Hemiarthroplasty Versus Reverse Total Shoulder Arthroplasty for Acute Proximal Humerus Fractures in Elderly Patients

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abstract

Proximal humerus fractures are the third most common fracture in elderly patients. Hemiarthroplasty has been the treatment of choice in patients with bone quality and fracture patterns not amenable to open reduction and internal fixation. Reverse total shoulder arthroplasty is a newer option that appears to be less dependent on tuberosity healing than hemiarthroplasty. The authors hypothesized that reverse total shoulder arthroplasty provides improved functional outcomes compared with hemiarthroplasty for fractures in elderly patients.

A retrospective review was performed of all patients treated with arthroplasty for acute proximal humerus fractures in an orthopedic practice using a Current Procedural Terminology code search, patient charts, and radiographs. Validated outcome scores were used to assess satisfaction, function, and general well-being. Twenty-three patients were treated for acute proximal humerus fractures (11 reverse total shoulder arthroplasties and 12 hemiarthroplasties). Three patients were lost to follow-up, and 6 patients were deceased. Mean follow-up was 3.6 years (range, 1.3-8 years). Reverse total shoulder arthroplasty outperformed hemiarthroplasty with regard to forward flexion, American Shoulder and Elbow Society score, University of Pennsylvania shoulder score, and Single Assessment Numerical Evaluation score.

Reverse total shoulder arthroplasty is a reliable option for acute, proximal humerus fractures that are not amenable to closed treatment or reconstruction in elderly patients. Improved functional outcomes when compared with hemiarthroplasty must be balanced against the increased cost and limited life expectancy of patients with this injury.
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cute proximal humerus fractures are the third most common fracture in elderly patients, accounting for 10% of all fractures.1 Although many of these fractures are not treated with arthroplasty, displacement is sometimes too great for closed treatment, and open reduction and internal fixation is contraindicated due to a high risk of fixation loss, malunion, nonunion, or avascular necrosis.2 Hemiarthroplasty has traditionally been the treatment of choice,2 advocated as the gold standard by Neer3,4 in patients with complex 3- and 4-part fractures with poor bone stock not amenable to reconstruction. However, the results of hemiarthroplasty for fracture in the literature are unpredictable, depending largely on the fate of the tuberosities.2,5 The frequency of tuberosity nonunion, malunion (39%-50%), and implant proximal migration has been confirmed in multiple studies.5,6 This leads to a high incidence of poor results, with a surgical complication rate >50%, 10% reoperation rate, and up to 62% dissatisfaction rate.5,7 Pain relief is often acceptable, but functional outcomes frequently vary.8-11

Reverse total shoulder arthroplasty is a newer option, mainly indicated for patients with rotator cuff arthropathy.12 The semiconstrained design with a fixed rotation center allows the deltoit to abduct or elevate the arm in the absence of a functional rotator cuff.13 When the rotator cuff is nonfunctional due to chronic fracture sequelae with tuberosity nonunion or resorption, reverse total shoulder arthroplasty has been used with predictable results.12,14,15 Few case series have reported mid-term results of reverse total shoulder arthroplasty for acute fracture,2,16-21 but few data exist comparing the 2 techniques.2

This article is a retrospective review of 23 consecutive, elderly patients treated in an orthopedic practice for acute proximal humerus fractures with hemiarthroplasty or reverse total shoulder arthroplasty. The hypothesis of this study was that reverse total shoulder arthroplasty provides improved functional outcome scores and patient satisfaction compared with hemiarthroplasty for fractures in elderly patients when arthroplasty is indicated.

MATERIALS AND METHODS

Between January 1, 2003, and January 1, 2011, all consecutive patients who underwent arthroplasty for acute fracture were identified by an International Statistical Classification of Disease (ICD) and Current Procedural Terminology (CPT) code search for reverse total shoulder arthroplasty (23472) and hemiarthroplasty (23470), in conjunction with proximal humerus surgical neck (812.01) or anatomic neck (812.02) fractures. A chart review excluded patients treated for chronic fracture sequelae and included patients treated with hemiarthroplasty or reverse total shoulder arthroplasty for acute proximal humerus fractures within 3 weeks of injury. Patients with axillary nerve palsies were excluded because these traumatic nerve injuries were not certain to resolve, and this is a contraindication to reverse total shoulder arthroplasty. The study was approved by the authors’ Institutional Review Board.

This query yielded 23 patients; 12 patients underwent hemiarthroplasty and 11 underwent reverse total shoulder arthroplasty. Three 3-part fractures, 15 four-part fractures, 2 four-part fractures with head splits, and 1 four-part fracture/dislocation were treated. All patients were treated in a multi-specialty orthopedic practice by 1 of 3 surgeons (M.D.P., B.S.T., M.L.R.). Treatment with hemiarthroplasty or reverse total shoulder arthroplasty was at the discretion of the treating physician.

