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Original Article

Computer Navigated Total Knee Arthroplasty: Rates of Adoption and Early Complications

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ABSTRACT

Background: When new technologies are introduced, it is important to evaluate the rate of adoption and outcomes compared with preexisting technology. The purpose of this study was to determine the adoption rate of computer-assisted navigation in total knee arthroplasty (TKA), to determine if the short-term complication rate changed over time with navigation, and to compare short-term complication rates of navigated and traditional TKA.

Methods: The American College of Surgeons National Surgical Quality Improvement Program database was used to identify 108,277 patients undergoing primary TKA between 2010 and 2014, of which 3573 cases (3.30%) were navigated. Rates of adoption of navigated TKA were determined. Differences in short-term complications by year were compared using propensity score matching.

Results: Navigation utilization decreased from 4.96% in 2010 to 3.06% in 2014. Blood transfusion rates for the entire cohort decreased from 19% in 2011 to 6% in 2014, and was not decreased with navigation compared with traditional TKA in 2014 ($P = .1309$). Operative time was not increased by navigation, and average 94.2 minutes. There were no significant differences in all-cause complications, reoperation rate, unplanned readmission, or length of stay for any year.

Conclusions: There was a 38.3% decrease in TKA navigation utilization from 2010-2014. Blood transfusion rates decreased 68% over the 5-year study, and were not decreased with navigation in 2014. Navigation was not found to increase operative time. There were no significant differences in short-term complications, readmission rate, or length of stay between navigated and traditional TKA.

When a new and potentially costly technology is introduced in orthopedics, especially in the case of a successful and widely performed procedure such as total knee arthroplasty (TKA), it is important to evaluate the adoption rates as well as the short-term and long-term outcomes in direct comparison with traditional technology. The first computer-navigated TKA case was first performed in 1997 [1]. The purported benefits of navigation in TKA include improved component positioning [2-8] as well as decreased rates of blood transfusion with navigation [9-14]. Previous studies have not found improved patient-reported outcomes or long-term benefits [15,16], and have shown navigation increases operative time [17-19]. A recent study from a large database evaluated short-term outcomes over a 3-year study interval, finding navigation was associated with increased blood transfusion rate, increased length of stay, increased minor complications, and an increased reoperation rate [20].

The purpose of this study was to evaluate the adoption rate of computer-navigated TKA over the 5-year study period from 2010 through 2014, for which navigation data are available in the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) database. Furthermore, we sought to determine if short-term complication rates have changed over time, as it is possible that complications associated with navigation change with increased surgeon's experience and familiarity with navigation. Finally, we wanted to evaluate

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short-term complications of traditional TKA over the 5-year study period, so that the effect of navigation on short-term complications could be isolated through use of propensity score matching.

Materials and Methods

Data Collection

This study was deemed exempt by our institutional review board at the University of Iowa. Patients undergoing TKA from 2010-2014 were identified in the ACS NSQIP database using CPT code 27447. A secondary CPT code of 20985 was used to identify patients who underwent TKA with imageless computer-assisted navigation. Fifty-six patients had fluoroscopic-guided navigation (CPT 0054T) and 68 patients had advanced imaging-guided navigation (CPT 0055T), and these patients were excluded from the study. International Classification of Diseases, Ninth Revision diagnosis codes and CPT codes were used to ensure that only primary, elective TKA cases were included. Specifically, cases involving emergency treatment, wound infection, major ligament reconstruction, bilateral surgery, or prosthesis revision were excluded.

The ACS NSQIP collects data from over 700 hospitals throughout the United States [21]. NSQIP has been widely used for evaluation of short-term complications in the orthopedic literature [22-25]. Clinical review is performed by trained reviewers at each participating institution using strict definitions to identify patient comorbidities, demographics, operative variables, and short-term medical and surgical complications as well as readmission and mortality data for 30 days postoperatively. Data collection continues regardless of discharge date or discharge location, with high data reliability obtained through a process that includes communication with patients by telephone, direct communication with treating surgeons, and thorough review of the medical record. As a result of this rigorous process and routine auditing, the rate of data disagreement is 2.0% [26].

