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Original research

Unicompartmental Knee Arthroplasty in Octogenarians: A National Database Analysis Including Over 700 Octogenarians

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ABSTRACT

Background: Unicompartmental knee arthroplasty (UKA) may be considered for select patients to relieve pain and restore function of the knee joint. Little research to date has explored the complication profile of UKA in an older population. The current study uses a large national surgical database to examine the 30-day postoperative adverse events in octogenarians compared with those in nonoctogenarians.

Material and methods: The 2012-2018 National Surgical Quality Improvement Program database was queried for all patients undergoing UKA for osteoarthritis. Those patients aged 80 years or older composed the octogenarian age group. Demographics and medical comorbidities were cataloged, in addition to 30-day adverse events. Multivariate regression analysis controlled for differences in demographics and comorbidities. Significance was set at $P < .05$.

Results: A total of 10,103 patients undergoing UKA were identified, of which 728 (7.2%) were octogenarians. The octogenarian cohort had significantly higher comorbidity burden than nonoctogenarians. After controlling for demographics other than age, American Society of Anesthesiologists score, and medical comorbidities, octogenarians had higher 30-day odds of death (odds ratio [OR] = 6.12, $P = .024$), minor adverse events (OR = 2.97, $P = .001$), prolonged hospital length of stay (OR = 2.30, <0.001), nonhome discharge (OR = 4.50, $P < .001$), and readmission (OR = 1.72, $P = .015$), but did not experience increased odds of serious adverse events (OR = 1.07, $P = .172$) or return to the operating room (OR = 0.97, $P = .881$).

Conclusion: The present study found a statistically significant increase in several adverse events within 30 days of surgery for patients aged ≥80 years when compared with patients younger than 80 years. Namely, UKA in octogenarians was associated with significantly increased odds of short-term mortality, urinary tract infection, transfusion, prolonged hospital stay, and readmission.

Introduction

Both total knee arthroplasty (TKA) and unicompartmental knee arthroplasty (UKA) are highly successful procedures performed frequently in the United States for patients with knee osteoarthritis. UKA accounted for 4.1% of all knee replacements in the United States in 2019 according to a recent American Joint Replacement Registry annual report [1] and is being increasingly performed for focal medial or lateral compartment arthritis.

When performed in appropriately selected patients, UKA has been found to have fewer complications, [2,3] superior restoration of knee kinematics [4] and overall function, [5] and is less costly [6,7] than TKA. Historically, concerns of mechanical loosening and need for revision slowed the adoption of UKA [8]. In recent years, computer-navigated and robot-assisted operations, along with improved implant design, have perhaps helped to improve UKA outcomes, with implant survivorship now ranging between 95% and 98% at 3 years [9].

Our institutional review board (IRB) granted an exemption for studies using the National Surgical Quality Improvement Program Database (NSQIP).

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Surgeries such as spinal fusion, total shoulder arthroplasty, and revision total hip arthroplasty (THA) have been studied in octogenarians, and 80 years of age was found to be an important threshold at which patients warrant additional considerations and may have a higher risk of adverse events [10-13]. Older patients tend to have more medical comorbidities, lower cardiac reserve, and increased difficulty maintaining balance [14]. However, as patients continue to live longer lives and expect to maintain a high degree of function and independence, they are likely to pursue elective partial and total knee joint arthroplasty to address the limitations derived from their knee joint arthritis pain.

Based on this, it is increasingly important to consider the risks and evaluate the outcomes of elective arthroplasty procedures in older patient populations, those older than 80 years. While a number of other arthroplasty procedures have been studied, this has not been the case for UKA thus far. The present study seeks to evaluate the short-term safety of UKA in octogenarian patients by comparing the risk of short-term postoperative adverse events in octogenarians to that in nonoctogenarians using a validated national quality database.

Materials and method

Data source

Data for this study were abstracted from the American College of Surgeon's National Surgical Quality Improvement Program (NSQIP) Database from January 2012 through December 2018. Our institutional review board has granted exemption for the use of this database given the deidentified nature of the data.

The NSQIP database is a multicenter prospectively collected database administered by the American College of Surgeons and collects data from almost 700 member hospitals in over a dozen countries. Data are collected and made available free of cost to participating member institutions annually.

