Does Surgeon Volume for Total Hip Arthroplasty Affect Outcomes After Hemiarthroplasty for Femoral Neck Fracture?

James B. Ames, MD, Jon D. Lurie, MD, MS, Ivan M. Tomek, MD, FRCSC, Weiping Zhou, MS, and Kenneth J. Koval, MD

Abstract

We conducted a study to compare complication rates in patients treated with hemiarthroplasty for femoral neck fracture by surgeons with variable experience in primary total hip arthroplasty (THA) and revision THA.

A cohort of Medicare beneficiaries (N = 115,352) was identified from Medicare part A claims from 1994 and 1995. All patients had undergone hemiarthroplasty for femoral neck fracture. Patients were grouped according to surgeon procedure volume (how many primary and revision THAs surgeon performed per year): 0 (no volume), 1-5 (low volume), 6-24 (mid volume), and 25+ (high volume). Claims were evaluated up to 5 years after surgery to identify patient encounters for complications, such as mortality, dislocation, and infection.

Compared with patients treated by no-volume surgeons, patients treated by high-volume surgeons had significantly lower rates of mortality, prosthetic dislocation, and superficial infection. The difference was significant for mortality at 30 days (5.6% vs 6.5%), 90 days (10.8% vs 12.8%), and 1 year (22.3% vs 23.8%); for prosthetic dislocation at 1 year (1.2% vs 1.7%); and for superficial infection at 90 days (1.1% vs 1.6%), 1 year (1.4% vs 1.9%), and 5 years (1.5% vs 2.0%). Revision surgery rates, however, were statistically higher for the high-volume group than for the no-volume group at 90 days (0.9% vs 0.7%), 1 year (3.3% vs 2.9%), and 5 years (8.4% vs 7.7%). There were no differences in rates of venous thromboembolism or deep infection between the groups.

Surgical experience in primary and revision THA has a significant effect on patient outcomes after hemiarthroplasty for femoral neck fracture.

Dr. Ames is Senior Resident, Department of Orthopedic Surgery, Dr. Lurie is Hospitalist, Division of Hospital Medicine, Dr. Tomek is Joint Surgeon, Dr. Zhou is Statistician, and Dr. Koval is Trauma Surgeon, Department of Orthopedic Surgery, Dartmouth-Hitchcock Medical Center, Lebanon, New Hampshire.

Address correspondence to: James B. Ames, MD, Department of Orthopaedic Surgery, Dartmouth Hitchcock Medical Center, 1 Medical Center Dr, Lebanon, NH 03756 (tel, 603-650-5133; fax, 603-650-2097; e-mail, james.b.ames@hitchcock.org).

Am J Orthop. 2010;39(8):E84-E89.

More than 300,000 hip fractures occur in the United States each year.[1,2] Most investigators estimate that, given the aging of the US population, this number will rise steadily, and top 600,000 annually by 2040.[3,4] Approximately 50% of hip fractures involve the femoral neck.[5] Despite debate about what constitutes optimal treatment for displaced femoral neck fractures in the elderly, with options including internal fixation, hemiarthroplasty, and total hip arthroplasty (THA), the vast majority of these patients are treated with hemiarthroplasty.[2,6]

Surgeon procedure volume has a significant effect on postoperative outcomes for many general surgery procedures[7] and for select orthopedic procedures, including hip,[8] knee,[9] and shoulder[10] arthroplasty. For primary THA, patients treated by low-volume surgeons are more likely to sustain a prosthetic dislocation and undergo revision surgery than are patients treated by high-volume surgeons.[8,11] For revision THA, patients treated by low-volume surgeons have higher mortality rates than patients treated by high-volume surgeons.[8] The association found between surgeon procedure volume and early failure occurs primarily during the first 18 months after surgery—suggesting technical error as the principal mechanism of early failure.[11]

The effect of surgeon procedure volume on outcomes after hemiarthroplasty for femoral neck fracture is less clear. One study found decreased mortality rates for surgeons who performed more than 12 hemiarthro-

