Outcomes after shoulder replacement: comparison between reverse and anatomic total shoulder arthroplasty

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Background: Anatomic total shoulder arthroplasty (TSA) and reverse total shoulder arthroplasty (RTSA) are increasingly common procedures employed to treat arthritic conditions. Although TSA is a widely accepted procedure for glenohumeral arthritis with intact rotator cuff, concerns about RTSA persist because of variable complication rates and outcomes.

Methods: This is a prospective, case-control study comparing outcomes and complications after TSA and RTSA. The study included 47 patients undergoing TSA for glenohumeral arthritis and 53 patients undergoing RTSA for rotator cuff tear arthropathy. Average clinical follow-up was more than 2 years in both groups. Major complications included infection, periprosthetic fracture, instability, glenoid loosening, and need for revision surgery. Patient outcome measures included the American Shoulder and Elbow Surgeons score, pain visual analog scale score, and goniometer-measured range of motion. Plain radiographs were reviewed to assess for degree of glenoid lucency in TSA and scapular notching in RTSA.

Results: At 2 years, there were no differences in rate of major complications (TSA, 15%; RTSA, 13%; \( P = .808 \)) or revision surgeries (TSA, 11%; RTSA, 9%). Outcomes assessed by the American Shoulder and Elbow Surgeons score and visual analog scale were also similar between the 2 groups. TSA patients had greater external rotation than RTSA patients did (53° vs 38°; \( P = .001 \)). Otherwise, forward flexion, abduction, and internal rotation were comparable in range of motion.

Conclusions: TSA and RTSA have similar complication rates, need for revision, patient-reported outcomes, and range of motion at 2 years of follow-up. The use of side-by-side cohorts in this study allows standardized comparison between these 2 shoulder arthroplasty procedures.

Level of evidence: Level III, Retrospective Cohort Design, Treatment Study.

Keywords: Reverse shoulder arthroplasty; total shoulder arthroplasty; rotator cuff tear arthropathy; osteoarthritis; postoperative complications

Reverse total shoulder arthroplasty (RTSA) and anatomic total shoulder arthroplasty (TSA) are increasingly common operations in the treatment of degenerative shoulder disease.\(^1\) Since its development by Neer in the 1970s, TSA has been a reliable method of treating primary...
glenohumeral arthritis with good medium- and long-term results. However, the outcome of TSA is highly dependent on the preserved function of the rotator cuff. In cuff-deficient patients, the unopposed action of the deltoid causes superior migration of the humeral head, leading to poor functional results, glenoid component loosening, and early surgical failures.

RTSA emerged as an alternative treatment option for glenohumeral arthritis in the setting of rotator cuff deficiency. In 1985, Grammont modified the reverse total shoulder design to increase stability and to improve the biomechanics of the prosthesis. By medializing the center of rotation and translating the humerus inferiorly, Grammont’s RTSA tensions the deltoid and lengthens its functional lever arm. This gives the deltoid a significant biomechanical advantage to perform overhead activities in the absence of a functional rotator cuff. Although it was initially developed for rotator cuff arthropathy, the indications for RTSA have expanded to include proximal humerus fracture and revision of TSA.

Although RTSA has been performed in Europe for more than 20 years with promising results, the Food and Drug Administration only recently approved the procedure for use in the United States. Around the time of approval by the Food and Drug Administration in 2004, multiple studies emerged cautioning clinicians about the high rates of early complications with RTSA. The literature reports variable complication rates, ranging from 0% to 75%. These rates are up to 4 times the current complication rates after TSA. The variability in RTSA complication rates may be attributed to differences in the reporting of complications, the surgeon’s experience, the indications for surgical intervention, and the implant design. Whereas TSA is a well-accepted treatment for primary shoulder osteoarthritis, concerns still surround the efficacy and longevity of RTSA.

To date, there are limited studies that compare the outcomes of TSA and RTSA in the United States. This current study investigates side-by-side cohorts to compare the 2 procedures in a standardized fashion with regard to major complications, patient-reported functional outcome, range of motion (ROM), and radiographic follow-up. To reduce heterogeneity in the comparison, we limited the indications for surgery to glenohumeral arthritis for TSA and rotator cuff tear arthropathy for RTSA. We hypothesized that RTSA in the treatment of rotator cuff tear arthropathy and TSA in the treatment of glenohumeral arthritis produce similar complication rates and patient outcomes.

