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SYMPOSIUM: REVERSE TOTAL SHOULDER ARTHROPLASTY

Is Reverse Shoulder Arthroplasty a Reasonable Alternative for Revision Arthroplasty?

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Abstract

Background Reverse shoulder arthroplasty (RSA) improves function in selected patients with complex shoulder problems. However, we presume patient function would vary if performed primarily or for revision and would vary with other patient-specific factors.

Questions/purposes We compared (1) the shoulder scores and (2) complications in patients with RSA for revision arthroplasty with patients who had RSA as a primary procedure; and (3) identified patient-specific factors that affect (1) and (2).

Patients and Methods We retrospectively compared 28 RSAs for failed arthroplasty with a control group consisting of 28 primary RSAs. We determined the Penn Shoulder (PENN), American Shoulder and Elbow Surgeons (ASES), and Single Assessment Numeric Evaluation (SANE) scores. Followup for shoulder outcome measures averaged 17.4 (range, 4.1–34) and 20.8 months (range, 7.3–34.9) for the study and control groups, respectively.

Results All scores were higher in primary RSA than in revision RSA (PENN score, 79.5 versus 57.1; ASES score, 81.4 versus 56.3; SANE score, 73.8% versus 48.8%), and ROM was better (122.7° versus 83.75°). Both groups experienced increases in active forward flexion. Ten of the 28 study RSAs (35.7%) versus five of the 28 control RSAs (17.8%) had complications. No patient-specific factors other than reason for surgery correlated with scores.

Conclusions Revision RSA is associated with lower function compared with primary RSA. However, we believe it a reasonable alternative and patients undergoing RSA for revision arthroplasty can expect improvements in function and shoulder scores to a mean of 50% of normal shoulders but must also accept a high complication rate.

Level of Evidence Level III, therapeutic study. See the Guidelines for Authors for a complete description of levels of evidence.

Introduction

Reverse shoulder arthroplasty (RSA) has become an important tool in the armamentarium of the shoulder surgeon. The nonanatomic prosthesis was originally designed to provide pain relief and to improve shoulder function in patients with cuff tear arthropathy (CTA) [3]. More recently the indications for implantation have been expanded to include revision arthroplasty. However, the prevailing literature reveals decreased shoulder outcomes measures and a higher complication rate in RSA for revision arthroplasty compared with other etiologies [1, 6, 8].

Boileau et al. in 2006 evaluated active forward flexion, Constant scores, and reoperation rates for RSA according to etiology, including CTA and revision arthroplasty [1]. At a mean followup of 40 months (range, 24–72 months), the study revealed mean gains in active forward flexion (CTA = 70°, revision arthroplasty = 57°) and Constant

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Each author certifies that his or her institution has approved the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research.

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scores (CTA = 49, revision arthroplasty = 32). Although both etiologies reported improvements, patients with CTA performed better. Moreover, the reoperation rates were appreciably increased in the revision arthroplasty compared with the CTA groups, 45% and 5%, respectively. In 2007, Wall et al. concluded that patients undergoing RSA for revision arthroplasty had less improvement and higher complication rates compared with patients having primary RSA for various reasons (CTA, massive rotator cuff rear, osteoarthritis, posttraumatic arthritis, tumor, acute fracture, rheumatoid arthritis) [7]. They noted worse postoperative Constant scores and ROM for the revision arthroplasty group at a mean of 39.9 months followup. This came with an increased complication rate of 36.7% in the revision group compared with 13.3% with primary surgery.

To confirm the literature, we therefore compared (1) the shoulder outcome measures and (2) complications in patients with RSA for revision arthroplasty with patients who had RSA as a primary procedure; and (3) identified patient-specific factors other than indications for surgery that affect (1) and (2).

Patients and Methods

We retrospectively reviewed the records of all 26 patients who had 28 RSAs for failed arthroplasty (27 shoulders) between March 2007 and October 2009. At the time of revision, the patients' average age was 71.2 years (95% confidence interval [CI], 55–88 years). Twenty of the 28 revisions (71.4%) were performed in women. Seventeen revisions (60.7%) were in the right shoulder. In eight shoulders, a previous revision had been performed. In 20 shoulders, revision was from a hemiarthroplasty. In the remaining eight shoulders, revision was from a RSA in five and anatomic total shoulder prosthesis in three. Thirteen hemiprostheses were originally placed for fracture sequelae. Indications for revision surgery included 11 (39%) glenoid arthrosis with cuff tears, five (17.9%) nonunions, three (10.7%) glenoid loosenings, three (10.7%) irreparable cuff tears, two (7.1%) periprosthetic fractures, two (7.1%) infections, one (3.5%) prosthetic malpositioning, and one (3.5%) instability. Postoperative followup was conducted on all study patients with an average followup of 15.1 months (range, 1–34 months). No patients were lost to followup. No patients were recalled specifically for this study; all data were obtained from medical records and telephone conversations. We had prior approval from the local Institutional Review Board.

