

# Comparative Effectiveness of Joint Reconstruction and Fixation for Femoral Neck Fracture: Inpatient and 30-Day Mortality

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## Abstract

Although functional outcomes of hip joint reconstruction may be superior to those of internal fixation, differences in mortality between the 2 procedures are poorly defined.

We conducted a retrospective study of patients 50 years and older with femoral neck fracture treated with joint reconstruction or internal fixation, performing adjusted logistic regressions to compare the odds of inpatient and 30-day mortality among patients according to surgery type.

Of 12,867 patients with femoral neck fracture, 9001 had joint reconstruction and 3866 had internal fixation. After adjustment for patient factors alone, the odds of inpatient mortality were higher with reconstruction (OR, 1.62; 95% CI, 1.18-2.23;  $P=.003$ ); however, the difference in the odds of 30-day mortality did not achieve statistical significance (OR, 1.18; 95% CI, 1.00-1.41;  $P=.053$ ). Controlling for patient and hospital factors, we found higher odds of both inpatient mortality (OR, 1.65; 95% CI, 1.19-2.28;  $P=.003$ ) and 30-day mortality (OR, 1.22; 95% CI, 1.02-1.46;  $P=.026$ ) with reconstruction. Joint reconstruction is associated with a 60% increase in the odds of inpatient mortality after femoral neck fracture.

For older adults, fractures of the hip or proximal femoral represent a global public health concern. More than 320,000 of these fractures occur each year in the United States,<sup>1</sup> and 1.7 million worldwide.<sup>2</sup> With the elderly population growing, the annual incidence of proximal femoral fractures is anticipated to increase to more than 500,000 in the United States<sup>3</sup> and 6.26 million worldwide<sup>4</sup> by 2050. Fractures of the femoral neck account for about half of all proximal femoral fractures,<sup>5</sup> with the majority of these demonstrating some degree of displacement between the proximal and distal fracture components.

Although surgical treatment is indicated for all displaced femoral neck fractures, it differs according to patient characteristics. Whereas reduction and internal fixation of fracture components are preferred for adults younger than age 65 years and for physiologically young patients without preexisting degenerative changes, hip joint reconstruction through partial joint replacement (hemiarthroplasty) or total hip arthroplasty (THA) is preferred for older adults.<sup>6</sup> Among older adults, 1-year functional outcomes are improved more with joint reconstruction than with fixation.<sup>7-9</sup> In addition, joint reconstruction techniques decrease the likelihood of orthopedic complications related to fracture treatment (eg, nonunion), which may require repair through a second, more complex surgery.<sup>10</sup>

These advantages have made primary joint reconstruction the preferred treatment for displaced femoral neck fracture in most older adults, but they are accompanied by immediate risks attributable to the surgical procedure itself. Compared with internal fixation, joint reconstruction involves more operative time and increased blood loss.<sup>11</sup> Furthermore, although internal fixation with percutaneous pinning can be performed with local anesthesia, joint replacement requires regional or general anesthesia, potentially increasing the risk for anesthesia-related complications.

Better defining the relative perioperative risks conferred by

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**Authors' Disclosure Statement:** The authors report no potential or actual conflict of interest in relation to this article. Although there was no external funding for this study, the data were obtained through the Pennsylvania Health Care Cost Containment Council (PHC4), an independent state agency responsible for addressing the problem of escalating health costs, ensuring the quality of health care, and increasing access to health care for all citizens regardless of ability to pay. PHC4 provided data to the authors in an effort to further the PHC4 mission of educating the public and containing health care costs in Pennsylvania. PHC4, its agents, and staff made no representation, guarantee, or warranty, express or implied, that the data (financial, patient-, payor-, physician-specific information) provided to this entity were error-free, or that use of the data would be subject to differences of opinion or interpretation. The analysis in this study was not prepared by PHC4, but by the authors of this article. PHC4, its agents, and staff bear no responsibility or liability for analysis results, which are solely the opinion of the authors.

joint replacement and internal fixation carries important implications for medical decision making and clinical practice. Although clinical trials have had conflicting results regarding the association between joint reconstruction and increases in postfracture mortality,<sup>9,12-16</sup> few studies have been adequately powered to detect differences in mortality between patients randomized to a given hip fracture treatment. Further, several trials comparing joint reconstruction and fixation excluded patients with multiple comorbidities from randomization because of concerns regarding the safety of major surgery in this population. As a result, key gaps in knowledge remain regarding the comparative effectiveness of joint reconstruction and internal fixation for improving postoperative mortality in patient populations commonly encountered in clinical practice.

