Geriatric Orthopaedic Surgery & Rehabilitation
2015, Vol. 6(3) 173-179

DOI: 10.1177/2151458515583515
gos.sagepub.com
SAGE

The Effect of Advancing Age on Total Joint Replacement Outcomes

Michele Fang, MD[1], Nicolas Noiseux, MD[2], Eric Linson, MBA[1], and Peter Cram, MD, MBA[1,3,4]

Abstract

Objective: To describe age-related differences in outcomes among older adults undergoing total hip arthroplasty (THA) and total knee arthroplasty (TKA). **Design:** Retrospective study. **Participants:** A total of 1792 patients who underwent primary THA or TKA at the University of Iowa Hospitals and Clinics between 2010 and 2013 were identified in the University HealthSystem Consortium Database and University of Iowa Orthopedics Joint Replacement Registry. **Main Outcome Measures:** Hospital length of stay (LOS), 30-day readmission rate, in-hospital mortality, number of days admitted to intensive care unit (ICU discharge disposition), in-hospital complications (pulmonary embolism, deep vein thrombosis, wound infection, hemorrhage, sepsis, or myocardial infarction), quality of life (measured using Short-Form 36 [SF-36]), discharge disposition (home, home with home health, nursing home, inpatient rehabilitation, transfer to another acute care hospital, and dead), and total patient level observed hospital cost (based on hospital charge information from each revenue code and estimated labor costs). Outcomes were compared in patients stratified by age and categorized by decade (ie, $\leq$50, 51-60, 61-70, 71-80, and $\geq$81). **Results:** A total of 871 THAs and 921 TKAs were performed. The mean age of our cohort was 60.5 years and 56.1% were women. In-hospital complication rates and ICU utilization progressively increased with increasing age. There was also a higher likelihood of skilled nursing facility placement and longer LOS. There was no increase in 30-day readmissions, mortality, or total cost. Improvements in patient reported outcomes (SF-36) scores were similar for all age-groups. **Conclusions:** Compared to younger patients, older THA and TKA recipients were more likely to experience postoperative complications, admission to the ICU, discharge to a skilled care facility, and had longer hospital LOS. Improvements in patient-related outcomes were similar across all age-groups. These findings may be helpful when counseling older patients regarding elective total joint arthroplasty.

Keywords
elderly, advanced age, total joint replacement

Introduction

The population is aging, and the number of centenarians is expected to reach the 4 million mark by the year 2050.[1] Osteoarthritis, rheumatoid arthritis, and posttraumatic arthritis are common causes of hip and knee pain, and all 3 worsen with age. Between 1991 and 2010, the annual primary total knee arthroplasty (TKA) volume among Medicare beneficiaries increased 161.5% with a 99.2% increase in per capita utilization.[2] The average age for primary total hip arthroplasty (THA) and TKA recipients has been reported at 65 years[3] and 67 years,[4] respectively.

Although THA and TKA are safe and highly effective procedures, both are major surgical procedures with veritable risks of adverse outcomes including mortality, morbidity, and complications. Studies have found perioperative mortality rates of approximately 0.4% and 0.3% among Medicare beneficiaries for THA[5] and TKA,[6] respectively. Composite major complications within 90 days of admission were 4.6% for THA and 3.1% for TKA among Medicare beneficiaries.[5,7] In addition, the cost burdens to Medicare, other insurance coverages, and private pay patients for THA and TKA are not trivial. The complete cost of THA including both the hospital fee and physician fee was found to range between US$11 000 and US$125 798.[8]

With the aging of the population, 1 key question for clinicians is whether advanced age is associated with greater risk of complications after THA and TKA. Numerous studies have

[1] Division of General Internal Medicine, Department of Internal Medicine, University of Iowa Carver College of Medicine, Iowa City, IA, USA
[2] Division of Orthopedic Surgery, University of Iowa Carver College of Medicine, Iowa City, IA, USA
[3] Faculty of Medicine, University of Toronto, Toronto, Canada
[4] Division of General Internal Medicine and Geriatrics, Mt Sinai/UHN Hospitals, Toronto, Canada