For comparison of outcomes, a control group was created with a one-to-one ratio to the cases. This control group consisted of only patients undergoing RSA as primary arthroplasty. Before data collection, the control subjects were matched to the cases according to gender, age, and date of surgery. This resulted in 28 patients with a mean age of 72.3 years (95% CI, 55–85 years). Of these, 22 patients (78.6%) underwent primary RSA in the right shoulder. Indications for RSA included 23 (82.1%) CTAs, four (14.3%) fracture sequelae, and one (3.5%) fixed anterior instability. Approach included 10 (35.7%) deltopectoral, 15 (53.6%) superior, and three (10.7%) unknown. At followup, none of the control subjects had died. Postoperative followup was conducted on all control subjects with an average followup of 16.4 months (range, 0.5–35 months). No patients were lost to followup.

All surgery in the case and control groups was performed by a single fellowship-trained shoulder and elbow surgeon (GRW) using the Delta III and Delta Xtend™ Reverse Shoulder Prosthesis (DePuy Orthopedics, Inc, Warsaw, IN). Access to the glenohumeral joint in the control group (primary RSA) was gained by either the superior or deltopectoral approach. Contraindications to the superior approach included revision cases, patients with a large inferior humeral osteophyte, and patients with external rotation of less than 30°. The incision for the superior approach was positioned in Langer's lines directly over the lateral border of the acromion. After subcutaneous flaps were developed, the deltoid was split longitudinally roughly 0.5 to 1 cm posterior to the anterolateral edge of the acromion. The anterior deltoid was then released medially to the lateral border of the clavicle. An acromioplasty was performed. Any soft tissue remaining superior to the humeral head was removed and the bicep was released if present, taking care to leave any intact anterior and posterior rotator cuff tendon. The humeral head-neck cut was made at 150° with 0° of version. A double-pronged retractor was placed inferior to the glenoid to gain access to the glenohumeral joint. A 360° capsular release was performed. A cannulated reaming system was used to place the metaglene at the inferior border of the glenoid in neutral tilt. The humerus was prepared and the humeral stem cemented in all cases. The polyethylene cup was sized to appropriately tension the prosthesis. The shoulder was then brought through a ROM and observed for gapping and impingement. The deltoid was reattached with four Number 2 Ethibond (Ethicon Inc, Somerville, NJ) sutures. One was sutured through the ligaments of the acromioclavicular joint, two were attached through transosseous tunnels in the acromion, and one brought together the upper border of the deltoid.

The deltopectoral approach was used to access the glenohumeral joint for all patients in the study group (RSA for failed arthroplasty) and many patients in the control group (primary RSA). Care was taken to develop the tissue planes, especially the subacromial and subdeltoid recesses. The anterior soft tissue envelope (any remaining subscapularis

and anterior capsule) was released directly from bone, starting at the medial lip of the bicipital groove and proceeding medially and inferiorly. In primary cases, the humerus was cut in neutral version at a 150° neck-shaft angle. In revision cases, the humeral head was removed and the stem left in place to protect the humeral bone during glenoid preparation. If the stem was monobloc, the stem was removed and a small-diameter broach was placed in the canal for protection.

The glenoid was then exposed and circumferential capsular release was performed. The glenoid was prepared and the metaglene and trial glenosphere were placed as described previously.

