Functional outcomes of reverse shoulder arthroplasty compared with hemiarthroplasty for acute proximal humeral fractures

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Background: Complex acute proximal humeral fractures may require prosthetic replacement of the proximal humerus. Reverse shoulder arthroplasty (RSA) has been suggested as an alternative to hemiarthroplasty in the management of such fractures. This study compared the functional outcomes of RSA with hemiarthroplasty in patients with acute proximal humeral fractures.

Materials and methods: All patients who underwent RSA or shoulder hemiarthroplasty for acute proximal humeral fractures between January 1, 1999, and December 31, 2010 were identified from The New Zealand Joint Registry. Baseline information, operative characteristics, and postoperative outcomes (Oxford Shoulder Score [OSS] at 6 months and 5 years, revision rate, and mortality rate) were examined and compared between the study groups.

Results: During the study period, 55 patients underwent RSA and 313 underwent shoulder hemiarthroplasty for acute proximal humeral fractures. Compared with hemiarthroplasty patients, RSA patients were significantly older (mean age, 79.6 vs 71.9 years; \( P < .001 \)) and more often women (93% vs 78%, \( P = .013 \)). The 6-month OSS was 28.1 for RSA and 27.9 for hemiarthroplasty, which was not significantly different (\( P = .923 \)); however, the RSA group had a significantly better 5-year OSS than the hemiarthroplasty group (41.5 vs 32.3, \( P = .022 \)). There was no significant difference between the RSA and hemiarthroplasty groups in revision rate per 100 component-years (1.7 vs 1.1, \( P = .747 \)) or in 1-year mortality (3.5% vs 3.6%, \( P > .99 \)).

Conclusions: Patients with acute proximal humeral fractures who undergo RSA appear to achieve superior 5-year functional outcomes compared with patients who undergo hemiarthroplasty.

Level of evidence: Level III, Retrospective Case Control Design, Treatment Study.

Keywords: Functional outcome; shoulder arthroplasty; reverse shoulder arthroplasty; hemiarthroplasty; proximal humeral fracture; shoulder fracture

Proximal humeral fractures are increasingly common in societies with aging populations and represent the third most common fracture in people aged older than 65 years.\(^3\) Undisplaced or minimally displaced fractures can generally be managed nonsurgically with satisfactory results.\(^{21,24} \)
Displaced fractures may require operative intervention; however, there is no consensus regarding the ideal management of these fractures.

Historically, complex proximal humeral fractures, including 4-part fractures, 3-part fractures in osteoporotic bone, fracture-dislocations, head-splitting fractures, and impression fractures involving >40% to 50% of the articular surface have been managed with shoulder hemiarthroplasty.\(^6\) Shoulder hemiarthroplasty is technically demanding, however, and anatomic tuberosity reconstruction, restoration of humeral length, and ideal retroversion are often difficult to achieve. Long-term studies have identified limitations with this procedure,\(^1\) and functional outcomes depend on several factors, primarily the displacement of the tuberosities.\(^5\) Satisfactory results can be achieved; however, even in the hands of experienced shoulder surgeons, clinical failures are common.\(^6\)

Reverse shoulder arthroplasty (RSA) has shown promising results in patients with cuff tear arthropathy, degenerative arthritis with concurrent cuff deficiency, painful pseudoparalysis, or proximal humeral malunion\(^4,14,26-28\) and has been proposed as an alternative management option for acute complex proximal humeral fractures.\(^7,8,18,19\) RSA holds a number of theoretic advantages over hemiarthroplasty in the management of these fractures. Functional outcomes appear to depend less on tuberosity healing and rotator cuff integrity, and patients have been observed to recover more quickly, with less requirement of careful protection and rehabilitation, than hemiarthroplasty patients.\(^14\) The aim of this study was to compare the functional outcomes of RSA with hemiarthroplasty in patients with acute proximal humeral fractures.

**Materials and methods**

Data covering the period of January 1, 1999, to December 31, 2010, were obtained from The New Zealand Joint Registry. Registry records of all patients who underwent primary RSA and those who underwent primary shoulder hemiarthroplasty during this time with the principle diagnosis of acute proximal humeral fracture were analyzed.

Patients undergoing RSA were compared with patients undergoing shoulder hemiarthroplasty with respect to baseline information (age, sex, surgeon case volume), operative characteristics (surgical approach, prostheses used, operative time), and postoperative outcomes, including the Oxford Shoulder Score (OSS)\(^11\) at 6 months and 5 years, the revision rate, and mortality rates at 6 months and 1 year.

