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Comparing Complications and Costs of Total Hip Arthroplasty and Hemiarthroplasty for Femoral Neck Fractures

A Propensity Score-Matched, Population-Based Study

Bheeshma Ravi, MD, PhD, Daniel Pincus, MD, Hayat Khan, MBChB, MSc, David Wasserstein, MD, MSc, Richard Jenkinson, MD, MSc, and Hans J. Kreder, MD, MPH

Investigation performed at the Division of Orthopaedic Surgery, Sunnybrook Health Sciences Centre, Toronto, Ontario, Canada

Background: Although the prevalence of displaced femoral neck fractures in the elderly population is increasing worldwide, there remains controversy as to whether these injuries should be managed with hemiarthroplasty or total hip arthroplasty. Although total hip arthroplasties result in better function, they are more expensive and may have higher complication rates. Our objective was to compare the complication rates and health-care costs between hemiarthroplasty and total hip arthroplasty for displaced femoral neck fractures in the elderly population.

Methods: A population-based, retrospective cohort study was performed on adults (≥60 years of age) undergoing either hemiarthroplasty or total hip arthroplasty for hip fracture between April 1, 2004, and March 31, 2014. We excluded patients who resided in long-term care facilities prior to the injury and those who were discharged to these facilities after the surgical procedure. Patients who underwent a hemiarthroplasty and those who underwent a total hip arthroplasty were matched using a propensity score encompassing patient demographic characteristics, patient comorbidities, and provider factors. After matching, we compared the rates of medical and surgical complications, as well as the perioperative and postoperative health-care costs in the year following the surgical procedure. The primary outcome was the occurrence of a medical complication (acute myocardial infarction, deep venous thrombosis, pulmonary embolism, ileus, pneumonia, renal failure) within 90 days or a surgical complication (dislocation, infection, revision surgical procedure) within 1 year. Additionally, we examined the change in health-care costs in the year following the surgical procedure, including costs associated with the index admission, relative to the year before the surgical procedure.

Results: Among 29,121 eligible patients, 2,713 (9.3%) underwent a total hip arthroplasty. After successfully matching 2,689 patients who underwent a total hip arthroplasty with those who underwent a hemiarthroplasty, the patients who underwent a total hip arthroplasty were at an increased risk for dislocation (1.7% compared with 1.0%; $p = 0.02$), but were at a decreased risk for revision (0.2% compared with 1.8%; $p < 0.0001$), relative to patients who underwent a hemiarthroplasty. Furthermore, the overall increase in the annual health-care expenditure in the year following the surgical procedure was approximately $2,700 in Canadian dollars lower in patients who underwent a total hip arthroplasty ($p < 0.001$).

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Conclusions: Among elderly patients with displaced femoral neck fractures, total hip arthroplasty was associated with lower rates of revision surgical procedures and reduced health-care costs during the index admission and in the year following the surgical procedure, relative to hemiarthroplasty.

Level of Evidence: Therapeutic Level III. See Instructions for Authors for a complete description of levels of evidence.

Femoral neck fractures are among the most common injuries in older adults, and their number continues to increase with a more aged population in North America[1,2]. For elderly patients (>60 years of age) with displaced femoral neck fractures, hemiarthroplasty is the most common operation. Although this procedure results in pain relief and a return to mobility, recent guidelines have recommended total hip arthroplasty instead[3,4]. Despite these guidelines, evidence has suggested poor compliance with this recommendation, with less than one-third of eligible patients undergoing total hip arthroplasty[5].

Elderly patients with hip fractures also have a high prevalence of end-stage osteoarthritis, and the more active patients in this cohort may require a subsequent conversion of a hemiarthroplasty to a total hip arthroplasty. Total hip arthroplasties have been associated with improved long-term function and pain relief relative to hemiarthroplasty[6,7]. However, total hip arthroplasty is a longer and more invasive procedure than hemiarthroplasty, with the potential for greater blood loss[8,9] and with a possibly increased risk for dislocation. Furthermore, total hip arthroplasty is more expensive[6,10], which may have implications for delivering appropriate care for increasing numbers of patients[1,2]. Alternatively, the improved function offered by a total hip arthroplasty may offset the increased initial cost with a reduced health-care utilization subsequent to discharge.

