Readmission, reoperation, and nonhome discharge rates in patients receiving surgical treatment for proximal humerus fractures

Kenny Ling, BS\textsuperscript{a}, Kevin I. Kashanchi, BS\textsuperscript{a}, Taylor VanHelmond, BS\textsuperscript{b}, Alireza Nazemi, MD, MS\textsuperscript{c}, Matthew Kim, BS\textsuperscript{a}, David E. Komatsu, PhD\textsuperscript{c}, Edward D. Wang, MD\textsuperscript{c}.\textsuperscript{*}

\textsuperscript{a}Renaissance School of Medicine at Stony Brook University, Stony Brook, NY, USA
\textsuperscript{b}Charles E. Schmidt College of Medicine at Florida Atlantic University, Boca Raton, FL, USA
\textsuperscript{c}Department of Orthopaedics, Stony Brook University, Stony Brook, NY, USA

\textsuperscript{*}Corresponding author: Edward D. Wang, MD, Department of Orthopaedics, Stony Brook University Hospital, HSC T-18, Room 080, Stony Brook, NY 11794-8181, USA. E-mail address: Edward.Wang@stonybrookmedicine.edu (E.D. Wang).

\begin{abstract}
Proximal humerus fractures (PHFs) are one of the most common osteoporotic fractures, accounting for roughly 6% of all fractures.\textsuperscript{22} The majority of PHFs are seen in elderly patients after low-energy trauma, such as ground-level falls.\textsuperscript{28} These fractures are also seen in the younger population after high-energy trauma. The majority of PHFs are treated nonoperatively with sling immobilization.\textsuperscript{28} However, in the younger population after high-energy trauma, the majority of PHFs are seen in elderly patients after low-energy trauma. The majority of PHFs are treated nonoperatively with sling immobilization.\textsuperscript{28} However, in the younger population after high-energy trauma, the majority of PHFs are treated nonoperatively with sling immobilization.\textsuperscript{28}

Surgical treatment is often indicated in more complex and displaced fracture patterns. Options for surgical treatment include open reduction internal fixation (ORIF), intramedullary nailing, hemiarthroplasty (HA), and total shoulder arthroplasty (TSA, anatomic or reverse).\textsuperscript{2,8,9} Selecting an optimal treatment strategy is complex and requires orthopedic surgeons to consider fracture patterns as well as numerous patient-specific factors. These patient-specific factors include age, bone quality, concurrent injuries, and overall health status.\textsuperscript{28} The complexity of fracture patterns and diversity in patient characteristics present challenges to establishing objective guidelines for the decision to undergo surgical treatment.\textsuperscript{18} Ideal management of these fractures would ensure maximal functional outcomes while minimizing complications and costs.

Readmission following surgical treatment of PHF increases patient morbidity and overall health-care expenditures. A majority of readmissions following surgical management of PHF are due to
\end{abstract}
complications such as septicemia, deep venous thrombosis, and secondary hip fracture. Unplanned readmission can also drastically increase health-care costs. One study found that readmission following surgical treatment of PHF increased in-hospital costs by $54,345.27 In order to prevent patient morbidity associated with readmission, specific policies such as the Hospital Readmission Reduction Program (HRRP) have been employed to reduce the number of preventable hospital readmissions and reoperations. 

Reoperation following surgical treatment of PHF is often secondary to surgical complications such as mechanical problems or dislocation. Reoperation rates have previously been utilized as a metric for monitoring hospital quality. Several studies have found that revision shoulder arthroplasty is associated with decreased functional outcomes and higher complication rates than primary shoulder arthroplasty. Therefore, identifying risk factors for reoperation following surgical treatment of PHF is instrumental to reducing patient morbidity and improving the delivery of care for these patients.

Nonhome discharge following surgical treatment of PHF is attributed to poorer functional independence. This increases health-care expenses. A study by Malik et al. found that 21.6% of patients who underwent surgical treatment of PHF from 2012 to 2016 had nonhome discharges. Patients of partially dependent functional health status were discharged to nursing homes or continuing-care facilities are at further risk for adverse health events, including thromboembolic and renal complications.

The primary objective of this study was to identify risk factors associated with 30-day readmission, 30-day reoperation, and nonhome discharge in patients undergoing surgical treatment of PHF with ORIF, HA, or TSA. A secondary objective of this study was to identify the association between procedure choice and individual rates of these adverse events.

### Materials and methods

The American College of Surgeons National Surgical Quality Improvement (NSQIP) database was queried for all patients who underwent ORIF, HA, or TSA as surgical treatment for closed PHFs between 2015 and 2017. The NSQIP database is fully deidentified, rendering this study exempt from approval by our university’s institutional review board. The NSQIP database collects data from over 600 academic and community hospitals within the United States. The data are collected by trained surgical clinical reviewers. The data are also periodically audited to maintain high fidelity.

Inclusion criteria were postoperative diagnosis of PHF and surgical treatment with ORIF, HA, or TSA. Postoperative diagnoses of PHFs were defined by International Classification of Diseases, Ninth Revision (ICD-9: 812.0, 812.00, 812.01, 812.02, 812.03, 812.09) or International Classification of Diseases, Tenth Revision (ICD-10) codes (Supplementary Appendix S1). Current Procedural Terminology (CPT) codes selected for each procedure were as follows: ORIF (23615, 23616, 23630, 23670, 23680), HA (23470), and TSA (23472). Cases were excluded if any of the following variables had missing information: age, height, weight, American Society of Anesthesiologists (ASA) classification, functional health, or discharge destination.