Corresponding Author:
Michele Fang, Division of General Internal Medicine, 200 Hawkins Drive GH 624, Iowa City, IA 52242, USA.
Email: michele-fang@uiowa.edu

examined the relationship between age and complication rates across a range of surgical procedures,[9,10-12] however, the number of studies focusing on the association between age and complication rates specifically in the primary TKA and THA population is actually quite limited.[13-15] A retrospective study of primary TKA in patients older than 75 years found an increased risk of perioperative mortality and medical morbidity but not surgical morbidity or functional outcomes.[16]

The objective of our study was to examine the relationship between patient age and outcomes after primary THA and TKA. In particular, we were interested in 6 separate outcomes available using an existing and well-studied clinical registry (The University of Iowa [UI] Joint Replacement Registry) and the University Health System Consortium Database. We hypothesized that older patients would have higher complication rates and poorer outcomes when compared to younger patients. The second hypothesis was that the absolute differences in outcomes between older and younger patients would be small or none, and thus that advancing age is not an isolated contraindication to surgery.

Methods

Data

We used data from the UI Joint Replacement Registry and The University HealthSystem Consortium (UHC) Database to identify all patients who underwent primary THA or primary TKA at UI between July 1, 2010, and June 31, 2013. The following 2 databases are complementary: the UHC database provides comprehensive, comparative information about patient characteristics, and perioperative outcomes based on participant discharge summaries and Uniform Billing data includes mortality, hospital length of stay (LOS), and intensive care unit (ICU) days. The UHC database has been previously used in prior studies.[17-19]

The University of Iowa Hospitals and Clinics Total Joint Registry prospectively collects detailed clinical elements during both the preoperative and the postoperative periods including education, musculoskeletal comorbidities, alcohol, and tobacco use. The registry also collects patient quality-of-life data through the administration of the Short-Form 36 (SF-36) both preoperatively and postoperatively. The registry includes all patients undergoing primary THA and TKA at the University of Iowa Hospitals and Clinics and has been used in previous research studies.[20] The data are collected at kiosks in the orthopedic surgery department or online via the personalized electronic medical record.

Patients

Eligible patients were identified in the UHC database using *International Classification of Disease, Ninth Revision* (*ICD-9*) procedure codes for primary THA (81.54) and TKA (81.52). In an effort to limit our analysis to patients undergoing elective primary THA and TKA, we excluded several populations including patients with hip fractures, patients admitted from the emergency department, patients with dislocation of a prosthetic joint (code 996.42), patients with joint implant failure (code 996.43), fracture nonunion (*ICD-9* code 73382), and several other codes that were not consistent with elective primary THA/TKA (codes 996.46, 996.47, 820.8, 996.44, 996.41, 996.49, 996.77, and 996.78).[2,5,21] The patients were compared across the 2 data sets (UHC and University of Iowa Orthopaedic Registry) using a common patient identification number (IDX visit codes) for purposes of our analysis.

Outcomes

Our outcomes included several complementary measures of interest to patients, physicians, and hospital administrators including (1) hospital LOS, (2) discharge disposition (defined as home, home with home health, nursing home, inpatient rehabilitation, and transfer to another acute care hospital, dead), (3) 30-day all-cause readmission, (4) in-hospital complications, (5) number of ICU days postoperatively, (6) hospital costs, and (7) quality of life based upon SF-36 data.

Complications included acute myocardial infarction, acute deep vein thrombosis or pulmonary embolism, surgical site infection, sepsis, hemorrhage, and mortality.[22,23] Patient-observed hospital cost was based on the detailed charges submitted by participating hospitals and the estimated labor costs. The detail charges are based on the Centers for Medicare & Medicaid Services (CMS) revenue code and the CMS ratio of cost to charges.[18] Preoperative SF-36 scores were compared to 6-and 12-month SF-36 scores. In cases where both 6- and 12-month SF-36 data were available, the 6-month data point was used.