Several previous studies have compared the outcomes and complication rates of hemiarthroplasty and total hip arthroplasty for displaced femoral neck fractures[6,9,11-16]. Several retrospective cohort studies on the topic did not adjust for confounders that were associated with treatment selection and that also predisposed a patient to a poor outcome (e.g., increased age or comorbidity)[6,17]. Previous randomized controlled trials did not examine the differences in the health-care costs in these patients, either before or after the surgical procedure. Therefore, the objective of this current study was to compare complications and costs among equivalent patients with a hip fracture treated with either a total hip arthroplasty or a hemiarthroplasty in a large, population-based, propensity score-matched cohort.

Materials and Methods

Study Design and Data Sources

We conducted a population-based cohort study utilizing administrative data from Ontario, Canada. Ontarians are insured under a single-payer system, which covers all medically necessary procedures, including the acute management and aftercare of hip fractures[18]. Hospital discharge abstracts were obtained from the Canadian Institute for Health Information Discharge Abstract Database (CIHI-DAD). The Ontario Health Insurance Plan (OHIP) Claims History Database was used to identify physician service claims. In addition to capturing relevant demographic information on each patient (e.g., age, sex, comorbidity) and physician (e.g., years in practice and volume), these databases also capture every interaction that a person has ever had with our health-care system[18]. Each resident of Ontario has his or her own unique identifier that allows for the totality of the interactions to be studied.

Participants

We identified a cohort of patients who underwent an acute hemiarthroplasty or total hip arthroplasty for a femoral neck fracture between April 1, 2004, and March 31, 2014. We excluded patients under the age of 60 years, as hip fractures in these patients are likely to be the result of high-energy injuries. We excluded patients who resided in long-term care facilities prior to their injury and those who were discharged to these facilities after a surgical procedure, as these patients were not likely to be candidates for total hip arthroplasty. We also excluded patients who were discharged to palliative care and those who died during the index admission.

Primary Outcome: Surgical Complications

The primary outcomes of interest included postoperative complications, including medical complications at 90 days (acute myocardial infarction, deep venous thrombosis, pulmonary embolism, ileus, renal failure, and pneumonia) and surgical complications within 365 days (dislocation, infection, and revision arthroplasty). These complications were identified using International Classification of Diseases, Tenth Revision (ICD-10) diagnostic, OHIP billing, and Canadian Classification of Health Interventions (CCI) procedure codes (see Appendix)[19].

Secondary Outcome: Direct Medical Costs

To assess medical costs incurred by treating patients with either total hip arthroplasty or hemiarthroplasty, we utilized data from the Ontario Ministry of Health and Long-Term Care (MOHLTC)[20-26] to determine the public medical costs in the year before and after admission for a hip fracture. Costs were assigned to each patient on the basis of the year when the costs were incurred and were then inflated to 2013 Canadian dollars using the health-care component of the Ontario consumer price index (CPI, https://www.statscan.gc.ca). (In 2013, $1 in U.S. currency was equal to $0.99 in Canadian currency.) Care episodes that spanned more than 1 fiscal year were divided pro rata. Cost differences within 1 year between the total hip arthroplasty group and the hemiarthroplasty group were then estimated using a person-level, difference-in-differences approach[27] to adjust for preexisting health status and utilization between the total hip arthroplasty group and the hemiarthroplasty group. A baseline cost for the year prior to the injury was deducted from the costs accrued in the first year following the surgical procedure in the total hip arthroplasty group (first difference). The difference between these costs was then compared with the same difference among patients who underwent a hemiarthroplasty (second difference).

Covariates of Interest

We measured several patient and provider covariates that have been previously shown to affect the risk of occurrence of complications following a hip surgical procedure[19,28-31]. Patient age and sex were obtained from the OHIP Registered Persons Database (RPDB). Comorbidities were identified from hospital discharge abstracts in the 5 years before the index hospital admission and were categorized according to an adaptation of the Deyo modification of the Charlson Comorbidity Index[19,32]. The Adjusted Clinical Groups (ACGs) indicator, based on the diagnosis codes from hospitalizations and physician visits in the 5 years preceding the index hip fracture surgical procedure, were used to identify frail patients[33,34]. Diabetes mellitus, congestive heart failure, and chronic obstructive pulmonary disease were identified using validated algorithms[35-37]. The median neighborhood household income quintile was used as a surrogate for socioeconomic status and living conditions[18,38-40]. Surgeon volume was defined as either the number of total hip replacements (primary or revision) or femoral neck fracture surgical procedures performed in the 365 days preceding the day on which the procedure was performed on the hip fracture[19].

