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Original Article

Referral Bias in Primary Total Knee Arthroplasty: Retrospective Analysis of 22,614 Surgeries in a Tertiary Referral Center

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ABSTRACT

Background: Patients who travel a significant distance to obtain surgical treatment typically experience better outcomes. This is called the referral bias and can limit the generalizability of studies performed at large tertiary care centers. We explored the influence of referral bias by comparing the clinical characteristics and outcomes of total knee arthroplasty (TKA) at a large tertiary care hospital in the United States.

Methods: The study cohort included 22,614 primary TKA procedures performed between 1985 and 2010. Patients were stratified into 5 groups using home address zip codes and according to travel distance from the hospital. Clinical characteristics and the risk of TKA complications and surgical outcomes (instability, surgical-site infections, and thrombovascular complications within the first year, reoperations, revisions, and mortality) were compared across the 5 groups.

Results: Compared with local patients, patients who traveled from other parts of the United States were significantly younger (mean age 67.8 vs 68.5 years; $P < .05$), were more likely to be male (47% vs 38%, $P < .001$), had lower body mass index (mean 30.4 vs 31.8 kg/m²; $P < .001$), were more likely to have inflammatory arthritis or neoplasms as surgical indications ($P < .05$), and were more likely to have a history of prior surgeries on the same knee (20% vs 14%; $P < .001$). Referral patients also had significantly higher American Society of Anesthesiologists scores and longer operative times (mean 173 vs 156 minutes $P < .001$). Despite these differences, the risk of instability, surgical-site infections, thrombovascular complications, reoperations, and revision surgeries were similar across the 5 groups.

Conclusion: Although referral patients differ from local patients, the groups seem to experience largely similar complication and revision rates after TKA.

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Total knee arthroplasty (TKA) is primarily an elective surgery in management of end-stage knee arthritis. Referral patterns in TKA have been described previously as part of studies on volume-outcome relationship [1,2]. About 25%-50% of TKA candidates and/or their providers choose to travel or refer patients to outside their hospital service area to mostly high-volume academic medical centers [1,2]. Improved outcomes at high-volume centers eventually led to discussion of regionalization policies that would selectively

shift TKA candidates to high-volume centers as a means to improve quality and surgical outcomes [1,3,4].

Several factors influence the process of referral and self-referral for TKA, such as demographics, socioeconomic status, patient preferences, surgical complexity, and urgency among others [5,6]. The same factors also influence surgical outcomes in TKA [7-9]. Consequently, referral patterns may distort the natural history (ie, disproportionate selection of patients from the different parts of the clinical spectrum) and outcomes in studies of TKA cohorts recruited at large academic referral centers. This is called the referral or distance bias and has been described previously in several medical and surgical conditions [10-19]. When referred patients are disproportionately healthier than their nonreferred counterparts, their perioperative morbidity and mortality underrepresents the outcomes of the entire TKA population. Two notable examples of such a phenomenon are abdominal aortic aneurysm and subarachnoid

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hemorrhage where the survival of local patients was much lower than the referral patients because the referral cohorts did not include patients who died before the opportunity for referral [10,12]. On the other hand, when referred patients are sicker and surgically more complex than their nonreferred counterparts, they typically experience poor outcomes which in turn lead to overestimation of the risk of surgical outcomes [18,19]. For example, patients who traveled the furthest to seek general surgical care at a large academic center were sicker and experienced a higher risk of severe complications than local patients [18]. As is the case in these examples, evidence to date suggests that the direction and the magnitude of the referral bias differ markedly according to the type of the surgical procedure. The extent of referral bias and how it distorts the clinical presentation and outcomes of patients undergoing TKA is unknown. In an earlier study, referral patients who underwent total hip arthroplasty (THA) at a large academic center were younger, more likely to be men, and less likely to have fracture as the underlying surgical indication for THA [20]. We, therefore, sought to determine the extent of referral bias in TKA by comparing the clinical characteristics and outcomes of 22,614 primary TKA procedures at a large academic referral center in the United States.

Methods

This was a historical cohort study. The study was approved by the Institutional Review Board with a waiver of informed consent due to the historical cohort study design. Patients who had denied authorization for use of their medical records in research were excluded.