Analysis

The primary objective of our study was to examine the relationship between age and the outcomes described previously. For our analyses, patient age was categorized by decade (age $\leq$50, 51-60, 61-70, 71-80, and $\geq$81). Additional demographic data included patient sex, race, primary insurance payor, primary *ICD-9* code (reason for surgery), and comorbidities. The patient's comorbidities such as diabetes mellitus (DM; complicated, uncomplicated, type 1, and type 2), congestive heart failure, obesity (body mass index > 35), and kidney failure were collected from the UHC database.

We used bivariate methods to explore differences in outcomes (eg, complications and quality-of-life measures) across categories of age. We used *t* tests for continuous measures and chi-square test or analysis of variance for categorical measures, with $P < .05$ deemed statistically significant. The reference category was defined as patients aged 61 to 70 years as this is the average age of THA and TKA recipients.

Data analysis was conducted using Microsoft Excel (Redmond, Washington). This study was determined to be exempt by the UI institutional review board.

Table 1. Patient Characteristics by Age-Group.[a]

Patient characteristics	Age ≤50	Age 51-60	Age 61-70	Age 71-80	Age >80
Procedure					
THA	183 (60.0)	309 (50.7)	208 (39.7)	133 (48.5)	38 (47.5)
TKA	122 (40.0)	300 (49.2)	316 (60.3)	141 (51.5)	42 (52.5)
Gender					
Women	155 (50.8)	330 (54.2)	312 (59.5)	151 (55.1)	57 (71.2)
Men	150 (49.2)	279 (45.8)	212 (40.5)	123 (44.9)	23 (28.8)
Race					
White	274 (89.8)	563 (92.5)	492 (93.9)	266 (97.1)	78 (97.5)
Black	17 (5.6)	26 (4.2)	6 (1.1)	2 (0.7)	0
Other	14 (4.6)	20 (3.3)	26 (5.0)	6 (2.2)	2 (2.5)
Primary payer					
Medicare	36 (11.8)	70 (11.5)	244 (46.6)	261 (95.7)	80 (100)
Medicaid	124 (40.6)	204 (33.7)	71 (13.5)	0	0
Private[b]	134 (43.9)	321 (52.5)	200 (38.2)	12 (4.3)	0
Other[c]	11 (3.6)	14 (2.3)	9 (1.7)	0	0
Indication					
OA	198 (64.9)	550 (90.4)	492 (93.9)	264 (96.7)	76 (92.7)
Aseptic[d]	47 (15.4)	30 (4.9)	9 (0.7)	4 (1.4)	2 (2.4)
Traumatic[e]	26 (8.5)	10 (1.6)	8 (1.5)	1 (0.4)	2 (2.5)
Cong Hip	18 (5.9)	8 (1.3)	4 (0.8)	1 (0.4)	0
Other[f]	12 (3.9)	10 (1.6)	8 (1.5)	3 (1.2)	0
Comorbidity					
Diabetes	21 (7.7)	79 (14.4)	89 (18.2)	45 (17.2)	7 (9.1)
CHF	6 (2.1)	10 (0.4)	14 (2.9)	13 (11.8)	10 (13.0)
Obesity	110 (38.1)	186 (32.0)	150 (30.6)	51 (19.5)	9 (13.0)
Renal failure	8 (2.8)	11 (1.9)	20 (4.1)	23 (8.8)	12 (15.6)

Abbreviations: OA, osteoarthritis; cong, congruent; CHF, congestive heart failure.

[a]Patient characteristics were expressed both as the total number of patients and by the percentage of the total in each age-group (in parenthesis). The number of procedures (total hip arthroplasty [THA] or total knee arthroplasty [TKA]), the gender (women or men), race (white, black, or other), primary payer (Medicare, Medicaid, Private insurance, which includes commercial Health Maintenance Organization (HMO), commercial Preferred Provider Organization (PPO), and traditional HMO, or other payer, which includes military, self-pay, workman's compensation, or charity), indication for surgery (osteoarthritis, aseptic necrosis, traumatic osteoarthritis, congenital hip dysplasia, or other), and the number of comorbidities present in each age-group.

[b]Private payers include commercial HMO, commercial PPO, and traditional HMO.

[c]Other payers include military, self-pay, charity, and worker compensation.

[d]Aseptic: aseptic necrosis.

[e]Traumatic: traumatic arthropathy.

