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Is Conversion TKA a Primary or Revision? Clinical Course and Complication Risks Approximating Revision TKA Rather Than Primary TKA

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ABSTRACT

Background: Conversion total knee arthroplasty (convTKA) is associated with increased resource utilization and costs compared with primary TKA. The purpose of this study is to compare 1) surgical time, 2) hospitalization length (LOS), 3) complications, 4) infection, and 5) readmissions in patients undergoing convTKA to both primary TKA and revision TKA patients.
Methods: The American College of Surgeons National Surgical Quality Improvement Project database was queried from 2008 to 2018. Patients undergoing convTKA (n = 1,665, 0.5%) were defined by selecting Current Procedural Terminology codes 27,447 and 20,680. We compared the outcomes of interest to patients undergoing primary TKA (n = 348,624) and to patients undergoing aseptic revision TKA (n = 8213). Univariate and multivariate logistic regression was performed to identify the relative risk of postoperative complications.
Results: Compared with patients undergoing primary TKA, convTKA patients were younger ($P < .001$), had lower body mass index ($P < .001$), and were less likely to be American Society of Anesthesiologist class III/IV ($P < .001$). These patients had significantly longer operative times (122.6 vs 90.3 min, $P < .001$), increased LOS ($P < .001$), increased risks for any complication (OR 1.94), surgical site infection (OR 1.84), reoperation (OR 2.18), and readmissions (OR 1.60) after controlling for confounders. Compared with aseptic TKA revisions, operative times were shorter (122.6 vs 148.2 min, $P < .001$), but LOS (2.91 vs 2.95 days, $P = .698$) was similar. Furthermore, relative risk for any complication ($P = .350$), surgical site infection ($P = .964$), reoperation ($P = .296$), and readmissions ($P = .844$) did not differ.
Conclusion: Conversion TKA procedures share more similarities with revision TKA rather than primary TKA procedures. Without a distinct procedural and diagnosis-related group, there are financial disincentives to care for these complex patients.
Level of Evidence: II.

Background

Total knee arthroplasty (TKA) after prior knee surgery can be associated with increased complexity and complications [1]. In addition, these procedures are typically longer and may require costly revision knee components such as stems and augments to address ligament instability, bone defects, and bony stress risers [2]. Kreitz et al. found that operative time for these cases was nearly 45% longer and there was a two and six-fold increased rates of reoperation and readmissions, respectively, within 90 days compared with primary TKA controls [3]. In addition, Yayac et al. reported an increase in mean implant cost exceeding $1000 USD compared with controls [2].

This research was performed at the University of Pennsylvania, Philadelphia, PA, USA.

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In today's value-based environment for arthroplasty, minimizing cost, variability, and complications can be critical to the financial wellbeing of the surgeons and health care facilities [4,5]. Currently, a distinct Current Procedural Terminology (CPT) code exists for conversion of previous hip surgery to total hip arthroplasty, but no analogo code exists on the knee side to account for the increased complexity of these cases. Furthermore, while several authors have previously reported increased perioperative complications, length of stay and readmissions in this patient population [1,3,6,7], these case series are smaller, single institutional experiences that may not be widely representative. Therefore, the purpose of this study is to use a nationwide administrative database to compare 1) surgical time, 2) hospital length of stay (LOS), 3) complications, 4) infection, and 5) readmissions in patients undergoing conversion of prior knee surgery with TKA (convTKA) with both primary TKA and revision TKA patients. We hypothesize that the postoperative complication risk for convTKA will more closely approximate revision TKA than primary TKA and may warrant evaluation for the addition of a new CPT code that appropriately values the added complexity of these procedures.

Materials and Methods

We retrospectively analyzed the data from the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database for the period of 2008-2018 to evaluate the 30-day complications and readmissions among patients undergoing convTKA after prior knee surgery with instrumentation. The ACS-NSQIP is a large, national, validated, risk adjusted, outcomes-based program designed to measure and improve the quality of surgical care. Because of this, it is set up to capture adverse events after surgery and therefore an ideal tool to study complications after arthroplasty [8].