Statistical Analyses

Baseline cohort characteristics were described using proportions and medians and were compared between groups using Wilcoxon rank sum tests for continuous variables and chi-square tests for categorical variables[19]. A propensity score for a patient undergoing a total hip arthroplasty was determined using a logistic regression model[41,42]. The covariates that were entered into the propensity score were sociodemographics (age, sex, income quintile), preexisting health status (Charlson Comorbidity Index score, frailty, hypertension, chronic obstructive pulmonary disease, congestive heart failure, cerebrovascular disease, chronic renal failure, diabetes, and health-care costs in the year prior to the surgical procedure), and provider characteristics (teaching hospital status and surgeon volume). Patients who underwent a total hip arthroplasty were matched to those who underwent a hemiarthroplasty, using calipers of a width equal to 0.2 of the standard deviation of the logit of the propensity score[19,43] via the greedy (or nearest neighbor without replacement) matching method[44]. A matching ratio of 1:1 was used[44]. We estimated the standardized differences for all covariates before and after matching, with a standardized difference of ≥10% considered indicative of imbalance[45]. Complications were compared between the 2 groups after matching. All analyses were performed using SAS software (version 9.3 and SAS Enterprise Guide 6.1; SAS Institute). The type-I error probability was set to $p < 0.05$ for all analyses.

Results

Baseline Patient and Provider Characteristics

Between April 1, 2004, and March 31, 2014, there were 29,121 patients with a femoral neck fracture (Table I); of these patients, 2,713 (9.3%) underwent a total hip arthroplasty. Patients who underwent a total hip arthroplasty were younger than patients who underwent a hemiarthroplasty, with a median age of 79 years compared with 83 years ($p < 0.001$); patients who underwent a total hip arthroplasty also came from areas with a higher median income, had a lower prevalence of comorbidities, and had lower (less expensive) health-care utilization in the year prior to the surgical procedure than patients who underwent a hemiarthroplasty (Table II). Total hip arthroplasties were more likely to be performed by surgeons with higher annual total hip arthroplasty volumes.

Matching

In this study, 2,689 patients who underwent a total hip arthroplasty (99%) were successfully matched to patients who underwent a hemiarthroplasty (Table II). After matching, absolute standardized differences were <10% for all measured confounders, indicating a successful match and balanced (or comparable) groups.

Outcomes After Matching

After matching, there was no significant difference ($p > 0.05$) between patients who underwent a total hip arthroplasty and those who underwent a hemiarthroplasty in terms of acute myocardial infarction, deep venous thrombosis, pulmonary embolism, ileus, or pneumonia (Table II). Patients who underwent a total hip arthroplasty had a lower prevalence of postoperative renal failure (1.7% compared with 2.5%; $p = 0.04$). Total hip arthroplasties were about 10 minutes longer, but there was no difference in the rates of blood transfusion or length of stay. Patients who underwent a total hip arthroplasty had a higher rate of dislocation (1.7% compared with 1.0%; $p = 0.02$), but were at a much lower risk for a revision arthroplasty within the first year (0.2% compared with 1.8%; $p < 0.001$).

TABLE I Selection of Patients for Inclusion

Criteria	No. of Patients
All hip fractures from April 1, 2004, to March 31, 2014	86,898
Exclusion criteria	
Age <60 years	5,968
Intertrochanteric or subtrochanteric fractures	50,846
Discharge to palliative care or died during index admission	963
Final cohort	29,121