[f]Other includes bone cancer, rheumatoid arthritis, multiple myeloma, and ankylosis spondyloarthropathy.

Results

Our study included 1792 patients who underwent elective primary total joint arthroplasty (n = 871 for THA; n = 921 for TKA) between 2010 and 2013. The mean age of our cohort was 60.5 years and 56.1% were women. The demographic characteristics and prevalence of key comorbid conditions stratified by patient age (decade) are described in Table 1. The most common indications for joint replacement were osteoarthritis (range 64.9%-96.7% across decades), aseptic necrosis (0.7%-15.4%), and posttraumatic arthropathy (0.4%-8.5%). In terms of comorbidities, the prevalence of congestive heart failure and renal failure increased with each decade of patient age ($P < .05$; Table 1); however, obesity and diabetes were more common among middle-aged patients (age 51-70).

The unadjusted hospital LOS increased progressively with increasing patient age (≤50 year: 2.6 days, 51-60 years: 2.6 days, 61-70 years: 2.8 days, 71-80 years: 3.1 days, and ≥81 years: 3.7 days, $P < .05$; Table 2). A progressive decrease in the percentage of patients discharged to home after surgery (age ≤50: 97%, age 51-60: 95%, age 61-70: 91%, age 71-80: 76%, and age ≥81: 37%) and a corresponding increase in discharge to skilled nursing facilities (age ≤50: 3.0%, age 51-60: 4.0%, age 61-70: 9.0%, age 71-80: 17.9%, and age >81: 58%) were also found. The all-cause 30-day readmission rate increased from 2.8% for patients ≤70 years old to 4.4% for patients 71 to 80 years old and 4.8% for patients ≥81 years old but these findings were not statistically significant.

Rates of complications increased progressively with increasing age (Table 3). Specifically, the percentage of patients who experienced 1 or more complications was 0.4% (age ≤50), 0.4% (age 51-60), 0.8% (age 61-70), 2.2% (age 71-80), and 5.2% for (age ≥81; $P < .05$ for ages 71-80, ≥81; Table 3). We also found a higher mortality rate for patients aged ≥81 years (1.3%) when compared to patients aged 71 to 80 (0.4%) and aged <70 (0%; $P > .05$), but this was not statistically significant. Similarly, older patients had the highest percentage of days spent in the ICU compared total days (0.6% for age ≤50, 1.4% age 51-60, 1.1% age 61-70,

Table 2. Length of Stay (LOS) and Discharge Disposition by Age-Group.[a,b]

Outcomes	Age ≤50	Age 51-60	Age 61-70	Age 71-80	Age >80
LOS, mean, days	2.6 (2.5-2.7)	2.6 (2.5-2.6)	2.8 (2.7-2.8)	3.1 (3.1-3.2)	3.8 (3.6-3.8)
Discharge disposition					
Home	97.0 (95.9-98.0)	95.7 (95.0-96.6)	90.5 (89.2-91.8)	76.8 (74.1-79.2)	36.7 (31.2-42.2)
SNF	3.4 (2.3-4.4)	4.0 (3.2-4.8)	9.5 (8.2-10.8)	17.9 (15.8-20.4)	58.2 (52.6-63.8)
Other	0.7 (0.2-1.2)	1.0 (0.6-1.4)	1.4 (0.9-1.9)	4.8 (3.5-6.1)	6.3 (3.6-9.1)
Home health	6.4 (4.9-7.8)	4.7 (3.8-5.5)	3.9 (3.1-4.8)	5.6 (4.3-6.0)	12.7 (8.9-16.4)

[a]The mean LOS was reported by each age-group in measures of days. The 95% confidence interval was also reported in parenthesis. Mean Percentage of patients discharged to home, skilled nursing facility (SNF), other, and home health were reported by each age-group with 95% confidence intervals reported.
[b]All *P* values were significant (<.05) in comparison to the 61 to 70 age-group.