In the hemiarthroplasty group, all patients were treated using a deltopectoral approach. Cemented, Global FX (DePuy, Warsaw, Indiana), or Aequalis fracture stems (Tornier, Edina, Minnesota) were implanted. The tuberosities were reattached as described by Boileau et al,5 with cerclage sutures and suture tension bands to fix the tuberosities to each other, the prosthesis, and the shaft. Postoperatively, the patients were immobilized in slings and started on passive range of motion (ROM) exercises on postoperative day 1. Gentle, well-arm assisted passive ROM with maximum supine forward flexion was limited to 130°, and external rotation was limited to 30°. When tuberosity healing was demonstrated radiographically, typically 6 to 8 weeks postoperatively, progressive ROM and strengthening were started.

In the reverse total shoulder arthroplasty group, 2 patients were treated with a superior approach and 9 were treated with a deltopectoral approach. All implants were cemented using 1 of 2 similar reverse design prostheses with a medialized rotation center: Delta III (DePuy) or Aequalis Reversed for Fracture (Tornier). The tuberosities were handled identically to the hemiarthroplasty cases, with the exception that the supraspinatus tendon was excised. The tuberosities were not excised or left unattached. Patients were immobilized in slings for 3 weeks postoperatively. The slings were removed, and patients were encouraged to perform deltoid activation exercises and activities as tolerated.

All patient charts were reviewed for patient history, operative technique, complications, and ROM. Radiographs taken at 6 weeks, 6 months, and 1 year postoperatively were reviewed for tuberosity healing, implant loosening, dislocation, notching (reverse total shoulder arthroplasty), and superior migration (hemiarthroplasty). Each patient was contacted, and validated outcome measures were used to assess satisfaction, function, and general well-being. The person administering the survey (G.E.G., P.S.J.) was blinded to the treatment of the patients. The validated Single Assessment Numeric Evaluation (SANE) score,22 University of Pennsylvania (Penn) shoulder score,23 American Shoulder and Elbow Society (ASES) score,24 and European Quality of Life Questionnaire-5 Domain (EQ5D)25 were used.

Data between the 2 groups were compared with Student’s 2-tailed t test. Intent-
to-treat analysis was used and was relevant for 2 hemiarthroplasty patients who were revised to reverse total shoulder arthroplasty. \(P\) values <.05 were considered significant.

**RESULTS**

Average patient age was 75 years, and average follow-up was 3.6 years (range, 1.3-8 years). Each patient sustained the injury from a fall: 1 from a step ladder, 1 down stairs, and the remainder from standing height. Four of 11 patients in the reverse total shoulder arthroplasty group were deceased, and 1 could not be contacted. Two of 12 patients in the hemiarthroplasty group were deceased, 1 had dementia and was unable to answer questions, and 2 could not be contacted. The deceased patients were an average age of 78 years at surgery and died an average of 3.3 years postoperatively (range, 1-6.7 years) from causes unrelated to their shoulders (Table 1). Overall, 19 (83%) of 23 patients had minimum 1-year clinical follow-up data.

As a retrospective study, the implant choice was at the surgeons’ discretion. Thus, aside from the similar injury types and injury mechanism, the 2 groups were not completely matched. Patients in the hemiarthroplasty group tended to be younger at surgery (mean age, 69 years; range, 57-87 years) than the reverse total shoulder arthroplasty patients (mean age, 81 years; range, 67-97 years). At last clinical follow-up, the reverse total shoulder arthroplasty patients had significantly greater active forward elevation (mean, 122°; range, 90°-145°) than the hemiarthroplasty group (mean, 90°; range, 30°-140°) (\(P<.05\)). Active external rotation was 33° for the reverse total shoulder arthroplasty group and 31° for the hemiarthroplasty group. This difference was not statistically different.

Validated functional outcome data from the living patients showed that reverse total shoulder arthroplasty outperformed hemiarthroplasty on ASES score (81 vs 47, respectively; \(P<.05\)), Penn score (82 vs 53, respectively; \(P<.05\)), and SANE score (85 vs 39, respectively; \(P<.05\)). The mean EQ5D quality of life measure was higher for reverse total shoulder arthroplasty but did not reach statistical significance (87 vs 64, respectively; \(P=.07\)) (Table 2).

