JAMA | Original Investigation

# Association Between Uncemented vs Cemented Hemiarthroplasty and Revision Surgery Among Patients With Hip Fracture

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**IMPORTANCE** Consensus guidelines and systematic reviews have suggested that cemented fixation is more effective than uncemented fixation in hemiarthroplasty for displaced femoral neck fractures. Given that these recommendations are based on research performed outside the United States, it is uncertain whether these findings also reflect the US experience.

**OBJECTIVE** To compare the outcomes associated with cemented vs uncemented hemiarthroplasty in a large US integrated health care system.

**DESIGN, SETTING, AND PARTICIPANTS** Retrospective cohort study of 12 491 patients aged 60 years and older who underwent hemiarthroplasty treatment of a hip fracture between 2009 and 2017 at 1 of the 36 hospitals owned by Kaiser Permanente, a large US health maintenance organization. Patients were followed up until membership termination, death, or the study end date of December 31, 2017.

**EXPOSURES** Hemiarthroplasty (prosthetic replacement of the femoral head) fixation via bony growth into a porous-coated implant (uncemented) or with cement.

**MAIN OUTCOMES AND MEASURES** The primary outcome measure was aseptic revision, defined as any reoperation performed after the index procedure involving exchange of the existing implant for reasons other than infection. Secondary outcomes were mortality (in-hospital, postdischarge, and overall), 90-day medical complications, 90-day emergency department visits, and 90-day unplanned readmissions.

**RESULTS** Among 12 491 patients in the study cohort who underwent hemiarthroplasty for hip fracture (median age, 83 years; 8660 women [69.3%]), 6042 (48.4%) had undergone uncemented fixation and 6449 (51.6%) had undergone cemented fixation, and the median length of follow-up was 3.8 years. In the multivariable regression analysis controlling for confounders, uncemented fixation was associated with a significantly higher risk of aseptic revision (cumulative incidence at 1 year after operation, 3.0% vs 1.3%; absolute difference, 1.7% [95% CI, 1.1%-2.2%]; hazard ratio [HR], 1.77 [95% CI, 1.43-2.19]; $P < .001$). Of the 6 prespecified secondary end points, none showed a statistically significant difference between groups, including in-hospital mortality (1.7% for uncemented fixation vs 2.0% for cemented fixation; HR, 0.94 [95% CI, 0.73-1.21]; $P = .61$) and overall mortality (cumulative incidence at 1 year after operation: 20.0% for uncemented fixation vs 22.8% for cemented fixation; HR, 0.95 [95% CI, 0.90-1.01]; $P = .08$).

**CONCLUSIONS AND RELEVANCE** Among patients with hip fracture treated with hemiarthroplasty in a large US integrated health care system, uncemented fixation, compared with cemented fixation, was associated with a statistically significantly higher risk of aseptic revision. These findings suggest that US surgeons should consider cemented fixation in the hemiarthroplasty treatment of displaced femoral neck fractures in the absence of contraindications.

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For treatment of displaced femoral neck fractures in older patients, hip arthroplasty (prosthetic joint replacement) is the standard approach[1] and is preferred over fracture fixation. Because of the tenuous blood supply of the proximal femur, fracture fixation is associated with high rates of nonunion (5%-28%) and avascular necrosis (5%-18%).[2] Although total hip arthroplasty (replacement of the femoral head and acetabulum) and hemiarthroplasty (replacement of the femoral head only) both represent viable treatment options,[3] most older patients with displaced femoral neck fracture are currently treated with hemiarthroplasty.[4]

During hip arthroplasty, fixation of the femoral stem can be accomplished with cement (**Figure 1**A) or via bony growth into a porous-coated implant (uncemented; Figure 1B), with the choice of the fixation technique based on surgeon preference. In elective total hip arthroplasty (ie, for arthritis), uncemented femoral components are currently favored by US orthopedic surgeons, whereas cemented stems are preferred by European orthopedists.[5]

Since 2010, systematic reviews[6] and consensus guidelines[1] have emerged suggesting that cementation may represent a more effective form of fixation in hemiarthroplasty procedures, with recommendations based on studies that reported cemented hemiarthroplasties were associated with lower risks of periprosthetic fracture[7-9] and revision surgery,[7] as well as higher levels of function[8-10] and patient satisfaction.[8] However, as of 2017, an estimated 60% of hemiarthroplasty procedures in the United States did not use cement.[11] Some reasons for a surgeon not to use cement may include longer procedure times, risk of bone cement implantation syndrome,[12] and lack of familiarity with the technique.