Table 3. Unadjusted Outcomes for Complications, ICU stay, and 30-Day Readmission by Age-Group.[a]

Outcomes	Age <50	Age 51-60	Age 61-70	Age 71-80	Age >80
Complications					
Mortality	0	0	0	1 (0.38)	1 (1.3)
PE or DVT	1 (0.35)	1 (0.17)	2 (0.41)	2 (0.76)	1 (1.3)
Wound infection	0	0	0	0	0
Hemorrhage	0	1 (0.2)	0	0	0
Sepsis	0	0	0	0	0
MI	0	1 (0.2)	0	1 (0.38)[b]	2 (2.6)[b]
Patient with ≥1 complication	1 (0.35)	2 (0.35)	4 (0.82)	6 (2.2)[b]	4 (5.2)[b]
ICU days used	0.017 (1.7)	0.030 (3.0)	0.016 (1.6)	0.39 (10.7)[b]	0.16 (16.4)[b]
30-Day readmission, all cause[c]	2.4 (1.5-3.3)	1.9 (1.3-2.4)	3.8 (2.9-4.6)	1.8 (1.0-2.7)	2.7 (0.6-5.6)

Abbreviation: PE, pulmonary embolism; DVT, deep vein thrombosis; MI, myocardial infarction; ICU, intensive care unit.
[a]The absolute number of complications were reported as an absolute number and percentage of the total number of patients in each category (in parenthesis). The total number of ICU days were reported per total number of ICU days per patient followed by the percentage of patients requiring the ICU (in parenthesis). The 30-day all-cause readmission rates were reported as a mean percentage followed by 95% confidence intervals. All values are actual represented as a percentage of each outcome.
[b]*P* values were significant (<.05) in comparison to the 61 to 70 age-group.
[c]Relative risk is stated for all values with a 95% confidence interval.

Table 4. Unadjusted Direct Costs by Age-Group.[a,b]

Direct costs	Age <50	Age 51-60	Age 61-70	Age 71-80	Age >80
Mean direct cost, US$	20 375	13 444	17 655	13 477	13 808
Std dev direct cost, US$	66 980	2770	41 800	3212	3365
95% CI	4076-24 451	13 116-13 772	15 794-19 515	13 096-13 857	13 409-14 206
Paired *t* test	0.34	0.16	Reference	0.25	0.39

Abbreviations: CI, confidence interval; Std dev, standard deviation.
[a]Mean direct cost in dollars was reported in each group followed by the standard deviation and 95% confidence interval. Paired *t* tests comparing each group to the 61- to 70-year-old age-group were performed.
[b]No significance ($P < .05$) was observed in comparison to the 61 to 70 age-group.

2.9% age 71-80, and 5% age >81, $P < .05$ for age 71-80, ≥81; $P < .05$).

Hospitalization costs did not differ significantly by patient age (Table 4). There was significant variation within groups for certain costs, especially in the <50-year-old group and 61 to 70-year-old group (Table 4).

Preoperatively, younger patients had lower physical SF-36 scores than older patients ($P < .05$) and older patients had higher SF-36 mental scores ($P < .05$). At 6 to 12 months postoperatively, all age-groups had improvements in the SF-36 physical scores, but there was a trend toward lesser improvements in the oldest patients. The percentage of improvement in physical scores at 6 to 12 months is as follows: age ≤50: 28.8%, age 51-60: 29.8%, age 61-70: 23.0%, age 71-80: 22.4%, and age ≥81: 11.7%. Similar improvements in the SF-36 mental score were also seen (age ≤50: 2.6% improvement, age 51-60: 5.6%, age 61-70: 2.9%, age 71-80: 5.7%, and age ≥81: 6.9%; Table 5). There were statistically significant differences ($P < .05$) between THA and TKA patients: the average age of the patient (average hip age 61.7 vs 59.1 years), sex (hip patients were 52% female vs 61% female for knee patients), average cost of the procedure (hip US$55 216 and knee US$46 366), and percentage that were insured by Medicare (hip 49% vs knee 41%). However, there were

Table 5. Functional Scores.[a]

Functional scores	Age <50	Age 51-60	Age 61-70	Age 71-80	Age >80
Preop overall mental score	46.9 (13.7)	48.4 (12.1)	46.5 (13.8)	51.2[b] (11.4)	51.1[b] (12.1)
Preop overall physical score	29.6[b] (8.6)	29.4[b] (9.3)	31.6 (8.9)	31.2 (8.7)	29.8 (7.4)
% improvement 6-12-month mental score	2.6	5.6	2.9	5.7	6.9
% improvement 6-12-month physical score	28.8	29.8	23.0	22.4	11.7