Patients from ACS-NSQIP participating sites were enrolled into the database in accordance with its reporting requirements. Demographic data and patient comorbidities were collected and correlated with 30-day surgical outcomes. We identified patients undergoing convTKA (n = 1665) by selecting those whose procedures listed both TKA (CPT 27447) and removal of deep implant (CPT 20680) [Addendum Table 1]. Patients were excluded if they carried the diagnosis codes for fracture, tumor, or nonelective surgery (in the ACS-NSQIP database). In addition, the data from patients undergoing elective primary TKA excluding fracture or tumor (CPT 27447) (n = 320,707) and aseptic revision TKA excluding infection or fracture (CPT 27487) (n = 8213) during the same time period were also queried. Review of ICD-9 and ICD-10 admission diagnosis codes with reference to infection, fracture, or tumor was used to apply the exclusion criteria.

Patient demographics and host factors including age, sex, body mass index (BMI), race, American Society of Anesthesiologist (ASA) score, diabetes, hypertension, smoking status, general anesthesia, hypoalbuminemia, procedure type, and the ACS-NSQIP preoperative morbidity index were also captured. The primary outcomes of interest included any complication including infection, deep venous thrombosis, pulmonary embolism, respiratory complications (pneumonia or reintubation), cardiovascular complications (cardiac arrest, myocardial infarction, and stroke), blood transfusions, sepsis, reoperation, and readmission. In addition, surgical time, hospital LOS, and discharge destination were also analyzed.

Statistical Analysis

A priori power analysis estimated a study sample size of at least 1366 in the convTKA group was required to detect a difference in any complication between groups (primary TKA) with a 100:1 enrollment ratio at an alpha of 0.004 and 80% power with an expected complication rate of 7.5% and 10.5% in the primary TKA and convTKA groups, respectively. These complication assumptions were estimates derived from review of the entire NSQIP database complication rates for CPT 27447 (7.5%) and 27,487 (13%), assuming convTKA would fall between these two rates. A minimum sample size of 7565 was needed in the revision TKA group to detect differences in complications of 7% in the convTKA group compared with the 10% or greater in the revision TKA group with the same confidence at a 5:1 sampling rate.

Categorical variables between patients undergoing convTKA as well as primary TKA and revision TKA patients were compared using either chi-square analysis or the Fisher's exact test. An unpaired Student's t-test was used to compare continuous variables between these groups. Baseline categorical characteristics

Table 1
TKA Patient Demographics Grouped by Primary, Conversion, and Revision, 2008-2018 NSQIP.

Categorical Variables	Overall n (%)	Primary TKA n (%)	Conversion TKA n (%)	Revision TKA n (%)	*P*-Value[a]
Overall population[b]	330,586 (100)	320,707 (97.0)	1665 (0.5)	8213 (2.5)	-
Sex (female)	204,412 (61.9)	198,626 (62.0)	784 (47.1)	5002 (60.9)	<.001
Race (Caucasian)	235,760 (81.9)	228,672 (82.0)	1182 (85.2)	5905 (77.9)	<.001
ASA score III-IV	163,198 (49.1)	157,820 (49.3)	671 (40.3)	4707 (58.0)	<.001
Independent functional status	324,646 (98.2)	315,053 (98.2)	1633 (98.1)	7959 (96.9)	<.001
Congestive heart failure	945 (0.3)	910 (0.3)	5 (0.3)	30 (0.4)	.391
Diabetic	60,167 (18.2)	58,296 (18.2)	218 (13.1)	1653 (20.1)	<.001
Hypertension	215,589 (65.2)	209,201 (65.2)	867 (52.1)	5520 (67.2)	<.001
Smoker	27,425 (8.3)	26,304 (8.2)	275 (16.5)	846 (10.3)	<.001
COPD	11,573 (3.5)	11,162 (3.5)	42 (2.5)	369 (4.5)	<.001
General anesthesia	153,197 (46.3)	147,618 (46.0)	873 (52.4)	4706 (57.3)	<.001
Continuous variables	**Overall mean (SD)**	**Primary TKA mean (SD)**	**Conversion TKA mean (SD)**	**Revision TKA mean (SD)**	***P*-value**
Age, Years	66.9 (9.5)	66.9 (9.5)	59.9 (10.2)	65.7 (10.2)	<.001
BMI, kg/m^2	33.0 (6.8)	33.0 (6.8)	32.1 (6.8)	33.6 (7.4)	<.001
Albumin	4.1 (0.4)	4.1 (0.4)	4.1 (0.4)	4.1 (0.4)	.792
Hematocrit	41.0 (4.0)	41.0 (4.0)	41.8 (4.1)	40.5 (4.2)	<.001
Operative time, minutes	90.5 (35.0)	90.3 (34.8)	122.6 (50.9)	148.2 (61.0)	<.001
Length of inpatient stay, days	2.7 (2.8)	2.7 (2.7)	2.9 (9.1)	3.0 (2.2)	<.001
Morbidity probability index, %	2.7 (1.2)	2.7 (1.2)	2.6 (1.2)	4.1 (1.7)	<.001

[a] Represents *P*-value for chi-square test or Fischer's exact test for categorical variables and t-test for continuous variables.
[b] Represents group included for final analysis.

