Short-Term Complications of Distal Humerus Fractures in Elderly Patients: Open Reduction Internal Fixation Versus Total Elbow Arthroplasty

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Abstract

Background: The purpose of this study was to evaluate 30-day postoperative complications of open reduction and internal fixation (ORIF) and total elbow arthroplasty (TEA) for the treatment of distal humerus fractures in elderly patients using a validated national database. Methods: Review of the National Surgical Quality Improvement Program (NSQIP) Database identified all elderly patients (>65 years) who underwent TEA or ORIF for the treatment of closed intra-articular distal humerus fractures from 2007 to 2013. Bivariate and multivariate analyses of risk factors for 30-day adverse events as defined by NSQIP between ORIF and TEA groups were assessed using preoperative and intraoperative variables. Results: Among the 176 patients with distal humerus fractures, there were 33 TEA and 143 ORIF. There was no difference in age, medical comorbidities, or functional status. Total elbow arthroplasty was associated with an increased odds of severe adverse event compared to ORIF (odds ratio = 1.57, P = .16), although it did not achieve statistical significance. Infection rate was 0.7% in ORIF and 0.0% in TEA (P = .99). Insulin-dependent diabetes and functional status were significant independent predictors of postoperative adverse events. Operative time (165 minutes vs 140 minutes, P = .06) and postoperative length of stay (3.6 days vs 2.3 days, P = .03) were longer for TEA compared to ORIF. Conclusion: Open reduction and internal fixation and TEA have similar 30-day postoperative complications for the treatment of distal humerus fractures among elderly patients. Despite favorable trends for TEA in recent studies, additional clinical results are needed to understand complications and limitation of TEA. Level of evidence: Level III, prognostic study.

Keywords
total elbow arthroplasty, open reduction and internal fixation, total elbow replacement, risk factors, complications

Introduction

Complex distal humerus fractures in the elderly patients continue to be challenging for surgeons, and their prevalence is expected to increase 3-fold by 2030.¹ Although it is well-accepted that open reduction and internal fixation (ORIF) can yield satisfactory outcomes in treating these fractures, several factors can impact the surgeon’s ability to achieve adequate fixation, including degree of comminution, osteoporosis, pre-existing joint damage (secondary to inflammatory conditions), and fracture pattern.²-⁴ First presented by Cobb and Morrey in 1997 for the treatment of acute distal humerus fractures, total elbow arthroplasty (TEA) has emerged as an alternative option even in fractures complicated by rheumatoid arthritis, osteoporosis, failed fixation, and nonunion.⁵-¹⁰ Still, TEA is not without limitations as patients must adapt to a permanent weight-bearing limitation and face potential long-term complications including infection, aseptic loosening, loss of bone stock, and periprosthetic fracture.¹¹,¹² Several prior studies have compared ORIF and TEA for the treatment of distal humerus fractures; however, sample sizes are limited.⁹,¹¹-¹³ Recently, Centers for Medicare and Medicaid Services have initiated quality improvement programs targeting orthopedic surgery, linking health-care quality and reimbursement. As such, understanding predictors of short-term outcomes and complications is becoming increasingly important. The National Surgical Quality Improvement Program (NSQIP), a high-quality, nationally representative sample of US patients, has proven to be a valuable tool in evaluating short-term outcomes throughout orthopedics.¹⁴,¹⁵

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The objectives of this study were to use the NSQIP database to (1) analyze and compare 30-day perioperative complication rates for primary TEA and ORIF in elderly patients and (2) identify risk factors for complications, readmission, reoperation, and mortality.

Materials and Methods

The NSQIP is a national surgical database that prospectively collects patient data from over 370 participating institutions. All data are validated with strict adherence guidelines including routine audits to ensure high-quality data. Data are collected up to 30 days postoperatively including after discharge by trained clinical reviewers from medical records, operative reports, and patient interviews. National Surgical Quality Improvement Program provides detailed demographics, functional status, body mass index (BMI), medical comorbidities, and American Society of Anesthesiologists (ASA) class. Intraoperative variables including wound classification, operative time, time to operation, and type of anesthesia were reviewed.

Adverse events within the first 30 days postoperatively are tracked by NSQIP and are classified as any, severe, minor, and infectious.\(^6\) Severe adverse events included death, myocardial infarction, cerebrovascular accident, renal failure, pulmonary embolism, venous thromboembolism, sepsis, septic shock, unplanned intubation, peripheral nerve injury, deep wound infection, organ/space infection, and return to operating room. Minor adverse events included superficial wound infection, urinary tract infection, and pneumonia. Infectious complications including deep wound infection, superficial wound infection, organ/space infection, sepsis, or septic shock were also compiled for separate analysis. Limited readmission data were also analyzed starting in 2011 when NSQIP began tracking readmission.