Abbreviations: preop, preoperative; SF-36, Short-Form 36.
[a]Preop SF-36 health survey mental and physical scores were obtained for each age-group. In parenthesis is the standard deviation. Statistical difference in these scores compared to the age 61 to 70 group was present if $P < .05$. Percentage improvement in 6- to 12-month mental and physical scores were also conducted.
[b]$P < .05$ compared to age 61 to 70 group.

no differences ($P > .05$) in LOS, race, number of ICU days, complications, or mortality.

Discussion

In an analysis of nearly 2000 patients who underwent primary total joint arthroplasty at a large academic medical center, we identified a number of important findings with respect to the relationship between patient age and outcomes. Although older patients had a longer hospital LOS, were less likely to be discharged home, and had a higher rate of postoperative complications, older patients seemed to have a similar improvement in quality of life. In aggregate, our results hint at the complexities of deciding whether or not to perform total joint arthroplasty in the oldest adults.

A number of points warrant further discussion. First, as expected older patients have higher prevalence of many comorbidities including heart failure and renal failure but less obesity. These findings of higher rates of heart failure and renal failure with increasing age mirror prior studies.[24-26] A population-based cohort study of Medicare recipients found that patients aged 66 to 90 had a 12% to 16% prevalence of DM, a 4% to 18% prevalence of CHF (highest in the very old), and a 6% to 11% prevalence of chronic obstructive pulmonary disease.[24] A greater proportion of people with a limiting long-standing illness is seen in the older population: 48% of those older than 75 years reported having a chronic illness compared with 37% of 65 to 74 years old.[27]

Second, we found that LOS and disposition to skilled nursing facilities increased as a function of age. In a prior longitudinal study, Cram et al found that over the last 20 years, the hospital LOS for THA and TKA Medicare patients has steadily decreased over time with increased readmissions and increased discharges to skilled nursing facilities.[2,5] Our study found that there was a dramatic increase in LOS and admission to skilled nursing facilities, after the age of 81, especially in patients with comorbidities. However, SNF discharges were relatively uncommon in patients <70 at our institution.

Third, we found that complication rates in older patients were increased when compared with younger patients. Although complications were relatively rare, there was a significant increase in rates of mortality, myocardial infarction, and the number of patients with more than 1 complication. These results are similar to past studies. Adam et al found that patients >75 had more myocardial infarctions, stroke, renal failure, delirium, pulmonary embolism, and mortality. In contrast, Biau et al found no difference in cardiac, genitourinary, neuropsychiatric, thromboembolism, or decubitus ulcer in patients older than 85 years old and those less than 75 years old.[28]

Fourth, we found that improvements in quality of life—inarguably the key reason for performing TKA and THA—were similar across age ranges. Physical and mental SF-36 scores were studied rather than functional knee or hip scores as it is more important to a patient to have an improvement in quality of life rather than only a better score on a functional knee scale. Osteoarthritis has high morbidity and mortality in and of itself—causing pain, having costs for medications, physical therapy, and requiring long-term care, and many of these important factors are not measured with the knee and hip scores. Scott et al found that younger age was associated with improved with fulfillment of THA and TKA expectations, but both older and younger patients had similar postop expectations.[29]

With the rapidly growing elderly population and the emphasis on value-based care, hospital costs, and posthospital costs will be more scrutinized. The costs for both older and younger patients were about the same, despite increased complications, ICU stays, and LOS. It may be that younger patients receive more expensive implants such as ceramic parts, more advanced bearings, or newer fixation and/or wear prevention technologies to aim for greater implant longevity and fixation. With bundled payments, older patients may ultimately cost more for a single joint replacement episode of care, with longer stays, more ICU days, and a higher likelihood of complications. As a tertiary care center, more elderly patients and more patients with comorbidities may be seen than at community surgical center. In addition, because elderly patients are more likely to discharge to skilled nursing facilities rather than home, they are more likely to incur more costs post hospital discharge than younger patients who do not need additional postdischarge care.

