Clin Orthop Relat Res (2014) 472:2006–2015
DOI 10.1007/s11999-014-3515-z

Clinical Orthopaedics and Related Research®
A Publication of The Association of Bone and Joint Surgeons®

CLINICAL RESEARCH

Is Changing Hospitals for Revision Total Joint Arthroplasty Associated With More Complications?

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Received: 30 July 2013 / Accepted: 5 February 2014 / Published online: 11 March 2014

Abstract

Background Many patients change hospitals for revision total joint arthroplasty (TJA). The implications of changing hospitals must be better understood to inform appropriate utilization strategies.

Questions/purposes (1) How frequently do patients change hospitals for revision TJA? (2) Which patient, community, and hospital characteristics are associated with changing hospitals? (3) Is there an increased complication risk after changing hospitals?

Methods We identified 17,018 patients who underwent primary TJA and subsequent same-joint revision in New York or California (1997–2005) from statewide databases. Medicare was the most common payer (56%) followed by private insurance (31%). We identified patients who changed hospitals for revision TJA and those who experienced in-hospital complications. Patient, community, and hospital characteristics were analyzed to determine predictors for changing hospitals for revision TJA and the effect of changing hospitals on subsequent complications.

Results Thirty percent of patients changed hospitals for revision. Older patients were less likely to change hospitals (odds ratio [OR], 0.84; 95% confidence interval [CI], 0.73–0.96); no other patient characteristics were associated with changing hospitals. Patients who had index TJA at the highest-volume hospitals were less likely to change hospitals (OR, 0.52; 95% CI, 0.48–0.57). Overall, changing hospitals was associated with higher complication risk (OR, 1.19; 95% CI, 1.03–1.39). Changing to a lower-volume hospital (6% of patients undergoing revision TJA) was associated with a higher risk of complications (OR, 1.36; 95% CI, 1.05–1.74). A post hoc number needed-to-treat analysis indicates that 234 patients would need to be moved from a lower volume hospital to a higher volume hospital to avoid one overall complication event after revision TJA.

Conclusions Although the complication risk was higher if changing hospitals, this finding was sensitive to the type of change. Our findings build on the existing evidence of a volume-outcomes benefit for revision TJA by examining the effect of volume in view of potential patient migration.

Level of Evidence Level III, therapeutic study. See Instructions for Authors for a complete description of levels of evidence.

One of the authors (CJD) certifies that he has received funding, during the study period, from the National Institute of Arthritis and Musculoskeletal and Skin Diseases (Grant T32-AR07281). One of the authors (SL) certifies that he has received funding, during the study period, from the National Institute of Arthritis and Musculoskeletal and Skin Diseases (Grant R03 AR05063) and the Agency for Healthcare Research and Quality (Grant U18-HS16075).
Each author certifies that his or her institution approved or waived approval for the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research.
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Introduction

Revision total joint arthroplasty (TJA) is a technically challenging procedure associated with increased resource utilization and perioperative risk compared with primary TJA [1, 4]. The volume of revision TJA is expected to grow tremendously in accordance with projected increases in the frequency of primary THA and TKA [16]. Revision TJA generates substantial costs for healthcare payers with total annual charges associated with revision hip and knee arthroplasty projected to exceed USD 8.6 billion by 2015 in the United States.

Referral centers perform a disproportionate share of revision TJAs [5, 13], indicating that a substantial number of patients are changing hospitals for their revision surgery. Although this pattern of care migration can be justified by the beneficial relationship between revision TJA volume and outcomes [12, 15], some of these patients may be at greater risk of complications as a result of disruptions in the continuity of their care and from the increased inconvenience and cost of travel [10, 11, 18, 26]. An understanding of the implications of changing hospitals between primary and revision TJA is necessary to inform individuals and policymakers as they choose how to balance the benefits of high-volume centers with the risk of transferring care.

We therefore sought to use administrative databases from two states (California and New York) to identify the influence of patient, community, and hospital characteristics on the frequency of undergoing revision TJA at a different hospital from that of the primary surgery. Additionally, we examined the effect of the type of hospital change on the risk of perioperative complications. We asked the following research questions: (1) How frequently do patients change hospitals for revision TJA? (2) What are the patient, community, and hospital characteristics associated with a patient changing hospitals for revision TJA? (3) Is there an increased complication risk after changing hospitals for revision TJA?