The database tabulates data on patient demographics and comorbidities, surgical variables, and a predefined set of postoperative adverse events through the 30th postoperative day, regardless of discharge destination. The data are rigorously audited by the American College of Surgeons, which employs clinical reviewers at each participating hospital tasked with gathering data directly from patient charts to input that into the database [15].

Patient population

All patients older than 18 years and undergoing elective UKA (CPT 27,446) for osteoarthritis (ICD-9715.XX, ICD-10 M17.XX) were identified. Patients who underwent surgery for diagnoses other than osteoarthritis such as for infections, neoplasia, trauma, or revision as identified by International Classification of Disease codes were excluded.

Preoperative patient characteristics recorded included age, sex, height, weight, functional status, and American Society of Anesthesiologists (ASA) score. Individual comorbidities were additionally tabulated: diabetes status, smoking status, congestive heart failure (CHF), congestive obstructive pulmonary disease (COPD), chronic corticosteroid use, hypertension, and presence of a bleeding disorder. Body Mass Index was calculated from abstracted heights and weights (kg/m^2) for each patient.

Surgical variables abstracted for the patients included the following. Anesthesia was tabulated as general or other. Operative time was abstracted, and those with an operative time greater than 1 SD above the mean ($\geq$120 minutes) were determined. Procedures performed as an inpatient vs outpatient were also indicated and analyzed.

Perioperative complications

The following perioperative complications were recorded: serious adverse events including wound-related complications, cardiac events (myocardial infarction or cardiac arrest requiring CPR), pneumonia, renal complications (acute kidney injury or postoperative renal insufficiency), cerebrovascular accident, thromboembolic events, sepsis and/or septic shock, and death. Minor complications were also recorded and included blood product transfusions given intraoperatively and within the first 72 hours postoperatively, as well as urinary tract infections (UTIs). Pulmonary embolism and deep vein thrombosis were categorized together as thromboembolic events. Superficial surgical site infection, deep wound infection, organ space infection, and wound dehiscence were collated to comprise the wound-related complication group.

Length of stay was defined as the number of days from the operation date until discharge (with a maximum of 30 days). Extended LOS was defined as any LOS greater than 1 standard deviation above the mean for all cases (defined as 3 days in this study). Any admission after the index admission for the procedure occurring within the 30-day postoperative period is recorded as a readmission in the NSQIP database.

Statistical analysis

Patients who underwent UKA were divided into 2 groups for analysis: octogenarian (aged $\geq$80 years [including age 90]) and nonoctogenarian (<80 years old). Preoperative demographics and comorbidities between the 2 groups were compared using a univariate chi-squared test of proportions. Univariate comparisons of continuous variables (mean age and length of stay) were conducted using a two-tailed Student's *t*-test. An alpha of 0.05 was used for all statistical analyses.

Next, a multivariate logistic regression analysis was used to compare the odds of adverse outcomes occurring within the 30-day postoperative period, controlling for preoperative demographic and comorbidity characteristics that were found to differ between the groups. All statistical analyses were completed using Stata version 15 (Stata Corporation, College Station, TX). Figures were generated using GraphPad Prism version 9.1 (GraphPad Inc, San Diego, CA).

Results

A total of 10,103 patients undergoing UKA were identified, 728 (7.2%) of them were 80 years of age or older. Most cases were performed in patients aged between 60 and 70 years (Fig. 1). The mean age of nonoctogenarian patients was 62.8 ± 9.1 years while the octogenarian group had a mean age of 83.4 ± 2.9 years. By univariate comparison, the octogenarian had significantly higher prevalence of dependent functional status, ASA class greater $\geq$4, CHF, COPD, hypertension, and bleeding disorders ($P < .05$). In contrast, the octogenarian cohort had significantly lower prevalence of smoking, general anesthesia, as well as a lower portion of patients experiencing prolonged operative times ($\geq$120 minutes) ($P = .001$). Finally, UKA was performed in an ambulatory setting at equal rates between the groups ($P = .425$) (Table 1).

The incidence of each complication was first compared by univariate comparison and then also by using a multivariate odds ratio (OR). The incidence of any complications in the 30-day postoperative period was higher for octogenarians (4.7% vs 2.8%, $P = .004$; OR = 1.46, 95% confidence interval [CI]: 0.98-2.14, $P = .057$) (Fig. 2). Rates of cardiac adverse events were higher in patients aged $\geq$80 years (0.6% vs 0.1%, $P = .001$; OR = 2.60, CI: 0.65-10.3, $P = .175$).