TABLE II Cohort Characteristics Before and After Matching

	Prior to Matching				After Matching			
Characteristic	All Patients	Total Hip Arthroplasty	Hemiarthroplasty	P Value	Total Hip Arthroplasty	Hemiarthroplasty	Standardized Difference	P Value
No. of patients	29,121	2,713	26,408		2,689	2,689		
Age* *(yr)*	83 (77 to 88)	79 (72 to 85)	83 (78 to 88)	<0.001	79 (72 to 85)	79 (73 to 85)	0.01	
Female sex†	21,000 (72.1%)	1,916 (70.6%)	19,084 (72.3%)	0.069	1,901 (70.7%)	1,901 (70.7%)	0	
Income quintile†‡				<0.001				
Lowest	6,495 (22.4%)	533 (19.7%)	5,962 (22.7%)		530 (19.7%)	538 (20.0%)	0.01	
2	5,859 (20.2%)	545 (20.1%)	5,314 (20.2%)		542 (20.2%)	531 (19.7%)	0.01	
3	5,460 (18.8%)	459 (17.0%)	5,001 (19.0%)		458 (17.0%)	453 (16.8%)	0	
4	5,579 (19.3%)	591 (21.8%)	4,988 (19.0%)		589 (21.9%)	583 (21.7%)	0.01	
Highest	5,580 (19.3%)	578 (21.4%)	5,002 (19.0%)		570 (21.2%)	584 (21.7%)	0.01	
Total health-care costs in the year prior to surgery*§	7,190 (2,845 to 29,122)	4,802 (2,057 to 14,604)	7,602 (2,944 to 30,739)	<0.001	4,803 (2,060 to 14,606)	4,974 (2,163 to 16,540)	0.02	
Comorbidities†								
Coronary artery disease	2,108 (7.2%)	150 (5.5%)	1,958 (7.4%)	<0.001	148 (5.5%)	169 (6.3%)	0.03	
Congestive heart failure	6,747 (23.2%)	476 (17.5%)	6,271 (23.7%)	<0.001	473 (17.6%)	488 (18.1%)	0.01	
Chronic obstructive pulmonary disease	5,425 (18.6%)	451 (16.6%)	4,974 (18.8%)	0.005	448 (16.7%)	433 (16.1%)	0.02	
Diabetes	7,714 (26.5%)	658 (24.3%)	7,056 (26.7%)	0.006	655 (24.4%)	706 (26.3%)	0.04	
Cerebrovascular disease	2,139 (7.3%)	152 (5.6%)	1,987 (7.5%)	<0.001	149 (5.5%)	155 (5.8%)	0.01	
Chronic renal failure	3,443 (11.8%)	311 (11.5%)	3,132 (11.9%)	0.542	307 (11.4%)	313 (11.6%)	0.01	
Frailty	5,064 (17.4%)	317 (11.7%)	4,747 (18.0%)	<0.001	316 (11.8%)	304 (11.3%)	0.01	
Charlson Comorbidity Index†				<0.001				
0	18,347 (63.0%)	1,886 (69.5%)	16,461 (62.3%)		533 (19.8%)	536 (19.9%)	0	
1	4,191 (14.4%)	335 (12.3%)	3,856 (14.6%)		330 (12.3%)	295 (11.0%)	0.04	
2	2,667 (9.2%)	219 (8.1%)	2,448 (9.3%)		218 (8.1%)	203 (7.5%)	0.02	
≥3	3,916 (13.4%)	273 (10.1%)	3,643 (13.8%)		273 (10.2%)	286 (10.6%)	0.02	
Admission characteristics								
Time from emergency department to surgery* *(hr)*	33 (22 to 51)	32 (22 to 50)	33 (22 to 51)	0.576	32 (22 to 50)	30 (21 to 50)	0.06	
Teaching hospital†	8,674 (29.9%)	892 (32.9%)	7,782 (29.5%)	<0.001	869 (32.3%)	865 (32.2%)	0	
Surgeon volume (fixation)*	16 (10 to 24)	15 (10 to 23)	17 (11 to 24)	<0.001	15 (10 to 23)	16 (10 to 23)	0.03	
Surgeon volume (arthroplasty)*	30 (2 to 57)	53 (30 to 79)	27 (1 to 55)	<0.001	53 (30 to 78)	51 (23 to 83)	0.07	
Outcomes								
Duration of surgery* *(min)*	103 (83 to 128)	110 (89 to 137)	102 (82 to 127)	<0.001	110 (89 to 136)	101 (80 to 126)		<0.001
Blood transfusion†	223 (0.8%)	21 (0.8%)	202 (0.8%)	0.959	21 (0.8%)	16 (0.6%)		0.409
Length of stay* *(day)*	7 (5 to 13)	7 (5 to 13)	7 (5 to 13)	0.304	7 (5 to 13)	7 (5 to 12)		0.743

continued

TABLE II (*continued*)