Given that all but one of the prior studies on this topic were performed outside the US, it remains uncertain whether these findings reflect the US experience. The purpose of this study was to compare the outcomes associated with cemented vs uncemented hemiarthroplasty in a large US integrated health care system.

### Key Points

**Question** What is the association between femoral stem fixation technique (uncemented vs cemented) and outcomes for patients undergoing hemiarthroplasty for hip fracture?

**Findings** In this retrospective cohort study of 12 491 patients who underwent hemiarthroplasty for hip fracture in a large US health maintenance organization, uncemented fixation was associated with a significantly higher risk of aseptic revision compared with cemented fixation (cumulative incidence, 3.0% vs 1.3% at 1 year after operation, respectively).

**Meaning** Among patients with hip fracture treated with hemiarthroplasty in a large integrated health care system in the US, uncemented fixation was associated with a statistically significantly higher risk of aseptic revision compared with cemented fixation.

## Methods

### Study Design and Data Source

This retrospective cohort study was approved by the Kaiser Permanente institutional review board prior to its commencement, including an exemption of informed consent. The study was conducted using the Kaiser Permanente Hip Fracture Registry, a database that captures information on all surgically treated hip fractures occurring within Kaiser Permanente, an integrated health care system covering more than 12 million members. The details of this registry—including data collection, participation, and other elements—have been previously published.[13,14] In brief, the registry collects data on patient demographics, medical comorbidities, procedure details, complications, and outcomes using information from the electronic medical record as well as other databases contained within Kaiser Permanente. The registry's coverage is 100% of surgically treated hip fractures occurring within Kaiser Permanente hospitals.

### Inclusion and Exclusion Criteria

Patients aged 60 years and older who underwent hemiarthroplasty treatment of a hip fracture at a Kaiser Permanente facility (Northern California, Southern California, Hawaii, and Northwest regions) between 2009 and 2017 were included in this study. Cases were excluded if they involved metastatic cancer, pathologic fracture, prior surgery or infection in the affected hip, or bilateral hip fracture or had missing implant data.

### Type of Femoral Fixation

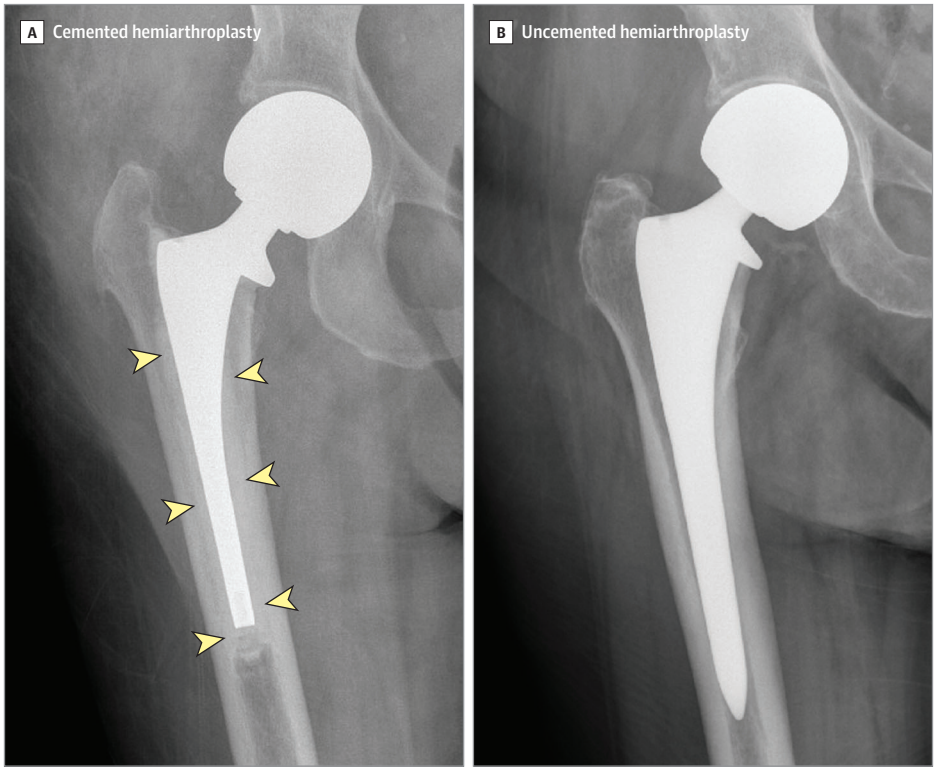
In the Kaiser Permanente system, the data for all implants (including cement) are entered into the electronic medical record at the time of implantation via a barcode scan. This detailed implant information is extracted from the electronic medical record by the registry and reviewed by clinical content experts, who classify each implant into its respective category (eg, cement). In this study, hemiarthroplasty procedures in which cement was implanted were categorized as cemented, and those in which cement was not used were categorized as uncemented.