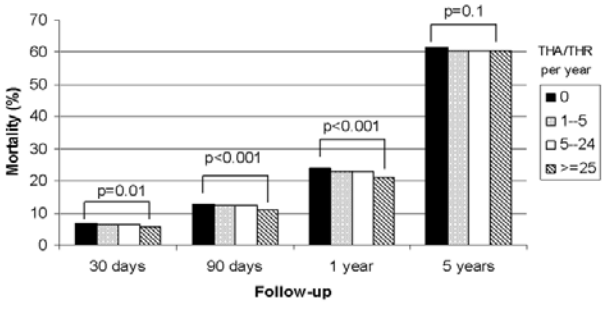

Figure 1. Association between surgeon volumes of total hip arthroplasty and mortality after hemiarthroplasty for femoral neck fracture.

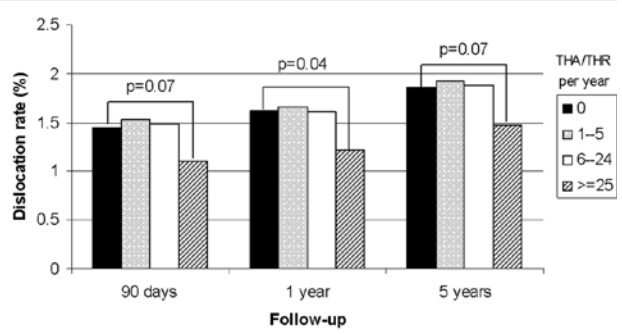

Figure 2. Association between surgeon volumes of total hip arthroplasty and dislocation rate after hemiarthroplasty for femoral neck fracture.

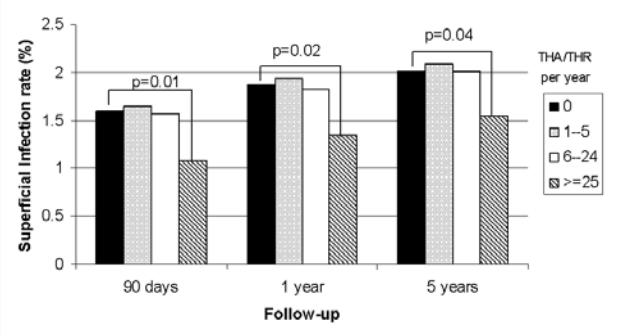

Figure 3. Association between surgeon volumes of total hip arthroplasty and superficial infection rate after hemiarthroplasty for femoral neck fracture.

plasties per year.[12] Another study found no difference in mortality with regard to surgeon hemiarthroplasty volume.[13]

The general surgery literature includes reports that patient outcomes after certain procedures are better predicted by surgeon subspecialty than by surgeon procedure volume.[14] Dimick and colleagues[14] reported that specialization in vascular surgery was associated with markedly decreased mortality in patients who underwent abdominal aortic aneurysm (AAA) repair, independent of surgeon AAA repair volume.

We conducted a study to compare complication rates in patients treated with hemiarthroplasty for femoral neck fracture by surgeons with variable experience in THA. Our null hypothesis was that more THA experience would not translate into better outcomes for patients after hemiarthroplasty for femoral neck fracture.

Methods

Database

Using a 100% Medicare part A claims database, we identified cases of hemiarthroplasty for femoral neck fracture and select postoperative outcomes from January 1994 through December 1995. Diagnosis and procedure codes classified according to the *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)* and physician claims containing procedure codes using the *Current Procedural Terminology (CPT), Fourth Edition* were used to identify cohorts and outcomes. The Medicare Unique Physician Identification Number (UPIN) allowed for surgeon-level analyses.

Selection of Study Cohort

A previously defined cohort of beneficiaries was identified from Medicare part A claims for 1994 and 1995. All patients had sustained a femoral neck fracture and been treated with hemiarthroplasty (Appendix A). We identified the UPIN that had been assigned to each surgeon who performed these procedures, and we used 100% Medicare part B claims data from 1996 and 1997 to calculate the number of primary and revision THAs performed by each surgeon (Appendix B). The 1996–1997 period was used to define surgeon arthroplasty volumes because a 100% sample of surgeon part B claims was available for this period, whereas only a 20% sample was available for 1994–1995. Given many surgeons' relatively low rates of arthroplasty, the 20% sample was deemed insufficient to adequately define arthroplasty volume groups.