Despite the increased risk of complications and LOS, we found that even the most elderly patients had measurable improvements in their SF-36 mental score and physical score. This is similar to past studies that found patients older than the age of 80 to have similar improvements in physical score

compared to younger patients. In addition, past studies have found that patients who decided against hip replacement and knee replacement surgeries had further worsening of their functional status with time.[30] In addition, the oldest population had the highest postoperative mental score of all the age-groups, suggesting that THA and TKA may have additional benefits in the older population than simply improved functionality.

Our study has several limitations worth mentioning. First, our study is based upon data from a single academic medical center in the Midwest and our results should be generalized to other settings with caution. Second, we focused our analysis on in-hospital complications and deaths and cannot comment about-mentioned adverse outcomes that occurred after discharge. Third, this study was a retrospective chart review, and a power analysis was not undertaken to determine the number of patients needed to detect clinical significance per decade subgroup. Finally, incomplete SF-36 data on some patients in our study population may have biased our patient-reported outcomes results.

Conclusion

In conclusion, we found that while older patients did have a longer hospital LOS, higher complication rates, and were more likely to require admission to skilled care after primary TKA and THA, older patients had similar improvements in quality of life to younger patients. We would suggest that although chronological age should be considered when planning for primary joint replacement, higher weight should be given to comorbidities and functional status.

Acknowledgments

The authors thank Alison Klaasen and Yubo Gao for their help with data extraction from the University of Iowa Orthopedics Joint Replacement Registry.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: PC is supported by a K24 award from NIAMS (AR062133) at the NIH.

References

1. Kurtz S, Mowat F, Ong K, Chan N, Lau E, Halpern M. Prevalence of primary and revision total hip and knee arthroplasty in the United States from 1990 through 2002. *J Bone J Surg Am Vol*. 2005;87(7):1487-1497.
2. Cram P, Lu X, Kates SL, Singh JA, Li Y, Wolf BR. Total knee arthroplasty volume, utilization, and outcomes among Medicare beneficiaries, 1991-2010. *JAMA*. 2012;308(12):1227-1236.
3. Passias P, Bono JV. Total hip arthroplasty in the older population. *Geriatr Aging*. 2006;9(8):535-543.
4. Bang H, Chiu YL, Memtsoudis SG, et al. Total hip and total knee arthroplasties: trends and disparities revisited. *Am J Orthop*. 2010; 39(9):E95-E102.
5. Cram P, Lu X, Kaboli PJ, et al. Clinical characteristics and outcomes of medicare patients undergoing total hip arthroplasty, 1991-2008. *JAMA*. 2011;305(15):1560-1567.
6. Cram P, Lu X, Kates SL, Singh JA, Li Y, Wolf BR. Total knee arthroplasty volume, utilization, and outcomes among Medicare beneficiaries, 1991-2010. *JAMA*. 2012;308(12):1227-1236.
7. Bozic K, Grosso LM, Lin Z, et al. Variation in hospital-level risk-standardized complication rates following elective primary total hip and knee arthroplasty. *J Bone Joint Surg Am*. 2014;96(8):640-647.
8. Rosenthal J, Lu X, Cram P. Availability of consumer prices from US hospitals for a common surgical procedure. *JAMA Intern Med*. 2013;173(6):427-432.
9. Massarweh NN, Legner VJ, Symons RG, McCormick WC, Flum DR. Impact of advancing age on abdominal surgical outcomes. *Arch Surg*. 2009;144(12):1108-1114.
10. Abouassaly R, Alibhai SM, Tomlinson GA, Urbach DR, Finelli A. The effect of age on the morbidity of kidney surgery. *J Urol*. 2011;186(3):811-816.
11. Alibakhshi A, Aminian A, Mirsharifi R, Jahangiri Y, Dashti H, Karimian F. The effect of age on the outcome of esophageal cancer surgery. *Ann Thorac Med*. 2009;4(2):71-74.
12. Oghalai JS, Buxbaum JL, Pitts LH, Jackler RK. The effect of age on acoustic neuroma surgery outcomes. *Otol Neurotol*. 2003; 24(3):473-477.
13. Lovald ST, Ong KL, Lau EC, Schmier JK, Bozic KJ, Kurtz SM. Mortality, cost, and downstream disease of total hip arthroplasty patients in the Medicare population. *J Arthroplasty*. 2014;29(1): 242-246.
14. Koenig K, Huddleston JI, III, Huddleston H, Maloney WJ, Goodman SB. Advanced age and comorbidiyt increase the risk for adverse events after revision total hip arthroplasty. *J Arthroplasty*. 2012;27(7):1402-1407.
15. Mahomed NN, Barrett JA, Katz JN, et al. Rates and outcomes of primary and revision total hip replacement in the United States medicare population. *J Bone Joint Surg Am*. 2003;85-A(1):27-32.
16. Adam RF, Noble J. Primary total knee arthroplasty in the elderly. *J Arthroplasty*. 1994;9(5):495-497.
17. Stack B, Moore E, Spencer H, Medvedev S, Bodenner DL. Outpatient thyroid surgery data from the University Health System (UHC) Consortium. *Otolaryngol Head Neck Surg*. 2013;148(5): 740-745.
18. Marino M, Spencer H, Hohmann S, Bodenner D, Stack BC, Jr. Costs of outpatient thyroid surgery from the University HealthSystem Consortium (UHC) database. *Otolaryngol Head Neck Surg*. 2014;150(5):762-769.
19. Ang D, Behrns KE. Usinga relational database to improve mortality and length of stay for a department of surgery: a comparative review of 5200 patients. *Am Surg*. 2013;108(3):142-147.
20. Herickhoff P, Callaghan JJ, Johnston R, Marsh JL, Clark CR, Noiseux N. Primary hip and knee replacement: "are we all operating on the same patients, even at the same institution?" *Iowa Orthop J*. 2010;30:109-114.