### Clinical Outcomes

The primary outcome measure in this study was aseptic revision, which was chosen as a clinically meaningful end point with the potential to vary by fixation technique, as based on prior research.[7] Aseptic revision was defined as any reoperation performed after the index procedure involving an implant exchange for reasons other than infection. Aseptic revision was manually validated via medical record review by trained research associates to ensure accuracy, and was continuously monitored until membership termination, death, or study end date (December 31, 2017).

Secondary outcome measures included mortality (in-hospital, postdischarge, and overall), 90-day medical complications, 90-day emergency department (ED) visits, and 90-day unplanned readmissions. Mortality information was obtained from the Social Security Administration, thus capturing all patients regardless of their insurance at the time

Figure 1. Cemented and Uncemented Hemiarthroplasty




A, Example of hemiarthroplasty in which fixation of the femoral stem has been achieved with cement (arrowheads). B, Example of hemiarthroplasty in which fixation of the femoral stem has been achieved via bony growth into a porous-coated implant (uncemented).

of death. Ninety-day medical complications included pneumonia, acute myocardial infarction, deep venous thrombosis, and pulmonary embolism, and were defined according to the Agency for Healthcare Research and Quality (AHRQ) quality indicators.[15] Deep venous thrombosis and pulmonary embolism were manually validated by clinical content experts to ensure database accuracy, including confirmation via ultrasound and/or computed tomography reports. ED visits included any ED encounter in the Kaiser Permanente system within 90 days of discharge, and readmission was defined as any rehospitalization within the Kaiser Permanente system in the 90 days following discharge.

## Covariates

Given that some surgeons may be more likely to select cemented fixation in patients who are older or have lower expected bone mineral density, the group of patients treated with cemented fixation differed from the group treated with uncemented fixation. To account for these differences, a series of potential confounders were controlled for including age, sex, American Society of Anesthesiologists (ASA) classification, body mass index, other medical comorbidities (chronic kidney disease, diabetes, chronic pulmonary disease, psychoses, alcohol misuse, and liver disease), and type of anesthesia (general, including conversion from regional to general, or regional). Comorbid conditions were identified using Elixhauser's algorithm[16] within 1 year prior to the surgery. To account for any potential time effect (eg, due to changes in technology or in practice over time), procedure year was also controlled for in the multivariable analysis.

## Statistical Analysis

Follow-up time for revision and overall mortality was defined as the time from the index procedure to the date of revision surgery, death, membership termination, or study end date, whichever came first. Follow-up time for postdischarge mortality was defined as the time from the index procedure to the date of death or the study end date, whichever came first. Median follow-up time was calculated using the reverse Kaplan-Meier method.[17]

Unadjusted incidence was calculated as the cumulative incidence at 1 year after operation for time-to-event outcomes (aseptic revision, overall mortality, and postdischarge mortality), and as the proportion of events per number at risk for the remaining outcomes (in-hospital mortality, 90-day medical complications, 90-day ED visits, and 90-day readmission). For time-to-event outcomes, the unadjusted absolute difference was calculated based on the cumulative incidence at 1-year follow-up.