Patients and Methods

Study Population and Data Sources

The New York State Department of Health Statewide Planning and Research Cooperative System captures information on all discharges from nonfederal acute-care hospitals in New York State. We used these data from 1997 to 2005 because the recording of unique patient identifiers began in 1997. The California Office of Statewide Health Planning and Development maintains a similar database from which we used data for the same time period. We elected to combine data from these two states because both databases are prospectively collected, rigorously audited, and contain an appropriate level of detail to facilitate analysis of our research questions. To minimize the effect of potential confounding, state of origin was included in our multivariable statistical analysis.

The American Hospital Association (AHA) Annual Survey provides information on hospital characteristics. These data were linked to the California and New York discharge data using AHA hospital identifiers, enabling us to identify teaching status, bed size, and rurality. US Census Bureau data were used to estimate community poverty and educational levels based on the patient's residential zip code.

Definition of Revision TJA Cohort

The index cohort was defined as New York and California residents undergoing a primary TKA (International Classification of Diseases, 9th Revision, Clinical Modification [ICD-9-CM] procedure code 81.54) or a primary THA (ICD-9-CM procedure code 81.51) from 1997 to 2005 with no diagnosis code indicating a prior knee or hip arthroplasty (ICD-9-CM V43.64 and V43.65). THA and TKA were studied together because they are performed by a similar cohort of surgeons on patients who are of similar demographics and payer mix. To minimize the effect of potential confounding, type of procedure (THA or TKA) was included in our multivariable statistical analysis. A total of 509,211 primary TJAs (301,955 primary TKAs; 207,256 primary THAs) were identified using these criteria. Subsequent admissions for patients in the index cohort were also identified. All records (index admission and subsequent admission) were investigated for revision TJA (ICD-9-CM codes 00.80–00.84, 81.55 for revision TKA; 00.70–00.73, 81.53 for revision THA) either on a subsequent day during the same admission (in-hospital revision before discharge) or in a subsequent admission within the study period. Additional procedures performed during revision TJA (eg, bone grafting) were also identified to adjust for case complexity. We identified 17,018 revisions (9310 revision TKAs; 7708 revision THAs) during the study period, representing our study cohort.

The median age for the study cohort was 67 years (interquartile range, 57–75 years). The majority (65%) of patients were between 50 and 75 years old, female (57%), and white (83%) (Table 1). Medicare was the most common insurance type (56%) followed by private insurance (31%), Medicaid (5%), and other insurances/uninsured (8%). Osteoarthritis was the most common diagnosis

Table 1. Patient demographics at the time of revision total joint arthroplasty (TJA) (n = 17,018)

Patient factors	Categories	Number (%)
Age (years)	< 50	1973 (11.6)
	50–75	11,023 (64.8)
	> 75	4022 (23.6)
Sex	Female	9755 (57.3)
	Male	7262 (42.7)
Race	White	14,073 (82.7)
	Black	1363 (8.0)
	Other	989 (5.8)
	Unknown	593 (3.5)
Insurance type	Medicare	9574 (56.3)
	Medicaid	759 (4.5)
	Private	5301 (31.2)
	Other	1384 (8.1)
Indication for TJA	Osteoarthritis	14,160 (83.2)
	Inflammatory arthropathy	810 (4.8)
	Avascular necrosis	897 (5.3)
	Congenital	201 (1.2)
	Fracture	673 (4.0)
	Neoplasm	154 (0.9)
	Other	123 (0.7)
Comorbidities*	Congestive heart failure	602 (3.5)
	Valvular disease	638 (3.8)
	Peripheral vascular disease	273 (1.6)
	Other neurological disorders	445 (2.6)
	Chronic obstructive pulmonary disease	2157 (12.7)
	Diabetes	2242 (13.2)
	Hypothyroidism	1735 (10.2)
	Obesity	1572 (9.2)
	Coagulopathy	278 (1.6)
	Fluid and electrolyte disorders	995 (5.9)
	Depression	1217 (7.2)
	Hypertension	8499 (49.9)

* Percentages do not add to 100% because some patients had more than one comorbidity.

(83%) followed by avascular necrosis (5%) and inflammatory arthropathies (5%).