Variables collected in this study included procedure type, procedure characteristics, patient demographics, comorbidities, reoperation rates, readmission rates, and discharge destination. Patient demographics and comorbidities including age, sex, height, weight, ASA physical classification class, smoking status, diabetes, chronic obstructive pulmonary disorder, congestive heart failure (CHF), hypertension, preoperative use of corticosteroids (steroids), and functional health status were collected. The NSQIP database codes patients’ functional health status into “independent,” “partially independent,” or “totally dependent.” In this analysis, functional health status was recoded into “independent” and “dependent.” “Dependent” functional health status included patients who were initially coded as “partially dependent” or “totally dependent.” Data on procedure type (ORIF, HA, TSA) and characteristics including mean operative time and inpatient or outpatient designation were also collected. Postoperative outcomes, including reoperation and readmission, were reported within 30 days of procedure. In this study, discharge destination was recoded into either “home” or “non-home.” Patients who were discharged “home” or “facility which was home” were considered to be discharged home. Patients who were discharged “rehab,” “separate acute care,” “skilled care,
not home,” and “unskilled facility not home” were considered to have a nonhome discharge.

All statistical analyses were conducted using SPSS Software version 26.0 (IBM Corp., Armonk, NY, USA). Patient demographics, comorbidities, and procedural characteristics were compared between cohorts using bivariate analysis. Multivariate logistic regression, adjusted for all significantly associated patient comorbidities, patient demographics, and procedural characteristics, was used to identify predictors of reoperation, readmission, and nonhome discharge. Odds ratios (ORs) were reported with accompanying 95% confidence intervals. The level of significance was set to $P < .05$.

Results

Following application of International Classification of Diseases, Ninth Revision (ICD-9), International Classification of Diseases, Tenth Revision (ICD-10), and Current Procedural Terminology (CPT) codes, there were 3000 cases of PHFs treated surgically in NSQIP from 2015 to 2017. Cases were excluded as follows: 61 for missing age, 82 for missing height and/or weight, 1 for missing ASA classification, 25 for missing functional health status prior to surgery, 1 for missing length of total hospital stay, and 5 for unknown discharge destination. A total of 2825 patients undergoing surgical treatment for PHF were included in the final cohort. The majority of the patients were between 51 and 80 years of age ($N = 2132; 75.4%$), with a mean age of 65.05 years. Most patients were female ($N = 2099; 74.3%$). The most common procedure performed was ORIF ($N = 1829; 64.7%$), followed by TSA ($N = 707; 25.0%$), and then HA ($N = 289; 10.2%$). Overall, there was a 30-day readmission rate of 4.2%, 30-day reoperation rate of 2.6%, and a nonhome discharge rate of 17.4%.

Readmission within 30 days

Of the 2825 patients included in our study, 122 (4.2%) were readmitted within 30 days of the principal procedure (Table I, Fig. 1). Of those readmitted, 65 (53.3%) underwent ORIF, 45 (36.9%) underwent TSA, and 12 (9.8%) underwent HA. In comparison to patients who were not readmitted, readmitted patients were older (69.98 years vs. 64.83 years, $P < .001$) and had a longer mean length of hospital stay (3.30 days vs. 2.23 days, $P < .001$). The readmitted cohort also had higher rates of ASA class $\geq 3$ (74.6% vs. 52.7%, $P < .001$), CHF (3.3% vs. 0.9%, $P = .030$), functional dependence (15.6% vs. 3.7%, $P < .001$), inpatient procedure designation (77.0% vs. 59.5%, $P < .001$), and nonhome discharge (32.0% vs. 16.7%, $P < .001$). In comparison to patients who were not readmitted, more readmitted patients had undergone TSA (24.5% vs. 36.9%, $P = .002$). In contrast, fewer readmitted patients had undergone ORIF (53.3% vs. 65.3%, $P = .009$).

After adjusting for all significantly associated variables, multivariate logistic regression identified ASA class $\geq 3$ (OR 1.95, 1.25-3.05; $P = .003$) and functional dependence (OR 3.15, 1.79-5.52; $P < .001$) as independent predictors of readmission (Table II). Procedure type (ORIF, TSA, and HA) was not a significant predictor of readmission. The mean number of days from primary procedure to readmission was 14.66 $\pm$ 8.13 days.

Reoperation within 30 days

Of the 2825 patients included in our study, 73 (2.6%) underwent reoperation within 30 days of the principal procedure (Table III, Fig. 2). Of those who underwent reoperation, 47 (64.4%) underwent ORIF, 20 (27.4%) underwent TSA, and 6 (8.2%) underwent HA. Patients who underwent reoperation were more likely to be male (42.5% vs. 25.3%, $P = .002$), functionally dependent (12.3% vs. 4.0%), and discharged to a facility other than home (28.8% vs. 17.1%, $P = .018$). Patients who ultimately underwent reoperation had higher rates of inpatient procedure designation (74.0% vs. 59.9%, $P = .002$) and had a greater mean length of hospital stay (3.67 days vs. 2.24 days, $P < .001$).