21. Higuera CA, Elsharkawy K, Klika AK, Brocone M, Barsoum WK. 2010 Mid-America Orthopaedic Association Physician in Training Award: predictors of early adverse outcomes after knee and hip arthroplasty in geriatric patients. *Clin Orthop Relat Res*. 2011;469(5):1391-1400.
22. Cram P, Ibrahim SA, Lu X, Wolf BR. Impact of alternative coding schemes on incidence rates of key complications afte total hip arthroplasty: a risk-adjusted analysis of a national data set. *Geriatr Orthop Surg Rehab*. 2012;3(1):17-26.
23. Hagen T, Vaughan-Sarrazin MS, Cram P. Relation between hospital orthopaedic specialization and outcomes in patients aged 65 and older: retrospective analysis of US Medicare data. *BMJ*. 2010;340:c165.
24. Cho H, Klabunde CN, Yabroff R, et al. Comorbidity-adjusted life expectancy: a new tool to inform recommendations for optimal screening strategies. *Ann Intern Med*. 2013;159(10): 667-676.
25. Rowe J, Andres R, Tobin JD, et al. The effect of age on creatinine clearance in men: a cross-sectional and longitudinal study. *J Gerontol*. 1976;31(2):155-163.
26. Lazzarini V, Mentz RJ, Fiuzat M, Metra M, O'Connor CM. Heart failure in elderly patients. *Eur J Heart Fail*. 2013;15(7):717-723.
27. Team GLS. General Lifestyle Survey 2009: Guidelines for using the data; 2011. http://doc.ukdataservice.ac.uk/doc/6716/mrdoc/pdf/2009_guidelines.pdf.
28. Biau D, Mullins MM, Judet T, Piriou P. Is anyone too old for a total knee replacement? *Clin Orthop Relat Res*. 2006;448: 180-184.
29. Scott CE, Bugler KE, Clement ND, MacDonald D, Howie CR, Biant LC. Patient expectations of arthroplasty of the hip and knee. *J Bone Joint Surg Br*. 2012;94(7):974-981.
30. George LK, Ruiz D, Jr, Sloan FA. The effects of total hip arthroplasty on physical functioning in the older population. *J Am Geriatr Soc*. 2008;56(6):1057-1062.