Surgeons were grouped according to procedure volume (how many primary and revision THAs each performed per year in 1996–1997): 0 (no volume), 1-5 (low volume), 6-24 (mid volume), and 25+ (high volume). The high-volume cutoff was based on the criteria for becoming a member of the American Association of Hip and Knee Surgeons[15]: Each candidate must "perform a minimum of fifty (50) total hip and/or knee arthroplasties or osteotomies about the hip and/or knee each calendar year." Using a liberal practice pattern

Table I. Baseline Characteristics of Medicare Beneficiaries Treated With Hemiarthroplasty for Femoral Neck Fracture in 1994 and 1995, Stratified Into 4 Groups by Average Annual Surgeon Volume of Primary and Revision Total Hip Arthroplasties

	Surgeon Volume							
	0 (No)		1-5 (Low)		6-24 (Mid)		25+ (High)	
Baseline Characteristic	n	%	n	%	n	%	n	%
Female	34,566	78.1	26,217	79.1	26,446	78.7	3391	78.2
White	41,393	93.5	30,990	93.5	32,005	95.2	4146	95.6
Charlson Comorbidity Index score 2+	5668	12.8	4163	12.6	4293	12.8	591	13.6
Age 75 or older	36,561	82.6	27,241	82.2	27,771	82.6	3603	83.0

Table II. Distribution of Hemiarthroplasty for Femoral Neck Fracture Performed in Medicare Beneficiaries in 1994 and 1995 According to Average Annual Surgeon Volume of Primary and Revision Total Hip Arthroplasties

Surgeon Volume	Hemiarthroplasty	
	n	%
0	44,254	38.4
1-5	33,147	28.7
6-24	33,612	29.1
25+	339	3.8
Total	**115,352**	**100**

estimate of 50% hip arthroplasty, we used this information to designate our high-volume group as 25+ primary or revision THAs per year. We then assigned the hemiarthroplasty patients into the 4 surgeon procedure volume groups and measured outcomes based on these 4 groups. Patients without a correctly assigned UPIN were excluded.

Outcomes

Measured outcomes included mortality, prosthetic dislocation, superficial infection not involving the prosthesis, deep infection involving the prosthesis, thromboembolic events, and revision hip surgery (Appendices C, D). These outcomes were measured at 90 days, 1 year, and 5 years. An additional measure of mortality was made at 30 days.

Covariates

Data regarding age, sex, race, and associated comorbidities were obtained from the database. Age was stratified into 5-year groups starting with 65 years and going to 85 years and older. Race was quantified white or nonwhite. Comorbidity status was quantified with the Charlson Comorbidity Index (CCI)[16]: 0, 1, or 2+ comorbidities.

Analyses

Linear regression was used to evaluate the effect of THA volume on outcomes after hemiarthroplasty for femoral neck fracture while controlling for covariates. Chi-square tests were used to evaluate for unequal distribution of covariates among the different cohorts. Pearson correlation coefficient was used to evaluate the relationship between THA volume and hemiarthroplasty volume. All analyses were performed with SAS Version 8 (SAS Institute, Cary, NC).

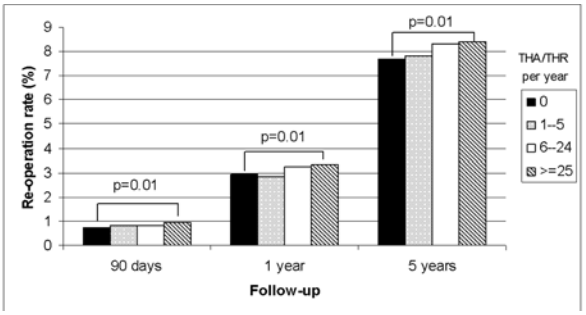

Figure 4. Association between surgeon volumes of total hip arthroplasty and revision hip surgery rate after hemiarthroplasty for femoral neck fracture.