After adjusting for all significantly associated variables, multivariate logistic regression identified male sex (OR 2.41, 1.49-3.90; $P < .001$) and functional dependence (OR 2.92, 1.37-6.22; $P = .006$) as independent predictors of reoperation within 30 days (Table IV). Procedure type (ORIF, TSA, and HA) was not a significant predictor of reoperation. The mean number of days from the primary procedure to reoperation was 15.48 $\pm$ 6.95 days.

Nonhome discharge

Of the 2825 patients included in our study, 491 (17.4%) were discharged to a facility other than home (Table V). Of those who had a nonhome discharge, 196 (39.9%) underwent ORIF, 225 (45.8%) underwent TSA, and 70 (14.3%) underwent HA. In comparison to patients who were discharged home, patients with a nonhome
discharge had a greater mean age (62.92 years vs. 75.22 years, \( P < .001 \)) and a greater mean operative time (114.85 minutes vs. 120.91 minutes, \( P = .020 \)). Non–home-discharge patients were more likely to be female (82.1% vs. 72.7%, \( P < .001 \)) and underweight (BMI < 18.5 kg/m\(^2\)) (4.3% vs. 2.2%, \( P = .011 \)). These patients also had higher rates of comorbidities including ASA class \( \geq 3 \) (81.5% vs. 47.8%, \( P < .001 \)), diabetes (28.9% vs. 18.2%, \( P < .001 \)), chronic obstructive pulmonary disorder (11.4% vs. 6.2%, \( P < .001 \)), CHF (2.4% vs. 0.7%, \( P < .001 \)), and hypertension (72.5% vs. 51.7%, \( P < .001 \)). Non–home-discharge patients also had higher rates of functional dependence (11.8% vs. 2.6%, \( P < .001 \)) and inpatient procedure designation (92.1% vs. 53.6%, \( P < .001 \)). Non–home-discharge patients also had a longer mean length of hospital stay (5.01 days vs. 1.70 days, \( P < .001 \)). In comparison to patients who were discharged home, more non–home-discharge patients underwent TSA (20.7% vs. 45.8%, \( P < .001 \)) and HA (9.4% vs. 14.3%, \( P = .002 \)). In contrast, fewer non–home-discharge patients underwent ORIF (70.0% vs. 39.9%, \( P < .001 \)).

After adjusting for all significantly associated variables, multivariate logistic regression indicated age \( \geq 66 \) years (OR 7.00, 3.06-15.98; \( P < .001 \)), age \( \geq 81 \) years (OR 16.31, 6.92-38.45; \( P < .001 \)), ASA class \( \geq 3 \) (OR 2.34, 1.74-3.15; \( P < .001 \)), functional dependence (OR 2.48, 1.59-3.89; \( P < .001 \)), and inpatient procedure designation (OR 3.32, 2.21-4.98; \( P < .001 \)) as independent predictors of nonhome discharge (Table VI). In comparison to ORIF, TSA (OR 1.41, 1.07-1.86; \( P = .014 \)) was significantly associated with increased rates of nonhome discharge.

### Discussion

In this study, we reported on the rates of readmission, reoperation, and nonhome discharge within 30 days in 2825 patients who underwent HA, TSA, or ORIF for 3- and 4-part PHFs. We found a 4.2% rate of readmission, 2.6% rate of reoperation, and 17.4% rate of nonhome discharge. Significant risk factors for readmission were ASA class \( \geq 3 \) and dependent functional status. Significant risk factors for reoperation were male sex and dependent functional status. Significant risk factors for nonhome discharge were age \( \geq 66 \) years, ASA \( \geq 3 \), dependent functional status, and inpatient status. In terms of procedure type, TSA was significantly associated with increased rates of nonhome discharge compared with ORIF.

PHFs are common osteoporotic fractures that are often seen in elderly patients following ground-level falls. While most PHFs can be treated nonoperatively, more severe 3- and 4-part fractures may require surgical treatment. There is debate in current literature on the effectiveness of operative vs. nonoperative PHF treatment. Several studies have reported no significant differences in functional or clinical outcomes between these two treatments. Technologic advances and a growing elderly population have made surgical treatment for PHF increasingly more commonplace. In fact, while the rate of PHFs has remained consistent over time, the rate of surgical correction has increased, along with the rate of reverse total shoulder arthroplasty (RTSA) for treatment. However, the decision to undergo surgical treatment for PHF remains complex and involves the assessment of many factors, including the patient’s bone quality, social independence, and surgical risk factors. Surgery is needed in most cases of fracture/dislocations, open fractures, and those with associated neurovascular deficit to prevent extreme loss of function. Nonoperative treatment of these fractures sometimes results in a poor outcome that requires subsequent surgery. Performing an acute operation in these cases can be easier than operating on a nonunion or malunion. Surgical treatment of PHF in the elderly aims to optimize functional outcomes while reducing complications, reoperations, and costs. The HRRP was enacted as part of the Affordable Care Act in 2010, aiming to decrease the amount of preventable hospital costs. The HRRP was enacted as part of the Affordable Care Act in 2010, aiming to decrease the amount of preventable hospital costs.