Patient Characteristics

More than 250 distinct patient variables are available for analysis from the ACS NSQIP database. Preoperative health status and comorbidities, preoperative laboratory values, and operative variables are provided by the database and available for analysis. Data elements are fully defined within the ACS NSQIP User Guide [26]. A complete listing of all patient variables that were used in this study can be seen in Table 1.

Table 1
Patient Demographics.

Characteristic	Traditional TKA (n = 104,704)	Navigated TKA (n = 3573)
Demographics		
Age, mean (SD)	66.75 (9.83)	67.09 (10.03)
Female gender, %	62.46	63.27
Race/ethnicity, %		
White	79.40	90.23
Black	6.95	5.66
Other	13.65	4.11
Preoperative health and comorbidities		
BMI (kg/m^2), mean (SD)	32.94 (7.10)	32.45 (6.98)
Recent weight loss, %	0.15	0.00
Diabetes mellitus, %	17.74	17.58
Smoking, %	8.54	7.92
Alcohol, %	2.50	2.41
Chronic obstructive pulmonary disease, %	3.52	4.59
Coronary artery disease (MI or CHF), %	0.24	0.34
Peripheral vascular disease, %	0.53	0.45
Hx of TIA, %	2.67	4.06
Dialysis, %	0.15	0.20
Steroids, %	3.45	2.99
Bleeding disorder, %	2.56	2.29
Preop blood transfusion, %	0.07	0.00
Open wound or wound infection, %	0.38	0.20
Radiation therapy, %	0.03	0.15
Chemotherapy, %	0.23	0.15
Other recent operation, %	0.29	0.15
Preop sepsis, %	0.18	0.14
Preoperative laboratory values		
WBC, mean (SD)	7.04 (2.13)	7.17 (2.13)
Hematocrit, mean (SD)	40.61 (4.05)	40.71 (3.96)
Platelets, mean (SD)	243.7 (66.37)	249.0 (68.45)
Creatinine, mean (SD)	0.92 (0.42)	0.91 (0.41)
Serum albumin, mean (SD)	4.10 (0.39)	4.10 (0.37)
INR, mean (SD)	1.03 (0.27)	1.04 (0.32)
ASA class, %		
1—no disturbance	2.16	1.71
2—mild disturbance	50.86	50.93
3—severe disturbance	45.38	45.93
4—life threatening disturbance/ 5—moribund	1.60	1.43
Length of operation		
Mean (SD)	94.63 (39.07)	94.69 (34.78)
Length of stay	3.19 (2.48)	3.17 (2.25)
Days from operation to discharge	3.16 (2.28)	3.16 (2.24)
Resident involvement, %	37.72	14.81
Complication, %	4.85	4.67
Functional status, %		
Independent	98.37	98.82
Dependent	1.63	1.18
Patient type		
Inpatients	99.24	99.86
Outpatients	0.76	0.14

ASA, American Society of Anesthesiologists; BMI, body mass index; CHF, congestive heart failure; INR, international normalized ratio; MI, myocardial infarction; SD, standard deviation; TIA, transient ischemic attack; TKA, total knee arthroplasty; WBC, white blood cell.

Outcomes

The primary outcome of interest was composite complications occurring within 30 days of TKA. Individual complications included nosocomial surgical site infections, defined by the Centers for Disease Control and Prevention criteria, and categorized into superficial infection, deep infection, organ-space infection, and wound dehiscence [27]. Postoperative blood transfusion was considered an independent complication and was not included in the overall complication rate because of variability in institutional and surgeon protocols for transfusion between centers. The transfusion rate also likely changed during the study period of 2010-2013, with changing transfusion triggers and the adoption of tranexamic acid (TXA) [28-31]. Systemic infectious complications included sepsis, septic shock, pneumonia, and urinary tract infection. Other medical complications considered included pulmonary embolism, deep venous thrombosis, unplanned reintubation, renal insufficiency and acute renal failure, stroke, coma, peripheral nerve injury, cardiac arrest, myocardial infarction, implant failure, postoperative blood transfusion within 72 hours of the operation, reoperation within 30 days, unplanned readmission, and mortality. Reoperation within 30 days of the index procedure was also considered a complication. Readmission data at 30 days was only available for 2012-2014 and was analyzed separately because it was not available for the entire cohort.

Statistical Analysis

Patient demographic variables and comorbidities were compared between the computer-assisted navigation TKA group and the