Results

We identified 115,352 Medicare beneficiaries who had sustained a femoral neck fracture and been treated with hemiarthroplasty between January 1, 1994, and December 31, 1995, by a surgeon with a valid UPIN; 1.13% of eligible cases were missing a UPIN and were dropped from analysis. The demographic characteristics of the entire cohort are listed in Table I. The majority of the cohort was female (78.6%), white (94.1%), and older than 80 (63.2%). Mean age was 81.8 years.

There were 44,254 patients in the no-volume surgeon group, 33,147 in the low-volume group, 33,612 in the mid-volume group, and 4,339 in the high-volume group. No significant differences were found between these 4 groups with regard to patient age distribution. The groups did differ slightly with respect to sex, race, and CCI score distribution. Percentage of white patients was higher in the groups treated by mid- and high-volume surgeons (95.2%, 95.6%) than in the groups treated by no- and low-volume surgeons (93.5%, 93.5%). Although patients treated by high-volume surgeons were more likely than patients treated by no-volume surgeons (13.6% vs 12.8%) to have a CCI score of 2+, they were also more likely to have a CCI score of 0 (56.5% vs 55.1%). Despite these distribution differences, mean CCI scores were 0.58 (no volume), 0.57 (low volume), 0.57 (mid volume), and 0.57 (high volume). When we

Table III. Select Outcomes After Hemiarthroplasty for Femoral Neck Fracture in Medicare Beneficiaries Treated in 1994 and 1995

Outcome	Time After Surgery							
	30 Days		90 Days		1 Year		5 Years	
	n	%	n	%	n	%	n	%
Death	7340	6.4	14,234	12.3	26,772	23.2	70,357	61.0
Dislocation	—	—	1697	1.5	1859	1.6	2158	1.9
Superficial infection	—	—	1828	1.6	2136	1.9	2320	2.0
Deep infection	—	—	585	0.5	873	0.8	1244	1.1
Revision hip surgery	—	—	906	0.8	3484	3.0	9152	7.9
Thromboembolism	—	—	1583	1.4	1782	1.5	2054	1.8

controlled outcome results for the minor differences between groups, there was no change in our statistical analysis.

Table II shows the distribution of patients within the 4 surgeon procedure volume groups. Most (67.1%) of the patients who underwent hemiarthroplasty for femoral neck fracture were treated by surgeons who performed 0 to 5 primary or revision THAs per year, and only 3.8% of patients were treated by surgeons who performed 25+ THAs per year.

To show that any measured effect of THA volume on outcomes after hemiarthroplasty was not related to a concomitant high hemiarthroplasty volume, we assessed for a correlation between these volumes. Correlation between number of THAs and number of hemiarthroplasties performed by individual surgeons was low (Pearson coefficient, .05), which suggests that the procedure volumes were relatively independent.

Outcomes for the entire patient cohort, including rates of death, dislocation, superficial infection, deep infection, revision hip surgery, and thromboembolic complications, are listed in Table III. Mortality rates were 6.4% (30 days), 12.3% (90 days), 23.2% (1 year), and 61% (5 years). Prosthetic dislocation was rare (1.9% at 5 years), with the majority occurring by 90 days. Similarly, superficial and deep infections were relatively rare (2.0% and 1.1%, respectively, at 2 years). Revision hip surgery was more common (7.9% at 5 years), with the majority of these cases occurring between 1 and 5 years after surgery.

Figure 1 shows the mortality rates for hemiarthroplasty patients in the 4 volume groups. These rates were significantly lower for patients treated by high-volume surgeons than for patients treated by no-volume surgeons at 30 days (5.6% vs 6.5%), 90 days (10.8% vs 12.8%), and 1 year (22.3% vs 23.8%). This difference persisted through 5 years (60.4% vs 61.7%) but was no longer statistically significant. At each interval, mortality rates decreased across groups as THA volume increased.