### Table II

| Predictors of readmission | Odds ratio | 95% CI | \( P \) value |
|---------------------------|------------|--------|--------------|
| ASA \( \geq 3 \)          | 1.95       | 1.25-3.05 | .003         |
| Dependent functional status | 3.15       | 1.79-5.52 | <.001        |

CI, confidence interval; ASA, American Society of Anesthesiologists. Bold \( P \)-values indicate statistical significance.

### Table III

| Characteristic | Reoperation within 30 d | \( P \) value |
|---------------|-------------------------|-------------|
| Sex           |                         | \( \text{No (n} = 2752\text{) Yes (n} = 73\text{)} \) |
| Female        | 2057 (74.7)             | 42 (57.5)   |
| Male          | 695 (25.3)              | 31 (42.5)   |
| Mean age (yr) | 65.02 ± 13.55           | 66.33 ± 12.75 | .415 |
| Age < 50      | 363 (13.2)              | 7 (9.6)     | .461 |
| Age 51-65     | 926 (33.6)              | 32 (43.8)   | .079 |
| Age 66-80     | 1151 (41.8)             | 23 (31.5)   | .092 |
| Mean BMI (kg/m\(^2\)) | 29.70 ± 7.48 | 29.50 ± 7.24 | .823 |
| BMI < 18.5    | 70 (2.5)                | 2 (2.7)     | .710 |
| BMI 18.5-24.9 | 707 (25.7)              | 21 (28.8)   | .588 |
| BMI 25.0-29.5 | 835 (30.3)              | 21 (28.8)   | .897 |
| BMI 30-34.9   | 600 (21.8)              | 16 (21.9)   | 1.000 |
| BMI 35-39.9   | 280 (10.2)              | 6 (8.2)     | .697 |
| BMI ≥ 40      | 260 (9.4)               | 7 (9.8)     | .406 |
| ASA class \( \geq 1 \) or 2 | 1280 (46.5) | 30 (41.1) | .170 |
| ASA class \( \geq 3 \) | 1472 (53.5) | 43 (58.9) | .553 |
| Smoking       |                         |             |
| Nonsmoker     | 2248 (81.7)             | 55 (75.3)   | .268 |
| Smoker        | 504 (18.3)              | 18 (24.7)   | .533 |
| Diabetes      |                         |             |
| No            | 2558 (93.0)             | 67 (91.8)   | .643 |
| Yes           | 194 (6.0)               | 6 (8.2)     | .722 |
| CHF           |                         |             |
| No            | 2725 (99.0)             | 72 (98.6)   | .734 |
| Yes           | 27 (1.0)                | 1 (1.4)     | .823 |
| Hypertension  |                         |             |
| No            | 1231 (44.7)             | 31 (42.5)   | .823 |
| Yes           | 1521 (55.3)             | 42 (57.5)   | .722 |
| Steroids      |                         |             |
| No            | 2662 (96.7)             | 71 (97.3)   | .823 |
| Yes           | 90 (3.3)                | 2 (2.7)     | .003 |
| Functional status | 2642 (96.0) | 64 (87.7) | .823 |
| Independent   | 110 (4.0)               | 9 (12.3)    | .015 |
| Dependent     |                         |             |
| Inpatient vs. outpatient | 1103 (40.1) | 19 (26.0) | .002 |
| Inpatient     | 1649 (59.9)             | 54 (74.0)   | .196 |
| Procedure type |                         |             |
| ORIF          | 1782 (64.8)             | 47 (64.4)   | 1.000 |
| TSA           | 687 (25.0)              | 20 (27.4)   | .681 |
| HA            | 283 (10.3)              | 6 (8.2)     | .697 |
| Mean operative time (min) | 115.80 ± 52.25 | 120.36 ± 50.75 | .462 |
| Mean length of hospital stay (d) | 2.24 ± 3.19 | 3.67 ± 4.87 | <.001 |

Table VI

| Characteristic | Discharge destination | \( P \) value |
|---------------|-----------------------|-------------|
| No            | 2282 (82.9)           | 52 (71.2)   |
| Nonhome       | 470 (17.1)            | 21 (28.8)   |

Table V

BMI, body mass index; ASA, American Society of Anesthesiologists; COPD, chronic obstructive pulmonary disorder; CHF, congestive heart failure; ORIF, open reduction internal fixation; TSA, total shoulder arthroplasty; HA, hemiarthroplasty. Bold \( P \)-values indicate patient demographics with statistical significance.
surgical readmissions as well. The goal of our study was to infarction, and heart failure. This measure has helped to decrease higher readmission rates in treatment of pneumonia, myocardial failure. This measure has helped to decrease surgical readmissions as well. The goal of our study was to determine readmission, reoperation, and nonhome discharge rates secondary to surgery for the treatment of PHFs and to identify major contributors to these outcomes. By looking at predictors for these outcomes, we can better consider cost when surgically treating PHFs. There are currently studies that look at readmission, these outcomes, we can better consider cost when surgically treating PHFs. There are currently studies that look at readmission, reoperation, or nonhome discharge for all 3 procedures separately, making our study unique in that we analyze and compare all 3 outcomes for each surgical group.