We conducted a study to examine the mortality differences between joint reconstruction and internal fixation for femoral neck fracture. Using a retrospective dataset of inpatient discharge records from the Commonwealth of Pennsylvania linked to public death records, we sought to test the hypothesis that, among comparable patients, joint reconstruction with hemiarthroplasty or THA would be associated with increased inpatient mortality when compared with internal fixation. To evaluate if mortality differences between patients having internal fixation or hemiarthroplasty continued beyond the hospital period, we compared the odds of mortality 30 days after hospital admission.

## Materials and Methods

### Data Sources

We obtained inpatient discharge abstracts from the Pennsylvania Health Care Cost Containment Council (PHC4), which collects information on all admissions to acute-care hospitals within the Commonwealth of Pennsylvania. The available dataset consisted of discharge abstracts for all inpatients admitted to an acute-care hospital in Pennsylvania with a principal or secondary diagnosis of femoral neck fracture (*International Classification of Diseases, Ninth Revision, Clinical Modification* [ICD-9-CM] diagnosis codes 820.00-09, 820.10-9, 820.8, 820.9) for the period from October 1, 2005 to September 30, 2007. For each patient, we defined the first admission for a femoral neck fracture within this period as the index admission. Each index admission file was linked, using a patient-specific identifier, to all other admissions to acute-care hospitals in Pennsylvania in the preceding 180 days. PHC4 linked index record files to vital statistics data maintained by the Pennsylvania Department of Health to indicate mortality in the 30 days after hospital admission on the basis of social security number, birth date, and sex. Variables were provided by PHC4 regarding the sequence and number of calendar days between hospitalizations for a given patient, and between the index hospitalization and date of death. The study was approved by the institutional review board of Perelman School of Medicine at the University of Pennsylvania.

### Definition of Study Groups

Our initial sample included 15,406 admissions for femoral neck

fracture. For patients with multiple admissions for hip fracture, we considered the admission occurring earliest as the index admission. We classified patients with a principal or secondary ICD-9-CM procedure code of 78.55, 79.15, or 79.35 as undergoing internal fixation with closed or open reduction. We classified patients with a principal or secondary ICD-9-CM procedure code of 81.52 (hemiarthroplasty) or 81.51 (THA) as undergoing joint reconstruction. Patients with records indicating both fixation and joint reconstruction within a single hospitalization were assigned to the fixation group on the basis of the clinical reasoning that joint reconstruction in these patients may have been a secondary procedure required to treat complications of a primary fixation procedure. We excluded patients younger than 50 years (685 patients), patients whose discharge record did not indicate joint reconstruction or fixation (1457 patients), and patients with concomitant femoral shaft fractures (ICD-9-CM codes 821.01 and 821.11; 14 patients) or acetabular fractures (ICD-9-CM code 808.01; 31 patients). We excluded patients whose permanent residence was outside Pennsylvania (352 patients) because of the inability to observe postdischarge outcomes among this group.

### Control Variables

Patient age, sex, and hospital data were obtained from the discharge abstracts for study admissions. Comorbidities were obtained from discharge diagnosis fields using algorithms published by Quan and colleagues<sup>17</sup> based on definitions advanced by Elixhauser and colleagues.<sup>18</sup> We included all principal and secondary diagnoses in hospital admissions occurring in the 180 days preceding the index admission, as well as secondary diagnosis codes for the index admission.

### Statistical Analyses

As the clinical indications for arthroplasty and fixation for femoral neck fractures differ according to patient age, we performed all analyses on the full study sample (patients older than 18 years) and on the subset of patients 70 years and older. To assess for differences in key independent and dependent variables between study groups, we used the Student t-test for continuous variables and the Pearson  $\chi^2$  test for categorical variables.

To assess the relative odds of inpatient and 30-day mortality among patients who had joint replacement or fixation, we developed adjusted logistic regression models. We evaluated 31 Elixhauser comorbidities for inclusion in the model and selected those found in unadjusted analyses to be associated with inpatient mortality at  $P < .1$ ; age and sex were included in the regression model based on clinical relevance. Model discrimination was assessed using the C statistic. Based on this model, we developed conditional logistic regressions, clustering on hospital, to evaluate mortality differences between surgical treatment groups while controlling for hospital effects.

