.4% vs. 1.6%, $p < 0.001$) and pneumonia (0.2% vs. 0.6%, $p = 0.009$). Readmission rate was not statistically different between the ambulatory and outpatient cohorts (Table 3).

Regression analysis demonstrated that ambulatory surgery was associated with decreased risk of blood transfusion (odds ratio (OR) 0.28, $p < 0.001$) and pneumonia (OR 0.23, $p = 0.008$), with no statistically significant difference in the odds of other complications between the cohorts Table 5.

4. Discussion

This study analyzed data from a nationwide insurance database to demonstrate that outpatient UKA can be successfully performed without an increased risk of postoperative medical or surgical complications. A large increase in the percentage of cases performed as an outpatient was also noted over the course of the study. These are relevant findings, as outpatient surgery is becoming more popular in the United States due to the increased emphasis on value-based care and streamlined clinical pathways in total joint arthroplasty [1–3]. For example, outpatient UKA has been associated with up to $20,000 fewer charges than inpatient surgery, with the primary cost savings related to the outpatient surgical facility fee [7]. However, reports on the safety of outpatient arthroplasty are variable [2,13,18–20], with one recent article demonstrating increased risks of medical and surgical complications following TKA using the same large, nationwide insurance claims database used in the present study [2]. In their 2017 article, Arshi et al. showed that outpatient TKA was associated with a higher incidence of DVT, acute renal failure, requirement for knee manipulation, and revision surgery [2]. As such, the authors recommended rigorous re-evaluation of patient selection protocols and further development of comprehensive clinical pathways for hospitals implementing outpatient TKA programs.

Table 2
Baseline demographics.

	All UKA (n = 7684)	%	Ambulatory (n = 2600)	%	Inpatient (n = 5084)	%	p
Age 39 and under	32	0.4	<11	<0.42	25	0.5	
Age 40–49	271	3.5	76	2.9	195	3.8	
Age 50–59	1010	13.1	329	12.7	681	13.4	
Age 60–69	2630	34.2	898	34.5	1732	34.1	
Age 70–79	2930	38.1	1024	39.4	1906	37.5	
Age 80–89	719	9.4	241	9.3	478	9.4	
Age 90 and over	92	1.2	25	1.0	67	1.3	0.14*
Gender (F)	4116	53.6	1382	53.2	2734	53.8	
Gender (M)	3568	46.4	1218	46.8	2350	46.2	0.60

UKA = unicompartmental knee arthroplasty.
* Denotes statistically significant, $p < 0.05$ on chi-squared test or Fisher's exact test for small sample size.

Table 3
Baseline Comorbidities.

Complication	All UKA (n = 7684)	%	Ambulatory (n = 2600)	%	Inpatient (n = 5084)	%	p
Congestive Heart Failure	225	2.9	63	2.4	162	3.2	0.06
Cardiac Arrhythmias	768	10.0	282	10.8	486	9.6	0.08
Heart Valvular Disease	420	5.5	150	5.8	270	5.3	0.40
Pulmonary Circulation Disorders	58	0.8	20	0.8	38	0.7	0.92
Peripheral Vascular Disorders	432	5.6	160	6.2	272	5.4	0.15
Hypertension*	3649	47.5	1148	44.2	2501	49.2	<0.001
Paralysis	<11	<0.14	<11	<0.42	<11	<0.22	0.32
Other Neurologic Disorders	95	1.2	35	1.3	60	1.2	0.53
Chronic Pulmonary Disease	832	10.8	305	11.7	527	10.4	0.07
Diabetes	1554	20.2	549	21.1	1005	19.8	0.16
Hypothyroidism	952	12.4	347	13.3	605	11.9	0.07
Renal Failure*	338	4.4	174	6.7	164	3.2	<0.001
Liver Disease	94	1.2	29	1.1	65	1.3	0.54
Peptic Ulcer Disease	44	0.6	12	0.5	32	0.6	0.37
HIV/AIDS	<11	<0.14	<11	<0.42	<11	<0.22	0.34
Lymphoma	21	0.3	<11	<0.42	15	0.3	0.61
Metastatic Cancer	16	0.2	<11	<0.42	14	0.3	0.11
Solid Tumors without Metastasis	510	6.6	168	6.5	342	6.7	0.66
Rheumatoid Arthritis/Collagen Vascular Diseases	246	3.2	86	3.3	160	3.1	0.71
Coagulopathy	124	1.6	41	1.6	83	1.6	0.86
Obesity*	619	8.1	247	9.5	372	7.3	<0.001
Weight Loss	18	0.2	<11	<0.42	12	0.2	1.00
Fluid and Electrolyte Disorders	250	3.3	83	3.2	167	3.3	0.83
Blood Loss Anemia	<11	<0.14	<11	<0.42	<11	<0.22	0.50
Deficiency Anemias	445	5.8	132	5.1	313	6.2	0.06
Alcohol Abuse*	35	0.5	19	0.7	16	0.3	0.01
Drug Abuse*	78	1.0	46	1.8	32	0.6	<0.001
Psychoses	248	3.2	87	3.3	161	3.2	0.67
Depression	475	6.2	176	6.8	299	5.9	0.13
Smoking	226	2.9	87	3.3	139	2.7	0.13