Table IV
Odds ratios for statistically significant predictors of reoperation.

| Predictors of reoperation | Odds ratio | 95% CI  | P value |
|---------------------------|------------|---------|---------|
| Male sex                  | 2.41       | 1.49-3.90 | <.001   |
| Dependent functional status| 2.92      | 1.37-6.22 | .006    |

CI, confidence interval.
Bold P-values indicate statistical significance.

Readmission within 30 days

The HRRP, established in March 2010 under the Affordable Care Act, provides financial incentive to hospitals by placing financial penalties on those that have higher-than-expected rates of readmission. Although the procedure-specific unplanned 30-day readmission measures of the HRRP are limited to elective total hip and knee arthroplasties, the concept still stands that unplanned readmissions are important factors in evaluating hospital performance. Furthermore, Thorsness et al. reported that readmissions following ORIF and HA had a 5.68-fold increase in in-hospital cost.27

In our study of 2825 patients, we saw a 30-day readmission rate of 4.2%. Previous studies suggest that readmission is a relatively frequent complication following surgical treatment of PHF. A study by Zhang et al. utilized a large database from 7 states to compare readmission rates and found an overall 30-day readmission rate of 8% for 27,017 patients.31

Furthermore, Zhang et al identified female sex, African American ethnicity, discharge to a nursing facility, and Medicaid insurance as risk factors for readmission following surgical treatment of PHF.31 This study also found that medical complications accounted for 75% of readmissions, highlighting the impact of medical comorbidities on readmission rates.31 Singh et al. reported that male sex and increased ASA class were risk factors for 30-day and 90-day readmission rates following HA.25 Our study identified ASA class ≥ 3 and dependent functional status to increase the risk of readmission within 30 days. These findings support the association between patient comorbidity and readmission rates following surgical treatment of PHF. Our results may help better understand the risk factors for readmission when weighing the risks and benefits of undergoing surgical treatment. For patients who are of dependent functional status or with ASA ≥ 3, they must be aware that their condition carries a higher risk for readmission, which could decrease their postoperative quality of life.

Our study identified dependent functional status and ASA class ≥ 3 to be significant predictors for readmission within 30 days. Previous studies have been inconclusive on specific risk factors for readmission and determined that patient comorbidities were important considerations prior to and after surgery. Our findings are consistent with the idea that patient comorbidities can increase the likelihood of readmission.

Reoperation within 30 days

Although the financial incentive of the HRRP only applies to rates of reoperation following hip and knee arthroplasties, healthcare organizations often use reoperation rates as indicators for hospital quality.1,14,15 A closer look at the significant predictors for reoperation can help hospitals to reduce their rates of reoperation and the associated increase in cost.

In our study of 2825 patients, we saw a reoperation rate of 2.6% within 30 days. A study by Dabija et al looked at 134,111 patients who were treated for PHF either surgically or nonsurgically.7 This study had a 4-year minimum follow-up and found that 6.6% of patients who underwent ORIF required a revision procedure and 7.2% of patients who underwent arthroplasty required revision.7 Several studies reported RTSA as an effective treatment option for failed HA and failed ORIF.17,23 Sebastia-Forcada et al reported that secondary RTSA led to significant functional outcomes and pain relief.23 However, secondary RTSA still had lower functional scores than primary RTSA, as well as higher complication rates.23 Nowak et al reported that the number of reoperations following...
Table V
Discharge destinations of patients based on patient demographics.

| Characteristic       | Discharge destination | P value |
|----------------------|-----------------------|---------|
|                      | Home (n = 2334)       | Nonhome (n = 491) |
| Sex                  |                       | <.001   |
| Female               | 1696 (72.7)           | 403 (82.1) |
| Male                 | 638 (27.3)            | 88 (17.9) |
| Mean age (yr)        | 62.92 ± 13.31         | 75.22 ± 9.29 | <.001 |
| Age < 50             | 362 (15.5)            | 8 (1.6)   | <.001 |
| Age 51-65            | 902 (38.6)            | 56 (11.4) | <.001 |
| Age 66-80            | 905 (38.8)            | 269 (54.8)| <.001 |
| Age > 81             | 165 (7.1)             | 158 (32.2)| <.001 |
| Mean BMI (kg/m²)     | 29.67 ± 7.32          | 29.76 ± 8.12 | .809 |
| BMI 18.5             | 51 (2.2)              | 21 (4.3)  | .011  |
| BMI 18.5-24.9        | 596 (25.6)            | 130 (26.5)| .691  |
| BMI 25.0-25.9        | 721 (30.9)            | 135 (27.5)| .145  |
| BMI 30-34.9          | 515 (22.1)            | 101 (20.6)| .508  |
| BMI 35-39.9          | 236 (10.1)            | 50 (10.2) | .935  |
| BMI > 40             | 213 (9.1)             | 54 (11.0) | .203  |
| ASA class            |                       | <.001   |
| 1 or 2               | 1219 (52.2)           | 91 (18.5) |
| ≥3                   | 1115 (47.8)           | 400 (81.5)|        |
| Smoking              |                       | <.001   |
| Nonsmoker            | 1872 (80.2)           | 431 (87.8)|        |
| Smoker               | 462 (19.8)            | 60 (12.2) |
| Diabetes             |                       | <.001   |
| Nondiabetic          | 1909 (81.8)           | 349 (71.1)|        |
| Diabetic             | 425 (18.2)            | 142 (28.9)|        |
| COPD                 |                       | <.001   |
| No                   | 2190 (93.8)           | 435 (88.6)|        |
| Yes                  | 144 (6.2)             | 56 (11.4) |
| Hypertension         |                       | <.001   |
| No                   | 1127 (48.3)           | 135 (27.5)| 1.000 |
| Yes                  | 1207 (51.7)           | 356 (72.5)|        |
| Steroids             |                       | 1.000   |
| No                   | 2258 (96.7)           | 475 (96.7)|        |
| Yes                  | 76 (3.3)              | 16 (3.3)  |
| Functional status    |                       | <.001   |
| Independent          | 2273 (97.4)           | 433 (88.2)|        |
| Dependent            | 61 (2.6)              | 58 (11.8)|        |
| Inpatient vs.        |                       | <.001   |
| Outpatient           | 1083 (46.4)           | 39 (7.9)  |
| Inpatient            | 1251 (53.6)           | 452 (92.1)|        |
| Procedure type       |                       | <.001   |
| ORIF                 | 1633 (70.0)           | 196 (39.9)|        |
| TSA                  | 482 (20.7)            | 225 (45.5)| <.001 |
| HA                   | 210 (9.4)             | 70 (14.3)| .002  |
| Mean operative time  | 114.86 ± 50.08        | 120.91 ± 61.11 | .020 |
| (min)                | 1.70 ± 2.61           | 5.01 ± 4.40| <.001 |
| Mean length of hospital stay (d) | 8.12 .809 |