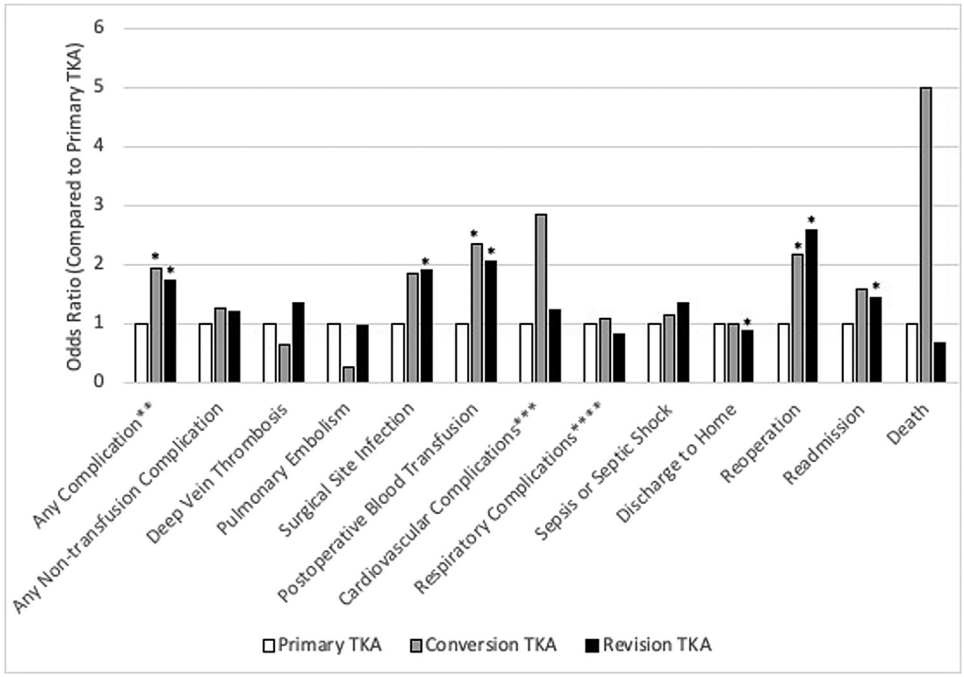

Fig. 1. Comparative bar graph of adjusted odds ratios (OR) for primary, conversion, and revision TKA.

including sex, race, ASA score, functional status, congestive heart failure, diabetes requiring medication, hypertension requiring medication, smoking status, chronic obstructive pulmonary disease, and general anesthetic were compared between all groups. Continuous variables included age, BMI, preoperative albumin, preoperative hematocrit, operative time, inpatient LOS, and ACS-NSQIP morbidity probability index.

Univariate analysis was performed to identify the relative risk of postoperative complications within thirty days of surgery among the patient groups. Outcomes of interest included any complication, any nontransfusion complication, deep vein thrombosis, pulmonary embolism, surgical site infection, postoperative blood transfusion, cardiovascular complications (i.e. stroke, cardiac arrest, and myocardial infarction), respiratory complications (i.e. pneumonia and unplanned reintubation), sepsis or septic shock, percent discharged to home, reoperation, readmission, and death. To minimize confounding variables, a multivariate logistic regression analysis was performed adjusting for age, sex, race, BMI, ASA score, diabetes, smoking, general anesthesia, chronic obstructive pulmonary disease, congestive heart failure, and hypertension. Finally, a Bonferroni correction was used to adjust alpha for significance to $P < .004$, given the evaluation of 13 variables of interest.

Results

Compared with patients undergoing primary TKA, convTKA patients were younger (mean 59.9 vs 66.9 years, $P < .001$), had lower BMI (32.1 vs 33.0 kg/m^2, $P < .001$), and were less likely to be ASA class III/IV (40.3% vs 49.3%, $P < .001$). Additional demographic and perioperative risk factors of interest are outlined in Table 1.