Methods

The authors performed a prospective case-control study with data collected on all patients undergoing shoulder replacement surgery from 2008 to 2011. Two surgeons (C.B.M. and B.T.F.) at a single institution performed both RTSA and TSA. During this period, 238 cases of shoulder arthroplasty were completed (99 TSAs and 139 RTSAs). We included only patients with a primary diagnosis of glenohumeral arthritis for TSA and rotator cuff tear arthropathy for RTSA. All other primary diagnoses, including proximal humerus fracture and revision TSA, were excluded. During the 4-year study period, 75 RTSAs and 77 TSAs met inclusion criteria. Follow-up data on complications (average, 2.1 ± 0.8 years) were available for 53 RTSA patients (71%) and 47 TSA patients (61%) (Fig. 1).

Surgical protocol

All patients received prophylactic antibiotics and a combination of regional and general anesthesia. Surgeries were performed in a semi–beach chair position with a deltopectoral approach. The subscapularis tendon was elevated off the lesser tuberosity for RTSA and tenotomized for TSA. RTSA was performed with the Zimmer Trabecular Metal Reverse Shoulder System (Zimmer, Warsaw, IN, USA). The humeral components were cemented in 10° to 20° of retroversion. The glenoid components were prepared with the trabecular metal baseplate affixed with 2 cancellous screws and a 36-mm glenoid sphere. All RTSAs employed standard polyethylene liners to ensure a firm fit. The subscapularis tendon was attached to the edge of the osteotomy if possible. TSA was performed with the Zimmer Bigliani/Flatow Shoulder system (Zimmer, Warsaw, IN, USA) with an all-polyethylene pegged glenoid design. We cemented both the humeral and glenoid components. The subscapularis muscle tendon was repaired with Ethibond tapes (Ethicon, Somerville, NJ, USA) through bone tunnels and augmented with No. 2 FiberWire suture (Arthrex, Inc, Naples, FL, USA).

Postoperatively, patients were immobilized in a sling for 6 weeks after both procedures. The RTSA group had strict immobilization for 6 weeks; the TSA group performed passive and active-assisted ROM. All patients were started on active range of motion at 6 weeks and strengthening at 12 weeks postoperatively with formalized physical therapy evaluation and treatment.

Clinical evaluation

Major complications included infection, periprosthetic fracture, instability, glenoid loosening, and need for revision surgery. An independent evaluator assessed patients’ clinical outcomes at their follow-up visits. Clinical outcome measures included the American Shoulder and Elbow Surgeons (ASES) score and visual analog scale (VAS) for pain. The ASES questionnaire assesses patient-reported pain, instability, ROM, ability to perform activities of daily living, and other indicators of shoulder-related health. The VAS provided an additional measure of shoulder pain. In addition, an independent examiner measured shoulder ROM in abduction, forward flexion, internal rotation, and external rotation.

Radiologic evaluation

We evaluated the patients’ most recent follow-up radiographs for glenoid lucency and scapular notching with a minimum of 2 views (anteroposterior and axillary lateral). The independent grader was blinded to the patients’ clinical history and outcomes.

Radiolucent lines were classified on the basis of radiolucency around the glenoid pegs and seating of the glenoid baseplate according to the grading system developed specifically for pegged polyethylene glenoid components by Lazarus et al. Peg radiolucency (Fig. 2) was graded 0 to 5: 0, no radiolucency; 1,
incomplete radiolucency around 1 or 2 pegs; 2, complete radio-
lucency (≤2 mm wide) around 1 peg only, with or without
incomplete radiolucency around 1 other peg; 3, complete radio-
lucency (≤2 mm wide) around 2 or more pegs; 4, complete
radiolucency (>2 mm wide) around 2 or more pegs; 5, gross
loosening. Baseplate seating was graded A to E: A, complete
component seating; B, <25% incomplete contact on a single
radiograph; C, 25% to 50% incomplete contact on a single
radiograph; D, <50% incomplete contact on both radiographs; E,
>50% incomplete contact on a single radiograph.

Scapular notching can occur at the inferior scapular neck after
RTSA (Fig. 3). The extent of radiographic notching was assessed
by a grading scheme similar to that of Sirveaux-Nerot. Notching
was graded 0 to 4: 0, absence of bone erosion in the
inferior scapular neck; 1, defect limited to the inferior pillar; 2,
erosion contacting the lower fixation screw of the baseplate; 3,
erosion covering the lower screw; 4, bone eroded under the
baseplate.