BMI, body mass index; ASA, American Society of Anesthesiologists; COPD, chronic obstructive pulmonary disorder; CHF, congestive heart failure; ORIF, open reduction internal fixation; TSA, total shoulder arthroplasty; HA, hemiarthroplasty. Bold P-values indicate patient demographics with statistical significance.

secondarily RTSA for failed ORIF was significantly higher than that after primary RTSA. The study concluded that primary arthroplasty is a better treatment choice in cases where the patient’s prognostic factors suggest a high reoperation rate for ORIF. These studies all showed that revision procedures yielded less optimal outcomes than a successful primary procedure. Our study identified dependent functional status and male sex as significant predictors for reoperation within 30 days. Some previous studies concluded higher readmission rates in females, while other studies concluded higher readmission rates in males. However, these studies looked at readmission rates in general and not specifically at reoperation rates. The variation in study results may be due to differences in timing or location of the data used for the study. Our study did not find male or female sex to be a significant predictor for readmission; male sex was only significant specifically for reoperation. For patients who are of dependent functional status or male sex, the decision for choice of procedure may be crucial in obtaining the optimal outcome.

Nonhome discharge

Nonhome discharge is a suboptimal outcome for patients due to their independence being compromised. Nursing homes or continuing-care facilities also have their own costs that contribute to the total cost incurred on the patient. Patients discharged to a nonhome destination have been found to have a higher likelihood of readmission.

In our study of 2825 patients, we saw a nonhome discharge rate of 17.4% within 30 days. A study by Malik et al looked at a total of 2674 patients and found a nonhome discharge rate of 21.5%.

Malik et al reported several significant risk factors associated with nonhome discharge following surgical management of PHF: age ≥ 65 years, partially dependent functional health status prior to surgery, inpatient surgery, ASA grade > 2, transfer from nursing home/chronic care facility undergoing a TSA vs. ORIF, length of stay > 2 days, and the occurrence of any pre-discharge complication.

While Malik et al associated shoulder arthroplasty with higher rates of nonhome discharge, Rajaei et al reported that RTSA patients were more likely to be discharged home than HA patients.

Our study identified dependent functional status, ASA ≥ 3, inpatient status, and age ≥ 66 years to be significant predictors for nonhome discharge. Patients treated with TSA also had higher rates of nonhome discharge than those treated with HA or ORIF. These findings are consistent with the study by Malik et al that identified age > 65 years, dependent functional status, inpatient status, and ASA > 2 to be significant predictors for nonhome discharge. The same study also found higher rates of nonhome discharge for patients who underwent RTSA instead of ORIF. Nonhome discharge is not an ideal outcome for patients because they do not have the same independence as they would at home. Patients with significant risk factors for nonhome discharge should be made aware of the associated risk when deciding to undergo surgical treatment for PHF.

Procedure choice

The choice among RTSA, ORIF, and HA often takes into consideration the high short-term complication and reoperation rates associated with ORIF and the superior short-term quality of life but lifelong complication risk associated with RTSA. ORIF is often used in patients aged 18-40 years because the lifespan of arthroplasty would likely necessitate revision in this age group. ORIF complications include screw cutout, malunion, avascular necrosis, and varus collapse. RTSA is more often utilized in lower demand, elderly individuals (> 65 years old) with nonreconstructable tuberosities and poor bone stock. RTSA complications include scapular notching, dislocation, glenoid loosening, deep infection, acromial or scapular spine fractures, and axillary neuropaxia. HA is a viable treatment option in patients aged 40-65 years with complex fracture-dislocations, head-splitting components that are otherwise likely to fail fixation. However, with HA, lesser and greater tuberosity nonunion may lead to diminished liftoff strength as well as active shoulder elevation and external rotation.
studies have reported that ORIF had higher rates of readmission to be significant predictors of nonhome discharge. The clinically significant risk factors for 30-day reoperation following surgical treatment for PHF are male sex and dependent functional status. The clinically significant risk factors for nonhome discharge following surgical treatment for PHF are age > 66 years, ASA ≥ 3, dependent functional status, and inpatient status. TSA was significantly associated with increased rates of nonhome discharge compared with HA and ORIF. Evaluation of these factors in patients undergoing surgical treatment for PHF can help with perioperative risk management and minimizing the cost of care associated with readmission, reoperation, and nonhome discharge.