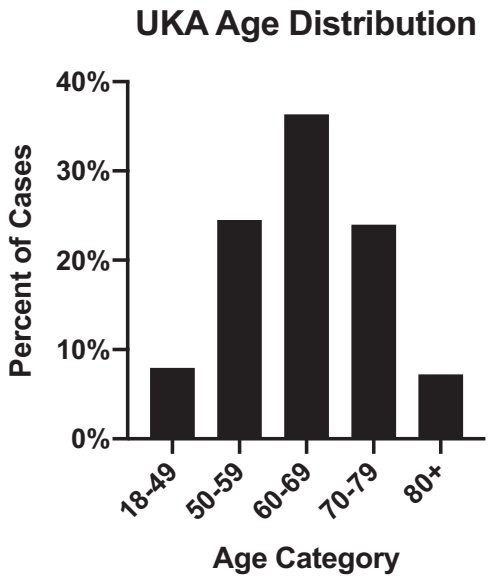

Figure 1. Distribution of patient ages in receiving unicompartmental knee arthroplasty (UKA) NSQIP 2012-2018.

Death within the 30-day postoperative period, while low overall (<0.5% in either group), was 6 times higher in patients aged ≥80 years and statistically significant even after controlling for differences in comorbidity burden (OR = 6.12, CI: 1.27-29.48, $P = .024$). Additionally, transfusion ($P = .011$) and UTI ($P = .011$) were significantly increased in patients aged ≥80 years, and when taken together, minor adverse events were significantly increased in octogenarian patients (OR = 2.97, CI: 1.55-5.68, $P = .001$). The cohort of patients aged ≥80 years had twice the proportion of patients with a prolonged postoperative hospital stay (OR = 2.30, CI: 1.67-3.14, $P < .001$) and almost quadruple the incidence of nonhome discharge (16.9% vs 4.3%, OR = 4.50, CI: 3.51-5.76, $P < .001$). Finally, odds of all-cause readmission was significantly higher in octogenarians (OR = 1.72, CI: 1.11-2.66, $P = .015$) (Table 2, Fig. 3).

Discussion

As the United States patient population aims to maintain a higher level of activity into older decades of life, UKA may be an appropriately indicated procedure for select patients even into their 80s. Previous papers on octogenarians undergoing orthopedic surgical procedures have included total shoulder arthroplasty as well as primary and revision hip and knee arthroplasty. In shoulder arthroplasty, patients were found to have higher odds of readmission, UTI, and pneumonia than nonoctogenarian patients [11]. For revision hip and knee arthroplasty, octogenarians have higher odds of transfusion and increased length of stay but no increased odds of other complications [13,16]. However, no data have been published to date on how the complication rates may differ between octogenarians undergoing UKA and nonoctogenarian counterparts. The present study examined over 10,000 UKA cases and found that octogenarian patients experienced a statistically significant increase in the odds of several minor and serious adverse events in the 30 days following the surgery after controlling for baseline differences in comorbidities, noting an increased odds of transfusion, UTI, and death.

Table 1
Demographic and comorbidities of patients in different age groups undergoing UKA for osteoarthritis in the NSQIP Database between 2012 and 2018.

Total	Age groups				*P*
	<80		≥80		
	N = 9375		N = 728		
Age (y)	62.8 ± 9.1		83.4 ± 2.9		**<.001**
Sex					.475
Male	4623	49.3%	369	50.7%	
Female	4752	50.7%	359	49.3%	
BMI					**.001**
18-25	992	10.6%	190	26.1%	
25-30	2945	31.4%	326	44.8%	
30-35	2947	31.4%	160	21.98%	
>35	2491	26.6%	52	7.14%	
Functional status					**.001**
Independent	9312	99.3%	707	97.1%	
Dependent	63	0.7%	21	2.9%	
ASA					**.001**
1-2	5832	62.2%	285	39.2%	
3	3462	36.9%	424	58.2%	
>4	81	0.9%	19	2.6%	
Diabetes mellitus					.590
Non-insulin-dependent	1070	11.4%	92	12.6%	
Insulin-dependent	374	4.0%	30	3.1%	
Smoker	929	9.9%	13	1.8%	**.001**
CHF	14	0.2%	4	0.6%	**.014**
COPD	252	2.7%	43	5.9%	**.001**
Hypertension	5112	54.5%	561	77.1%	**.001**
Chronic corticosteroid use	162	1.7%	17	2.3%	.232
Bleeding disorder	149	1.6%	23	3.2%	**.002**
Anesthesia type (general)	4187	44.7%	297	40.8%	**.043**
Prolonged operative time (≥120 min)	1169	12.5%	60	8.2%	**.001**
Procedure performed outpatient	3403	36.3%	275	37.8%	.425

BMI, Body Mass Index.
Significance was set at $P < .05$ and indicated by bold font.