Surgical times were significantly longer in patients undergoing conversion of prior knee surgery to TKA than primary TKA. The mean operative time was 122.6 minutes (range 3-560 mins) in the convTKA group compared with 90.3 minutes (range 1-1435 mins) in the primary TKA group. Compared with patients undergoing aseptic revision TKA procedures, the operative times tended to be shorter in patients undergoing convTKA (122.6 vs 148.2 minutes (range 5-837 mins, $P < .001$).

Despite patients being younger and generally healthier, convTKA procedures were associated with longer hospital LOS than primary TKA. The average LOS in convTKA patients was 2.9 days (range 0-368 d) compared with 2.7 (range 0-369 d) in patients undergoing primary TKA ($P < .001$). Discharge to home was higher among convTKA patients than primary TKA patients (83.0% vs 76.0%, $P < .001$), but this finding failed to demonstrate significance after multivariate controlled analysis. In contrast, the hospital course in patients after conversion procedures were similar to those undergoing revision TKA for aseptic failures (LOS 2.91 vs 2.95 days, $P = .698$).

Complications in the convTKA group also were increased compared with primary TKA patients but similar to the revision TKA group. During the study period, the rate of any complication was 10.8% in the convTKA group compared with 7.5% in primary TKA patients ($P < .001$). The most common complications were postoperative blood transfusion (7.2%), readmission within 30 days (3.6%), and surgical site infection (2.3%). Conversion patients were more likely to develop surgical site infections (2.3% vs 1.0%, $P < .001$) and require postoperative blood transfusions (7.2% vs 4.1%, $P < .001$) and reoperations within 30 days (1.9% vs 1.1%, $P = .002$) [Figure 1]. Even after Bonferroni correction, the rate of any complication, need for postoperative blood transfusion, and reoperation within 30 days remained significantly increased compared with the primary TKA group. The complications between the two groups are outlined in Table 2. The rate and profile of complications were similar between convTKA and revision TKA patients. The adjusted relative risk between these two groups for any complication ($P = .350$), surgical site infection ($P = .964$), blood transfusion ($P = .308$), and reoperation ($P = .296$) did not significantly differ. The specific complications and relative risks are outlined in Tables 3 and 4, and Figure 1.

Patients undergoing convTKA were 1.84 times more likely to develop a surgical site infection compared with patients undergoing primary TKA [OR 1.84, 95% CI 1.08-3.13, $P = .026$]. In

Table 2
Elective TKA Patient 30-D Complications Grouped by Primary Versus Conversion TKA, 2008-2018 NSQIP.

Postoperative Complications Within 30 D	Primary TKA n (%)	Conversion TKA n (%)	Revision TKA n (%)	*P*-Value[b]
Any complication[a]	24,104 (7.5)	180 (10.8)	1087 (13.2)	<.001
Any nontransfusion complication	10,880 (3.4)	60 (3.6)	339 (4.1)	.639
Deep vein thrombosis	2555 (0.8)	8 (0.5)	69 (0.8)	.147
Pulmonary embolism	1729 (0.5)	3 (0.2)	42 (0.5)	.042
Surgical site infection	3125 (1.0)	38 (2.3)	161 (2.0)	<.001
Postoperative blood transfusion	13,224 (4.1)	120 (7.2)	748 (9.1)	<.001
Cardiovascular complications[b]	1077 (0.3)	9 (0.5)	33 (0.4)	.151
Respiratory complications[c]	1306 (0.4)	4 (0.2)	36 (0.4)	.434
Sepsis or septic shock	778 (0.2)	4 (0.2)	32 (0.4)	1
Discharge to home	243,719 (76.0)	1382 (83.0)	5790 (70.5)	<.001
Reoperation	3611 (1.1)	32 (1.9)	231 (2.8)	.002
Readmission	9402 (2.9)	60 (3.6)	363 (4.4)	.106
Death	330 (0.1)	4 (0.2)	7 (0.1)	.097

[a] Includes DVT, PE, surgical site infection, postoperative blood transfusion, pneumonia, unplanned intubation, renal insufficiency or acute failure, urinary tract infection, stroke, cardiac arrest or myocardial infarction, and sepsis or septic shock. Excludes reoperation, readmission, and death.
[b] Includes stroke, cardiac arrest, and myocardial infarction.
[c] Includes pneumonia and unplanned reintubation.

Table 4
Adjusted Odds Ratios From Multivariate Logistic Regression Comparing Conversion With Revision TKA, 2008-2018 NSQIP.