UKA = unicompartmental knee arthroplasty.
* Denotes statistically significant, $p < 0.05$ on chi-squared test or Fisher's exact test for small sample size.

Despite these findings, UKA may be better suited to outpatient surgery [14] given the decreased morbidity and decreased postoperative pain as compared to total knee arthroplasty [5,10,13,16,21,22]. A number of recent studies have reported on outpatient UKA. The feasibility and safety of performing outpatient UKA by using multidisciplinary, rapid recovery pathways has been described [14,15]. Cross et al. demonstrated that 100% (105 out of 105) of their patients indicated for outpatient UKA were discharged on the same day of surgery, with minimal complication risk regardless of age and medical condition [14]. Several small, single institution studies reported on their experiences with outpatient UKA as compared to inpatient rapid-recovery clinical pathway, demonstrating increased patient satisfaction [5], with no increase in postoperative pain [5,16], opioid use [16], postoperative nausea or vomiting [16] or complications [5,16]. Unfortunately, these studies were limited by small sample sizes (<160 patients) and therefore unable to properly detect rates of rare, but serious peri- and post-operative complications. Meanwhile, Bovonoratwet et al. utilized the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database and demonstrated no significant difference in 30-day readmission or complication rates between propensity-matched cohorts undergoing outpatient and inpatient UKA. That study was limited in that it only analyzed 568 outpatient cases and did not assess outcomes at 90 days postoperatively, an important benchmark for patients, surgeons and payors. Also, due to the manner in which

Table 4
Postoperative complications.

Complication	All UKA (n = 7684)	%	Ambulatory (n = 2600)	%	Inpatient (n = 5084)	%	p
DVT (30 d)	101	1.3	28	1.1	73	1.4	0.19
Transfusion RBCs (30 d)*	94	1.2	11	0.4	83	1.6	<0.001
Myocardial Infarction (7 d)	16	0.2	<11	<0.42	13	0.3	0.29
Pneumonia (7 d)*	32	0.4	<11	<0.42	28	0.6	0.009
Sepsis (7 d)	<11	<0.14	<11	<0.42	<11	<0.22	0.99
Surgical Site Bleeding (30 d)	<11	<0.14	<11	<0.42	<11	<0.22	N/A
Pulmonary Embolism (30 d)	52	0.7	13	0.5	39	0.8	0.18
Mechanical Complications (90 d)	86	1.1	21	0.8	65	1.3	0.064
Infection (90 d)	47	0.6	17	0.7	30	0.6	0.73
Total Complications	438	5.7	97	3.7	332	6.5	<0.001
Readmission (90 d)	565	7.4	171	6.6	394	7.7	0.19

d = days; N/A = could not be calculated; UKA = unicompartmental knee arthroplasty; DVT = deep venous thrombosis; RBCs = red blood cells.
* Denotes statistically significant $p < 0.05$ on chi-squared test or Fisher's exact test for small sample size.

Table 5
Regression analysis of postoperative complications.

Complication	OR	p
DVT (30 d)	0.78	0.275
Transfusion RBCs (30 d)*	0.28	<0.001
Myocardial Infarction (7 d)	0.50	0.286
Pneumonia (7 d)*	0.23	0.008
Sepsis (7 d)	0.92	0.910
Surgical Site Bleeding (30 d)	0.00	0.998
Pulmonary Embolism (30 d)	0.62	0.162
Mechanical Complications (90 d)	0.70	0.165
Infection (90 d)	1.07	0.839
Readmission (90 d)	0.83	0.062

OR = odds ratio; d = days; DVT = deep venous thrombosis; RBCs = red blood cells; * denotes statistical significance; "inpatient" acts as baseline.

the data was collected, they were unable to report on the incidence of the outpatient UKA. To our knowledge, no study has compared the 90-day outcomes between these two pathways.