**Statistical analyses**

Baseline demographic and operative measures were compared between the groups using Fisher exact tests, independent \(t\) tests, and Mann-Whitney \(U\) tests, as appropriate. A general linear model was used to compare OSS outcomes between groups in a multivariate analysis that included age, sex, and surgeon case volume. Mortality rates were compared using Fisher exact tests, and log-rank tests were used to compare revision rates during the entire follow-up period. A two-tailed \(P < .05\) was taken to indicate statistical significance.

**Methodologic considerations**

The New Zealand Joint Registry was established in 1998 and became fully national early in 1999. The registry prospectively records baseline characteristics, operative characteristics, and postoperative outcome measures for patients undergoing arthroplasty surgery throughout New Zealand, with the compliance rate among public hospitals exceeding 98%.\(^25\) The registry records patient functional outcomes after shoulder arthroplasty using the self-assessed OSS,\(^11\) with questionnaires sent to patients 6 months and 5 years after surgery. The OSS, a patient-reported outcome measure designed to assess functional outcomes after shoulder surgery, has been validated in several studies\(^9,10\) and correlates well with the Constant shoulder score in patients with proximal humeral fractures.\(^2\) The OSS score ranges from 0 (the most severe disability) to 48 (normal shoulder function). The New Zealand Joint Registry classifies OSS results according to the system of Kalairajah et al,\(^17\) who have recommended a category of excellence for a score \(>41\), good for a score of 34 to 41, fair for 27 to 33, and poor for scores \(<27\).

**Results**

During the study period, 55 patients who underwent primary RSA and 313 patients who underwent primary shoulder hemiarthroplasty with the principle diagnosis of acute proximal humeral fracture were identified from New Zealand Joint Registry records.

**Baseline information**

At the time of surgery, the RSA patients were significantly older (mean age, 79.6 vs 71.9 years; \(P < .001\)) and more often women (93% vs 78%, \(P = .013\)) than the hemiarthroplasty patients (Table I). There was a statistically significant difference in surgeon case volume between the 2 patient groups, with RSA more frequently performed by higher-volume shoulder surgeons (73% [RSA] vs 31% [hemiarthroplasty] of cases completed by surgeons performing \(\geq 10\) cases per year, \(P < .001\)).

**Operative characteristics**

All patients in the RSA and hemiarthroplasty groups underwent a deltopectoral approach to the shoulder. The most commonly used prostheses in the RSA patients were the SMR Modular Shoulder (Limacorporate S.p.a., Udine, Italy) system in 28 and the Delta XTEND Reverse Shoulder system (DePuy, Warsaw, IN, USA) in 24. The most commonly used prostheses systems in the hemiarthroplasty patients were the Global (DePuy, Warsaw, IN, USA) in 178, the SMR in 34, and the Aequalis (Tornier SAS, Montbonnot, France) in 34. There was no significant difference in operative time between the
RSA and hemiarthroplasty groups (mean, 123 vs 118 minutes; \( P = .308 \); Table I).

**Postoperative outcomes**

**Oxford Shoulder Score**

No statistically significant difference was noted in the 6-month mean OSS between the RSA (28.1) and hemiarthroplasty (27.9) groups (\( P = .923 \); Table II). There was, however, a statistically significant difference at 5 years, with the RSA group displaying a superior OSS of 41.5 vs 32.3 in the hemiarthroplasty group (\( P = .022 \)).

With respect to the most commonly used implant systems, there was no statistically significant difference in OSS in the RSA group (\( P = .167 \)) or the hemiarthroplasty group (\( P = .80 \)) according to implant system used.

Multivariate analyses showed that patient age (\( P = .931 \)), sex (\( P = .638 \)), and surgeon case volume (\( P = .375 \)) did not have independently significant effects on postoperative OSS.

**Revision rate**

The difference in revision rate between the RSA group and the hemiarthroplasty group was not statistically significant (1.7 vs 1.1 revisions per 100 component-years; \( P = .747 \); Table II). New Zealand Joint Registry recorded reasons for revision include pain, instability, implant loosening, deep infection, and fracture. There was no statistically significant difference in revision rates between the 2 groups for any of these reasons for revision. The prosthetic-specific revision rates for the RSA or the hemiarthroplasty groups did not differ significantly.

**Mortality**

There was no statistically significant difference in the mortality rates at 6 months in RSA vs hemiarthroplasty patients (3.5% vs 2.2%; \( P = .63 \)) or at 1 year (3.5% vs 3.6%; \( P > .99 \); Table II).