Endpoints of Analysis

Patients in whom both the primary and revision TJAs were performed at the same hospital were classified as "same hospital." Patients in whom the primary and revision TJAs were performed at different hospitals were classified as "different hospital."

In-hospital complications after revision TJA were identified using ICD-9-CM diagnosis codes. The complications were grouped into categories: orthopaedic, cardiovascular and cerebrovascular, pulmonary embolism and deep venous thrombosis, infection, and other medical complications (Appendix 1).

Definitions of Predictors

The patient demographics age, sex, race, surgical diagnosis, comorbidities, and insurance status at the time of revision were considered potential patient-level predictors of a change in hospital between primary and revision TJA. Race was defined as white, black, Hispanic, Asian/Pacific Islander, Native American, or other. A comorbidity index was calculated using the Deyo modification of the Charlson Comorbidity Index [8, 9]. Expected payer (insurance status) was defined as private, health maintenance organization, self-pay, Medicare, Medicaid, no charge, or other. Surgical diagnosis was defined as osteoarthritis, inflammatory arthritis (eg, rheumatoid arthritis), trauma, avascular necrosis, or other based on the ICD-9-CM diagnosis codes. The "other" category was only used in cases in which none of the aforementioned diagnoses were coded. In cases in which a second diagnosis was coded in addition to osteoarthritis, the nonosteoarthritis diagnosis was chosen to minimize overreporting of osteoarthritis as the primary reason for TJA.

Community and institutional characteristics including education (percentage of residents with a college degree) and household income poverty (percentage of residents living below the poverty level) were estimated based on patient residential zip code using US Census Bureau data from the 2000 census. Hospital volume for primary and revision TJA was calculated for the four quarters before the quarter of the index surgery for each patient. For primary TJA, the volume categories were fewer than 200 per year, 200 to 400 per year, and more than 400 per year. Patients in whom hospital changes occurred were further grouped by primary TJA volume as staying within the same volume category, moving to a higher volume category, or moving to a lower volume category. Number of hospital beds and teaching status were identified using the AHA Annual Survey for each institution. The designation of the hospital as urban or rural was based on the Rural-Urban Commuting Area Codes [24].

Reason for Revision

Reason for revision was determined from review of the principal/admitting diagnosis coding at the time of

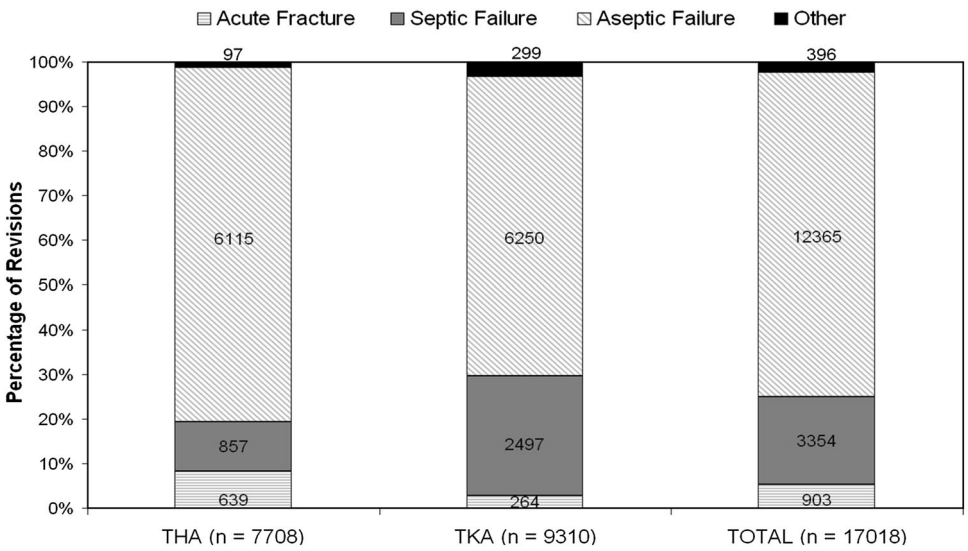

Fig. 1 Reasons for undergoing revision TJA based on admitting surgical diagnosis are shown.

revision. ICD-9 codes were used to categorize reasons for revision as acute fracture, septic failure, aseptic failure, and other (Fig. 1; ICD-9 codes listed in Appendix 2).