A retrospective review of the American College of Surgeons National Surgical Quality Improvement Program database was conducted to identify all elderly patients (\(\geq 65\) years old) who underwent either TEA or ORIF for closed intra-articular distal humerus fractures from 2007 to 2013. Inclusion criteria included patients aged 65 years or older with an intra-articular distal humerus fracture treated with either ORIF or TEA. Exclusion criteria included open distal humerus fractures and patients with compromised soft tissues preoperatively corresponding to wound classes III (contaminated) and IV (dirty). The TEA cohort was identified using Current Procedural Terminology (CPT) code (24363) with an associated postoperative diagnosis International Classification of Diseases, Ninth Revision (ICD-9) code of distal humerus fracture (812.2, 812.40, 812.41). The ORIF cohort was identified using CPT codes corresponding to ORIF intraarticular distal humerus fractures (24546, 24579, 24586) with similarly associated ICD-9 codes. Patients with incomplete data were removed from the analysis.

Statistical analysis was conducted using SAS (version 9.3) with a 2-tailed \(z\) of 0.05. Bivariate analysis comparing demographics, comorbidities, and 30-day outcomes was compared between the ORIF and TEA cohorts. Categorical analysis was conducted with Fisher exact test and \(\chi^2\) where appropriate. Continuous variables were analyzed using Student \(t\) test or Mann-Whitney \(U\) test after testing for normality and equal variance. Multivariate logistic regression models were built using a stepwise backward elimination approach with an exclusion \(P\) value < .20. Likelihood ratio tests confirmed removed variables were not significant predictors, and all variables were assessed for confounding and interaction where appropriate. Final models were assessed for goodness of fit using the Hosmer-Lemeshow test.

Results

Among the 176 patients included in the study, there were 33 TEA and 143 ORIF for distal humerus fracture. Patients who underwent TEA were of similar age, gender, functional status, and BMI to those who underwent ORIF (Table 1). The majority of patients in both cohorts were classified as ASA 3 or 4 and similar for both TEA and ORIF cohorts (76\% vs 61\%, \(P = .11\)). Nearly all patients underwent general anesthesia in both groups. Operative time was 25 minutes longer in TEA compared to ORIF, which approached significance (\(P = .06\)). Comparison of postoperative 30-day outcomes revealed similar frequency of adverse events in the ORIF (8.4\%) and TEA (12\%) groups (Table 2). Severe adverse events were more common in TEA compared to ORIF, however, this did not achieve statistical significance (21\% vs 12\%, \(P = .24\)). Infectious complications were uncommon as only 1 infection in an ORIF patient was noted. Total elbow arthroplasty was associated with a significantly increased postoperative length of stay compared to ORIF (3.6 days vs 2.3, \(P = .03\)). The most common severe adverse events were unplanned return to operating room (2.1\% ORIF, 3.0\% TEA), stroke (<1\% ORIF, 3.0\% TEA), and myocardial infarction (ORIF 1.4\%, 0\% TEA).

Multivariate logistic regression analysis revealed that TEA compared to ORIF was associated with a nonsignificantly increased odds of any adverse event (odds ratio [OR] 1.13, \(P = .35\)) and severe adverse event (OR 1.57, \(P = .16\)) groups (Table 2). Independent predictors of any adverse event included functional status (OR 1.82, \(P = .04\)) and insulin-dependent diabetes (OR 2.45, \(P = .03\)) 6. Disabilities of the Arm, Shoulder and Hand Insulin-dependent diabetes (OR 1.95, \(P = .02\)) was also an independent predictor of severe adverse events.

Discussion

This study used the NSQIP database to compare 30-day surgical outcomes after treatment of closed distal humerus fractures in patients older than 65 years with TEA and ORIF. Importantly, the sample size achieved (176 patients) is one of the largest studies to date comparing TEA and ORIF. Moreover, the centers that participate in NSQIP are an approximate representation of US medical centers, making our findings generalizable.