Figure 2 shows the prosthetic dislocation rates for hemiarthroplasty patients in the 4 volume groups. These rates were consistently lower for patients treated by high-volume surgeons than for patients treated by no-volume surgeons. This difference was statistically significant at 1 year (1.22% vs 1.66%). Within the 3 groups of patients treated by surgeons with any THA experience, dislocation rates trended downward as THA volume increased.

Figure 3 shows the superficial infection rates for hemiarthroplasty patients in the 4 volume groups. These rates were lowest for patients treated by high-volume surgeons at all intervals, and, again, within the 3 groups of patients treated by surgeons with any THA experience, rates trended downward as THA volume increased.

Figure 4 shows the revision surgery rates for hemiarthroplasty patients in the 4 volume groups. These rates were statistically higher for patients treated by high-volume surgeons than for patients treated by no-volume surgeons at 90 days (0.9% vs 0.7%), 1 year (3.3% vs 2.9%), and 5 years (8.4% vs 7.7%). In addition, there seemed to be a trend toward higher revision surgery rates with increasing THA volume.

There were no significant differences between patients treated by high- and no-volume surgeons in rates of thromboembolic events at 90 days (1.5% vs 1.5%), 1 year (1.6% vs 1.7%), or 5 years (1.9% vs 1.9%) or in rates of deep infections at 90 days (0.6% vs 0.5%), 1 year (0.8% vs 0.8%), or 5 years (1.2% vs 1.1%).

Discussion

In this analysis of Medicare beneficiaries who sustained a femoral neck fracture and were treated with hemiarthroplasty, patients treated by higher volume THA surgeons had lower rates of mortality, dislocation, and superficial infection. Rates of thromboembolic events and deep infection were unaffected by THA volume. Rate of revision surgery, however, was higher for patients treated by higher volume surgeons. In the interpretation of results, it is important to understand that the 4 volume groups represent only the volume of Medicare THA cases. It is likely that our high-volume surgeons were performing a significant number of THAs for non-Medicare patients and that their volume was considerably higher than our cutoff of 25 THAs per year. To our knowledge, this is the first orthopedic literature report to show that the volume of one surgical procedure has an effect on outcomes after a different but related surgical procedure. Certainly, there is no previous report of the effect of primary and revision THA volume on outcomes after hemiarthroplasty for femoral neck fracture.

Our combined cohort mortality rates of 6.4% (30 days), 12.3% (90 days), 23.2% (1 year), and 61% (5 years) are consistent with previously rates reported.[17,18] Lu-Yao and colleagues[18] showed overall post–hip-fracture mortality rates among Medicare beneficiaries of 7% (30 days), 13% (90 days), and 24% (1 year). One of the significant findings in the present study was lower mortality in patients treated by the highest volume surgeons. There appeared to be a dose–response rate: higher THA volume correlating with improved survival after hemiarthroplasty. Several factors could have influenced this finding. One might suspect that higher volume surgeons' treating younger, healthier patients accounted for improved survival. In our cohort, however, there were no patient age differences across the 4 groups, and, compared with the no- and low-volume groups, the high-volume group actually had a higher percentage of patients with 2 or more comorbidities. No difference among the 4 volume groups with regard to rates of deep vein thrombosis and pulmonary embolus also argues against any marked patient selection effect. If a group had significantly healthier patients, one would suspect that group might have had lower rates of thromboembolic complications. Our study did not capture patients who had undergone THA for a femoral neck fracture. One

would suspect that higher volume surgeons might be performing THAs for younger, healthier patients with femoral neck fractures. Although true, this potentially strengthens our study conclusions, as it suggests higher volume surgeons select older, less healthy patients for hemiarthroplasty and still achieve superior outcomes.