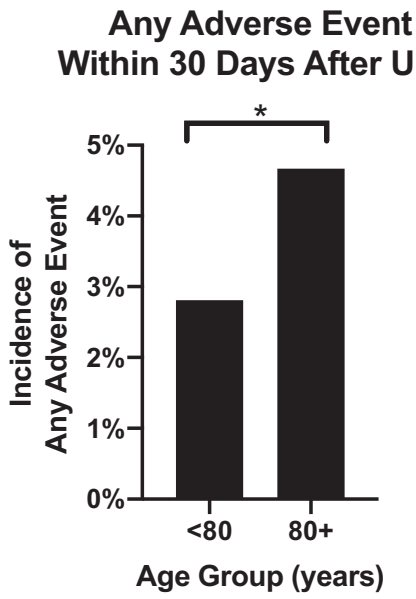

Figure 2. Rate of any adverse event within the 30-day postoperative period by age group for patients undergoing UKA in NSQIP between 2012-2018.

Octogenarian patients in our study were found to have a higher mean ASA class along with significantly higher prevalence of CHF, COPD, hypertension, chronic steroid use, and bleeding disorders. All these conditions correlate with increased age and are important to consider when counseling patients regarding the risks of surgery and optimization of medical comorbidities. The higher prevalence of both cardiac comorbidities and bleeding disorders within the octogenarian group potentially could offer an explanation for the significantly higher mortality rate within 30 days of surgery. Moreover, the higher prevalence of comorbid factors may also explain the significantly shorter operative times and decreased use of general anesthesia.

Rates of several serious and minor adverse events were higher in the octogenarian population. Most prominently, octogenarian patients had a roughly 6 times increase in odds of mortality within 30 days of surgery; however, it should be noted that the absolute mortality was exceedingly rare (<0.5%), and this result is likely skewed by the occurrence of a few rare events. The overall short-term postoperative mortality rate for primary TKA and THA reported across several national registries ranges from 0.1% to 0.2% [17-19]. Increased risk of mortality in patients aged 80 years or older can be explained in part by the higher comorbidity burden preoperatively and aligns with published literature on total joint arthroplasty reporting age as a primary risk factor for complications including mortality [20].

A higher incidence of bleeding requiring transfusion was observed in the octogenarian group. This finding may be explained in part by the fact that hemoglobin transfusion thresholds in arthroplasty tend to be higher (often above 8) for patients with cardiac comorbidities, and patients with bleeding disorders are more likely to receive a transfusion [21,22]. One study comparing UKA to TKA found that transfusion rates for both UKA and TKA were low, but measured blood loss was significantly less for UKA, about 90cc per case, with none of the UKA cases transfused compared with 2% of the TKA cohort [23]. UKA also tends to be performed in younger, more active patients who are likely to have higher preoperative hemoglobin values, enabling them to sustain greater volumes of blood loss before meeting standard thresholds for transfusion. While hemoglobin was not reported in this study, previous studies found that preoperative anemia did not increase the risk of transfusion in UKA [23]. Octogenarians were also significantly more likely to experience a UTI, a finding corroborated by many other studies examining surgical procedures, both orthopedic and nonorthopedic, in this age group secondary to incontinence, dementia, and higher rates of urinary retention [11,24,25].

In the present study, octogenarians did not have increased odds of pneumonia or cardiac complications even after adjusting for differences in baseline comorbidity burden. Other similar studies found octogenarians to have increased risk of pneumonia,

Table 2
Rate of serious and minor adverse events and statistical comparisons using univariate chi-squared comparisons and multivariate logistic regression odds ratios.