One of 11 reverse total shoulder arthroplasty patients had Sirveaux grade 1 notching, and 2 of 12 hemiarthroplasty patients had tuberosity nonunion (Table 3). Both patients were revised to reverse total shoulder arthroplasties, but their scores are included in the hemiarthroplasty group under the intent-to-treat principle. One patient had 30° of forward elevation after hemiarthroplasty and 150° after conversion to reverse total shoulder arthroplasty. The scores were one of the best of the hemiarthroplasty group.

### Table 1

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Implant</th>
<th>Age at Surgery, y</th>
<th>Cause of Death</th>
<th>Time from Surgery to Death, y</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Reverse</td>
<td>78</td>
<td>Unknown/no autopsy</td>
<td>1.8</td>
</tr>
<tr>
<td>2</td>
<td>Reverse</td>
<td>82</td>
<td>Metastatic cancer</td>
<td>3.8</td>
</tr>
<tr>
<td>3</td>
<td>Reverse</td>
<td>92</td>
<td>Pulmonary embolus</td>
<td>3.8</td>
</tr>
<tr>
<td>4</td>
<td>Reverse</td>
<td>77</td>
<td>Unknown/no autopsy</td>
<td>2.8</td>
</tr>
<tr>
<td>5</td>
<td>Hemi</td>
<td>75</td>
<td>Metastatic cancer</td>
<td>6.7</td>
</tr>
<tr>
<td>6</td>
<td>Hemi</td>
<td>77</td>
<td>Cerebrovascular accident</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Mean 3.3

Abbreviations: Hemi, hemiarthroplasty; Reverse, reverse total shoulder arthroplasty.

*Thirty percent of patients (30%) died of unrelated causes at a mean of 3.3 years postoperatively.

### Table 2

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Hemiarthroplasty</th>
<th>Reverse Total Shoulder Arthroplasty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients, No.</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Deceased, No.</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Age at surgery, y</td>
<td>69.3 (57-87)</td>
<td>80.5 (67-97)</td>
</tr>
<tr>
<td>Time to surgery, d</td>
<td>9 (1-21)</td>
<td>7 (1-14)</td>
</tr>
<tr>
<td>Forward elevation, deg</td>
<td>91 (30-140)</td>
<td>121 (90-145)</td>
</tr>
<tr>
<td>External rotation, deg</td>
<td>31 (5-60)</td>
<td>34 (10-45)</td>
</tr>
<tr>
<td>Penn</td>
<td>52.5 (29-86)</td>
<td>81.5 (73-99)</td>
</tr>
<tr>
<td>ASES</td>
<td>47.4 (30-81)</td>
<td>81.1 (75-88)</td>
</tr>
<tr>
<td>SANE</td>
<td>38.5 (0-90)</td>
<td>85 (70-95)</td>
</tr>
<tr>
<td>EQ5D:VAS</td>
<td>64.2 (40-90)</td>
<td>86.6 (70-100)</td>
</tr>
</tbody>
</table>

Abbreviations: ASES, American Shoulder and Elbow Society score; deg, degrees; EQ5D, European Quality of Life Questionaire-5 Domain; Penn, University of Pennsylvania shoulder score; RSA, reverse shoulder arthroplasty; SANE, Single Assessment Numeric Evaluation; VAS, visual analog scale.

*Note the improved functional results with RSA across most measures.
Complications After Hemiarthroplasty and RSA for Acute Fracture

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Implant</th>
<th>Age at Surgery, y</th>
<th>Complication</th>
<th>Penn</th>
<th>ASES</th>
<th>SANE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Reverse</td>
<td>78</td>
<td>Grade 1 notching, no loosening</td>
<td>Patient deceased</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Hemi</td>
<td>63</td>
<td>Tuberosity nonunion, revised to RSA</td>
<td>84</td>
<td>82</td>
<td>90</td>
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<tr>
<td>8</td>
<td>Hemi</td>
<td>65</td>
<td>Tuberosity resorption, revised to RSA</td>
<td>32</td>
<td>13</td>
<td>20</td>
</tr>
<tr>
<td>9</td>
<td>Hemi</td>
<td>77</td>
<td>Brachial plexopathy, glenoid erosion, revised to TSA, periprosthetic fracture</td>
<td>29</td>
<td>23</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>Hemi</td>
<td>57</td>
<td>Brachial plexopathy</td>
<td>36</td>
<td>47</td>
<td>10</td>
</tr>
</tbody>
</table>

Abbreviations: ASES, American Shoulder and Elbow Society score; Hemi, hemiarthroplasty; Penn, University of Pennsylvania shoulder score; RSA, reverse shoulder arthroplasty; SANE, Single Assessment Numerical Evaluation; TSA, total shoulder arthroplasty.