Most prosthetic dislocations occurred within the first 90 days after surgery. This finding and the overall dislocation rates of 1.5% (90 days), 1.6% (1 year), and 1.9% (5 years) are consistent with recent reports.[19] Prosthetic dislocation after hemiarthroplasty for femoral neck fracture is generally considered a rare complication. In this study, patients treated by surgeons with higher THA volume appeared to have lower dislocation rates. Patients treated by the highest volume surgeons had a dislocation rate 25% lower than that for patients treated by the lowest volume surgeons. There is debate about another surgical factor that may have affected the dislocation rate. Bush and Wilson[20] reviewed 375 patients and found 9 dislocations for an overall dislocation rate of 2.3% at 6-month follow-up. All 9 dislocations occurred in patients treated through a posterior approach, suggesting that operative approach might be an important factor in the dislocation rate. In a larger series, Sierra and colleagues[19] reviewed 1,812 bipolar hemiarthroplasties performed predominantly for femoral neck fracture. They found 32 dislocations at up to 20 years of follow-up and no association between surgical approach and dislocation rate. Our study did not include information on surgical approach and thus does not add to this debate.

One interesting result of our study is that revision surgery rates were higher for patients treated by higher volume surgeons, despite the fact that rates of the most common complications, prosthetic dislocation and superficial infection, were lower for the high-volume group. This suggests that high-volume surgeons were revising THAs for reasons other than treating these 2 complications. Acetabular erosion is a common mechanical complication after hemiarthroplasty for femoral neck fracture.[21] Acetabular erosion or "prosthetic arthritis" can cause groin pain and lead to a need for revision surgery. In a study of 106 consecutive patients who underwent unipolar hemiarthroplasty, 37% of the 71 patients followed for 2 years needed or had undergone THA; in most of these patients, the indication for THA was "acetabular derangement."[22] A recent randomized, controlled trial comparing hemiarthroplasty and THA for femoral neck fracture found that the rate of radiographic acetabular erosion was higher than 50% at 3 years.[23] Arthroplasty surgeons are trained to monitor implants after performing THA and total knee arthroplasty and are vigilant in looking for signs of osteolysis and component loosening. It seems plausible that the higher revision rates in the higher volume groups might have stemmed from increased surveillance among arthroplasty surgeons for radiographic abnormalities such as acetabular erosion and femoral stem loosening. In addition, given their comfort with revision surgery, arthroplasty surgeons may have a lower threshold for recommending this intervention.

Most of the literature on the volume–outcome relationship in surgical procedures has concluded that, to optimize patient outcomes, certain procedures should be regionalized to high-volume centers with high-volume surgeons.[7,8] The question arising from our study is whether patients with a femoral neck fracture should be transferred to centers with high-volume arthroplasty surgeons. Although our data show lower mortality, dislocation, and superficial infection rates for patients treated by high-volume surgeons, it is not clear that efforts to regionalize hemiarthroplasty care are warranted. Urgency and timing may play a significant role in outcomes for elderly patients with a femoral neck fracture[24] but do not exist for most elective procedures in which the volume–outcome relationship has been defined. It is unclear whether the benefits gained by transfer to a surgeon with substantial THA experience would outweigh the detrimental effects of surgical delay.

One limitation of this study is that it was a retrospective database study with the usual methodologic problems. We could not independently verify data accuracy, standardization, or input. Furthermore, the Medicare database does not include detailed clinical information on medications, severity of associated comorbidities, lifestyle factors, body composition, or radiography. Therefore, we did not have all the information necessary to fully evaluate the appropriateness of specific interventions or to control for all relevant patient factors that may affect the rates of complications after THA. Furthermore, the laterality problem—*ICD-9-CM* codes do not distinguish between left and right sides—prevented us from knowing with certainty whether adverse events after hip fracture treatment were related to the joint treated surgically at the index stay. In addition, as only a 20% sample of surgeon part B claims was available for 1994–1995 (when our cohort was established), we had to obtain data on surgeon THA volume from 1996–1997 (100% sample of surgeon part B claims). Although there was a potential to misclassify surgeon procedure volume rates, we feel that the practice patterns of individual surgeons were likely relatively stable from one year to the next. We also recognize that these data were a decade old, but again we were limited to the 100% part B sample from 1996–1997. Last, we did not control for hospital volume of hemiarthroplasty or THA.