Postoperative Complications Within 30 D	Adjusted OR[a]	Adjusted 95% CI	*P*-Value
Any complication[b]	1.12	0.88-1.43	.35
Any non-transfusion complication	0.89	0.59-1.33	.561
Deep vein thrombosis	0.45	0.16-1.25	.126
Pulmonary embolism	0.25	0.03-1.83	.171
Surgical site infection	1.01	0.57-1.81	.964
Postoperative blood transfusion	1.16	0.87-1.54	.308
Cardiovascular complications[c]	2.33	0.84-6.42	.103
Respiratory complications[d]	1.06	0.31-3.66	.926
Sepsis or septic shock	0.50	0.11-2.22	.361
Discharge to home	1.13	0.87-1.48	.355
Reoperation	0.77	0.48-1.25	.296
Readmission	1.04	0.71-1.51	.844
Death	3.91	0.87-17.49	.075

[a] Adjusted for age, sex, race, BMI, ASA score, diabetes, smoking, general anesthesia, COPD, CHF, and hypertension.
[b] Includes DVT, PE, surgical site infection, postoperative blood transfusion, pneumonia, unplanned intubation, renal insufficiency or acute failure, urinary tract infection, stroke, cardiac arrest or myocardial infarction, and sepsis or septic shock. Excludes reoperation, readmission, and death.
[c] Includes stroke, cardiac arrest, and myocardial infarction.
[d] Includes pneumonia and unplanned reintubation.

comparison, the relative risks for infection were similar compared with revision TKA patients [OR 1.01, 95% CI 0.57-1.81, $P = .964$]. Finally, the risk of 30-day readmission was also increased in patients undergoing convTKA procedures compared with primary TKA patients [OR 1.60, 95% CI 1.13-2.27, $P = .008$]. However, the risk for readmission was similar between the convTKA and revision TKA cohorts [OR 1.04, 95% CI 0.71-1.51, $P = .844$].

Post hoc sensitivity analysis that included selection for convTKA patients defined by simultaneous coding of CPT 27447 with CPTs 20,680 or 20,670. This subanalysis added 43 convTKA patients and did not significantly change the complication rate.

Discussion

Costs and complications must be minimized among arthroplasty patients to maintain access to these procedures. Otherwise, economic disincentives to surgeons and health care facilities will make performance of these procedures financially unsustainable [4]. Unlike in the hip, a distinct CPT code for conversion of previous knee surgery to TKA is not available, and there are no risk adjustments to account for the increased complexity of these cases. These results show that the postoperative clinical course and complication profiles of patients undergoing convTKA procedures more closely approximates those patients undergoing aseptic revision TKA procedures.

Our study has several limitations. First, administrative databases rely on the accuracy of coding and data entry. Because there is not a specific code for convTKA procedures, the risk for under coding and undercounting is increased. Medicare does not allow payment for 20,680 in conjunction with TKA if the hardware removal is necessary to perform the arthroplasty procedure. Thus, surgeons and coders aware of this rule are unlikely to include this code even for cases where hardware removal is performed. This would systematically underestimate the conversion TKA definition and increase the number of these procedures within the primary TKA group, biasing the results of this study toward the null value. Thus, the true complication rate observed in this study is likely an underestimate

Table 3
Univariate and Adjusted Odds Ratio From Multivariate Logistic Regression Comparing Conversion TKA and Revision TKA to Primary TKA, 2008-2018 NSQIP.

Postoperative Complications Within 30 D	Conversion TKA				Revision TKA			
	Univariate OR	Adjusted OR[a]	Adjusted 95% CI	P-value	Univariate OR	Adjusted OR[a]	Adjusted 95% CI	*P*-Value
Any complication[b]	1.49	1.94	1.57-2.41	<.001	1.88	1.74	1.58-1.91	<.001
Any nontransfusion complication	1.06	1.26	0.87-1.84	.22	1.23	1.21	1.03-1.41	.015
Deep vein thrombosis	0.60	0.66	0.25-1.78	.417	1.06	1.36	1.0-1.83	.042
Pulmonary embolism	0.33	0.28	0.04-2.02	.208	0.95	0.98	0.64-1.51	.93
Surgical site infection	2.37	1.84	1.08-3.13	.026	2.03	1.91	1.51-2.41	<.001
Postoperative blood transfusion	1.80	2.36	1.83-3.04	<.001	2.33	2.07	1.85-2.31	<.001
Cardiovascular complications[c]	1.61	2.86	1.17-6.95	.021	1.20	1.23	0.80-2.01	.314
Respiratory complications[d]	0.59	1.10	0.35-3.44	.875	1.08	0.82	0.50-1.32	.411
Sepsis or septic shock	0.99	1.15	0.28-4.62	.848	1.61	1.35	0.82-2.24	.237
Discharge to home	1.63	1.00	0.78-1.27	.979	0.81	0.88	0.80-0.97	<.001
Reoperation	1.72	2.18	1.39-3.42	.001	2.54	2.58	2.15-3.09	<.001
Readmission	1.24	1.60	1.13-2.27	.008	1.53	1.44	1.25-1.67	<.001
Death	2.34	4.99	1.57-15.81	.006	0.83	0.69	0.26-1.87	.466