*Patients revised from hemiarthroplasty to RSA were analyzed with the hemiarthroplasty cohort under the intent-to-treat principle.

In elderly patients with contraindications to closed treatment or internal fixation, arthroplasty for acute proximal humerus fractures has traditionally been hemiarthroplasty. However, multiple studies have shown significant complications and poor clinical outcomes with this treatment. The hypothesis of the current study was that reverse total shoulder arthroplasty would provide improved functional outcome scores and patient satisfaction compared with hemiarthroplasty when used for fractures in elderly patients. This study showed a statistically and clinically significant superiority of reverse total shoulder arthroplasty vs hemiarthroplasty for fracture. The mean ASES score (81 vs 47, respectively; \( P<.05 \)), Penn score (82 vs 53, respectively; \( P<.05 \)), and active forward elevation (122° vs 90°, respectively; \( P<.05 \)) showed a difference, even given the small number of patients included in the study.

The best results for reverse total shoulder arthroplasty are for rotator cuff arthropathy, but its effectiveness has also been demonstrated for fracture sequelae, including tuberosity nonunion. Levy et al reported that reverse total shoulder arthroplasty is an option for the revision of a failed hemiarthroplasty due to glenoid arthritis or rotator cuff deficiency following tuberosity failure. However, despite improvements in pain, motion, and function, the complication rate for this procedure is 28%. The unpredictability of reverse total shoulder arthroplasty for the revision of failed fracture hemiarthroplasty is demonstrated by patients 7 and 8, with different outcome scores after the same revision procedure (Table 3). More recently, several small studies and case reports have shown good results when reverse total shoulder arthroplasty is performed for acute fracture compared with the results of managing chronic fracture sequelae.

Prior studies evaluating reverse total shoulder arthroplasty for acute proximal humerus fracture have mostly come from the European literature and, thus, most have used the recommended score of the European Society for Shoulder and Elbow Surgery, the Constant score. The Constant scores ranged between 44 and 55 for reverse total shoulder arthroplasty and 39 and 41 for hemiarthroplasty. Our ASES scores are not directly comparable, but because both scores take into account pain and function, the higher mean Constant score for reverse total shoulder arthroplasty in many studies is not surprising.

Young et al evaluated a consecutive series of patients after changing their preferred management from hemiarthroplasty to reverse total shoulder arthroplasty. They reported no statistical difference in ASES score with 65 (range, 40-88) for reverse total shoulder arthroplasty and 67 (range, 26-100) for hemiarthroplasty. This is similar to the results of Sirveaux et al, who reported that the best hemiarthroplasty patients were better than the best reverse total shoulder arthroplasty patients, but mean results were equivalent because the hemiarthroplasty results were bimodal and dependent on tuberosity healing. Although mean ASES scores in the current study were 81 for reverse total shoulder arthroplasty and 47 for hemiarthroplasty, our functional results echo this somewhat, with reverse total shoulder arthroplasty SANE scores in a relatively tight range (range, 70-95), whereas in the hemiarthroplasty group, the SANE scores had a
bimodal appearance with patients clustered between 0 and 20 and 60 and 90. Multiple authors have shown that reverse total shoulder arthroplasty for acute fracture is a reproducible procedure,21 with results that are less dependent on tuberosity healing than hemiarthroplasty.17,26

Range of motion is also related to tuberosity healing.26 Perhaps due to this effect, a wider distribution existed of forward elevation in the hemiarthroplasty group (range, 30°-140°) vs the reverse total shoulder arthroplasty group (range, 90°-145°). The variability introduced by tuberosity healing, coupled with variability in technique and small sample size, may explain why previous studies have failed to report a difference between elevation after hemiarthroplasty and reverse total shoulder arthroplasty.22,26 In the current study, mean active forward elevation after reverse total shoulder arthroplasty was 122°, similar to other studies of reverse total shoulder arthroplasty for acute proximal humerus fracture that have reported 97° to 123°.2,17,19,21,26

The hemiarthroplasty results are more variable, with the current study’s mean of 90° between that of Gallinet et al’s 17 mean flexion of 53° after hemiarthroplasty and Young et al’s 5 mean of 108°. Gallinet et al’s 17 poor results after hemiarthroplasty resulted in a statistically significant difference when compared with reverse total shoulder arthroplasty, whereas Young et al’s 5 good hemiarthroplasty results showed no difference. The current study’s active external rotation of 33° in the reverse total shoulder arthroplasty and 31° in the hemiarthroplasty groups is also similar to the published literature.17,19,21,26 The only outlier was Gallinet et al.,17 whose technique for reverse total shoulder arthroplasty involved tuberosity excision. Consequently, they had a mean of 9° of active external rotation.17 Thus, tuberosity healing is critical to the results of hemiarthroplasty and affects external rotation after reverse total shoulder arthroplasty.