Aseptic revision and mortality were considered as competing events and modeled as time-to-event outcomes using mixed-effect Cox proportional hazard regression in a cause-specific hazard model. Patients who experienced septic revision or membership termination were censored. The cause-specific hazard model allowed estimation of the association between covariates and the rate of occurrence of the outcome in those patients who are currently event free (ie, patients who are still alive and have not undergone revision surgery).[18] In-hospital and postdischarge mortality were analyzed in the same survival model using a time-dependent covariate. Time of health care membership termination was

included as a censored event in the regression models. Ninety-day outcomes (medical complications, ED visits, and readmission) were analyzed using multiple logistic regression in a generalized linear mixed model. In the multivariable analysis, which was performed for both the main and instrumental variable analyses, all of the potential confounders described above were included as fixed effects. In addition, a random intercept for operating surgeon was also included as a random effect in the models. A random variable for hospital was considered but not included due to concerns regarding collinearity with the surgeon variable (because most surgeons only operate at a single hospital). Only patients who did not have in-hospital mortality were included in the ED visit and readmission analyses. Surgeon variability was addressed via a random intercept in patient outcome, which improved the model's ability to describe how fixed effects relate to outcomes.

The proportional hazards assumption for the exposure variable was checked by plotting the Schoenfeld residuals against the vector of unique failure times and met, implying that the factor investigated had a constant effect on the hazard—or risk—over time. To account for missing values, fully conditional specification multiple imputations using the Markov chain Monte Carlo estimation method was performed to create 50 versions of the analytic data set. Each data set was separately analyzed using the same model and the results were combined using Rubin's rules.[19] The imputation model included all variables and the baseline hazard function.[20] Hazard ratios (HRs) are presented for time-to-event outcomes and odds ratios (ORs) are presented for 90-day outcomes, both along with 95% CIs. Analyses were performed using R version 3.3.0 (module tidyverse for data preparation, mice for multiple imputation by chained equations, coxme for mixed effects Cox modeling, lme4 for the linear mixed effect model, and ggplot2 for figures). $P < .05$ was the statistical significance threshold used for this study and all tests were 2-sided. Because of the potential for type I error due to multiple comparisons, findings for analyses of secondary end points should be interpreted as exploratory.

### Secondary Analysis

A secondary analysis using surgeon preference for type of femoral fixation as an instrumental variable was also conducted.[21,22] While the typical surgeon might select cemented or uncemented fixation based on patient characteristics, surgeons with a strong preference for fixation type are less likely to deviate from their preferred method of fixation based on the characteristics of the patient before them. As such, there are fewer systematic differences expected between the groups of patients treated by these surgeons. Specifically, surgeon preference for type of femoral fixation represents a viable candidate for an instrumental variable analysis because (1) the instrumental variable (surgeon preference for femoral fixation type) is associated with the treatment (type of femoral fixation); (2) the instrumental variable (surgeon preference) is not clearly associated with unmeasured confounders after conditioning on measured confounders; and (3) the instrumental variable (surgeon preference) affects the outcome only through the treatment (type of femoral fixation).[23,24]

To perform this instrumental variable analysis, patients treated by surgeons who demonstrated a strong preference for cemented fixation (those who used cemented fixation >90% of the time; n = 35 surgeons) were compared with patients treated by surgeons who demonstrated a strong preference for uncemented fixation (those who used uncemented fixation >90% of the time; n = 31 surgeons) (minimum cumulative volume of 30 cases; eFigure in the Supplement). The surgeons comprising these 2 groups were also compared with one another to determine whether they differed on the basis of factors (other than femoral fixation preference), which could theoretically influence clinical outcomes (including measures of experience and adherence to quality measures).

### Post Hoc Analysis

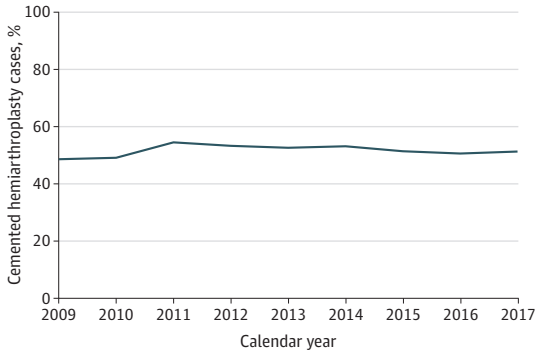
To characterize the differences in aseptic revision risk that were observed between cemented and uncemented fixation, the 1-year cumulative revision risks were assessed by the reason for revision, including periprosthetic fracture. Cumulative incidence was calculated using the Andersen-Johansen estimate, which accounted for the competing risks of death and other revision reasons, and censored patients if they had not experienced any event. In addition, to determine whether the risk of aseptic revision associated with uncemented fixation was confined to a certain age group, the aseptic revision risk was evaluated by stratified age group (60-69, 70-79, 80-89, and >90 years old) using a log-likelihood ratio test for the interaction between fixation and age group.