[a] Adjusted for age, sex, race, BMI, ASA score, diabetes, smoking, general anesthesia, COPD, CHF, and hypertension.
[b] Includes DVT, PE, surgical site infection, postoperative blood transfusion, pneumonia, unplanned intubation, renal insufficiency or acute failure, urinary tract infection, stroke, cardiac arrest or myocardial infarction, and sepsis or septic shock. Excludes reoperation, readmission, and death.
[c] Includes stroke, cardiac arrest, and myocardial infarction.
[d] Includes pneumonia and unplanned reintubation.

of the increased risk in these cases. In addition, the heterogeneity of prior surgical procedures requiring subsequent TKA makes it difficult to make definitive statements about the risks of increased complications associated with each procedure. Second, by defining the study population to include only patients who had an additional removal of hardware code (20,680), the risk of selection bias for only the most complex and severe cases is increased. This can lead to an overestimation of the risk of complications after these procedures. However, several authors have reported that even prior arthroscopy to TKA can adversely impact immediate postoperative outcomes [1,9,10]. Therefore, the impact of any prior surgical procedures before arthroplasty cannot be underestimated. Third, the heterogeneity of revision TKA procedures can also be a barrier to meaningful comparisons between the 2 groups without the specific granular details of each case (e.g. bone loss and need for stems and/or augments). Limiting the comparisons to specific and well-defined parameters (i.e. overall complication rate, LOS, and readmissions) and adjusting for confounding variables prevents both type I and II errors. Finally, our analysis did not include any cost data or analysis related to each procedure. The principal goal of this study was to show that convTKA cases behaved more like revision TKA cases rather than primary TKA procedures. Future studies with cost data stratified by preoperative diagnosis are needed to define the impact of a specific prior knee procedure on the cost and complication profiles after conversion to primary TKA.

Deformity, joint stiffness, bone loss, and soft tissue compromise increase the complexity of conversion TKA cases and lead to longer operative times. Patients undergoing convTKA had mean surgical times 33% longer than patients undergoing primary TKA (122.6 vs 90.3 minutes, $P < .001$). These results are consistent with previously published reports. Kreitz et al. reported similar increased in mean operating room time (102.1 vs 71.7 min) [3], while Ge et al. reported an association of longer operation time with increasing number of prior knee surgeries and conversions for prior fractures about the knee joint [11]. Kester et al. reported similarly increased rates of postoperative wound complications, postoperative blood transfusion, and longer operative times among a group of 674 patients with a diagnosis of post-traumatic arthritis than a large cohort of primary osteoarthritis TKA patients [12]. In the hip, there is recognition of increased complexity of conversion of prior hip surgery to total hip arthroplasty (convTHA). In accordance with the 2020 Medicare Fee Schedule, convTHA procedures were assigned 25.69 revenue value units compared with 20.72 revenue value units for total hip arthroplasty alone: a nearly 25% increase [12]. However, because the analogous code does not exist for knee arthroplasty, surgeons may be disincentivized to take care of patients who already require a higher level of expertise and care than patients undergoing routine TKA. Some of this is being seen in patients who require revision TKA procedures. Peterson, et al. showed a disproportionate reimbursement for the time spent during revision surgery compared with primary TKA ($7.90/min vs $9.33/min) [13]. Similarly, Samuel et al. demonstrated further differences when revisions are performed for infections versus aseptic failures [14]. These economic drivers may explain the increasing shift of revision and infection cases to tertiary care, teaching institutions. Finally, while a surgeon can add a modifier code for either increased complexity or hardware removal, the reimbursement of these codes require increased resource utilization for documentation and appeals and can be inconsistent depending on payors [15]. Consequently, the development of a distinct CPT code for these procedures is not only fair and warranted but necessary to prevent loss of access to care for our patients.

