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Computer-Assisted Total Knee Arthroplasty: Is There a Difference Between Image-Based and Imageless Techniques?

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ABSTRACT

Background: Image-based and imageless computer-assisted total knee arthroplasty (CATKA) has become increasingly popular. This study aims to compare outcomes, including perioperative complications and transfusion rate, between CATKA and conventional total knee arthroplasty (TKA), as well as between image-based and imageless CATKA.
Methods: Using the 9th revision of the International Classification of Diseases codes, we queried the Nationwide Inpatient Sample database from 2005 to 2011 to identify unilateral conventional TKA, image-based, and imageless CATKAs as well as in-hospital complications and transfusion rates.
Results: A total of 787,809 conventional TKAs and 13,246 CATKAs (1055 image-based and 12,191 imageless) were identified. The rate of CATKA increased 23.13% per year from 2005 to 2011. Transfusion rates in conventional TKA and CATKA cases were 11.73% and 8.20% respectively ($P < .001$) and 6.92% in image-based vs 8.27% in imageless ($P = .023$). Perioperative complications occurred in 4.50%, 3.47%, and 3.41% of cases after conventional, imageless, and imaged-based CATKAs, respectively. Using multivariate analysis, perioperative complications were significantly higher in conventional TKA compared to CATKA (odds ratio = 1.17, 95% confidence interval 1.03-1.33, $P = .01$). There was no significant difference between imageless and image-based CATKA ($P = .34$). Length of hospital stay and hospital charges were not significantly different between groups ($P > .05$).
Conclusion: CATKA has low complication rates and may improve patient outcomes after TKA. CATKA, especially the image-based technique, may reduce in-hospital complications and transfusion without increasing hospital charges and length of hospital stay significantly. Large prospective studies with long follow-up are required to verify potential benefits of CATKA.

Accurate component orientation is important for successful outcomes of total knee arthroplasty (TKA). Malalignment of the prosthesis can result in poorer outcomes and shorter survivorship of the knee [1–3]. Computer-assisted navigation systems have been utilized in TKA to improve accuracy and are increasingly popular among orthopedic surgeons. Multiple computer-assisted total knee arthroplasty (CATKA) methods have been developed, utilizing intraoperative, image-based, and imageless navigation systems [4]. Compared to conventional TKA instrumentation, both image-based and imageless CATKAs have been shown to result in greater accuracy [5–19], less blood loss [20,21], less emboli [22,23], better functional outcomes [24,25], likely better cost efficiency [26], and lower rates of postoperative cardiac complications [27]. Furthermore, CATKA has little impact on postoperative mortality compared to conventional TKA. However, the use of CATKA remains controversial, as evidenced in the current literature [8,28–30].

There is a paucity of studies comparing outcomes between CATKA navigation systems. However, those studies that focused particularly on radiological alignment found no difference in

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functional outcomes between computed tomography (CT)-based and CT-free navigation systems [31,32]. Despite the advent of navigation systems using different techniques, imageless navigation systems have become popular because of lower costs in surgery and shorter operative times [6,20]. Whether mortality and morbidity are improved in either method is unknown. We hypothesized that using imaging systems during CATKA can affect the rate of perioperative complication and transfusion. The purpose of this study is to compare the postoperative outcomes, including perioperative complications and transfusion, in patients who had imageless CATKA, image-based CATKA, and conventional TKA using nationally representative data.

Methods

We used the Nationwide Inpatient Sample (NIS) database to identify patients who underwent CATKA from 2005 to 2011. The NIS is the largest United States public database of hospital discharges available, encoding data from approximately 20% of all discharges from non-Federal hospitals (about 8 million hospital admissions per year). The sampling strategy used to create the NIS database considers 5 hospital characteristics including geographic region, location (urban or rural), teaching status, ownership, and bed size to maximally represent all hospitalizations in the United States. This database includes patient's age, length of stay (LOS), up to 15 diagnoses and 15 procedures, hospital charges, and discharge destination. The Healthcare Utilization Project of the Agency maintains the database for Healthcare Research and Quality. Because the NIS database has been sufficiently de-identified, this study was exempt from institutional board review.