Statistical Analysis

The effect of patient, institutional, and community variables on the likelihood of changing hospitals was evaluated using univariate statistical methods, independent-samples t-tests for continuous variables (eg, age and hospital volume), and chi square or Fisher's exact tests for categorical variables (eg, diagnosis and teaching status).

For the primary research question, patients were categorized as same hospital or different hospital. This measure was the dependent variable. The frequency and percentage of patients defined as different hospital were calculated for all revision TJAs. The effect of patient and institutional characteristics on likelihood of revision at a different hospital was estimated using a multivariable generalized estimating equation (GEE).

For the secondary research question, the effect of changing hospitals (adjusted for patient, community, and institutional characteristics) on likelihood of postsurgical complication was estimated using a multivariable GEE. The effect of moving to or from a teaching hospital was tested in subanalyses. Additionally, the effect of the type of hospital switch with respect to primary TJA volume (staying in a similar volume category, moving to a higher volume category, or moving to a lower volume category) was tested in subanalyses.

All eligible variables were included in the models. All analyses were performed using SAS® System for Windows® 9.2 (SAS Institute, Inc, Cary, NC, USA).

Results

Frequency of Patients Changing Hospitals for Revision TJA

Of the 17,018 revisions, 5102 (30%) were performed at a different hospital from the primary TJA. Of those who changed hospitals for revision TJA, nearly two-thirds of the revisions (63%) were performed in hospitals in the same volume category; 18% changed to a hospital in a higher volume category; and 19% changed to a hospital in a lower volume category.

Predictors of Changing Hospitals for Revision TJA

Of the patient factors predicting hospital change, older patients were less likely to undergo revision TJA at a different hospital (odds ratio [OR], 0.84; 95% confidence interval [CI], 0.73–0.96) (Table 2). Black patients were not more likely than white patients to change hospitals for revision. The strongest predictor for moving to another hospital for revision was time since surgery with the likelihood increasing over time (Fig. 2). Patients revised within the first 6 months after their index TJA went to another center approximately 15% of the time, but this nearly doubled by 12 months and continued to climb until reaching a plateau of around 40% at approximately 3 years. Sex, insurance status, and surgical diagnosis (except for neoplasm) were not related to likelihood of a change in hospital.

Of the community and hospital factors predicting hospital change, patients who had their primary surgery performed at the highest volume hospitals were less likely to change institutions for revision than those who had their primary surgery performed at lower volume hospitals

Table 2. Patient factors associated with changing hospitals for revision TJA

Patient factor	Revision TJA (n = 17,018)		
	OR	(95% CI)	p value
Age (years)			
50–75 versus < 50	0.94	(0.84–1.06)	0.303
> 75 versus < 50	0.84	(0.73–0.96)	0.013
Female	0.99	(0.92–1.06)	0.773
Race			
Black versus white	1.02	(0.90–1.17)	0.734
Other versus white	1.03	(0.89–1.20)	0.692
Unknown versus white	2.00	(1.67–2.39)	< 0.001
Insurance			
Medicare versus private	1.03	(0.94–1.12)	0.529
Medicaid versus private	0.85	(0.71–1.02)	0.078
Other versus private	1.03	(0.94–1.12)	0.529
Surgical reason			
Inflammatory arthropathy versus osteoarthritis	0.94	(0.80–1.11)	0.469
Avascular necrosis versus osteoarthritis	1.09	(0.93–1.28)	0.293
Congenital versus osteoarthritis	0.85	(0.60–1.21)	0.369
Acute fracture versus osteoarthritis	1.15	(0.95–1.39)	0.164
Neoplasm versus osteoarthritis	0.59	(0.39–0.92)	0.019
Other versus osteoarthritis	0.95	(0.60–1.49)	0.816
Charlson Comorbidity	1.04	(1.00–1.07)	0.056
Year of index case	1.03	(1.02–1.05)	< 0.001
Time to revision			
6–12 months versus < 6 months	2.45	(2.17–2.77)	< 0.001
12–24 months versus < 6 months	3.66	(3.27–4.09)	< 0.001
24–36 months versus < 6 months	4.29	(3.78–4.86)	< 0.001
36–48 months versus < 6 months	4.58	(3.97–5.29)	< 0.001
48–60 months versus < 6 months	4.75	(4.03–5.61)	< 0.001
60–84 months versus < 6 months	4.98	(4.28–5.81)	< 0.001
> 84 months versus < 6 months	4.73	(3.82–5.85)	< 0.001

TJA = total joint arthroplasty; OR = odds ratio; CI = confidence interval.