	Prior to Matching				After Matching			
Characteristic	All Patients	Total Hip Arthroplasty	Hemiarthroplasty	P Value	Total Hip Arthroplasty	Hemiarthroplasty	Standardized Difference	P Value
Within 90 days†								
Acute myocardial infarction	175 (0.6%)	10 (0.4%)	165 (0.6%)	0.101	10 (0.4%)	15 (0.6%)		0.316
Deep venous thrombosis	201 (1.4%)	14 (1.1%)	187 (1.4%)	0.345	14 (1.1%)	11 (0.9%)		0.553
Pulmonary embolism	211 (1.4%)	12 (0.9%)	199 (1.5%)	0.104	12 (0.9%)	16 (1.2%)		0.441
Ileus	20 (0.1%)	≤5	19 (0.1%)	0.506	≤5	≤5		0.99
Renal failure	739 (2.5%)	46 (1.7%)	693 (2.6%)	0.003	45 (1.7%)	66 (2.5%)		0.798
Pneumonia	1,138 (3.9%)	73 (2.7%)	1,065 (4.0%)	<0.001	72 (2.7%)	88 (3.3%)		0.199
Within 365 days†								
Dislocation	341 (1.2%)	45 (1.7%)	296 (1.1%)	0.013	45 (1.7%)	26 (1.0%)		0.023
Infection	821 (2.8%)	65 (2.4%)	756 (2.9%)	0.162	65 (2.4%)	77 (2.9%)		0.307
Revision	408 (1.4%)	≤5	405 (1.5%)	<0.001	≤5	49 (1.8%)		<0.001
Costs*§								
Hospital	14,049 (11,512 to 24,671)	13,523 (11,381 to 23,329)	14,142 (11,533 to 24,851)	<0.001	13,540 (11,391 to 23,345)	13,781 (11,670 to 24,193)		0.01
Physician	3,510 (1,754 to 5,567)	3,864 (2,305 to 5,818)	3,467 (1,699 to 5,540)	<0.001	3,877 (2,307 to 5,842)	3,566 (2,007 to 5,624)		<0.001
Rehabilitation and continuing care	9,761 (1,401 to 22,534)	6,760 (1,391 to 17,388)	10,241 (1,405 to 23,046)	<0.001	8,974 (2,060 to 22,921)	12,834 (2,938 to 29,267)		<0.001
Change in yearly health care	30,632 (17,473 to 52,817)	27,336 (17,313 to 45,661)	31,071 (17,507 to 53,491)	<0.001	27,388 (17,379 to 45,754)	30,061 (17,815 to 51,332)		<0.001

*The values are given as the median, with the interquartile range in parentheses. †The values are given as the number of patients, with the range in parentheses. ‡Data were missing for some patients in the prior to matching section, so the percentages were based on the total number of patients given for each category. §The values are given in 2013 Canadian dollars. In 2013, $1 in U.S. currency was equal to $0.99 in Canadian currency.

Patients who underwent a total hip arthroplasty also had lower median costs for rehabilitation following the surgical procedure at $8,974 compared with patients who underwent a hemiarthroplasty at $12,834 ($p < 0.001$). Patients in the total hip arthroplasty group also had a smaller median increase in annual health-care costs subsequent to the hip fracture (including costs for the index admission) at $27,388 compared with patients in the hemiarthroplasty group at $30,061 ($p < 0.001$).