The analysis suggests that short-term rate of severe adverse events, including infection and unplanned readmission, does not differ significantly between patients treated with TEA or
ORIF. In contrast to this study, most existing literature focuses upon orthopedic and functional outcomes rather than medical and surgical complication rates of distal humerus fractures. Multiple retrospective and small prospective studies have shown that TEA has equivalent or improved outcomes compared with ORIF for distal humerus fractures in select patient populations. Frankle et al\textsuperscript{13} were the first to report better results with total elbow arthroplasty than with internal fixation in a study of 24 patients. They suggest that patients treated with TEA had better outcomes in terms of pain, range of motion, patient satisfaction, and rates of reoperation. Furthermore, 2 additional retrospective studies by Jost et al\textsuperscript{17} (14 patients) and Egol et al\textsuperscript{9} (20 patients) found no significant difference in functional outcome, range of motion, or pain, though Mayo elbow performance scores (MEPS) were higher on average for the TEA group. Collectively, the 3 retrospective studies

### Table 1. Comparison of Patient Demographic Characteristics.

|                          | Open Reduction Internal Fixation | Total Elbow Arthroplasty | P Value |
|--------------------------|----------------------------------|--------------------------|---------|
| Age                      | 76.2 (SD 7.5)                    | 74.7 (SD 7.5)            | .29     |
| Gender                   |                                  |                          |         |
| Male                     | 22 (15%)                         | 6 (28%)                  |         |
| Female                   | 121 (85%)                        | 27 (82%)                 |         |
| Race                     |                                  |                          |         |
| Caucasian                | 104 (73%)                        | 19 (58%)                 |         |
| Hispanic                 | 11 (8%)                          | 3 (9%)                   |         |
| African American         | 6 (4%)                           | 2 (6%)                   |         |
| Asian                    | 1 (1%)                           | 0 (0%)                   |         |
| Unknown                  | 21 (15%)                         | 9 (27%)                  |         |
| Transfer status          |                                  |                          | .31     |
| Home                     | 127 (89%)                        | 28 (85%)                 |         |
| Acute setting            | 4 (3%)                           | 2 (6%)                   |         |
| Chronic care setting     | 9 (6%)                           | 1 (3%)                   |         |
| Other                    | 3 (2%)                           | 0 (0%)                   |         |
| Functional status        | 16 (11%)                         | 5 (15%)                  | .55     |
| BMI                      |                                  |                          | .60     |
| Greater than 40          | 6 (4%)                           | 3 (9%)                   |         |
| Less than 40             | 137 (96%)                        | 30 (91%)                 |         |
| History of smoking       | 10 (7%)                          | 3 (9%)                   | .71     |
| Insulin-dependent diabetes| 16 (11%)                        | 2 (6%)                   | .53     |
| History of pulmonary disease | 10 (7%)                        | 3 (9%)                   | .68     |
| History of cardiac disease | 23 (16%)                        | 8 (24%)                  | .27     |
| Hypertension             | 95 (66%)                         | 24 (73%)                 | .36     |
| History of stroke        | 11 (8%)                          | 3 (9%)                   | .73     |
| History of renal disease | 2 (1%)                           | 0 (0%)                   | 1.00    |
| Steroids for chronic condition | 4 (3%)                           | 3 (9%)                   | .12     |
| Disseminated cancer      | 1 (1%)                           | 0 (0%)                   | 1.00    |
| Bleeding-causing disorders | 13 (9%)                          | 4 (12%)                  | .53     |
| Wound class              |                                  |                          | 1.00    |
| Wound class 1/2          | 143 (100%)                       | 33 (100%)                |         |
| Wound class 3/4          | 0 (0%)                           | 0 (0%)                   |         |
| ASA class                |                                  |                          | .16     |
| ASA class 1/2            | 56 (39%)                         | 8 (24%)                  |         |
| ASA class 3/4            | 87 (61%)                         | 25 (76%)                 |         |
| Operation within 30 days of procedure | 1 (1%)                           | 2 (6%)                   | .09     |
| Anesthesia               |                                  |                          | 1.00    |
| General                  | 134 (194%)                       | 32 (97%)                 |         |
| Regional                 | 8 (6%)                           | 1 (3%)                   |         |
| Other                    | 1 (1%)                           | 0 (0%)                   |         |
| Days from admission to operation | 1.1 (SD 1.7)                      | 1.0 (SD 1.4)             | .81     |
| Operative time (mean)    | 140 (SD 70)                      | 165 (SD 70)              | .06     |