Conclusions

Given the limitations in this study of Medicare beneficiaries, volume of primary and revision THAs appeared to have a significant effect on outcomes after hemiarthroplasty for femoral neck fracture. Patients treated by surgeons with substantial THA experience had higher rates of revision surgery but lower rates of death, dislocation, and superficial infection.

Authors' Disclosure Statement

The authors report no actual or potential conflict of interest in relation to this article.

References

1. Gehlbach SH, Avrunin JS, Puleo E. Trends in hospital care for hip fractures. *Osteoporos Int.* 2007;18(5):585-591.
2. Bhandari M, Devereaux PJ, Tornetta P 3rd, et al. Operative management of displaced femoral neck fractures in elderly patients. An international survey. *J Bone Joint Surg Am.* 2005;87(9):2122-2130.
3. Schneider EL, Guralnik JM. The aging of America. Impact on health care costs. *JAMA.* 1990;263(17):2335-2340.
4. Morris AH, Zuckerman JD. National Consensus Conference on Improving the Continuum of Care for Patients with Hip Fracture. *J Bone Joint Surg Am.* 2002;84(4):670-674.
5. Koval KJ, Aharonoff GB, Rokito AS, Lyon T, Zuckerman JD. Patients with femoral neck and intertrochanteric fractures. Are they the same? *Clin Orthop.* 1996;(330):166-172.
6. Iorio R, Schwartz B, Macaulay W, Teeney SM, Healy WL, York S. Surgical treatment of displaced femoral neck fractures in the elderly: a survey of the American Association of Hip and Knee Surgeons. *J Arthroplasty.* 2006;21(8):1124-1133.
7. Birkmeyer JD, Stukel TA, Siewers AE, Goodney PP, Wennberg DE, Lucas FL. Surgeon volume and operative mortality in the United States. *N Engl J Med.* 2003;349(22):2117-2127.
8. Katz JN, Losina E, Barrett J, et al. Association between hospital and surgeon procedure volume and outcomes of total hip replacement in the United States Medicare population. *J Bone Joint Surg Am.* 2001;83(11):1622-1629.
9. Katz JN, Barrett J, Mahomed NN, Baron JA, Wright RJ, Losina E. Association between hospital and surgeon procedure volume and the outcomes of total knee replacement. *J Bone Joint Surg Am.* 2004;86(9):1909-1916.
10. Jain N, Pietrobon R, Hocker S, Guller U, Shankar A, Higgins LD. The relationship between surgeon and hospital volume and outcomes for shoulder arthroplasty. *J Bone Joint Surg Am.* 2004;86(3):496-505.
11. Losina E, Barrett J, Mahomed NN, Baron JA, Katz JN. Early failures of total hip replacement: effect of surgeon volume. *Arthritis Rheum.* 2004;50(4):1338-1343.
12. Shah SN, Wainess RM, Karunakar MA. Hemiarthroplasty for femoral neck fracture in the elderly surgeon and hospital volume-related outcomes. *J Arthroplasty.* 2005;20(4):503-508.
13. Lavernia CJ. Hemiarthroplasty in hip fracture care: effects of surgical volume on short-term outcome. *J Arthroplasty.* 1998;13(7):774-778.
14. Dimick JB, Cowan JA Jr, Stanley JC, Henke PK, Pronovost PJ, Upchurch GR Jr. Surgeon specialty and provider volumes are related to outcome of intact abdominal aortic aneurysm repair in the United States. *J Vasc Surg.* 2003;38(4):739-744.
15. American Association of Hip and Knee Surgeons. American Association of Hip and Knee Surgeons Bylaws. http://www.aahks.org/about/AAHKSBylaws.pdf. Approved November 1993. Revised November 7, 2009. Accessed June 29, 2010.
16. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis.* 1987;40(5):373-383.
17. Bass E, French DD, Bradham DD, Rubenstein LZ. Risk-adjusted mortality rates of elderly veterans with hip fractures. *Ann Epidemiol.* 2007;17(7):514-519.
18. Lu-Yao GL, Baron JA, Barrett JA, Fisher ES. Treatment and survival among elderly Americans with hip fractures: a population-based study. *Am J Public Health.* 1994;84(8):1287-1291.
19. Sierra RJ, Schleck CD, Cabanela ME. Dislocation of bipolar hemiarthroplasty: rate, contributing factors, and outcome. *Clin Orthop*. 2006;(442):230-238.
20. Bush JB, Wilson MR. Dislocation after hip hemiarthroplasty: anterior versus posterior capsular approach. *Orthopedics.* 2007;30(2):138-144.
21. Beckenbaugh RD, Tressler HA, Johnson EW Jr. Results after hemiarthroplasty of the hip using a cemented femoral prosthesis. A review of 109 cases with an average follow-up of 36 months. *Mayo Clin Proc.* 1977;52(6):349-353.
22. Kofoed H, Kofod J. Moore prosthesis in the treatment of fresh femoral neck fractures. A critical review with special attention to secondary acetabular degeneration. *Injury.* 1983;14(6):531-540.
23. Baker RP, Squires B, Gargan MF, Bannister GC. Total hip arthroplasty and hemiarthroplasty in mobile, independent patients with a displaced intracapsular fracture of the femoral neck. A randomized, controlled trial. *J Bone Joint Surg Am.* 2006;88(12):2583-2589.
24. Moran CG, Wenn RT, Sikand M, Taylor AM. Early mortality after hip fracture: is delay before surgery important? *J Bone Joint Surg Am.* 2005;87(3):483-489.