To evaluate the extent to which our results may have been explained by differential use of joint reconstruction versus internal fixation in older versus younger patients, we repeated these models in a sample restricted to adults aged 70 years and older. Finally, to assess the sensitivity of our results to our selec-

**Table I. Baseline Characteristics and Outcomes in Patients With Femoral Neck Fracture Treated With Joint Reconstruction or Internal Fixation, Pennsylvania, 2005–2007**

Patients aged 50 years and older			
	Reconstruction n=8896	Internal Fixation n=3971	P
Age (SD)	81.5 (8.9)	79.0 (10.9)	<0.0001
Male (%)	28.1	27.6	0.609
Congestive heart failure (%)	21.1	18.7	0.002
Chronic obstructive pulmonary disease (%)	23.0	23.8	0.337
Chronic renal insufficiency (%)	12.3	11.6	0.276
Solid tumor (%)	1.3	2.0	0.001
Metastatic cancer (%)	1.4	1.9	0.052
Weight loss (%)	3.5	3.8	0.353
Mortality (%): In-hospital	2.3	1.3	<0.0001
Mortality (%): 30-day	6.5	5.0	<0.0001
Patients aged 70 years and older			
	Reconstruction n=7994	Internal Fixation n=3235	P
Age (SD)	83.7 (6.2)	83.2 (6.4)	<0.0001
Male (%)	26.9	27.7	0.111
Congestive heart failure (%)	22.1	20.9	0.169
Chronic obstructive pulmonary disease (%)	22.3	23.8	0.093
Chronic renal insufficiency (%)	12.7	12.3	0.637
Solid tumor (%)	1.1	2.0	<0.0001
Metastatic cancer (%)	1.3	1.8	0.048
Weight loss (%)	3.6	4.1	0.156
Mortality (%): In-hospital	2.6	1.4	<0.0001
Mortality (%): 30-day	7.1	5.9	0.014

Abbreviation: SD, standard deviation.

tion of joint reconstruction procedures for study, we replicated all analyses in a sample excluding THA patients.

**Results**

After exclusions, we obtained a study sample of 12,867 patients admitted with femoral neck fracture. Of these patients, 8896 (69.1%) had a joint reconstruction procedure, 3866 (30.0%) had internal fixation, and 105 (0.8%) had both reconstruction and fixation. For analysis purposes, the patients who had both procedures were combined with the patients who had fixation only. Of the 9001 patients who had reconstruction, 8184 (90.9%) had hemiarthroplasty, and 817 (9.1%) had THA.

Table I presents unadjusted comparisons of the study groups. In the overall sample, joint replacement patients were older, had more congestive heart failure (CHF), and had fewer solid malignancies. The magnitude of these differences reflected the preferential use of joint replacement in older patient groups; among

patients aged 70 years and older, those who had joint reconstruction were slightly older than those who had internal fixation, but there was no significant difference in CHF incidence.

Our logistic regression model for inpatient mortality included controls for age, sex, and 13 Elixhauser comorbidities associated with inpatient mortality at P<0.1 in unadjusted comparisons. Comorbidities included CHF, cardiac valvular disorders, prior arrhythmia, uncomplicated hypertension, complicated hypertension, chronic obstructive pulmonary disease, pulmonary vascular disease, renal insufficiency, electrolyte abnormalities, coagulopathy, hypothyroidism, weight loss, and depression. The C statistic for the full model was 0.81.

Adjusted logistic regression (Table II) showed that among the full patient sample, the odds of inpatient mortality were higher for patients who had joint reconstruction than for patients who had internal fixation (odds ratio [OR], 1.62; 95% confidence interval [CI], 1.18–2.23; P = .003). However, the difference in

**Table II. Adjusted Logistic Regression Output for Mortality in Patients With Femoral Neck Fracture Treated With Joint Reconstruction or Internal Fixation**

Patients aged 50 years and over			
	Adjusted OR*	95% CI	P
Mortality: in-hospital	1.62	1.18, 2.23	0.003
Mortality: 30-day	1.18	1.00, 1.41	0.053
Patients aged 70 years and over			
	Adjusted OR*	95% CI	P
Mortality: in-hospital	1.69	1.22, 2.35	0.002
Mortality: 30-day	1.17	0.98, 1.39	0.080

Abbreviations: CI, confidence interval; OR, odds ratio.