### Table 2. Bivariate Analysis of 30-Day Postoperative Complications.

|                          | Open Reduction Internal Fixation | Total Elbow Arthroplasty | P Value |
|--------------------------|----------------------------------|--------------------------|---------|
| Any adverse event        | 12 (8.4%)                        | 4 (12%)                  | .51     |
| Severe adverse event     | 8 (5.6%)                         | 4 (12%)                  | .24     |
| Deep wound infection     | 0 (0%)                           | 0 (0%)                   |         |
| Organ/space infection    | 0 (0%)                           | 0 (0%)                   |         |
| Wound dehiscence         | 0 (0%)                           | 1 (3.0%)                 | .19     |
| Unplanned intubation     | 0 (0%)                           | 1 (3.0%)                 | .19     |
| Thrombolic event (DVT/PE)| 1 (<1%)                          | 0 (0%)                   | 1.00    |
| Renal insufficiency      | 0 (0%)                           | 0 (0%)                   |         |
| Stroke/CVA               | 1 (<1%)                          | 1 (3.0%)                 | .34     |
| Paraplegia               | 0 (0%)                           | 1 (3.0%)                 | .19     |
| Cardiac arrest requiring | 0 (0%)                           | 0 (0%)                   |         |
| CPR                      |                                  |                          |         |
| Myocardial infarction    | 2 (1.4%)                         | 0 (0%)                   | 1.00    |
| Sepsis                   | 1 (<1%)                          | 0 (0%)                   | 1.00    |
| Septic shock             | 0 (0%)                           | 0 (0%)                   |         |
| Return to operating room | 3 (2.1%)                         | 1 (3.0%)                 | .57     |
| Death                    | 1 (<1%)                          | 0 (0%)                   | 1.00    |
| Minor adverse event      | 2 (1.4%)                         | 0 (0%)                   | 1.00    |
| Superficial infection    | 0 (0%)                           | 0 (0%)                   |         |
| Pneumonia                | 0 (0%)                           | 0 (0%)                   |         |
| Urinary tract infection  | 2 (1.4%)                         | 0 (0%)                   | 1.00    |
| Infectious complication  | 1 (<1%)                          | 0 (0%)                   | 1.00    |
| Readmission              | 5 (3.5%)                         | 0 (0%)                   | .59     |
| Total length of stay     | 3.4 (SD 3.4)                     | 4.6 (SD 3.9)             | .06     |
| Length of stay from operation to discharge (days) | 2.5 (SD 1.8) | 3.6 (SD 3.2) | .03 |

### Table 3. Multivariate Analysis of Risk Factors for Adverse Events.

| Outcome/Risk Factor          | Odds Ratio (95% CI) | P Value |
|-----------------------------|---------------------|---------|
| Any adverse event           | 1.13 (0.42-3.24)    | .35     |
| Functional status           | 1.82 (1.07-4.22)    | .04     |
| Insulin-dependent diabetes  | 2.45 (1.03-6.95)    | .03     |
| Severe adverse event        | 1.57 (0.74-2.65)    | .16     |
| Insulin-dependent diabetes  | 1.95 (1.15-3.38)    | .02     |

**Abbreviations:** CVA, cerebrovascular accident; CPR, cardiopulmonary resuscitation; DVT, deep vein thrombosis; PE, pulmonary embolism; SD, standard deviation.

\textsuperscript{a} Unique number of patients with severe or minor adverse event.

\textsuperscript{b} Unique number of patients with severe adverse event.

\textsuperscript{c} Unique number of patients with minor adverse event.

\textsuperscript{d} Unique number of patients with superficial surgical site infection, deep surgical site infection, organ/space infection, sepsis, or septic shock.
recommended TEA for elderly patients with rheumatoid arthritis, osteoporosis, or chronic conditions requiring systemic steroids.9,13,17 The Société orthopédique de l’Ouest also confirmed these results, reporting better MEPS and Disabilities of the Arm, Shoulder and Hand (DASH) scores in TEA than in ORIF.18 In that study, complications occurred in 14% in TEA (reoperation rate 6%) compared to 20% in ORIF (reoperation rate 13%). Despite the analysis of 238 cases, the findings did not reach statistical significance.