Appendix A. ICD–9–CM and CPT Codes Used in Selection of Study Cohort

820.0	Fracture of neck of femur—transcervical fracture, closed
820.1	Fracture of neck of femur—transcervical fracture, open
820.2	Fracture of neck of femur—pertrochanteric fracture, closed
820.3	Fracture of neck of femur—pertrochanteric fracture, open
820.8	Unspecified part of neck of femur, closed

Abbreviations: ICD–9–CM, International Classification of Diseases, Ninth Revision, Clinical Modification; CPT, Current Procedural Terminology, Fourth Edition.

Appendix B. CPT Codes Used in Determining Surgeon Experience in Total Hip Arthroplasty

27130	Arthroplasty, acetabular and proximal femoral prosthetic replacement (total hip arthroplasty), with or without autograft or allograft
27132	Conversion of previous hip surgery to total hip arthroplasty, with or without autograft or allograft
27134	Revision of total hip arthroplasty, both components, with or without autograft or allograft
27137	Acetabular component only, with or without autograft or allograft
27138	Femoral component only, with or without autograft or allograft

Abbreviation: CPT, Current Procedural Terminology, Fourth Edition.

Appendix C. ICD–9–CM Codes Used in Determining Postoperative Complications After Femoral Neck Fracture Surgery

Thromboembolic Complication	
415.1	Pulmonary embolism and infarction
453.9	Embolism or thrombosis of vein, not otherwise specified
V12.51	Venous thrombosis and embolism
Hip Dislocation	
79.75	Closed reduction of dislocation of hip
79.85	Open reduction of dislocation of hip
718.3	Recurrent dislocation of joint
835.1	Open dislocation of hip
Superficial Infection	
998.5	Postoperative infection —Includes wound postoperative —Excludes infection due to implanted device (996.60–996.69)
Deep Infection	
996.0	Infection and inflammatory reaction due to internal prosthetic device, implant
996.66	Due to internal joint prosthesis
996.67	Due to other internal orthopedic device, implant and graft
Revision Hip Surgery	
81.51	Total hip replacement
81.52	Partial hip replacement
81.53	Revision of hip replacement
81.59	Revision of joint replacement of lower extremity, not elsewhere classified

Abbreviation: ICD–9–CM, International Classification of Diseases, Ninth Revision, Clinical Modification.

Appendix D. Mortality Data

Mortality data from this cohort were collected for 5 years after index hip fracture surgery by cross-referencing each patient from cohort with Social Security Death Index and were expressed in terms of 30-Day, 90-Day, 1-Year, and 5-Year mortality rates for each of the groups.

This paper will be judged for the Resident Writer's Award.