\*The full logistic regression model included an indicator variable for joint reconstruction versus internal fixation as well as controls for age, sex, weight loss, valvular disorders, prior arrhythmia, congestive heart failure, coagulopathy, chronic obstructive pulmonary disease, depression, electrolyte abnormality, hypertension (uncomplicated), hypertension (complicated), hypothyroidism, pulmonary vascular disease, and renal insufficiency. C-statistic = 0.81.

**Table III. Conditional Logistic Regression Output for Mortality in Patients With Femoral Neck Fracture Treated With Joint Reconstruction or Internal Fixation, Controlling for Patient and Hospital Effects**

Patients aged 50 years and over			
	Adjusted OR*	95% CI	P
Mortality: in-hospital	1.65	1.19, 2.28	0.003
Mortality: 30-day	1.22	1.02, 1.46	0.026
Patients aged 70 years and over			
	Adjusted OR*	95% CI	P
Mortality: in-hospital	1.71	1.22, 2.39	0.002
Mortality: 30-day	1.20	1.00, 1.43	0.048

Abbreviations: CI, confidence interval; OR, odds ratio.

\*The conditional logistic regression model included an indicator variable for joint reconstruction versus internal fixation as well as controls for age, sex, weight loss, valvular disorders, prior arrhythmia, congestive heart failure, coagulopathy, chronic obstructive pulmonary disease, depression, electrolyte abnormality, hypertension (uncomplicated), hypertension (complicated), hypothyroidism, pulmonary vascular disease, and renal insufficiency; the regression was clustered according to 98 hospital identifiers.

the odds of 30-day mortality was not statistically significant (OR, 1.18; 95% CI, 1.00–1.41;  $P = .053$ ). We found a similar pattern in samples limited to patients aged 70 years and older.

On the basis of the original regression model, we developed conditional logistic regressions, clustering on hospital, to evaluate mortality differences according to treatment type while controlling for both patient and hospital effects (Table III). After controlling for hospital, we found higher odds of mortality after joint reconstruction than after internal fixation among the full study sample both during hospitalization (OR, 1.65; 95% CI, 1.19–2.28;  $P = .003$ ) and at 30 days (OR, 1.20; 95% CI, 1.02–1.46;  $P = .026$ ) (Table IV). Again, regressions restricted to patients aged 70 years and older yielded similar results (Table V).

Lastly, to evaluate the possibility that the mortality differences between joint reconstruction and internal fixation could be caused by the inclusion of THA patients in the joint

reconstruction group, we replicated all analyses in a sample excluding the 817 THA patients in our original sample. These results (Tables IV and V) did not differ systematically from our main study results but did show a significant association between hemiarthroplasty and increased mortality at 30 days among all patients aged 50 years and older (OR, 1.21; 95% CI, 1.02–1.44;  $P = .033$ ).

## Discussion

Our study of 12,867 patients with femoral neck fracture finds more than a 60% increase in the odds of death during hospitalization among patients who had joint reconstruction than among patients who had internal fixation of fracture components. These findings persist after controlling for age, sex, comorbidities, and hospital effects. Although regressions controlling for patient factors alone demonstrated no differences in 30-day mortality according to surgical procedure, we found

**Table IV. Adjusted Logistic Regression Output for Mortality in Patients With Femoral Neck Fracture Treated With Hemiarthroplasty or Internal Fixation**

Patients aged 50 years and over			
	Adjusted OR*	95% CI	P
Mortality: in-hospital	1.68	1.22, 2.31	0.001
Mortality: 30-day	1.21	1.02, 1.44	0.033
Patients aged 70 years and over			
	Adjusted OR*	95% CI	P
Mortality: in-hospital	1.75	1.26, 2.43	0.001
Mortality: 30-day	1.19	1.00, 1.42	0.053

Abbreviations: CI, confidence interval; OR, odds ratio.

\*The full logistic regression model included an indicator variable for hemiarthroplasty versus internal fixation as well as controls for age, sex, weight loss, valvular disorders, prior arrhythmia, congestive heart failure, coagulopathy, chronic obstructive pulmonary disease, depression, electrolyte abnormality, hypertension (uncomplicated), hypertension (complicated), hypothyroidism, pulmonary vascular disease, and renal insufficiency. C-statistic = 0.81.