According to the results of our study, UKA is a safe procedure when performed in the outpatient setting. The overall complication rate was 5.7%, with DVT, blood transfusion, and mechanical complications respectively as the largest contributors. This value is slightly higher than those reported in two prior national database studies using NSQIP, likely related to the 90-day complications reported in our study versus 30-day complications in their studies, as well as differences in database data collection methods [8,9,23]. In our study, there was a significantly decreased number of total complications in the outpatient cohort (3.7% vs. 6.5%, $p < 0.001$) on univariate analysis, primarily driven by the decreased number of blood transfusions, pneumonia, and mechanical complications, although rates of each of these complications was low. Multivariate analysis revealed no increased complication risk for ambulatory cases as opposed to those undergoing inpatient stay. Meanwhile, the risk of pneumonia (OR 0.23 at 7 days) and blood transfusion (OR 0.28 at 30 days) was significantly increased for those patients requiring inpatient stay, even when controlling for age and comorbidities. Risk for hospital-acquired infection, such as pneumonia, has long been used as justification for initiatives focused on shortening postoperative length of stay and transition to outpatient surgery. Although absolute numbers were low, our study does report decreased risk of pneumonia at seven days postoperatively (0.2% vs. 0.6%) with outpatient surgery. Meanwhile, blood transfusion rates were decreased in the outpatient cohort (0.4% vs 1.6%). It is hard to draw clinical relevance from this finding, as it is unlikely the surgical technique or hemostasis protocol varied from outpatient to inpatient. This result may be confounded by patients with high blood loss requiring transfusion and subsequently converted from outpatient to inpatient status. Alternatively, it is possible that acute blood loss anemia is picked up in inpatients undergoing routine postoperative blood analysis, leading to transfusion. It is likely that interventions such as routine use of tranexamic acid and more stringent transfusion protocols may further decrease the postoperative transfusion rate in the future.

Our findings were noted with the preconceived notion that patients undergoing outpatient surgery would be selectively healthier. However, evaluation of preoperative comorbidities demonstrated that patients undergoing outpatient surgery had higher rates of renal failure, obesity, and history of drug and alcohol abuse. Meanwhile, hypertension was the only comorbidity with a statistically higher incidence in the inpatient surgery group. There was no difference in age between the groups. As most institutions have careful selection protocols to identify ideal candidates for outpatient surgery, it is possible that certain variables related to health status, such as sleep apnea, may have played a role in patient selection that were not captured in our analysis.

An important barrier to both patient and provider comfort with outpatient surgery is the risk of acute, severe cardiopulmonary event following discharge. The results of this study found this risk to be very small in both cohorts. While death is not a tracked outcome in our dataset, the incidence of myocardial infarction (<0.3%), sepsis (0.1%), and pulmonary embolism (<0.8%) was very low in both cohorts and not significantly different between inpatient and outpatient cases. Additionally, as these outcomes are tracked at seven and 30 days postoperatively, it is unlikely these adverse events would have been identified during an inpatient hospital stay. Meanwhile, 90-day readmission rate in this study was 7.4%, with a slightly decreased rate in the outpatient cohort (6.6% vs. 7.7%), which was not statistically significant. This value represents an increase from the previously cited NSQIP studies, likely secondary to the longer 90-day outcomes captured in our dataset [8,9].

Limitations of this study include the use of a national database and the associated limits in assessing outcomes based on the accuracy of coded variables. For instance, mortality is not reliably reported in the Pearl-Diver database and thus was not an included outcome in this study. Additionally, the Pearl-Diver database provides aggregate rather than individualized data due to patient privacy concerns. Furthermore, despite the similarities in preoperative demographics and comorbidities between the cohorts, and the use of multivariate analysis, there is likely inherent selection bias in those patients chosen to be performed as an outpatient for which we are unable to control in our study. Finally, patient reported outcomes are not collected, and the available collected outcomes are limited to 90 days postoperatively, meaning longer-term outcomes like implant failure are not assessed, although this is beyond the scope of this manuscript.

Strengths of this study include, to our knowledge, the largest outpatient UKA cohort reported in the literature, as well as reporting of 90-day postoperative complications. The large sample size allowed for evaluation of rarer outcomes unable to be

assessed by smaller, lower powered studies. Additionally, our cohort of patients from multiple institutions across the country allowed for reporting on the nationwide incidence of outpatient UKA as well as more generalizable conclusions.

5. Conclusions

The results of this study demonstrate that outpatient UKA has become increasingly popular over the past decade, with more than 50% of UKA cases occurring on an outpatient basis in the first two quarters of 2016. Meanwhile, 90-day complication and readmission rates were not higher in the outpatient setting, despite similar comorbidity profiles between the outpatient and inpatient cohorts. These findings are particularly important given the recently reported data from the same nationwide insurance database questioning the safety of outpatient TKA. The results of this study further separate UKA as a distinct surgery with unique postoperative course as compared to TKA, and provide useful information for surgeons and health-care administrators with regard to patient selection and counseling.

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