Humeral preparation was the next step. In revision cases, removal of the prior prosthesis was performed in a stepwise fashion. First, the proximal portion of the stem was freed of all soft tissue debris and contact with the metaphyseal bone. An osteotome was passed along the stem circumferentially and a rongeur was used to remove enough of the medial calcar to expose the medial aspect of the proximal portion of the stem. Second, a punch was placed under the medial portion of the stem at the calcar and a mallet was used to attempt to remove it. If this was not successful, a longitudinal episiotomy was created just lateral to the bicipital groove using a microsagittal saw. The split traverses the entire superoinferior distance of the stem. At the distal end of the episiotomy, a drill hole was placed to dissipate the stresses created by the split. A large (2-inch), straight osteotome was then used within the episiotomy to crack the cement mantel the length of the prosthesis and another attempt to remove the prosthesis with a tamp and mallet was undertaken. Ninety percent of the time, this is successful. In cases in which the prosthesis was still fixed, a second drill hole is placed 1 to 1.5 cm posterior to the first one and the two holes are connected with a microsagittal saw. The large osteotome is then replaced into the longitudinal episiotomy in its distal third and is twisted about its long axis until the bone separates slightly. This is continued superiorly along the entire length of the episiotomy, which is opened only wide enough to loosen the prosthesis or provide access to the cement mantle. On removing the humeral prosthesis, any residual cement mantle was resected using the OSCAR PMMA cement removal system (Orthosconics, Chatham, NJ). If an episiotomy or window had been required, the humerus is immediately fixed with cerclage wires or cables. A C-arm was used in all cases of episiotomy or windowing. The humeral stem and glenosphere were placed using a standard technique and the incision was closed over a drain in all cases. Care must be taken to remove any cement that extrudes from the window or episiotomy site.

Postoperatively, patients were placed in a sling for 2 weeks only to come out for elbow, wrist, and hand exercises. At the 2-week followup, patients were allowed to discontinue the use of the sling and begin using the arm at waist height as tolerated. At 6 weeks postoperatively, the patients were encouraged to use their arm for daily activities that included overhead use. A home overhead pulley was added at 10 weeks postoperatively in patients who did not yet have the ability to raise the arm above shoulder height. Formalized physical or occupational therapy was never used. Patients were evaluated in the office at 2 weeks, 6 weeks, 3 months, and 6 months. Radiographs were obtained at each visit.

Three of us (LS, BZ, EC) attempted to contact all patients by telephone for outcome scores. Patient-reported outcome was assessed with the Penn Shoulder Score (PENN) [4], American Shoulder and Elbow Surgeons (ASES) [5], and Single Assessment Numeric Evaluation (SANE) [9] patient questionnaires. In addition, pre- and postoperative degree of flexion was used to quantify improvements in ROM. Nineteen of the 26 patients in the study group (73.1%) responded to outcome surveys at an average 17.4 months (range, 4–34 months); a sole patient had died (6 months postoperatively) and six did not respond. Twenty-one of the 28 control subjects (75%) responded to outcome surveys at an average of 20.8 months (range, 7.3–35 months) posttotal shoulder arthroplasty (post-TSA). Postoperative ROM was analyzed for patients whose last postoperative visit was at least 2 months after surgery. This included 18 study patients (20 revisions) at an average 11.2 months (range, 2–32 months). Postoperative ROM was acquired in 24 control subjects at an average of 9.8 months (range, 2–32 months) post-TSA.

Complications were collected from discharge summaries, office visit notes, and telephone communications in both groups for all patients.

In determining factors affecting outcome after revision to a RSA, indications for primary and revision surgery were investigated along with patient-specific factors (previous revisions, type of resected prosthesis, preoperative ROM, age, gender, arthroplasty history, diabetes, rheumatoid arthritis) and surgery-specific factors (humeral episiotomy or window and previous prosthetic cementation).

We analyzed differences in shoulder outcome measures (PENN, ASES, and SANE scores) between the study and control cohorts using Student's t-test. Normality of the data was confirmed using the Shapiro-Wilk W statistic. If data were identified as nonparametric, they were assessed using Mann-Whitney-Wilcoxon U test. The complication rates in the study and control cohorts were compared using McNemar's test. Descriptive statistics were performed on the study group to show differences among potential indicators of outcome (ie, gender, age, etc). However, the

small sample size precluded comparative statistics. Statistical analysis was performed with PASW Statistics 18.0 (SPSS, Chicago, IL).

Results

The postoperative outcomes measures (PENN, ASES, SANE) were all greater in the control group versus the study group (Table 1). Both the study and control groups experienced a positive delta ROM ($p = 0.003$ and $p < 0.001$, respectively). Although both preoperative and postoperative ROM were greater in the control group ($p = 0.16$ and $p < 0.001$, respectively), the delta ROM was also greater in the control group ($p = 0.067$).