**Table V. Conditional Logistic Regression Output for Mortality in Patients With Femoral Neck Fracture Treated With Hemiarthroplasty or Internal Fixation, Controlling for Patient and Hospital Effects**

Patients aged 50 years and over			
	Adjusted OR*	95% CI	P
Mortality: in-hospital	1.74	1.25, 2.42	0.001
Mortality: 30-day	1.25	1.04, 1.49	0.015
Patients aged 70 years and over			
	Adjusted OR*	95% CI	P
Mortality: in-hospital	1.76	1.25, 2.47	0.001
Mortality: 30-day	1.21	1.01, 1.46	0.035

Abbreviations: CI, confidence interval; OR, odds ratio.

\*The conditional logistic regression model included an indicator variable for hemiarthroplasty versus internal fixation as well as controls for age, sex, weight loss, valvular disorders, prior arrhythmia, congestive heart failure, coagulopathy, chronic obstructive pulmonary disease, depression, electrolyte abnormality, hypertension (uncomplicated), hypertension (complicated), hypothyroidism, pulmonary vascular disease, and renal insufficiency; the regression was clustered according to 98 hospital identifiers.

a significant relationship between surgery type and mortality at 30 days from hospital admission.

These findings provide important insights regarding the comparative effectiveness of current treatments for femoral neck fracture among older adults. Clinical trials have shown that hemiarthroplasty and THA after displaced femoral neck fracture improve functional outcomes and lower the rates of orthopedic complications.<sup>9,19-25</sup> However, these trials have produced conflicting results regarding the magnitude of immediate risk posed by the more extensive surgical and anesthetic requirements of joint reconstruction approaches compared with internal fixation. Our findings argue that the potential benefits of joint reconstruction, as it is currently used, may come at the cost of higher odds of inpatient mortality. As our results were conflicting with regard to the association of surgery type and 30-day mortality in regressions with and without controls for hospital, they cannot support definitive conclusions regarding an association between

repair type and mortality after hospitalization.

Our findings have important implications for medical decision making in the context of current orthopedic practice. According to results from 3 meta-analyses of randomized clinical trials and results from later well-designed trials, hemiarthroplasty is the predominant approach to managing femoral neck fractures in older adults,<sup>10,26,27</sup> with an emerging trend toward increased use of total joint replacement procedures in this population.<sup>28</sup> Our study results do not invalidate the potential benefits of partial or total joint replacement for patients capable of surviving the procedure; however, our results do suggest that in subsets of vulnerable patients, the short-term risks of joint reconstruction approaches to femoral neck fracture may not be trivial. Such risks raise the possibility that there may be patient subgroups for whom a desire to minimize the odds of short-term mortality could make internal fixation preferable to joint reconstruction.



Our findings must be interpreted in the context of several key limitations. As with all observational studies of retrospective data, our results may reflect the effect of unobservable differences between the treatment groups in key dimensions such as disease severity or prefracture functional status. We have sought to minimize this concern by controlling for a range of potential confounders. Furthermore, although patients who had hemiarthroplasty appeared in the full patient sample to be older, with a higher burden of comorbidities, our analysis of the subgroup of patients older than age 70 years suggests that this finding is an artifact of the preferential use of hemiarthroplasty among older patients. Notably, among patients older than 70 years, the association between joint replacement and inpatient mortality persisted despite a few observable differences between study groups.

Even though hospital discharge records allowed us to distinguish femoral neck fractures from other hip fracture types, our dataset did not include information on fracture displacement or reducibility. Therefore, we are unable to comment on the extent to which fracture displacement differences potentially explain our outcome differences. Moreover, we did not examine outcomes associated with specific fixation techniques, and thus are unable to comment in more detail as to whether one specific hip fracture fixation method may be associated with lower mortality odds. Given the nature of hospital discharge data, we were unable to examine functional outcomes after either operative treatment.

Despite these limitations, our findings have important implications for health-care policy and practice. Although not arguing categorically for or against either treatment for femoral neck fracture, our results suggest that the potential functional benefits of joint reconstruction procedures may need to be balanced against higher relative odds of inpatient mortality compared with internal fixation procedures. These findings highlight potential opportunities to improve both the patient-centeredness and effectiveness of hip fracture surgery through further research on the risks of competing treatments for subsets of vulnerable patients. Our findings also offer opportunities for work aimed at better defining patient preferences related to the short- and long-term risks associated with alternative therapies for femoral neck fracture.

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