Discussion

This is the first large administrative data set study, to our knowledge, to compare total hip arthroplasty and hemiarthroplasty in equivalent patients after controlling for several patient and provider factors. This is also the first study to examine the impact of the treatment choices of total hip arthroplasty or hemiarthroplasty on costs for hospitals, physicians, rehabilitation, and continuing care and the change in yearly health-care costs. During the study period, only 9% of patients who had femoral neck fractures and were eligible for a total hip arthroplasty underwent the procedure. After matching, patients who underwent a total hip arthroplasty had a higher rate of dislocation, but a lower rate of revision at 1 year, and a smaller increase in yearly medical costs relative to patients who underwent a hemiarthroplasty (median cost savings of approximately $2,700 in Canadian dollars). Patients who underwent a total hip arthroplasty had a lower rate of renal failure. There was no difference in the occurrence of other complications, rate of blood transfusion, or length of stay.

In addition to the high perioperative mortality rate, hip fractures are associated with a considerable decline in function and loss of independence. Total hip arthroplasty for hip fractures in this demographic group has traditionally been used to maintain function in patients who are more mobile before the hip fracture, with benefits demonstrated in a randomized controlled trial[13]. The National Institute for Health and Care Excellence (NICE) in the United Kingdom has recommended managing hip fractures with total hip arthroplasty in every elderly patient who has good cognitive and physical function and is fit enough for a surgical procedure[4]. Despite these guidelines, recent evidence has suggested that compliance with this recommendation is poor, with less than one-third of eligible patients undergoing a total hip arthroplasty[5]. Possible reasons include the lack of strong evidence comparing total hip arthroplasty and hemiarthroplasty and the difficulty in identifying patients in whom hemiarthroplasty is less suitable.

Although total hip arthroplasties were, on average, longer than hemiarthroplasties, there was no difference in the rates of blood transfusions between groups. After matching, patients who underwent a total hip arthroplasty had a higher risk for dislocation, but a lower risk for revision, relative to patients who underwent a hemiarthroplasty. As the only difference between the groups is the acetabular component, it seems plausible that the increased rate of revision in patients who underwent a hemiarthroplasty reflects the need to convert to a total hip arthroplasty, whether this is due to early acetabular erosion[16] or preexisting symptomatic osteoarthritis. Revision procedures may also have been necessary secondary to infection, dislocation, or periprosthetic fracture[46-48]. Although the dislocation rate for patients who underwent a total hip arthroplasty was higher, it is plausible that these patients were primarily managed with a closed reduction. Although total hip arthroplasties are more expensive in terms of physician fees, our finding that patients who underwent a hemiarthroplasty had increased health-care costs in the year following the surgical procedure indicates that this initial increased investment is offset by eventual cost-savings that may, in turn, reflect the increased functional benefit offered by total hip arthroplasties. It is worth pointing out that rehabilitation costs factor in the length of stay at a rehabilitation center[49,50]; as such, it is possible that the lower rehabilitation costs in the total hip arthroplasty cohort reflect a shorter length of stay, consistent with the improved functional results identified after total hip arthroplasty[51,52].

Previous studies comparing hemiarthroplasty and total hip arthroplasty have had limitations including the lack of adequate risk adjustment. Patients who underwent a hemiarthroplasty were typically older, had a higher burden of comorbidity, and were more likely to live in, or be discharged to, long-term care facilities. Improved outcomes after total hip arthroplasty observed in these studies may have thus been exaggerated and reflective of patient selection[12,53-55]. However, poorer outcomes for total hip arthroplasty may also be attributed to the inclusion of these patients, as they are typically at a higher risk for surgical complications, including dislocation[14,17]. In the current study, we excluded patients who either resided in long-term care facilities (such as nursing homes) prior to the injury or were discharged to such a facility after a surgical procedure. We also controlled for both patient factors (age, sex, comorbidity, socioeconomic status) and provider factors (surgeon volume, hospital volume, teaching hospital status). The balance of prognosis between groups after matching is further strengthened by the median health-care utilization in the year prior being balanced between patients undergoing a total hip arthroplasty ($4,803) and those undergoing a hemiarthroplasty ($4,974) (standardized difference = 0.02). As such, our findings indicate that total hip arthroplasty reduces the prevalence of revision surgical procedures and medical costs in patients with femoral neck fractures.