Total	Age < 80 y		Age ≥ 80 y		*P*	OR	95% CI	*P*
	N = 9375		N = 728					
Any adverse event	263	2.8%	34	4.7%	.004	1.46	0.98-2.14	.057
Serious adverse event	166	1.8%	18	2.5%	.172	1.07	0.64-1.81	.785
Wound complication	79	0.8%	6	0.8%	.958	0.82	0.35-1.96	.661
Cardiac event	9	0.1%	4	0.6%	**.001**	2.60	0.65-10.3	.175
Pneumonia	14	0.2%	3	0.4%	.096	1.41	0.35-5.63	.627
Renal complications	3	0.02%	0	0.0%	-	-	-	-
Stroke	2	0.01%	0	0.0%	-	-	-	-
DVT/PE	52	0.6%	2	0.3%	.318	0.44	0.11-1.91	.278
Sepsis or septic shock	10	0.11%	4	0.55%	**.002**	3.36	0.86-13.2	.083
Death	**5**	0.05%	3	0.41%	**.001**	6.12	1.27-29.48	**.024**
Minor adverse event	59	0.6%	14	1.9%	**<.001**	2.97	1.55-5.68	**.001**
Blood transfusion	23	0.3%	7	1.0%	**.001**	3.42	1.32-8.86	**.011**
Urinary tract infection	37	0.4%	8	1.1%	**.006**	2.98	1.29-6.92	**.011**
Return to operation room	85	0.9%	7	1.0%	.881	0.97	0.43-2.21	.954
Prolonged LOS (>3 d)	433	4.6%	60	8.2%	**<.001**	2.30	1.67-3.14	**<.001**
Non-home discharge[a]	403	4.3%	123	16.9%	**<.001**	4.50	3.51-5.76	**<.001**
Readmission	176	2.3%	29	4.8%	**<.001**	1.72	1.11-2.66	**.015**

BMI, Body Mass Index; DVT, deep vein thrombosis; PE, pulmonary embolism.
Regression analysis adjusted for ASA class, BMI, functional status, tobacco use, use of general anesthesia, CHF, COPD, bleeding disorder, and prolonged operative time with the nonoctogenarian population used as the reference cohort. Significance was set at $P < .05$ and indicated by bold font. Empty cells indicate one or more comparisons had less than 10 patients.
[a] Home discharge was considered home or to a facility which was considered home at the time of admission.

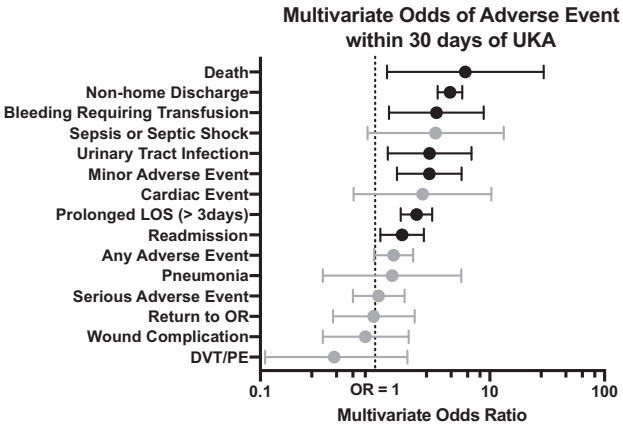

Figure 3. Forest plot of multivariate odds of perioperative adverse events within the 30-day postoperative period. Darkened error bars indicate statistical significance ($P < .05$).

including in total shoulder arthroplasty, revision TKA, and THA [11-13]. Moreover, cardiac complication rates were not different between age cohorts, a finding that is contrary to existing reports on older patients undergoing primary and revision total joint arthroplasty [10-13,26]. The concurrent finding in our study noting the reduced use of general anesthesia and shorter operative times may help to explain the parity in cardiac complications, as general anesthesia has been established as a risk factor for cardiac dysrhythmias [27,28].

The data within this study from 2012 to 2018 showed that the majority of all UKAs in this data set were performed as inpatient cases and the minority as outpatient during that timeframe. At the present time in our institution, almost all UKAs are performed as outpatient procedures, with either truly same-day discharge for the majority of UKA patients or rare overnight observation and <23-hour stay for older patients or those with known cardiac disease at baseline. Since postoperative cardiac dysrhythmia was previously shown as a common complication in octogenarians, and both cardiac complications and death were shown to be significant findings here in this current series, routine overnight observation for telemetry monitoring may indeed be appropriate for patients older than 80 years following UKA [29].