(Table 3). Patients who had primary surgery in urban areas were more likely to change to other hospitals for their revision case than those who had primary surgery in rural areas. Additionally, patients from communities with a higher percentage of residents with a college degree were less likely to undergo revision TJA at a different hospital.

Association Between Changing Hospitals With Complications After Revision TJA

After adjusting for patient, community, hospital factors, reason for revision, and additional procedures performed during the revision case, any change in hospital between the primary and revision TJA was associated with an increased risk of in-hospital complications after the revision surgery (OR, 1.19; 95% CI, 1.03–1.39) (Table 4). The most common complication type was orthopaedic, which occurred in 2.8% of patients after revision TJA (Table 4). Additional procedures during revision TJA were reported in 0.5% of patients with hospital change for revision and 0.4% of patients without hospital change. Patients who had additional procedures performed had an increased risk for orthopaedic complications (OR, 2.77; 95% CI, 1.34–5.74) but no increase in risk for overall complications. The additional procedures variable was included in the regression models to account for orthopaedic case complexity.

Patients changing between two teaching hospitals (19% of all patients) had a higher risk of complications compared with those who switched between two nonteaching hospitals (70%) (OR, 1.24; 95% CI, 1.02–1.50). However, changing to a lower volume hospital for revision (a change undertaken by 6% of patients who underwent revision) was associated with a higher risk of overall complications compared with staying at the same hospital (70% of patients who underwent revision) (OR, 1.36; 95% CI, 1.05–1.74) (Table 4). There was no significant difference in overall complications when moving to a higher volume hospital for revision (5% of patients who underwent revision) compared with staying at the same hospital.

A post hoc number needed-to-treat analysis indicates that 234 patients would need to be moved from a lower volume hospital to a higher volume hospital to avoid one overall complication event after revision TJA.

Discussion

Revision TJA will be increasingly more common [16], particularly as TJA is used in younger and more active individuals [17, 22]. Given the intense resource consumption associated with revision TJA [4], opportunities to mitigate complication risk are needed to maximize value to patients and payers [3]. We have demonstrated that nearly one-third of patients change hospitals for revision TJA, which increases the risk of in-hospital complications. Evidence indicates that undergoing primary TJA at a high-volume hospital is not only beneficial in decreasing complications (such as mortality, revision, and infection) within 90 days and 1 year after the index surgery [12, 14, 25], but our data demonstrate that it also decreases the likelihood of changing hospitals for revision TJA in the future. Because these favorable hospital characteristics have implications for care delivery [5], this pattern of maintaining care within the same high-volume system should be encouraged, presuming that the care delivered is

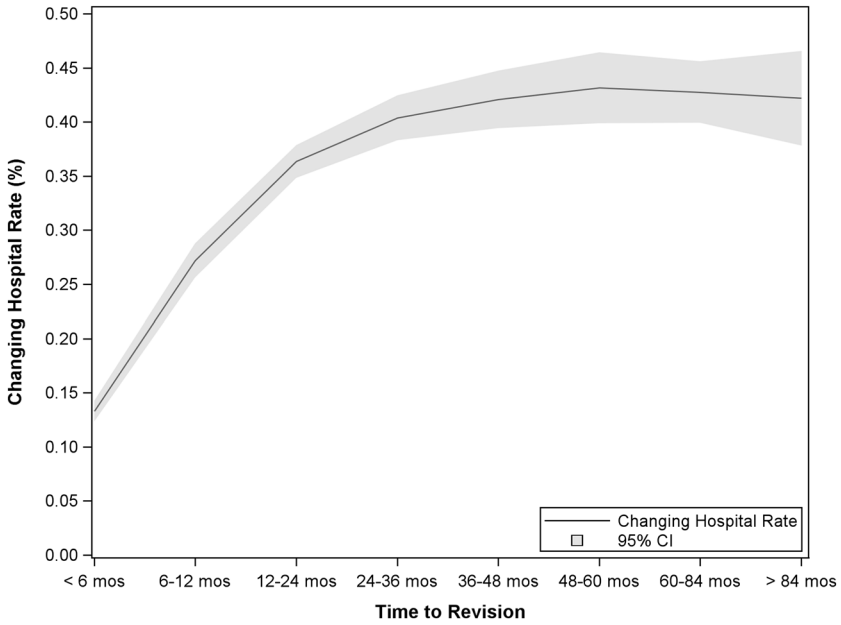

Fig. 2 The rate of changing hospitals for revision TJA by time since the primary TJA is shown. mos = months.

also of high quality (as has been suggested suggested by some studies [12, 14, 25]).

