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How Much Do Adverse Event Rates Differ Between Primary and Revision Total Joint Arthroplasty?

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A B S T R A C T

Background: It is not known which adverse events occur more commonly following revision than following primary total joint arthroplasty.
Methods: Patients undergoing total hip arthroplasty (THA) or total knee arthroplasty (TKA) during 2011 to 2013 as part of the America College of Surgeons National Surgical Quality Improvement Program were identified. Rates of adverse events were compared between patients undergoing primary and patients undergoing revision procedures with adjustments for demographic and comorbidity characteristics.
Results: In total, 48 307 THA patients and 70 605 TKA patients met inclusion criteria. Of the THA patients, 43 247 (89.5%) underwent primary procedures, while 5060 (10.5%) underwent revision procedures. Of the TKA patients, 65 694 (93.0%) underwent primary procedures, while 4911 (7.0%) underwent revision procedures. Patients undergoing revision procedures had higher rates of systemic sepsis (for THA, 0.3% vs 0.1%, adjusted relative risk [RR], 3.5; 95% confidence interval [CI], 1.7-7.0; $P < .001$; for TKA, 0.3% vs 0.1%, adjusted RR, 3.0; 95% CI, 1.7-5.2, $P < .001$), deep incisional surgical site infection (for THA, 1.3% vs 0.3%, adjusted RR, 4.3; 95% CI, 3.2-5.8, $P < .001$; for TKA, 0.7 vs 0.2%, RR, 4.0; 95% CI, 2.7-5.9, $P < .001$), and organ/space infection (for THA, 1.8% vs 0.2%, RR, 7.4; 95% CI, 5.4-10.0, $P < .001$; for TKA, 1.1% vs 0.1%, adjusted RR, 7.5; 95% CI, 5.4-10.6, $P < .001$). Patients undergoing revision procedures did not have higher rates of pulmonary embolism or deep vein thrombosis ($P \geq .05$ for each).
Conclusions: Public reporting of adverse events should be interpreted in the context of the differences between primary and revision procedures, and reimbursement systems should reflect the greater amount of postoperative care that patients undergoing revision procedures require.

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Reporting agencies and external regulatory bodies have begun publishing information on surgeon- and hospital-specific outcomes in orthopaedic surgery [1]. Such information is often presented in the form of physician or hospital "report cards," which include rates of various postoperative adverse events and other metrics such as the rate of hospital readmission and postoperative length of stay. The purpose of such reporting is to improve the quality and lower the cost of care by giving patients the information needed to choose providers with superior performance [2]. Using similar information, the Centers for Medicare and Medicaid Services (CMS) has begun instituting direct penalties for hospitals performing below others in various areas, including the rate of hospital readmission within 30 days [3].

Interest is also growing in the use of bundled payments as a method for controlling costs in orthopaedic surgery, and in particular for total hip arthroplasty (THA) and total knee arthroplasty (TKA) procedures [4–6]. In the bundled payment system, a pre-defined dollar amount is provided for the total cost of a procedure, including surgeon, hospital, implant, rehabilitation, pharmaceutical, home health service, and readmission costs. The system places the incentive on the provider to deliver care efficiently. It also places the risk in terms of liability for any increased costs secondary to postoperative adverse events on the providers rather than the payers. Pilot programs have demonstrated reductions in cost of 10% to 15%, and implementation of these types of programs is expected to grow [5].

One concern about the bundling of payments is that differences in patient demographics, comorbidities, and procedure complexities, all of which might result in different costs, may not be adequately accounted for [4,6]. Regarding this concern, while revision implants are clearly more costly than primary implants [4,5], there remain many questions regarding how revision and primary procedures compare in terms of risk for many specific postoperative adverse events. These questions also have implications for systems of pay-for-performance and

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interpretation of publically reported metrics. As more patients undergo revision arthroplasty each year [7], any differences in adverse event rates or other perioperative outcomes between revision and primary procedures become more important. To the knowledge of the present authors, such differences have to date only been investigated in sufficient sample sizes using administrative data [8,9], which is subject to an array of potential biases [10–13].

The American College of Surgeons National Surgical Quality Improvement Program (NSQIP) is a prospective surgical registry that follows patients during the 30-day postoperative period following an array of common orthopaedic procedures [10,11,14–16]. The NSQIP collects detailed, high-quality demographic and comorbidity information, which enables effective risk adjustment. Using NSQIP data, the present study directly compares perioperative outcomes between primary and revision total joint arthroplasty (TJA) procedures, with emphases on (1) rates of specific postoperative adverse events, (2) postoperative hospital length of stay, and (3) hospital readmission. The purpose is to better prepare patients and providers for the postoperative period and to aid policymakers in the design of payment and reporting systems.

Methods

Patients undergoing primary or revision THA or TKA as part of the NSQIP during 2011–2013 were identified using current procedural terminology codes (Appendix A). In the NSQIP, patients undergoing surgical procedures at academic and community centers nationwide are prospectively identified and enrolled in the program [14–16]. Over the 30 days following surgery, highly trained surgical clinical reviewers analyze patient records, contact patients, and/or contact patients' providers to complete data fields regarding patient demographics, comorbidities, operative factors, and postoperative adverse events. NSQIP data have been shown to be highly accurate through routine continuous auditing [14,16], and the NSQIP has achieved a high degree of acceptance as a powerful and valid data source in both the general [17] and orthopaedic [10,11,18,19] surgery literature.