Even after large randomized trials on this topic are completed, our study may continue to assist with treatment decisions for femoral neck fractures[56,57]. This is because the requirement in these trials that total hip arthroplasties be conducted by hip surgeons may limit their external validity in scenarios in which arthroplasty surgeons are not readily available to conduct nonelective total hip arthroplasties[56,57]. We did find that total hip arthroplasty was performed by higher-volume hip surgeons even in our cohort. Regionalizing care among hip fracture centers to improve access to higher-volume arthroplasty surgeons[58,59] may be one way of improving the uptake of the procedure. In either case, the fact that only a little over 1 in 10 patients with a femoral neck fracture in this study underwent a total hip arthroplasty, which is similar to reports from other jurisdictions, indicates that quality improvement efforts are required to increase the number of total hip arthroplasties being performed for hip fractures.

The strengths of this study include our use of validated population-wide administrative databases that allowed us to track patients and complications if they occurred, even if the patients were lost to follow-up from their original surgeon. We were also able to control for a wide variety of patient and provider factors that strongly influence outcomes after a surgical procedure. Our definitions for complications were based on diagnostic and physician billing codes. As Ontario's health-care system is solely single-payer, physicians are only paid for procedures that they perform if they bill the government. As such, we are confident that the definitions for our outcomes, particularly those requiring a further surgical procedure, are fully sensitive and specific[60-64]. Finally, we used a validated technique to quantify and compare medical costs between the groups. Using this technique, we were able to account for >92% of all health-care costs for medically necessary care, including aftercare provided following each patient's discharge to the hospital up to 1 year postoperatively[20-26].

The limitations of this study primarily related to data that could not be assessed or measured in the province's administrative databases. These included radiographs and thus whether the femoral neck fractures considered in this study were displaced or not. We mitigated this by focusing on fractures that were managed with either a total hip arthroplasty or a hemiarthroplasty and excluding those managed with internal fixation. Other outcomes that we could not assess but may be clinically important in this population and that potentially relate to the choice of surgical procedure were patient-reported outcomes and costs incurred by patients, physicians, and society. Finally, although we were able to measure and control for several potential confounders (e.g., comorbidity, income quintile, and prior health-care usage), there were several unmeasured factors that may have influenced the observed association between hemiarthroplasty and increased costs and complications[65]. Most importantly, we did not have any measures of preoperative function; we attempted to mitigate this by including preoperative health-care expenditure in our propensity score match, as decreased function is associated with increased expenditure. However, it is possible that the increased rehabilitation costs in the hemiarthroplasty group after matching resulted from worse preoperative function in this group. For assessing costs, the difference-in-differences approach at the individual patient level reduced residual confounding even before matching, because any preexisting difference in health-care utilization for each patient was eliminated[66].

Conclusions

Despite higher rates of dislocation, femoral neck fractures that are treated with total hip arthroplasty have lower revision rates and subsequent health-care costs than those treated with hemiarthroplasty.

Appendix

eA Information showing ICD-10 and physician billing codes used to identify patients, covariates, and outcomes and a table showing the sensitivity and specificity of various codes for comorbidities are available with the online version of this article as a data supplement at jbjs.org (http://links.lww.com/JBJS/F133). ■

Bheeshma Ravi, MD, PhD[1,2]
Daniel Pincus, MD[1,3]
Hayat Khan, MBChB, MSc[1]
David Wasserstein, MD, MSc[1,2]
Richard Jenkinson, MD, MSc[1,2,3]
Hans J. Kreder, MD, MPH[1,2,3]

[1]Division of Orthopaedic Surgery, Department of Surgery (B.R., D.P., H.K., D.W., R.J., and H.J.K.), and Institute of Health Policy, Management and Evaluation (D.P. and H.J.K.), University of Toronto, Toronto, Ontario, Canada

[2]Division of Orthopaedic Surgery, Sunnybrook Health Sciences Centre, Toronto, Ontario, Canada

[3]Institute for Clinical Evaluative Sciences, Toronto, Ontario, Canada

E-mail address for B. Ravi: bheeshma.ravi@sunnybrook.ca

ORCID iD for B. Ravi: 0000-0003-1829-6885
ORCID iD for D. Pincus: 0000-0003-3783-8205
ORCID iD for H. Khan: 0000-0001-9707-1806
ORCID iD for D. Wasserstein: 0000-0003-0347-0481
ORCID iD for R. Jenkinson: 0000-0002-1589-9632
ORCID iD for H.J. Kreder: 0000-0001-9406-5232

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