Data analysis

Statistical analysis was performed with SPSS 21 statistics package
(IBM, Armonk, NY, USA). Comparison of ASES score, VAS
score, and ROM was done with paired samples t test. Qualitative
variables were evaluated with Fisher exact test. The significance
value was set at P < .05.

Results

There were no significant differences between the TSA and
RTSA cohorts with respect to age, gender, and body mass
index. At 2-year follow-up, both groups had similar rates of
complications and revisions (Table I). Major complications
occurred in 7 of 47 (15%) TSA patients and 7 of 53 (13%)
RTSA patients (P = .808). In the RTSA group, the com-
plications included 1 postoperative dislocation, 2 prosthetic
infections, and 4 fractures. Of the 4 fractures, 2 glenoid
fractures occurred after ground-level falls, and 2 fractures
(1 coracoid and 1 acromion) were related to insufficiency or
stress fractures. The 2 patients with infected prostheses
underwent successful 2-stage reimplantation with tempo-
rary antibiotic cement spacer and 6 weeks of intravenous
antibiotic therapy. Five (9%) RTSA patients required revi-
sion surgeries (2 infections, 2 glenoid fractures, 1 disloca-
tion). In the TSA group, major complications included 4
rotator cuff tears, 1 prosthetic infection, and 2 glenoid
loosening. Five (11%) of the TSA patients needed revision
surgery (1 infection, 3 rotator cuff tears, and 1 glenoid
loosening).

Patient-reported outcomes data at 2-year follow-up were
available for 43 RTSA and 40 TSA patients (Table II). The
2 patient cohorts reported similar outcomes for the VAS subjective pain rating (TSA, 2; RTSA, 1; \( P = .284 \)), normalized ASES function score (34 RTSA vs 39 TSA; \( P = .076 \)), and ASES combined pain and function score (77 RTSA vs 80 TSA; \( P = .709 \)). Comparing ROM, patients had significantly greater external rotation after TSA at 2-year follow-up (TSA 53° vs RTSA 38°; \( P = .001 \)). Otherwise, ROM in forward flexion (TSA 144° vs RTSA 136°), abduction (TSA 136° vs RTSA 129°), and internal rotation (L2 vs L2 spinous process) did not differ significantly between the 2 groups.

Radiographic follow-up at 2 years was available for 50 RTSA patients and 47 TSA patients (Figs. 4 and 5). For RTSA, 15 patients (30%) exhibited evidence of scapular notching; 10 were grade 1 and 5 were grade 2. No patients had grade 3 or grade 4 scapular notching or required revision for glenosphere loosening secondary to scapular notching. For TSA, 55% of patients had some degree of lucency adjacent to the glenoid pegs, and 62% had evidence of incomplete seating of the baseplate. Only 9 of 47 patients had grade 0 peg lucency with grade A baseplate seating, i.e. radiographically ideal glenoid cementing. Despite the high frequency of radiolucency adjacent to the glenoid, only 2 of 47 patients demonstrated radiographic evidence of glenoid loosening.

**Discussion**

The initial reports of alarmingly high rates of complications after RTSA led to the cautious adoption of the procedure in the United States. In a review of RTSA literature, Wierks et al found published rates of up to 68% complications and 38% revisions after RTSA. Subsequently, they retrospectively reviewed 20 of their cases and found a 75% rate of perioperative complications. In addition, a separate review of more than 80 RTSAs found complication rates that ranged from 10% to 60%. In contrast to these early studies, more recent literature reports lower rates of RTSA complications and revisions in the United States.

The heterogeneity of studies on complications after RTSA makes the interpretation of the literature difficult. Studies reporting higher complication rates tend to include minor adverse events including stitch abscess, glenoid redrilling, and heterotopic ossification. Scapular notching is a relatively common finding after RTSA that has been intermittently reported and included in the published complication rates. Other variables including inexperience of the surgeon, revision procedures, and post-traumatic arthritis have been associated with higher complication rates after RTSA.

To account for these factors, the current study examined only primary RTSA for rotator cuff tear arthropathy and primary TSA for glenohumeral arthritis in the hands of experienced shoulder surgeons. In addition, we limited the cohorts to recent data to help standardize the surgical techniques, implants, and rehabilitation protocols.