Using data collected through the NSQIP, patients were characterized in terms of age, sex, body mass index, baseline functional status, and American Society of Anesthesiologists (ASA) score. They were also characterized in terms of presence/absence of congestive heart failure, dyspnea on exertion (which was considered to be present also for patients noted to have dyspnea at rest), hypertension, diabetes, end-stage renal disease, chronic obstructive pulmonary disease, and current smoking status.

Similar to previous studies [19–21], two composite adverse event outcomes were generated: "serious adverse events" and "any adverse event." A serious adverse event was defined as the occurrence of any of the following adverse event categories: unplanned intubation (including both on ventilator > 48 hours and unplanned intubation after the procedure), coma >24 hours, death, pulmonary embolism, cardiac arrest, stroke, myocardial infarction, and systemic sepsis (including systemic sepsis both with and without shock). Any adverse event was defined as the occurrence of any of the following adverse event categories: any of the adverse event categories listed in the prior sentence, pneumonia, urinary tract infection, renal insufficiency (including both progressive renal insufficiency and acute renal failure), peripheral nerve injury, organ/space infection, deep incisional surgical site infection, superficial incisional surgical site infection, wound dehiscence, graft/prosthesis/flap failure, and deep vein thrombosis. The NSQIP reports postoperative length of stay beyond 30 days (in contrast to the 30-day limit for most NSQIP variables); however, to limit the influence of outliers on the analysis, patients with postoperative length of stay longer than 30 days were considered in the analysis to have postoperative length of stay of exactly 30 days.

Statistical tests were conducted using a level of significance of $\alpha = .05$. Using Pearson's χ^2 test, patients undergoing revision vs primary TJA were compared in terms of demographics and comorbidities, including age (18-59, 60-69, 70-79, or ≥80 years), sex, body mass index (≤24, 25-29, 30-34, 35-39, ≥40), functional status (independent vs dependent), ASA score (1–2 vs 3–4), and the following comorbidities: congestive heart failure, dyspnea on exertion, hypertension, diabetes, end-stage renal disease, chronic obstructive pulmonary disease, and current smoker status.

All remaining analyses were each conducted first with bivariate models and second with multivariate models adjusting for the demographics and comorbidities detailed in the prior paragraph. Postoperative length of stay was compared between patients undergoing primary vs revision procedures using linear regression. The rates of serious adverse events, any adverse events, specific adverse events, and hospital readmission were compared between patients undergoing primary vs revision procedures using Poisson regression with robust error variance [22]. For the specific adverse events, comparisons were only conducted for events for which the minimum rate among the four comparison groups (revision and primary THA and TKA) was at least 0.05%.

Results

In total, 48307 THA patients and 70605 TKA patients met inclusion criteria. Of the THA patients, 43247 (89.5%) underwent primary procedures, while 5060 (10.5%) underwent revision procedures. Of the TKA patients, 65694 (93.0%) underwent primary procedures, while 4911 (7.0%) underwent revision procedures. Most demographics and comorbidities had statistically significant differences between primary and revision procedures both for patients undergoing THA (Table 1) and for patients undergoing TKA (Table 2).

All associations presented in the following text have been adjusted for demographic and comorbidity differences between patients undergoing revision and primary procedures. For both THA and TKA, the rate of serious adverse events was greater for patients undergoing revision than primary procedures (for THA, 3.1% vs 1.2%, adjusted relative risk [RR], 1.9; 95% confidence interval [CI], 1.6-2.3; $P < .001$; for TKA, 2.7% vs 1.4%, adjusted RR, 1.8; 95% CI, 1.5-2.1, $P < .001$; Fig. 1). Similarly,

Table 1
Demographics and Comorbidities, Primary vs Revision Total Hip Arthroplasty.

	Primary THA		Revision THA		*P*
	Number	Percent	Number	Percent	
Total	43247	100.0%	5060	100.0%	
Age					<.001
18-59	13298	30.8%	1546	30.6%	
60-69	14158	32.7%	1394	27.6%	
70-79	10489	24.3%	1206	23.8%	
≥80	5302	12.3%	914	18.0%	
Sex					.789
Male	19128	44.2%	2248	44.4%	
Female	24119	55.8%	2812	55.6%	
Body mass index					<.001
≤24	9496	22.0%	1315	26.0%	
25-29	14905	34.5%	1666	32.9%	
30-34	10532	24.4%	1167	23.1%	
35-39	5211	12.1%	559	11.1%	
≥40	3103	7.2%	353	7.0%	
Functional status					<.001
Independent	42057	97.3%	4689	92.7%	
Dependent	1190	2.8%	371	7.3%	
ASA score					<.001
1-2	25743	59.5%	2248	44.4%	
3-4	17504	40.5%	2812	55.6%	
Congestive heart failure	161	0.4%	47	0.9%	<.001
Dyspnea on exertion	2289	5.3%	347	6.9%	<.001
Hypertension	24602	56.9%	2970	58.7%	.014
Diabetes	4960	11.5%	660	13.0%	<.001
End-stage renal disease	117	0.3%	37	0.7%	<.001
COPD	1820	4.2%	316	6.3%	<.001
Current smoker	5691	13.2%	736	14.6%	.006

COPD, chronic obstructive pulmonary disease.