## Results

Of 12 491 patients who underwent hemiarthroplasty treatment of a hip fracture during the study period (January 1, 2009, to December 31, 2017), 51.6% received cemented fixation (n = 6449) and 48.4% received uncemented fixation (n = 6042). This proportion of cemented fixation remained constant over time (**Figure 2**). The procedures were performed by 481 surgeons at 36 hospitals. For the overall cohort, the median patient age was 83 years and 69.3% (n = 8660/12 491) were women, and 75.8% (9259/12 213) had an ASA classification of 3 or greater (**Table 1**). Data were missing on ASA classification for 278 patients (2.2%), on body mass index for 137 patients (1.1%), and on anesthesia type for 4 patients (0.03%). The crude 1-year mortality rate was 20.9% (2613/12 491), and the median follow-up time was 3.8 years (minimum, 1 year; maximum, 9 years).

In the main multivariable analysis controlling for potential confounders, patients receiving uncemented fixation had a significantly higher risk of aseptic revision (cumulative incidence at 1 year following operation, 3.0% vs 1.3%; absolute difference, 1.7% [95% CI, 1.1%-2.2%]; HR, 1.77 [95% CI, 1.43-2.19]; $P < .001$) (**Table 2**). In a post hoc analysis, this difference in aseptic revision rates was primarily due to a difference in the rate of periprosthetic fracture, which was significantly higher for uncemented fixation (cumulative

Figure 2. Proportion of Hemiarthroplasty Cases Performed With Cement, by Year




| No. at risk | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Uncemented | 532 | 683 | 587 | 640 | 619 | 614 | 700 | 835 | 832 |
| Cemented | 503 | 659 | 703 | 730 | 687 | 696 | 740 | 855 | 876 |

The proportion of hemiarthroplasty cases performed with cement (solid line) remained relatively constant over time.

incidence at 1 year following operation, 1.6% [95% CI, 1.3%-1.9%]) than for cemented fixation (cumulative incidence at 1 year following operation, 0.2% [95% CI, 0.1%-0.4%]). Uncemented fixation was associated with higher aseptic revision rates in all age groups, although the HR was higher among older patients (HR range, 1.21-2.78; interaction $P = .007$). There were no statistically significant differences in the risks of mortality, 90-day medical complications, 90-day ED visits, or 90-day readmission (Table 2).

In the secondary analysis, surgeon preference for type of femoral fixation was used as an instrumental variable. The patients treated by surgeons with a preference for cemented fixation underwent cemented hemiarthroplasty 95.3% (1651/1733) of the time, while patients treated by surgeons with a preference for uncemented fixation underwent cemented fixation 2.9% (50/1751) of the time (standardized difference, 4.84). Aside from fixation preference, the surgeons included in this analysis were not found to differ on the basis of parameters measured by the registry (all standardized differences >0.2).[26] Likewise, the patients treated by these 2 groups of surgeons were not found to differ with regard to measured baseline characteristics (all standardized differences >0.2; eTable in the Supplement). In this instrumental variable analysis, uncemented fixation was also found to be associated with a significantly higher risk of aseptic revision (cumulative incidence at 1 year following operation, 2.6% vs 1.0%; HR, 1.74 [95% CI, 1.10-2.75]; $P = .02$). There were no statistically significant differences in the risks of mortality, 90-day medical complications, 90-day ED visits, or 90-day readmission (Table 2).