Despite patients being younger and generally healthier, convTKA patients had a longer average hospital LOS compared with primary patients and a similar LOS compared with revision TKA patients. The mean LOS of stay for this group was 2.9 days (SD 9.1). These results are expectedly consistent with prior studies but importantly illustrate the increase in resource utilization currently unaccounted for [2,5–7]. Increased surgical times, implant costs, postacute costs, and total episode cost of care are already not reimbursed under the current payment model [16]. In addition, because Medicare's removal of TKA from the Inpatient Only List in 2018, an increasing number of payors are denying inpatient hospital stays for patients undergoing TKA, requiring time consuming peer to peer reviews and payment delaying appeals and costly audits [17,18]. Using Medicare claims data, Davis et al. reported that on average, hospitals received 30% less payment for outpatient compared with inpatient TKA. These changes further disadvantage tertiary care academic centers which generally take care of sicker, disadvantaged, and more complex patients. Davis et al. found that since the shift from inpatient to outpatient TKA at their institution, postacute utilization rates and readmissions increased while reimbursements decreased nearly 1 million dollars over an 18-month period with further reductions expected [19]. Some authors have advocated that convTKA needs its own diagnosis-related group (DRG) code[2,3,7]. Consequently, without appropriate concessions and risk adjustments, facilities taking care of patients requiring convTKA procedures will further be significantly disadvantaged and may be disincentivized to continue to provide care.

Patients undergoing convTKA procedures have complication profiles more closely resembling patients undergoing aseptic revision TKA rather than primary TKA. Compared with primary TKA patients, convTKA patients were 1.94 times more likely to develop any complications, 1.84 times more likely to develop surgical site infection, 2.18 times more likely to require reoperations, and 1.60 times more likely to be readmitted within 30 days [Table 3]. However, there were no differences in any of these metrics when compared with patients after aseptic revision TKA procedures [Table 4]. Complications and readmissions can significantly impact the financial wellbeing of hospitals and physicians participating in value-based bundled payment programs [4]. Clair et al. reported a mean cost of complications and readmissions after TKA of $38,953 (range $4790-$104,794) at their institution [20]. Furthermore, Phillips et al. also showed that readmissions for complications after revisions (which convTKA patients mostly resemble) were associated with the highest overall episode of care costs exceeding $50,000 [21]. While conversion of prior hip surgery to total hip arthroplasty procedures were associated with increased complications compared with elective THA procedures, there were no significant differences in costly readmissions in an analysis of the ACS-NSQIP database by Qin et al [22]. However, the substantial difference in complications, reoperations, and readmissions automatically makes the patient who requires convTKA a potential bundle buster. These data are supportive of a different DRG and CPT code for patients undergoing conversion of prior knee surgery requiring hardware removal to TKA.

The informed consent process is also affected by the result of this study. In addition to the economic need to acknowledge convTKA with its own DRG and CPT code, patients must be made aware of the elevated complication profile for these procedures preoperatively. Future research efforts into the true risk after these procedures would also be improved by being able to identify this cohort of patients by a specific CPT code.

Summary

Patients with prior knee surgery who require hardware removal at the time of TKA are at increased risks of complications compared with elective TKA patients and in line with patients undergoing revision TKA for aseptic failure. Because of the lack of a specific

diagnosis code and patient-specific details, our analysis could not determine the precise degree of increased risk specific to the type of previous surgery. However, without risk adjustments or its own procedural code, surgeons and facilities who care for these patients are disadvantaged and may be disincentivized to provide treatment. This ultimately may impact a patient's access to care.

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Appendix

Appendix Table 1
Admission Diagnosis Breakdown for Conversion TKA Patients.

Admission Diagnosis	N	%
Osteoarthritis	1087	65.2
Post-traumatic arthritis	312	18.7
Complication of knee prosthesis	50	3.0
Pain due to knee prosthesis	16	1.0
Arthralgia	11	0.7
Status post knee arthroplasty	7	0.4
Breakdown of internal fixation	6	0.4
Rheumatoid arthritis	5	0.3
Secondary arthritis	3	0.2
Bone disorder	2	0.1
Knee deformity	1	0.1
Juvenile arthritis	1	0.1
Arthralgia	1	0.1
Sprain of ACL	1	0.1
Unspecified	162	9.7