We queried the database based on the International Classification of Disease, 9th Revision, Clinical Modification (ICD-9-CM) codes to identify patients who underwent primary TKA (ICD-9 code 81.54). Patients who had been coded twice for TKA during the same hospitalization were identified as probable bilateral TKA patients. These were excluded to avoid potential biases on outcomes such as LOS and total charges.

Patients who had been coded for both TKA (81.54) and computer-assisted surgery (00.3) were considered as CATKA cases. ICD-9 code for computer-assisted surgery was further categorized into computer-assisted surgery with CT scan (00.31), computer-assisted surgery with magnetic resonance imaging (00.32), computer-assisted surgery with fluoroscopy (00.33), imageless computer-assisted surgery (00.34), and computer-assisted surgery with multiple datasets (00.35). We used these classifications for our groups and divided patients into 2 groups of image-based CATKA (ICD-9 codes 00.31, 00.32, 00.33, and 00.35) and imageless CATKA (ICD-9 code 00.34). We also included patients who underwent unilateral conventional TKA during the same time period as the third group.

We used the same coding system to identify those patients who needed packed red cell transfusion (ICD-9 code 99.04). Surgical complications and patient comorbidities were also identified using ICD-9 codes (Table 1). The Charlson comorbidity index (CCI) was calculated using 17 items for patient comorbidities as described previously [33]. ICD-9 codes used for these conditions are listed in Table 1. Because we entered age as a separate variable in the multivariate model, we did not adjust the CCI for age. In this study, we compared in-hospital surgical complications, blood transfusion, LOS, and hospital charges among imageless CATKA, image-based CATKA, and conventional TKA.

Statistical Analysis

All statistical analyses were performed using R 3.0.1 (R Foundation for Statistical Computing, Vienna, Austria). Chi-squared test

Table 1
ICD-9 Diagnosis and Procedures Codes Used in the Study.

Categories	Condition or Procedure	ICD-9-CM Code
Computer-assisted TKA (81.54)	Imageless	00.34
	Image-based	00.31, 00.32, 00.33, 00.35
Blood transfusion	Allogeneic	99.04
In-hospital complications	Myocardial infarction	410.x1, 412
	Ischemic stroke	997.02, 433.x1, 434.x1
	Cardiac complications	997.1
	Respiratory complications	997.3
	GI complications	997.4, 560.1
	Urinary complication	997.5
	Pulmonary embolism	415.11, 415.19
	Deep vein thrombosis	451.11, 451.19, 451.81, 451.83, 451.89, 453.40-453.42, 453.8, 453.9
	Hematoma	998.12, 719.16
	Other joint infection	730.25, 730.26, 998.51, 711.06, 711.05, 682.6
	Mechanical malfunction	996.4x, 996.77, 996.78, 718.35, 718.36, 718.55, 718.56,
Charlson comorbidity index	Acute myocardial infarction (1 point)	410, 412
	Congestive heart failure (1 point)	428
	Peripheral vascular disease (1 point)	441, 4439, 7854, V434
	Cerebral vascular accident (1 point)	430, 431, 432, 433, 434, 435, 436, 437, 438
	Dementia (1 point)	290
	Pulmonary disease (1 point)	490, 491, 492, 493, 494, 495, 496, 500, 501, 502, 503, 504, 505
	Connective tissue disorder (1 point)	7100, 7101, 7104, 7140, 7141, 7142, 5171, 725
	Peptic ulcer (1 point)	532, 533, 534
	Liver disease (1 point)	5712, 5714, 5715, 5716
	Diabetes (1 point)	2500, 2501, 2502, 2503, 2507
	Diabetes with complications (2 points)	2504, 2505, 2506
	Hemiplegia (2 points)	342, 3441
	Renal disease (2 points)	582, 5830, 5831, 5832, 5833, 5834, 5835, 5836, 5837, 5855, 586, 588
	Cancer (2 points)	14, 15, 16, 18, 170, 171, 172, 174, 175, 176, 179, 190, 191, 192, 193, 194, 1950, 1951, 1952, 1953, 1954, 1955, 1958, 200, 201, 202, 203, 204, 205, 206, 207, 208
	Metastatic cancer (3 points)	196, 197, 198, 1990, 1991
	Severe liver disease (3 points)	5722, 5723, 5724, 5728
	AIDS (6 points)	042, 043, 044

GI, gastrointestinal; AIDS, acquired immune deficiency syndrome.