## Discussion

In this study of 12 491 patients with hip fracture who underwent hemiarthroplasty in a large US integrated health care system, uncemented femoral fixation was associated with a significantly higher risk of aseptic revision compared with cemented femoral fixation. The magnitude of this risk was consistent across the 2 methods of analysis used in the study. With regard to medical complications and perioperative mortality, the rates were not significantly different between the cemented and uncemented groups. These findings suggest that the better outcome associated with cemented hemiarthroplasty performed for fracture may exist even in settings where uncemented fixation represents the usual mode of femoral fixation in elective total hip arthroplasty (in the Kaiser Permanente system, 93% of primary total hip arthroplasty procedures performed for elective conditions, such as arthritis, are uncemented).

While prior research comparing cemented and uncemented femoral fixation in elective total hip arthroplasty has generally been inconclusive,[27] studies of patients undergoing hemiarthroplasty for femoral neck fracture have generally favored cemented fixation. Parker and colleagues[10] conducted a randomized clinical trial involving 400 patients

Table 1. Characteristics of 12 491 Hemiarthroplasty Procedures, by Type of Femoral Fixation (Main Analysis)

| | Cemented hemiarthroplasty group (n = 6449) | Uncemented hemiarthroplasty group (n = 6042) |
|---|---|---|
| **Demographics** | | |
| Age, median (IQR), y | 84 (78-89) | 82 (75-87) |
| Sex | | |
| Women | 4586 (71.1) | 4074 (67.4) |
| Men | 1863 (28.9) | 1968 (32.6) |
| **Medical comorbidities** | | |
| ASA classification ≥3[a] | 4881 (76.8) [n = 6357] | 4378 (74.8) [n = 5856] |
| BMI, median (IQR) | 23.1 (20.4-26.2) | 23.5 (20.9-26.5) |
| <22.0 | 2472/6386 (38.7) | 2100/5968 (35.2) |
| 22.0-24.9 | 1731/6386 (27.1) | 1673/5968 (28.0) |
| 25.0-29.9 | 1683/6386 (26.4) | 1671/5968 (28.0) |
| ≥30 | 500/6386 (7.8) | 524/5968 (8.8) |
| Chronic kidney disease | 2280 (35.4) | 1938 (32.1) |
| Diabetes | 1780 (27.6) | 1725 (28.6) |
| Chronic pulmonary disease | 1525 (23.6) | 1570 (26.0) |
| Psychoses | 974 (15.1) | 1014 (16.8) |
| Alcohol misuse | 295 (4.6) | 339 (5.6) |
| Liver disease | 237 (3.7) | 220 (3.6) |
| **Anesthesia type** | n = 6448 | n = 6039 |
| General | 3661 (56.8) | 3364 (55.7) |
| Regional | 2787 (43.2) | 2675 (44.3) |
| **Operating surgeon** | | |
| Hip fracture cases per year, median (IQR) | 18 (14-24) | 18 (13-26) |

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); IQR, interquartile range.

[a] The ASA classification is a subjective assessment of a patient's medical comorbidities, which is assigned by the anesthesiologist at the time of surgery. Possible classifications include 1 (normal healthy patient), 2 (mild systemic disease), 3 (severe systemic disease), 4 (severe systemic disease that is a constant threat to life), and 5 (moribund patient who is not expected to survive without the operation).[25]

Table 2. Complications Following Hemiarthroplasty for the Treatment of Hip Fracture