Building on the notion that TEA provides better outcomes, McKee et al12 conducted a randomized prospective study in 2009 involving 42 patients. They found that the TEA patients had immediate stability, earlier mobilization with faster rehabilitation, and better short-term functional outcomes in a subset of elderly patients with osteoporosis. The MEPS was better in patients treated with TEA at all-time points up to 2 years. The DASH score was better early on, but that trend reversed by 2-year follow-up. The rate of revision in the TEA group was 12% versus 27% in the ORIF group. In the same study, 25% of the ORIF patients were converted to TEA due to intraoperative findings, highlighting the need for a standardized algorithm to guide surgeon decision making in treating these fractures. This trend has held true in multiple retrospective studies.11,18-22

Multivariate analysis revealed insulin-dependent diabetes and functional status to be independent predictors of adverse events after TEA and ORIF. The importance of addressing modifiable risk factors such as diabetes prior to surgery is generally agreed upon and is currently being tested through models such as the perioperative surgical homes, however, we recognize this may not always be possible for elderly patients undergoing emergency ORIF or TEA.23,24 Our finding regarding functional status is consistent across major orthopedic procedures as illustrated by Pugley et al25 and Basques et al26 who analyzed 19,800 primary hip/knee replacement and 4400 ankle ORIF patients and found functional status to be an independent risk factor for short-term complications and unplanned readmission. Furthermore, looking across specialties, Hoyer et al26 analyzed 9405 patients to show that functional status during the postoperative inpatient stay is an independent predictor for 30-day readmission. Though dependent functional status is often multifactorial, it could be managed pre- and postoperatively using several strategies including setting up a perioperative surgical home to develop a customized care plan for the patient well before surgery or utilizing hospital-based exercise programs to allow early mobilization during the postoperative stay.26-28

Beyond addressing modifiable risk factors, intraoperative soft-tissue management is critical to limiting complications as distal humerus fractures in elderly patients frequently present with a compromised soft-tissue envelope. Given this context and a desire to minimize any further risk of infection, surgeons may be hesitant to treat these fractures with TEA given the high historical infection rate in elective TEA.29 For closed distal humerus fractures without compromised tissue envelop, our analysis found a very low infection rate overall without any meaningful difference in infections up to 30 days postprocedure.

In our study, operative time was longer in the TEA group (165 minutes vs 140 minutes, P = .06). These findings are in contrast to McKee et al who note that operative time in TEA was significantly shorter than ORIF (140 minutes vs 108 minutes, P = .01). This may reflect either that treating surgeons were unfamiliar with TEA instrumentation or failed initial intraoperative attempts at ORIF, which McKee et al describe in 25% of attempted ORIF. Limiting operative time is a modifiable surgeon-dependent risk factor and has similarly been established as a predictor of infection in ankle and tibial plateau fractures.23,30 These findings suggest that the intraoperative decision to convert from ORIF to TEA should be made decisively. Surgeons seeking to perform TEA for fractures in the elderly patients should ensure they are proficient with the surgical technique and equipment of TEA. Additionally, preoperative rehearsal, practice, and prior experience all serve to streamline operations and make them more time efficient.

An additional point of interest identified in our analysis was the length of stay is longer for the TEA group. The reasoning behind this fact is unclear, as medical comorbidities and functional status were similar in both ORIF and TEA groups as well as complication rates. Perhaps, increased length of stay may reflect limited provider experience with TEA versus ORIF.

There are several limitations to this study. First and foremost are those intrinsic to national database studies. Prior literature has found inaccuracies in the NSQIP database.31 This database is not an orthopedic-specific database and functional outcomes are not collected, however, the relevance of NSQIP throughout orthopedics has been widely established.14,15,32 Additionally, late complications of TEA such as triceps insufficiency33,34 and loosening8 are not captured in our analysis. However, our study establishes several relevant short-term complications such as perioperative medical complication, transfusion, and readmission. Although inclusion was limited to intra-articular distal humerus fractures with the same ICD-9 codes, exact radiographic fracture classification cannot be compared between cohorts. At the same time, usage trends of TEA have shown that fracture has rapidly overtaken inflammatory conditions suggesting that indications for TEA in fracture are expanding and are likely no longer confined to most severely comminuted fractures.35 Lastly, our data do not capture functional outcomes, which determine whether a treatment is actually successful. Multiple studies have compared the functional outcome of TEA versus ORIF and found both to be favorable.8,9,11,13,17-22

**Conclusion**

Our study suggests a similar short-term complication profile of ORIF and TEA for distal humerus fractures in elderly patients. Independent risk factors of short-term complications including insulin-dependent diabetes and dependent functional status should be targeted to reduce postoperative complication rates. Although TEA has gained the reputation of being a faster more reliable option to ORIF in certain studies, our findings in a national validated database may indicate otherwise.
Declaration of Conflicting Interests
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