**Discussion**

The comparable 6-month functional results seen in our study support the findings of previous studies, which did not identify substantial early functional benefit of RSA over hemiarthroplasty in the management of acute proximal humeral fractures\(^{13,29}\). We have identified an important midterm difference between the 2 patient groups, however, with RSA patients achieving 5-year functional results superior to hemiarthroplasty patients. In addition to patient functional benefits, this superior OSS is important for expected implant longevity, because joint registry research has identified a statistically significant relationship between the postoperative OSS and the risk of revision at 2 years: 0.18% with an OSS exceeding 42 compared with 4.96% with an OSS of less than 34\(^{,25}\). It is also interesting to note that although fracture morphology and patient characteristics differ, the promising midterm OSS seen in our RSA group compares favorably with reports of OSS in proximal humeral fracture patients managed nonoperatively\(^{,7}\) with plate osteosynthesis\(^{,30}\) and with intramedullary nail fixation\(^{,23}\).

Other authors have investigated postoperative function after hemiarthroplasty for acute proximal humeral fractures with mixed results. Antuna et al\(^{1}\) reported 57 patients with an average age of 66 years (range, 23-89 years), of which 84% reported no shoulder pain at a mean follow-up of 10.3 years but only 49% graded their overall result as excellent. Goldman et al\(^{15}\) published results of 22 patients at a mean follow-up of 30 months. Although 73% of patients reported only slight or no pain, 73% of patients reported difficulty with at least 3 of 15 functional tasks. Boileau et al\(^{5}\) presented the results of 66 patients, who were a mean age of 66 years (range, 31-85), with an average follow-up of 27 months. The Constant score in this group averaged 56 of 100, 42% of patients were disappointed with their results, and tuberosity malposition correlated with an inferior functional result.

Despite a number of theoretic advantages over hemiarthroplasty, the published functional outcomes after RSA for acute proximal humeral fractures have been similarly mixed: Bufquin et al\(^{7}\) published the results of 43 patients who were a mean age of 78 years (range, 65-97 years). At a mean of 22 months postoperatively, their mean Constant score was 44. The authors cautioned against recommending RSA in this patient group before long-term results were available.

<table>
<thead>
<tr>
<th>Variable*</th>
<th>RSA ( (n = 55) )</th>
<th>Hemiarthroplasty ( (n = 313) )</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient age, years</td>
<td>79.6 (57-90)</td>
<td>71.9 (27-96)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Female sex</td>
<td>51 (92.7)</td>
<td>244 (78.0)</td>
<td>.013</td>
</tr>
<tr>
<td>Surgeon ≥10 cases/year</td>
<td>40 (72.7)</td>
<td>97 (31.0)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Operative time, min</td>
<td>123.3 ± 23.9</td>
<td>118.8 ± 34.2</td>
<td>.308</td>
</tr>
</tbody>
</table>

* Continuous data are recorded as mean (range) or ± standard deviation, and categoric data as number of patients (percentage of group of patients).

† Surgeon case volume for RSA or hemiarthroplasty, respectively.
Cazeneuve and Cristofari\(^8\) reported 23 patients (mean age, 75 years). At an average follow-up of 86 months, the mean Constant score was 60 points.

Klein et al\(^18\) presented a comprehensive functional review of 20 patients (mean age, 75 years). After an average follow-up of 33 months, the mean Constant score was 68 points, the mean Disabilities of Arm, Shoulder and Hand (DASH) score was 47 points, the mean modified American Shoulder and Elbow Surgeons (ASES) score was 68, and the physical and mental components of the Medical Outcome Study 36-Item Short Form (SF-36) Health Survey were 38 and 53 points, respectively. The authors felt that the good functional outcome seen in their series supported the use of RSA as a treatment option for elderly patients with complex acute proximal humeral fractures.

The comparative literature contrasting the functional outcomes of RSA with hemiarthroplasty in the management of acute proximal humeral fractures is relatively limited. Young et al\(^29\) published their comparison of 10 patients receiving RSA with 10 patients receiving hemiarthroplasty for acute proximal humeral fractures. The patients were a mean age of 77 years for the RSA group and 75 years for the hemiarthroplasty group, and the average follow-up was 22 months and 44 months, respectively. The authors found no statistically significant difference in ASES or OSS between the two groups.