Ten of 28 patients had postoperative complications in the study group, whereas five of 28 did in the control group; although this difference was not statistically significant ($p = 0.30$), we believe it might reflect an important trend toward more complications in the revision group. A post hoc power analysis suggested 96 patients in each arm would be necessary to find a significant difference. Three (11.53%) in the study group and one (3.6%) in the control group had nerve paresthesias remaining at final followup. Two anterior deltoid detachments requiring a second surgery to repair the deltoid occurred in the control group. Both patients had the diagnosis of CTA and were operated on through the superior approach. One dislocation requiring open reduction occurred in the control group. This patient had a diagnosis of CTA and was operated on through the deltopectoral approach. The remaining complications included two hematomas (study), one infection (study), four intraoperative fractures (three study, one control), and one humeral canal perforation with cement extravasations requiring return to surgery for cement removal (study) (Table 2).

Descriptive statistics of patient-specific variables did not correlate with shoulder outcome measures, ROM, or complication rate after RSA for failed arthroplasty (Table 3).

Discussion

Function after RSA for revision arthroplasty is reportedly inferior [1, 7, 8] to primary procedures and the literature

Table 2. Complication profile

Complication	Case (percent of total)	Control (percent of total)
Hematoma	2 (20%)	0
Intraoperative fracture	3 (30%)	1 (20%)
Humeral canal perforation	1 (10%)	0
Infection	1 (10%)	0
Nerve paresthesias	3 (30%)	1 (20%)
Anterior deltoid detachment	0	2 (40%)
Dislocation	0	1 (20%)
Total	10	5

Table 1. Demographic, outcome, ROM, and complication comparison between case and control groups

Category	Case (revision)	Control (primary)	Statistical significance
Demographics			
Age (95% CI)	70.5 (68.3–74.2)	72.3 (69.8–74.8)	
Females (%)	20 (71.4%)	20 (71.4%)	
Average length of followup (range)	14.3 (1–34.2)	16.6 (0.5–34.9)	
Right shoulders (%)	17 (60.7%)	22 (78.6%)	
Diabetes (%)	4 (14.3%)	3 (10.7%)	
Rheumatoid arthritis (%)	2 (7.1%)	2 (7.1%)	
Smoker (%)	0 (0%)	2 (7.1%)	
Outcome			
PENN (95% CI)	57.1 (49.6–64.6)	79.5 (73.5–85.6)	< 0.001
ASES (95% CI)	56.3 (47.4–65.2)	81.4 (76.2–86.5)	< 0.001
SANE (95% CI)	48.8% (36.8%–60.6%)	73.8% (65.4%–82.1%)	< 0.001
Preoperative forward flexion (95% CI)	47.2 (35.0–59.3)	59.4 (44.8–73.9)	0.42
Postoperative forward flexion (95% CI)	83.1 (66.4–99.8)	122.7 (114.7–130.1)	< 0.001
Delta flexion (95% CI)	35 (10.7–59.3)	66.5 (49.8–83.1)	0.069
Complications (%)	10 (35.7%)	5 (17.9%)	0.30

CI = confidence interval; PENN = Penn Shoulder Score; ASES = American Shoulder and Elbow Surgeons; SANE = Single Assessment Numeric Evaluation.