| Outcome | Main analysis | | | | | Instrumental variable analysis[a] | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No./total No. (%) | | Value (95% CI) | | | No./total No. (%) | | Value (95% CI) | | |
| | Cemented hemiarthroplasty | Uncemented hemiarthroplasty | Unadjusted absolute difference | Adjusted effect estimate[b] | *P* Value | Cemented hemiarthroplasty | Uncemented hemiarthroplasty | Unadjusted absolute difference | Adjusted effect estimate[b] | *P* Value |
| **Primary outcome** | | | | | | | | | | |
| Aseptic revision | 136/6449 (1.3)[c] | 239/6042 (3.0)[c] | 1.7 (1.1 to 2.2)[d] | 1.77 (1.43 to 2.19) | <.001 | 35/1733 (1.0)[c] | 55/1751 (2.6)[c] | 1.5 (0.7 to 2.4)[d] | 1.74 (1.10 to 2.75) | .02 |
| **Secondary outcomes** | | | | | | | | | | |
| Mortality | | | | | | | | | | |
| Overall | 2953/6449 (22.8)[c] | 2470/6042 (20.0)[c] | 2.9 (1.4 to 4.3)[d] | 0.95 (0.90 to 1.01) | .08 | 811/1733 (20.1)[c] | 778/1751 (21.2)[c] | 1.1 (−1.6 to 3.9)[d] | 1.05 (0.95 to 1.17) | .35 |
| In-hospital | 129/6449 (2.0) | 101/6042 (1.7) | 0.3 (−0.2 to 0.8) | 0.94 (0.73 to 1.21) | .61 | 32/1733 (1.8) | 28/1751 (1.6) | 0.2 (−0.7 to 1.2) | 1.01 (0.61 to 1.65) | .98 |
| Postdischarge | 2902/6320 (21.8)[c] | 2491/5941 (19.4)[c] | 2.4 (0.9 to 3.9)[d] | 0.96 (0.90 to 1.01) | .11 | 800/1701 (19.1)[c] | 776/1723 (20.6)[c] | 1.5 (−1.3 to 4.2)[d] | 1.06 (0.95 to 1.17) | .29 |
| 90-d Complications | | | | | | | | | | |
| Medical complications | 1026/6449 (15.9) | 883/6042 (14.6) | 1.3 (0.02 to 2.6) | 0.93 (0.83 to 1.03) | .16 | 265/1733 (15.3) | 253/1751 (14.4) | 0.8 (−1.6 to 3.3) | 0.87 (0.69 to 1.09) | .23 |
| ED visits | 1265/6320 (20.0) | 1241/5941 (20.9) | 0.9 (−0.6 to 2.3) | 1.05 (0.96 to 1.15) | .29 | 310/1701 (18.2) | 363/1723 (21.1) | 2.8 (0.1 to 5.6) | 1.15 (0.96 to 1.39) | .13 |
| Readmission | 1208/6320 (19.1) | 1179/5941 (19.8) | 0.7 (−0.7 to 2.2) | 1.04 (0.94 to 1.14) | .45 | 302/1701 (17.8) | 324/1723 (18.8) | 1.1 (−1.6 to 3.7) | 1.03 (0.82 to 1.28) | .81 |

Abbreviation: ED, emergency department.

[a] Secondary analysis using surgeon preference for type of femoral fixation as an instrumental variable.

[b] Multivariable regression models adjusted for age, sex, American Society of Anesthesiologists classification, body mass index, chronic kidney disease, diabetes, chronic pulmonary disease, psychoses, alcohol misuse, liver disease, anesthesia type, operating surgeon, and procedure year. Hazard ratio is reported for time-to-event outcomes (aseptic revision and mortality) and odds ratio is reported for 90-day outcomes.

[c] Unadjusted incidence calculated as cumulative incidence at 1 year following operation.

[d] Absolute difference based on cumulative incidence at 1 year following operation.

who underwent hemiarthroplasty in the United Kingdom and found cemented fixation to be associated with less pain and better mobility. Similarly, Taylor et al[9] performed a randomized clinical trial in 160 patients in New Zealand and found cement to be associated with less subsidence (distal migration of the stem after implantation), less periprosthetic fracture, and better Oxford hip scores. More recently, Inngul and colleagues[8] conducted a randomized clinical trial among 141 patients undergoing arthroplasty for a femoral neck fracture in Sweden and also found cemented fixation to be associated with fewer periprosthetic fractures, as well as better outcomes as measured by the Harris Hip Scale, Short Musculoskeletal Functional Assessment, and EuroQol-5D scores.

The specific reasons for the improved outcomes observed among patients undergoing cemented hemiarthroplasty have not been definitively elucidated. However, one theory is that cemented fixation may better resist periprosthetic fracture among patients with risk factors such as advanced age, osteoporosis, and/or a history of falls.

As a result of these prior studies, the American Academy of Orthopaedic Surgeons' Clinical Practice Guideline on the Management of Hip Fractures in the Elderly recommended the use of cemented femoral stems in patients undergoing arthroplasty for femoral neck fractures.[1] Cochrane systematic reviews on this topic have arrived at similar conclusions.[6]

Despite these recommendations, most hemiarthroplasties performed in the US continue to use uncemented fixation. In an analysis of 2017 data from the American Joint Replacement Registry, for example, uncemented stem designs were still used in 60% of all hemiarthroplasties performed.[11] While the use of cement is somewhat higher in the Kaiser Permanente system, uncemented stems still accounted for nearly half of all the hemiarthroplasty procedures in this study.