In the current series, complications were rare after reverse total shoulder arthroplasty, with 1 case of grade 1 notching and no dislocations. The hemiarthroplasty group sustained multiple complications (Table 3). Boileau et al2 and Smith et al2 reported that tuberosity healing is the key issue with hemiarthroplasty for fracture. Both patients with tuberosity nonunion after hemiarthroplasty were revised to reverse total shoulder arthroplasty. Underscoring the unpredictability of reverse total shoulder arthroplasty for chronic fracture sequelae as opposed to reverse total shoulder arthroplasty for acute proximal humerus fracture, one of these revisions had the best scores of the hemiarthroplasty patients, whereas the other had some of the worst. Two patients also had brachial plexopathy in the hemiarthroplasty group. The etiology for this is unclear, but the continued neuropathic pain negatively affected the outcome scores. One of the hemiarthroplasty patients sustained a periprosthetic humerus fracture during another fall, emphasizing the frailty of this patient population. Other authors have shown a high degree of mortality from unrelated causes in this patient population. Bufquin et al19 reported that 5 (12%) of 43 patients died <2 years postoperatively.

Even with a slightly younger average patient age at surgery (75 vs 78 years) compared with Bufquin et al,19 a higher percentage of patients in the current study were deceased at follow-up (6/20, 30%). This may be due to our longer mean follow-up (3.6 vs <2 years), especially when considering that deceased patients lived an average of 3.3 years postoperatively. Cazeneuve and Cristofari18 evaluated 36 reverse total shoulder arthroplasties for acute fractures at 2 time points. A large percentage of their elderly patients died during follow-up due to unrelated causes (9/45, 20%). At a mean follow-up of 6.6 years, they reported a decrease in the Constant score from 55 to 53. In addition, the number of scapular notches increased from 14 to 19 during this time. No statistical analysis was provided to determine significance, but they concluded that further follow-up was required to determine if reverse total shoulder arthroplasty has a place in the management of acute proximal humerus fractures.18

Aside from the approximately 50% long-term complication rate of hemiarthroplasty dominated by the healing of the tuberosities,5,11 large database cohorts have provided guidance on the rate of major short-term complications. Farring et al29 used the Medicare database to evaluate the 90-day complication rate of >5000 hemiarthroplasties for fracture. A 2.9% mortality rate and 1% revision rate were found.29 Singh et al30 used the Mayo Clinic joint registry and reported a 1% mortality rate for all hemiarthroplasties. One explanation for the low revision rate with a high complication rate is that patients and physicians are willing to accept the poor outcome instead of choosing revision arthroplasty.

Reverse total shoulder arthroplasty for fracture has not been performed as long as hemiarthroplasty, and large cohort data do not exist. However, Zumstein et al31 performed a meta-analysis, including 782 reverse total shoulder arthroplasties from multiple studies, and reported complications in 24% of cases, with instability being the most common (4.7%). Scapular notching and hematoma were not defined as complications but were noted as problems because they did not significantly change the outcome. If these cases were included, the overall rate would have more than doubled. The revision rate after primary reverse total shoulder arthroplasty was 6.3%, after revision reverse total shoulder arthroplasty was 15.7%, and after acute fracture was 12.5%.31 Mortality after reverse total shoulder arthroplasty is not known, perhaps confounded by the lack of a distinct CPT code for this procedure that makes searching the Medicare database impossible.

Longer follow-up would be preferred. However, to the authors’ knowledge, the current study’s mean follow-up of 3.6 years (range, 1.3-8 years) makes this the longest comparative study of reverse total shoulder arthroplasty vs hemiarthroplasty for acute proximal humerus fracture. The
study is limited by its retrospective nature. In particular, the hemiarthroplasty and reverse total shoulder arthroplasty groups are nonrandomized. Differences between the groups, including the older mean age of the reverse total shoulder arthroplasty patients, reflected surgeon preference and experience that favored reverse total shoulder arthroplasty over hemiarthroplasty in more elderly patients. A prospective, randomized trial of reverse total shoulder arthroplasty vs hemiarthroplasty is necessary to answer this question, and such a trial is currently underway at the authors’ institution.

**Conclusion**

Reverse total shoulder arthroplasty is a reliable option for acute proximal humerus fractures in elderly patients. Improved functional outcomes when compared with hemiarthroplasty must be balanced against the increased cost and limited life expectancy of patients with this injury.

**References**