Disclaimers:
Funding: No funding was disclosed by the authors. Conflicts of interest: The authors, their immediate families, and any research foundation which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

Supplementary data
Supplementary data to this article can be found online at https://doi.org/10.1016/j.jseint.2022.02.008

Table VI

| Predictors of nonhome discharge | Odds ratio | 95% CI | P value |
|---------------------------------|------------|-------|---------|
| Age ≤ 50                        | Reference  | –     | –       |
| Age 51-65                       | 1.67       | 0.72-3.90 | .232   |
| Age 66-80                       | 7.00       | 3.06-15.98 | <.001  |
| Age ≥ 81                        | 16.31      | 6.92-38.45 | <.001  |
| ASA ≥ 3                        | 2.34       | 1.74-3.15 | <.001  |
| Dependent functional status     | 2.48       | 1.50-3.89 | <.001  |
| Inpatient                      | 3.320      | 2.21-4.98 | <.001  |
| ORIF                            | Reference  | –     | –       |
| TSA                             | 1.41       | 1.07-1.86 | .014   |
| Hemiarthroplasty               | 1.21       | 0.829-1.77 | .322   |

CI, confidence interval; ASA, American Society of Anesthesiologists; ORIF, open reduction internal fixation; TSA, total shoulder arthroplasty. Bold P-values indicate statistical significance.

respectively.29 Previous studies suggest that RTSAs may offer superior functional outcomes to HA.2
In terms of choice of procedure (ORIF, HA, or TSA), several studies have reported that ORIF had the lowest probability of needing follow-up surgery and overall complications.5,7 Other studies have reported that ORIF had higher rates of readmission and reoperation than RTSAs.29,31 These different conclusions may be explained by the variations of location and timing of data used for the studies, since RTSAs has recently become more common for treatment of PHF.29 Most of these studies concluded that patient comorbidities are important considerations both before and after operation.

Our study did not find the choice of procedure to be a significant predictor for readmission or reoperation. However, TSA was found to be significantly associated with increased rates of nonhome discharge compared with ORIF. As mentioned above, TSA is the procedure of choice in elderly individuals. The increased prevalence of chronic comorbidities in an older cohort may contribute to higher rates of nonhome discharge. Further studies that investigate significant differences between procedure types with matched aged groups would likely provide a better understanding. The retrospective nature of this study also carries an inherent bias in procedure selection. Ideally, a double-blind randomized study would provide the best comparison across procedure types, although not in practicality.

Our study was limited by the information available on the NSQIP database. We could not account for perioperative variables such as experience of the surgeon, mechanism of injury, fracture pattern, institution where the procedure was performed, and postoperative rehabilitation. These factors could have contributed to the rates of readmission, reoperation, and nonhome discharge. Another limitation of our study was that readmission and reoperation were only considered within a 30-day period. This is particularly important when considering reoperation, as reoperation rates are typically low within 30 days postoperatively. This foregoes later revisions due to failure of hardware which could have been avoided by placement of a prosthesis. A follow-up period over 1 year would likely yield better insight into risk factors for reoperation. The NSQIP database also does not include orthopedic-specific scores to properly assess the outcomes of these investigations.

This is the first study to investigate and compare rates of readmission, reoperation, and nonhome discharge following TSA, HA, and ORIF treatment for PHF. Previous studies have investigated risk factors for these rates individually.

Conclusion
The clinically significant risk factors for 30-day readmission following surgical treatment for PHF are ASA class ≥ 3 and dependent functional status. The clinically significant risk factors for 30-day reoperation following surgical treatment for PHF are male sex and dependent functional status. The clinically significant risk factors for nonhome discharge following surgical treatment for PHF are age > 66 years, ASA ≥ 3, dependent functional status, and inpatient status. TSA was significantly associated with increased rates of nonhome discharge compared with HA and ORIF. Evaluation of these factors in patients undergoing surgical treatment for PHF can help with perioperative risk management and minimizing the cost of care associated with readmission, reoperation, and nonhome discharge.