The study cohort included 22,614 primary TKA procedures performed at our institution over a 26-year period between January 1, 1985 and December 31, 2010. The institutional Total Joint Registry and the electronic medical records were used for data collection. Data collection included age, sex, body mass index (BMI), surgical indications, operative time, American Society of Anesthesiologists' (ASA) score, and details of prior nonarthroplasty surgeries on the same joint. Electronic medical records were used to capture residency information. Patients were then stratified into 5 groups using home address zip codes and according to travel distance. Residents of Olmsted County, Minnesota (N = 3271), were classified as local patients, whereas nonresidents of Olmsted County were considered as referral patients. Referral patients were then split into 4 groups according to geographic proximity: Minnesota patients from outside Olmsted County (N = 7646), patients traveling from the 5 surrounding states (North Dakota, South Dakota, Nebraska, Iowa, and Wisconsin, N = 7555), patients from the rest of United States (N = 3729), and international patients from outside the United States (N = 413).

TKA outcomes (ie, complications, reoperations, revision surgeries, and death) were ascertained using follow-up data from the institutional Total Joint Registry. Complications were limited to outcomes that occurred within the first year following surgery and included instability, surgical-site infections, and thrombovascular events. Briefly, as part of the registry procedures, patients

were routinely evaluated in person, by telephone, or with a mailed questionnaire by the trained registry personnel at 2 months, 1 year, 2 years, 5 years, ten years, 15 years, 20 years, 25 years, and 30 years after the TKA. At each time point, the patients were asked specifically about predefined complications and reoperations. Completeness of follow-up was excellent and remained higher than 85% at 20 years, except for patients from outside the United States (Table 1). Overall, of the 16,625 knees with the potential for at least 5 years of follow-up (ie, knees in patients who had not reached an end point of death or revision before 5 years), 13,664 (82.2%) had been followed for at least 5 years. This proportion was similar across all residency groups, except for patients coming from outside the United States (44.0%). Of the 11,642 knees with the potential for at least 10 years of follow-up, 10,053 (86.4%) had been followed for at least 10 years. Again, this proportion was similar across all groups, except for patients coming from outside the United States (48.6%). Of the 4095 knees with the potential for at least 20 years of follow-up, 3555 (86.8%) had been followed for at least 20 years. This proportion was 88.5% for Olmsted County patients, 87.4% for Minnesota patients outside of Olmsted County, 85.8% for patients from the surrounding States, 88.0% for patients from other parts of the United States, and 72.1% for non-US patients.

Descriptive statistics were used to summarize the data, including mean and standard deviations for continuous data and counts and percentages for categorical data. Patient characteristics and baseline clinical data were compared between the residency groups using logistic regression models for categorical data and analysis of variance for continuous data. Patients who were lost to follow-up were censored at the time of last contact (clinical or telephone/questionnaire-based contact). Patients who died with the implant intact were censored at the date of death. Multivariable Cox proportional hazard regression models were used to compare baseline clinical characteristics and the risk of TKA outcomes (ie, all complications, surgical-site infections, thrombovascular complications, reoperations, revisions, and mortality).

Results

The characteristics of the TKA patients according to residency are shown in Table 2. Apart from a significantly higher percentage of males (44% vs 38%) and inflammatory arthritis patients, and longer operative times (mean 170 vs 156 minutes), patients from other parts of Minnesota were similar to the local Olmsted County patients. Patients who traveled to the hospital from the 5 states surrounding Olmsted County were significantly more likely to be male (46% vs 38%), had slightly lower BMI (mean 31.1 vs 31.8 kg/m²), and were more likely to have inflammatory arthritis or neoplasms as the underlying indication for surgery compared with the local patients. They also had significantly longer operative times (mean 170 vs 156 minutes) than the local patients. Their ASA scores were similar to local patients. A similar pattern was observed for patients from the 5-state surrounding area.

Table 1
Completeness of Follow-Up by Travel Distance.

Potential Follow-Up	Overall N = 22,614	Olmsted County N = 3271	MN Outside Olmsted County N = 7646	5-State Area N = 7555	Other United States N = 3729	Outside United States N = 413
5 y	13,664/16,625 (82.2%)	1746/2076 (84.1%)	4619/5511 (83.8%)	4759/5786 (82.2%)	2392/2916 (82.0%)	148/336 (44.0%)
10 y	10,053/11,642 (86.4%)	1142/1278 (89.4%)	3251/3707 (87.7%)	3635/4202 (86.5%)	1901/2200 (86.4%)	124/255 (48.6%)
15 y	6780/7765 (87.3%)	712/802 (88.8%)	2135/2417 (88.3%)	2486/2861 (86.9%)	1361/1551 (87.8%)	86/134 (64.2%)
20 y	3555/4095 (86.8%)	347/392 (88.5%)	1058/1211 (87.4%)	1321/1539 (85.8%)	785/892 (88.0%)	44/61 (72.1%)

MN, Minnesota.

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