Gallinet et al\(^13\) compared 16 patients treated with RSA and 17 patients treated with hemiarthroplasty for proximal humeral fracture. Their patients were an average age of 74 years, and the mean follow-up was 12.4 months in the RSA group and 16.5 months in the hemiarthroplasty group. Although the authors identified a higher postoperative Constant score in the RSA group, DASH scores in the 2 groups were identical.

Patients presenting with proximal humeral fractures are typically elderly, often with significant medical comorbidities. The mortality rates seen in our patients were relatively low compared with previous studies, however. Olsson et al\(^22\) found a 1-year mortality of 9% in 100 patients with a mean age of 74 years, Johnell et al\(^19\) detected a 1-year mortality of 13% in 237 patients with a mean age of 75.1 years, and Farnig et al\(^12\) found a 90-day mortality rate of 2.9% in 5044 patients with a mean age of 71.9 years who received varied management for proximal humeral fractures. The lower than expected mortality rates in our study are difficult to explain, but may suggest that patients with proximal humeral fractures who are medically unwell are less likely to be put forward for shoulder arthroplasty than patients with minimal comorbidities. In any case, it was interesting to note that our RSA group was older than our hemiarthroplasty group but the difference in early postoperative mortality was not significant. Although acknowledging the limited statistical power for this comparison, it does suggest that our 2 groups were medically comparable.

Our study has several limitations. Firstly, the patient groups were not equivalent at baseline because they differed with respect to age, sex, and surgeon case volume. Multivariate analyses were performed to adjust the OSS comparison for these potential confounding variables, however, and this had no effect on the significance of the differences between the two patient groups.

Secondly, preoperative OSS was not assessed, which would have assisted interpretation of postoperative function. However, because the patients in our study were all admitted and managed acutely after shoulder trauma, the validity of premorbid shoulder functional assessment is questionable.

Thirdly, the New Zealand Joint Registry does not include preoperative or postoperative radiographic assessment, assessment of associated soft tissue injury, or the specific indications for RSA or hemiarthroplasty in each case, restricting result stratification with respect to fracture severity, soft tissue damage, tuberosity healing, and treatment algorithm. Tuberosity healing is of particular importance, because near-anatomic tuberosity healing in hemiarthroplasty patients has been shown to significantly positively affect patient outcomes.\(^5\)

Fourthly, owing to the registry-based nature of our study, functional evaluation was restricted to the OSS, which is purely a subjective scoring system. Objective functional evaluation, with assessment of range of motion and power, would have significantly strengthened our group comparisons.

Finally, the patient diagnosis of acute fracture is entered into the New Zealand Joint Registry records by the operating surgeon only and is not validated; although unlikely,

### Table II  Postoperative outcomes for patients undergoing reverse shoulder arthroplasty (RSA) compared with patients undergoing hemiarthroplasty for acute proximal humeral fracture

<table>
<thead>
<tr>
<th>Variable</th>
<th>RSA</th>
<th>Hemiarthroplasty</th>
<th>(P)</th>
</tr>
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<tbody>
<tr>
<td>Oxford Shoulder Score*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 months</td>
<td>28.1 (0.7)</td>
<td>27.9 (0.8)</td>
<td>.923</td>
</tr>
<tr>
<td>5 years</td>
<td>41.5 (2.3)</td>
<td>32.3 (1.2)</td>
<td>.022</td>
</tr>
<tr>
<td>Revision rate†</td>
<td>1.7</td>
<td>1.1</td>
<td>.747</td>
</tr>
<tr>
<td>1-year mortality‡</td>
<td>2 (3.6)</td>
<td>11 (3.5)</td>
<td>&gt;.99</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable</th>
<th>Data presented as mean (standard error).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revision rate per 100 component-years.</td>
<td></td>
</tr>
<tr>
<td>Number of patients who died (percentage of group of patients).</td>
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</tbody>
</table>
this could have resulted in an inaccurate diagnosis for certain patients and consequent information bias.

Conclusion
In this nationwide registry-based cohort study comparing 55 patients undergoing primary RSA with 313 patients undergoing primary hemiarthroplasty for acute proximal humeral fractures, RSA appeared to produce functionally superior results to hemiarthroplasty at 5 years postoperatively. To our knowledge, this study reports the largest series with functional postoperative outcome data comparing RSA with hemiarthroplasty in the management of acute proximal humeral fractures. Our results support RSA as a successful surgical option for patients with acute proximal humeral fractures requiring prosthetic replacement of the humeral head. Longer follow-up is required to confirm the functional benefit of RSA in this patient group.

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The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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