References
1. Adams C. Do 30-day reoperation rates adequately measure quality in orthopedic surgery? Jt Comm J Qual Patient Saf 2020;46:72-80. https://doi.org/10.1016/j.jqcs.2019.11.005.
2. Anakwenze OA, Zoller S, Ahmad CS, Levine WN. Reverse shoulder arthroplasty for acute proximal humerus fractures: a systematic review. J Shoulder Elbow Surg 2014;4:73-80. https://doi.org/10.1016/j.jse.2013.09.012.
3. Austin DC, Torchia MT, Tosteson ANA, Gitajn IL, Tapp SJ, Bell JE. The cost-effectiveness of reverse total shoulder arthroplasty versus open reduction internal fixation for proximal humerus fractures in the elderly. Iowa Orthop J 2020;40:20-9.
4. Bell JE, Leung BC, Spratt RF, Koval KJ, Weinstein JD, Goodman DC, et al. Trends and variation in incidence, surgical treatment, and repeat surgery of proximal humeral fractures in the elderly. J Bone Joint Surg Am 2011;93:121-31. https://doi.org/10.2106/JBJS.L.1015005.
5. Chun YM, Kim DS, Lee DH, Shin SJ. Reverse shoulder arthroplasty for four part proximal humeral fractures in elderly patients: can a healed tuberosity improve the functional outcomes. J Shoulder Elbow Surg 2017;26:1216-21. https://doi.org/10.1016/j.jse.2016.11.034.
6. Cvetanovich GL, Chalmers PN, Verma NN, Nicholson GP, Romeo AA. Open reduction internal fixation has fewer short-term complications than shoulder arthroplasty for proximal humeral fractures. J Shoulder Elbow Surg 2016;25:624-631.e1. https://doi.org/10.1016/j.jse.2015.09.011.
7. Dabijs DI, Guan H, Nevisier A, Jain NB. Readmissions, revisions, and mortality after treatment for proximal humeral fractures in three large states. BMC Musculoskelet Disord 2019;20:419. https://doi.org/10.1186/s12891-019-2812-9.
8. Dezfuli B, King JJ, Farmer KW, Struk AM, Wright TW. Outcomes of reverse total shoulder arthroplasty as primary versus revision procedure for proximal humerus fractures. J Shoulder Elbow Surg 2016;25:1133-7. https://doi.org/10.1016/j.jse.2015.12.002.
9. Familiari F, Rojas J, Doral MN, Huri G, McFarland EG. Reverse total shoulder arthroplasty. EFORT Open Rev 2018;3:58-69. https://doi.org/10.1302/2058-5241.13.017046.
10. Farshad M, Gerber C. Reverse total shoulder arthroplasty—from the most to the least common complication. Int orthopaedics 2016;40:1075-82. https://doi.org/10.1007/s00264-015-1125-9.
11. Gregory TM, Vandenbussche E, Augereau B. Surgical treatment of three and four part proximal humerus fractures. Orthopedics Traumatol Surg Res 2013;1:197-207. https://doi.org/10.1016/j.otsr.2012.12.006.
12. Halikarainen TW, Arhabi S, Willis MM, Davidson GH, Flum DR. Outcomes of patients discharged to skilled nursing facilities after acute care hospitalizations. Ann Surg 2016;263:280-5. https://doi.org/10.1097/SLA.0000000000001367.
13. Huang H. Treatment of the surgical neck fracture of the humerus with a novel external fixator in the elderly with osteoporosis: biomechanical analysis. BMC Musculoskelet Disord 2010;20:218. https://doi.org/10.1186/1471-2474-11-259-8.
14. Ibrahim AM, Nathan H, Thumba JR, Dimick JB. Impact of the hospital readmission reduction program on surgical readmissions among medicare
15. Kroon HM, Breslau PJ, Lardenoye JW. Can the incidence of unplanned reoperations be used as an indicator of quality of care in surgery? Am J Med Qual 2007;22:198-202. https://doi.org/10.1177/1062860607300652.

16. Malik AT, Barlow JD, Jain N, Khan SN. Incidence, risk factors, and clinical impact of non-home discharge following surgical management of proximal humerus fractures. Shoulder Elbow 2019;11:430-9. https://doi.org/10.1017/1758573218809505.

17. Nowak LL, Hall J, McKee MD, Schemitsch EH. A higher reoperation rate following arthroplasty for failed fixation versus primary arthroplasty for treatment of proximal humerus fractures. Bone Joint J 2019;101B:1272-9. https://doi.org/10.1302/0301-620X.101B10.BJJ-2019-0142.R2.

18. Onsen LT, Rivers M, Cheski R, Izquierdo R. Post operative day 1 discharge following elective shoulder arthroplasty. J Shoulder Elb Arthroplast 2017;1. https://doi.org/10.1177/2471549217708322.

19. Sebastian AS, Polites F, Glasgow AE, Habermann EB, Cima RR, Kakar S. Current quality measurement tools are insufficient to assess complications in orthopedic surgery. J Hand Surg Am 2017;42:10-15.e1. https://doi.org/10.1016/j.jhsa.2016.09.014.

20. Rajaee SS, Yalamanchili D, Noori N, Debbi E, Mirocha J, Lin CA, et al. Increasing use of reverse total shoulder arthroplasty for proximal humeral fractures: primary arthroplasty versus secondary arthroplasty after failed proximal humeral locking plate fixation. J Orthop Trauma 2017;31:e236-40. https://doi.org/10.1097/BOT.0000000000000856.

21. Zhang AL, Schairer WW, Feeley BT. Hospital readmissions after surgical treatment of proximal humerus fractures: is arthroplasty safer than open reduction internal fixation? Clin Orthop Relat Res 2014;472:2317-24. https://doi.org/10.1007/s11999-014-3613-y.