Our study has limitations, specifically those inherent to administrative database research. We were unable to capture complications or changes to hospitals that may have occurred outside of California or New York. We attempted to minimize this effect by including only residents from California or New York who had their primary TJA in their respective state. Therefore, we likely underestimated the frequency of a change in hospital, because both revision TJAs performed out of state and revision surgeries performed within California or New York on patients who had their primaries elsewhere would qualify as such. Additionally, our administrative data relied on consistent and accurate entry of complication codes. Inconsistent reporting or systematic underreporting of complications by individual hospitals would have an uncertain effect on our estimates of the effect of a change in hospital on complication risk. Furthermore, detailed reasons for revision (using new ICD-9-CM coding introduced October 1, 2005) were only available during the last 3 months of our 8-year time period. Because of this limitation, we categorized the admitting diagnosis for revision as fracture, septic failure, aseptic failure, or other. Although this technique is not as precise as detailed coding, the frequency of infection as a reason for revision in our cohort (11% for THA, 27% for TKA) is similar to studies using the updated specific reason for revision codes (15% for THA, 25% for TKA) [5, 6]. Another limitation of our data is the inability to include surgeon characteristics in our analysis because these data are not available in California. Patients who change hospitals may be following their original surgeon to a new center. Lastly, we did not directly evaluate the education and income level of each individual patient. Rather, we used community-level census data to measure these variables. Despite these drawbacks, our analysis of administrative data extends the current knowledge of hospital selection for revision TJA.

We confirmed the belief that many patients change hospitals between primary and revision TJA [5, 13]; our analysis indicates that 30% of patients change hospitals for revision TJA. Our evaluation of patient characteristics

Table 3. Community and hospital factors associated with changing hospitals for revision TJA

Community and hospital factors	Revision TJA (n = 17,018)		
	OR	(95% CI)	p value
Community factors			
Education (percent with college degree)	0.76	(0.59–0.98)	0.032
Poverty (percent living below poverty level)	1.66	(0.94–2.94)	0.083
Primary TJA hospital factors			
Primary TJA volume			
> 400 versus ≤ 200	0.52	(0.48–0.57)	< 0.001
200–400 versus ≤ 200	0.39	(0.33–0.45)	< 0.001
Bed size			
< 50 versus > 400	2.63	(2.00–3.44)	< 0.001
50–200 versus > 400	1.35	(1.21–1.52)	< 0.001
200–400 versus > 400	1.15	(1.03–1.27)	0.010
Teaching hospital	0.96	(0.86–1.08)	0.500
Urban versus rural	1.27	(1.09–1.47)	0.002

OR = odds ratio; CI = confidence interval.

Table 4. Frequency of complications after revision TJA (n = 17,018) and the effects of changing hospitals for revision and moving to a higher or lower volume category for revision

Complication	Number (%)	Changing hospitals (n = 5102) (30% of all revisions), odds ratio (95% CI)* (compared to staying at the same hospital)	Moving to a higher volume category (n = 919) (5% of all revisions), odds ratio (95% CI)* (compared with changing to staying at the same hospital)	Moving to a lower volume category (n = 974) (6% of all revisions), odds ratio (95% CI)* (compared to staying at the same hospital)
Overall complications‡	1237 (7.3)	1.19 (1.03–1.39)†	0.75 (0.53–1.06)	1.36 (1.05–1.74)†
Infection	113 (0.7)	1.04 (0.60–1.80)	0.38 (0.08–1.79)	0.81 (0.29–2.28)
Orthopaedic complication	480 (2.8)	1.27 (1.01–1.61)†	0.90 (0.52–1.56)	1.21 (0.79–1.86)
Cardiovascular and cerebrovascular complications	208 (1.2)	1.21 (0.85–1.71)	0.78 (0.33–1.88)	1.44 (0.82–2.50)
Pulmonary embolism and deep venous thrombosis	241 (1.4)	1.00 (0.69–1.44)	0.51 (0.26–1.00)†	1.13 (0.60–2.16)
Other medical complication	362 (2.1)	1.25 (0.96–1.64)	0.69 (0.34–1.40)	1.57 (1.06–2.32)†