The possible need for overnight observation in the octogenarian population is a pertinent consideration for surgeons. The United States Center for Medicare and Medicaid Services recently moved TKA and THA off of the “Inpatient Only List” in 2018 and 2020, respectively. These policy changes, along with the multiple recent waves of the COVID-19 pandemic, have driven more arthroplasty surgeons to perform outpatient arthroplasty care. This is especially true for UKA although it was not on, or directly removed from, the IPO list in recent years. The present study intentionally focused on the period leading up to 2018 to avoid selection biases relating to changes in arthroplasty practice secondary to the IPO rule changes. The effects of outpatient surgery on complications have been well studied in THA and TKA, [30,31] but future investigation is still required for UKA with only one study to date that has demonstrated no difference in complications between inpatient and outpatient UKA [32].

Bundled payment models of reimbursement are becoming increasingly important to the provision of arthroplasty care, and the fact that octogenarian patients experienced prolonged hospital stays ($\geq$3 days) in this study should be noted [33]. In addition to resulting in increased hospital costs, a prolonged length of stay can predispose patients to nosocomial infections including Clostridium difficile [34-36]. Comorbidity burden also plays a significant role in hospital length of stay, as a recent study conducted in the United Kingdom found cardiovascular disease and an ASA status greater than or equal to ASA 3 predicted an extended hospital stay after UKA [37]. In addition, the higher rates of nonhome discharge observed in the octogenarian population also result in increased health-care costs [38-40]. This study found that octogenarians saw a nonhome discharge rate of 16.9% compared with 4.30% in the nonoctogenarian cohort. Tse et al. found that costs differed by about $13,000 on average between patients with a disposition of subacute rehab and those with acute rehab after TKA, revealing how costly postoperative care for older patients with multiple medical comorbidities could be if a higher level of postoperative care and rehabilitation is necessitated [38]. Moreover, the present study found increased rates of readmission in octogenarians, which can be another contributor to high costs in a bundled payment environment [40].

One popular cost-saving approach is to perform UKA in an outpatient setting in appropriately selected patients. However, the present study found that octogenarians were not managed with inpatient designation after UKA at higher rates than non-octogenarians, with outpatient utilization in each group being similar at 36.3% vs 37.8%, respectively. This finding is consistent with recent work by Gruskay et al. in whuch they observed outpatient UKA was associated with decreased transfusion risk and lower rates of postoperative pneumonia [41]. As a result, it would seem that based on transfusion requirement and pneumonia risk, octogenarians undergoing UKA could indeed be considered as outpatient candidates. Additionally, the reduced risk of transfusion and pneumonia may make selection of UKA in older patients more favorable than TKA if unicompartmental arthritis is present; but comparative analysis of this concept will require future research.

This study benefits from a large sample of over 700 octogenarians receiving UKA for osteoarthritis across multiple institutions and surgeons in the NSQIP database. The primary limitations of this study include those inherent to retrospective studies using this large national retrospective database. These include the inability to assess radiographic features including implant type and implant positioning as well as certain patient variables including the degree of osteoarthritis, degree of preoperative deformity, as well as other factors including surgeon experience with UKA, varying institutional thresholds for transfusion, and postoperative outcomes beyond 30 days.

Conclusions

Even after adjusting for comorbid factors, octogenarian patients undergoing UKA experienced an increased risk of several adverse events when compared with nonoctogenarians. Specifically, our study found significantly increased odds of individual complications including death as well as several minor adverse events including transfusion, UTI, and prolonged length of stay. Ultimately, these findings not only reinforce the importance of careful patient selection but also underscores the importance of medical optimization and risk-benefit consideration when counseling patients aged 80 years or older who are indicated for UKA.

Conflicts of interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: H. G. Moore is an associate editor for the *North American Spine Society Journal*. J. N. Grauer is in the editorial or governing board of North American Spine Society and is a member of the Lumbar Spine Research Society. L. E. Rubin has served as a paid

consultant for DePuy Synthes and ConvaTec, received royalties/financial or material support from SLACK Inc. Publishers and Johns Hopkins University Press, been a part of the medical/orthopedic publications editorial/governing board of the *Journal of Arthroplasty*, *Arthroplasty Today*, and *Reconstructive Review*, and been a board member of the AAOS; all other authors declare no potential conflicts of interest.

For full disclosure statements refer to https://doi.org/10.1016/j.artd.2022.02.009.

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