In this study, we found similarly low rates of complications (TSA 13% and RTSA 11%) and revisions (TSA 11% and RTSA 9%) between the 2 treatment groups at 2-year follow-up. RTSA and TSA were also similar in patient-reported pain and function scores as well as in ROM, with the exception of external rotation. External rotation is known to be limited with the RTSA design because of the medialized center of rotation.

Given that radiographic findings after shoulder arthroplasty are controversial, we elected to report radiolucency of TSA and RTSA scapular notching in a separate analysis from our major complications. We found that scapular...
notching was present in 30% of RTSAs at 2 years. These results are comparable to those of a recent review that reported a scapular notching rate of 35.4%. In general, scapular notching of grade 1 is not considered clinically significant. Only 10% of our patients had grade 2 scapular notching, and no patients had grade 3 or grade 4 scapular notching. Meanwhile, only 9 of 47 TSAs had ideal glenoid cementing without lucency. These results compare favorably with the series of pegged glenoids by Lazarus et al that reported only 2 of 328 shoulders with perfect radiographic glenoid appearance. Although scapular notching and glenoid lucency are common findings after shoulder arthroplasty, the significance of these radiographic abnormalities remains to be determined.

This study has several limitations. Our study population had surgery dates after 2009, which limited our follow-up to 4 years or less. Therefore, long-term prosthetic failure could not be measured with the current study. For a more homogeneous patient cohort with similar operative indications to be obtained, we decreased our sample size. Our study may be inadequately powered to detect small differences between the 2 treatment groups. Our prospective database also illustrated the inherent difficulties with clinical data collection. Despite efforts to contact patients to maximize clinical follow-up, we achieved only a 60% to 70% follow-up rate at 2 years. We reported only deaths for which we had confirmed outcomes, and there certainly can be more patients who were lost to follow-up because of death. This limitation may selectively bias our complication and revision rates; however, the demographics of patients lost to follow-up did not differ significantly between the TSA and RTSA cohorts. This study draws comparisons between 2 surgical procedures for 2 separate surgical indications. Nevertheless, this comparison is valuable given the limited side-by-side data previously available.

Despite prior concerning reports of RTSA in the United States, this study demonstrates that with the evolution of implant design and techniques, RTSA and TSA may have similar clinical outcomes at 2-year follow-up. When they are performed by experienced surgeons, both procedures are successful treatments for their specific surgical

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**Table I** Comparison of complications at 2-year follow-up

<table>
<thead>
<tr>
<th></th>
<th>Total*</th>
<th>RTSA</th>
<th>TSA</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>13% (7 of 53)</td>
<td>15% (7 of 47)</td>
</tr>
<tr>
<td>Infection</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Dislocation</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fracture</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cuff tear</td>
<td>0</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Glenoid loosening</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Revision surgeries</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

There was no difference in the rate of postsurgical complications between the RTSA and TSA groups.

* $P = .808$.

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**Table II** Functional outcomes

<table>
<thead>
<tr>
<th></th>
<th>RTSA</th>
<th>TSA</th>
<th>$P$</th>
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<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Standard deviation</td>
<td>Mean</td>
</tr>
<tr>
<td>Pain rate (VAS)</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Pain score (ASES)</td>
<td>44</td>
<td>10</td>
<td>41</td>
</tr>
<tr>
<td>Function score (ASES)</td>
<td>34</td>
<td>12</td>
<td>39</td>
</tr>
<tr>
<td>ASES total score</td>
<td>77</td>
<td>19</td>
<td>80</td>
</tr>
<tr>
<td>Forward elevation</td>
<td>136</td>
<td>31</td>
<td>144</td>
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<tr>
<td>Abduction</td>
<td>129</td>
<td>34</td>
<td>136</td>
</tr>
<tr>
<td>External rotation (spine)</td>
<td>38</td>
<td>23</td>
<td>53</td>
</tr>
<tr>
<td>Internal rotation (spinus process)</td>
<td>L2</td>
<td>4</td>
<td>L2</td>
</tr>
</tbody>
</table>

VAS, visual analog scale; ASES, American Shoulder and Elbow Surgeons.
indications, TSA for glenohumeral arthritis and RTSA for rotator cuff tear arthropathy. Further research is needed to compare medium- and long-term outcomes between RTSA and TSA, with the goal of further understanding the role of each procedure in addressing chronic shoulder disease.

Conclusions

RTSA for rotator cuff tear arthropathy and anatomic TSA for glenohumeral arthritis are successful procedures with similar patient outcomes, complication rates, and need for revision at 2 years of follow-up.

References