* Adjusted for patient factors (age, sex, race, insurance type, index surgical diagnosis, reason for revision, Charlson comorbidity index, time from index surgery to revision surgery, and additional procedures performed during revision), community factors (education, poverty, population density), and hospital factors (for hospital performing revision: primary TJA volume, revision TJA volume, teaching status, urban or rural location, state indicator—California or New York, and surgical site—hip or knee); †statistical significance; ‡number of patients who experienced at least one complication; subcategories of complications do not sum to overall number/percentage as a result of some patients having more than one complication; TJA = total joint arthroplasty; CI = confidence interval.

revealed that patients > 75 years old are less likely to change hospitals for revision TJA, which is substantiated by previous findings that older patients are less likely to report having an active role in selecting hospitals for TKA [20]. We also demonstrated that patients who had their primary TJA at a high-volume hospital are less likely to change hospitals for revision, which is supported by the findings of previous investigators of fewer after primary TJA at high-volume hospitals [12, 14, 25]. Although our analysis provides initial insight into the factors affecting hospital selection for revision TJA, more detailed investigation is needed to inform future efforts to optimize TJA resource utilization.

There was a higher complication rate in patients who changed hospitals for revision. We believe this is largely attributable to more technically challenging cases and more medically complex patients being referred to other centers for revision TJA. We attempted to account for orthopaedic case complexity by including additional procedures done at the time of revision TJA (such as bone grafting and internal fixation) in our analyses. However, administrative data do not allow us to fully capture patient complexity. The increased risk of orthopaedic complications in patients with additional procedures likely reflects the higher level of case difficulty, supporting our belief that the complex nature of these cases may be driving the increased overall complication risk. In the small subset (6% of all patients who underwent revision TJA) of patients who switched to a lower volume hospital for revision, there was an even greater risk of complications, suggesting that this particular type of change should be avoided if possible; however, because the proportion of patients in this study who made this kind of change was small, and the confidence intervals around the effect size approached unity, this second-order finding needs to be validated by other studies in order to confirm it. Interestingly, there was no difference in complication risk among patients who changed from lower volume hospitals to higher volume hospitals, with the exception of a decreased risk for deep venous thrombosis or pulmonary embolism. The absence of a decreased overall complication risk (which is what we would have anticipated) in this scenario indicates that there may be other factors influencing the occurrence of complications after changing hospitals for revision TJA. Although we did not find a difference in complications with this type of hospital change, we explored this scenario further to inform future referral strategies. A post hoc number needed-to-treat analysis indicates that 234 patients would need to be moved from a lower volume hospital to a higher volume hospital to avoid one overall complication event after revision TJA.

A single previous study was limited only to Medicare beneficiaries and did not evaluate the implications of changing hospitals on complications after revision TJA [12]. Although the benefits of undergoing revision TJA at high-volume hospitals are established [12, 15], prior investigations have not considered the effect of volume in the context of changing hospitals, which commonly occurs

in revision TJA [5, 13]. Simultaneous consideration of volume and hospital change is necessary to inform decisions about how to best weigh the benefits of referring to high-volume centers [2, 18, 21] with the potential complications associated with regionalization of surgical care [10, 11, 18, 19, 26]. In the case of TJA, our results demonstrate that changing hospitals may result in an increased risk of complications if patients are switching to a lower volume hospital for the revision. Further investigation is needed to determine criteria that responsibly guide patient movement.

Although increases in surgical case complexity may justify changing hospitals for revision TJA, the implications of doing so should be considered. The increased risk of complications after changing hospitals for revision TJA suggests that providers should pay close attention to ensuring appropriate medical management if patients change hospitals. Coordination of specialist care deserves further investigation, particularly as health policy reforms encourage patient-centeredness and medical home models [7, 23]. Because undergoing revision TJA at a different hospital may entail specific risks, we need a deeper exploration of the reasons for patient movement and a better understanding of how to maximize the quality of perioperative care and long-term results if patients change hospitals.