There are many possible explanations for the continued use of uncemented hemiarthroplasty fixation in the US. Some surgeons may be concerned regarding the risks of bone cement implantation syndrome, a phenomenon in which patients can experience acute hypoxia and/or hypotension intraoperatively around the time of cement implantation.[12] While mild reductions in systolic blood pressure and oxygen saturation around the time of cement implantation are common (occurring up to 25%-38% of the time), catastrophic cardiovascular collapse resulting in on-table mortality is rare (0.1%-0.4%), especially if appropriate precautions are taken (eg, not using cement in patients with severe cardiorespiratory illness at baseline).[28]

Another reason for the persistence of uncemented hemiarthroplasty in the US may be that cemented fixation takes more time and, if a revision surgery becomes necessary in the future, cement removal can be difficult. Additionally, because most elective total hip arthroplasties in the US are currently performed without cement (95% in the most recent American Joint Replacement Registry report[11]), it is also possible that some surgeons may not feel as comfortable implanting cemented prostheses.

As previously noted, all but one of the prior studies on this topic have been performed outside the US, often in countries where cemented femoral fixation is more commonly used. For example, the rate of cemented femoral fixation in elective total hip arthroplasty for the studies cited above is currently 54% in the United Kingdom,[29] 54% in New Zealand,[30] and 65% in Sweden.[31] This is in comparison with a cementation rate of 5% among elective total hip arthroplasties currently performed in the US.[11]

To our knowledge, only 1 prior study has compared the outcomes following cemented and uncemented hemiarthroplasty in the US. Specifically, DeAngelis and colleagues[32] conducted a randomized clinical trial of patients aged 55 years and older who underwent cemented or uncemented hemiarthroplasty and found no differences between the 2 procedures on any outcome measure including acute postoperative complications, discharge disposition, reoperation, mortality, or functional outcome at 1 year. While this study had many important strengths, it also had a relatively small sample size (n = 125 patients) and there was no follow-up beyond 1 year.[32]

## Limitations

This study has several limitations. First, it was a retrospective analysis. However, the data were collected from the electronic medical record used to provide care in a large integrated health care system with manual validation of multiple outcome measures,[13,33] and the procedures were conducted by a large number of community-based orthopedic surgeons at a variety of facilities in the US, which may increase generalizability. Second, to account for potential differences between the groups, estimates were adjusted for a wide variety of potential confounders in the multivariable analysis. While there is still a risk of residual confounding (incomplete controlling), similar results were documented in an instrumental variable analysis on the basis of surgeon preference for femoral fixation type. Third, the instrumental variable analysis could have been affected if there were differences in surgeon skill that were associated with the choice of femoral fixation technique. However, the 2 groups of surgeons did not have important differences on any measured variable aside from femoral fixation preference (eTable in the Supplement). Fourth, patients did not undergo routine dual-energy x-ray absorptiometry testing so the models were unable to account for bone mineral density, which could affect the risk of periprosthetic fracture. However, all of the patients in the study met the clinical criteria for osteoporosis by definition (having sustained a low-energy hip fracture).[34] Moreover, if low bone density were to have been unevenly distributed between the 2 groups, it would likely have been more common in the cemented group, and the observed effect would be an underestimate. Fifth, these findings demonstrate association and not necessarily causation.

## Conclusions

Among patients with hip fracture treated with hemiarthroplasty in a large US integrated health care system, uncemented fixation, compared with cemented fixation, was associated with a statistically significantly higher risk of aseptic revision. These findings suggest that US surgeons should consider cemented fixation in the hemiarthroplasty treatment of displaced femoral neck fractures in the absence of contraindications.


### ARTICLE INFORMATION

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*Concept and design:* All authors.
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*Drafting of the manuscript:* Okike, Chan, Paxton.
*Critical revision of the manuscript for important intellectual content:* All authors.
*Statistical analysis:* Chan, Prentice.
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