Acknowledgments We thank Timothy Wright PhD, Hospital for Special Surgery, New York, NY, USA, for guidance in the development of the research questions and scientific approach and Huong Do MA, Hospital for Special Surgery, New York, NY, USA, for assistance with preparation of the data for further analysis.

Conflict of Interest All ICMJE Conflict of Interest Forms for authors and *Clinical Orthopaedics and Related Research* editors and board members are on file with the publication and can be viewed on request.

Appendix 1. Categorization of in-hospital complications

Orthopaedic complications	Cardiovascular and thromboembolic complications	Pulmonary embolism and deep venous thrombosis	Infectious complications	Other complications
Fractures (hip: ICD-9 820, 821.0, 821.1; knee ICD-9 821.2, 821.3, 822, 823, 827)	Acute myocardial infarction (ICD-9 410.0–410.91)	Pulmonary embolism (ICD-9 415.1–415.19)	Infection and inflammatory reaction resulting from internal prosthetic device implant and graft (ICD-9 996.60, 996.66, 996.67, 996.69)	Complications affecting specified body systems (ICD-9 997; excluding 997.1 and 997.2)
Dislocations (hip: ICD-9 718.2, 718.3, 835; knee ICD-9: 718.2, 718.3, 836)	Cardiac complications (ICD-9 997.1)	Deep venous thrombosis (ICD-9 451.1–451.9, 453.0, 453.2–453.9)	Postoperative wound infection (ICD-9 998.3, 998.6, 998.5, and 998.83)	
Other complications of procedure (ICD-9 998)	Cerebrovascular events (ICD-9 434.01, 434.11, 434.91, 997.02)			
Complications of medical care (ICD-9 999)	Peripheral vascular complications (ICD-9 997.2)			
Mechanical complication of internal orthopaedic device (ICD-9 996.4)				

ICD-9 = International Classification of Diseases, 9th Revision.

Appendix 2. International Classification of Diseases, 9th Revision codes used for reason for revision

Acute fracture
733.15 Pathologic fracture of other specified part of femur
733.8 Malunion and nonunion of fracture
733.9 Other and unspecified disorders of bone and cartilage
808 Fracture of pelvis
820 Fracture of neck of femur
821.0 Fracture of other and unspecified parts of femur—shaft or unspecified part, closed
821.1 Fracture of other and unspecified parts of femur—shaft or unspecified part, open
822 Fracture of patella
823 Fracture of tibia and fibula
827 Other, multiple, and ill-defined fractures of lower limb
Septic failiure
996.60 Infection and inflammatory reaction resulting from unspecified device, implant, and graft
996.66 Infection and inflammatory reaction resulting from internal joint prosthesis
996.67 Infection and inflammatory reaction resulting from other internal orthopedic device, implant, and graft
996.69 Infection and inflammatory reaction resulting from other internal prosthetic device, implant, and graft
998.51 Infected postoperative seroma
998.59 Other postoperative infection
Aseptic failure
718.2 Pathological dislocation
718.3 Recurrent dislocation of joint
718.4 Other derangement of joint
718.5 Ankylosis of joint
718.6 Unspecified intrapelvic protrusion of acetabulum
719.x5 Other and unspecified disorders of joint (pelvic region and thigh)
719.x6 Other and unspecified disorders of joint (lower leg)
835 Dislocation of hip
998 Other complications of procedures, not elsewhere classified
999 Complications of medical care, not elsewhere classified
996.4 Mechanical complication of internal orthopedic device, implant, and graft
996.7 Other complications of internal prosthetic device, implant, and graft
Other
715.36 Osteoarthrosis, localized, not specified whether primary or secondary (lower leg)
715.95 Osteoarthrosis, unspecified whether generalized or localized, pelvic region and thigh
715.96 Osteoarthrosis, unspecified whether generalized or localized (lower leg)
730.16 Chronic osteomyelitis (lower leg)
733.42 Aseptic necrosis of bone (head and neck of the femur)
736.3 Acquired deformities of hip
736.6 Other acquired deformities of knee
996.59 Mechanical complication of other specified prosthetic device, implant, and graft resulting from other implant and internal device, not elsewhere classified

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