Table 3. Descriptive statistics of patient-specific variables

Patient Variables	Count	Complications	PENN score	ASES score	SANE	Preoperative ROM	Postoperative ROM	Delta ROM	Nerve symptoms
Previous revisions									
Yes	8	3 (38%)	54.5	51.6	44.2	45.8	75	21.3	0
No	20	8 (40%)	58.2	58.3	50.7%	47.6	87.5	39.5	3
Previous prosthesis									
Hemiarthroplasty	20	8 (40%)	56.5	57.9	0.5	48.7	83.9	33.3	3
TSA	8	3 (38%)	58.4	53.3	0.5	44.4	83.3	36.7	0
Preoperative ROM									
Correlation	23	R = 0.35	R = 0.17	R = 0.19	R = 0.29	N/A	R = 0.09	R = −0.59	R = 0.30
Main indication									
Glenoid arthrosis	11	6 (55%)	57.0	59.3	53.6%	56.9	103.3	46.7	3
Infection	2	1 (50%)	62.0	74.2	50.0%	0.0	100.0	110.0	0
Nonunion	5	1 (20%)	67.6	68.5	53.3%	38.8	31.7	−15.0	0
Glenoid loosening	3	1 (33%)	46.9	29.8	42.5%	28.3	40.0	12.5	0
Irreparable cuff tears	3	1 (33%)	62.6	51.0	53.3%	75.0	130.0	40.0	0
Periprosthetic fracture	2	1 (50%)	47.0	60.0	30.0%	55.0	55.0	0.0	0
Malpositioning	1	0	65.8	60.4	55.0%	35.0	130.0	95.0	0
Instability	1	0	22.4	24.3	10.0%	20.0	UNK	UNK	0
Age									
Correlation	28	R = −0.02	R = −0.23	R = −0.26	R = −0.07	R = 0.05	R = 0.04	R = −0.13	R = −0.05
Gender									
Male	8	4 (50%)	64.86	65.71	62.6%	47.86	94.29	55.00	2
Female	20	7 (35%)	52.98	51.25	41.3%	46.88	78.08	21.11	1
Humeral episiotomy or window									
Yes	6	3 (50%)	43.0	40.0	36.50%	45.8	65.0	17.5	2
No	15	5 (33%)	59.7	60.6	51.57%	42.1	85.0	43.8	1
Previous prosthetic cemented									
Yes	18	6 (33%)	58.5	59.1	50.73%	45.6	70.4	26.7	2
No	6	4 (67%)	56.2	56.0	49.50%	44.0	120.0	66.7	1
Diabetes									
Yes	4	2 (50%)	56.9	63.5	47.5%	36.7	120	102.5	0
No	23	9 (39%)	57.5	56.9	50.0%	48.9	77.4	24.2	3

PENN = Penn Shoulder Score; ASES = American Shoulder and Elbow Surgeons; SANE = Single Assessment Numeric Evaluation; TSA = total shoulder arthroplasty; N/A = not applicable; UNK = unknown.

reports complication and reoperation rates as high as 47% and 45%, respectively [1]. We intended to confirm that the function and complication rates for RSA are affected by indication for surgery and to evaluate other patient-specific factors that may affect outcomes. Therefore, we compared (1) the shoulder outcomes measures and (2) complications in patients with RSA for revision arthroplasty with patients who had RSA as a primary procedure; and (3) identified patient-specific factors other than indication for surgery that affect (1) and (2).

Our study is limited by several features. First, we had a short followup (mean, 15.9 months; range, 0.5–35 months), which would likely result in an underestimate of our complication and reoperation rates. However, a previous study ascertained the majority of complications occur in the first several weeks after surgery and therefore our complication profile is likely to be accurate [8]. Second, we had a relatively small sample size (n = 56). Although this is one of the larger series in the literature, we were not able to develop a set of patient-specific factors other than indication for surgery that accurately predict patient outcomes. Third, our followup consisted of a retrospective review of the chart and a telephone interview with a 73% response rate. Lastly, our clinical followup was not as long as telephone followup and was performed with chart review.

With the goal of comparing the outcomes of our study group (RSA for failed arthroplasty) versus a control group (RSA as the primary arthroplasty), we reviewed our experience. This study revealed better outcomes using three outcome measures (PENN, ASES, and SANE scores) in the control group than in the study group. We further found greater postoperative active forward flexion (83.8° versus 122.7°) in the control group than in the study group. These findings corroborate those of other studies in the literature. Four prior series have reported on the RSA and all found inferior function for revision arthroplasty compared with other indications for surgery [1, 2, 7, 8]. Despite this, RSA can benefit, albeit to a lesser degree, patients with prior failed arthroplasty. We report the extrapolated results from the literature of RSA for failed arthroplasty (Table 4). All five studies demonstrate mean improvements in active forward flexion and outcome measures. However, we find most outcome measures are difficult to explain to patients trying to make surgical decisions. We therefore tabulated the postoperative SANE score and found patients subjectively rate their shoulder as 48.8% of a normal shoulder after RSA for failed arthroplasty. We therefore recommend this procedure to patients with SANE scores below this threshold.

Patients must weigh these potential benefits against considerable complication and reoperation rates. We report a 35.7% complication rate in our study group, which is higher than the 17.9% rate in the control group. Of the complications in the study group, only two (7.1%) required repeat operations (deep infection and humeral fracture), and three patients (11.5%) had residual nerve symptoms at latest followup. These nerve symptoms included hand numbness, thumb numbness, and numbness in the small finger. Complications in the control group included two anterior deltoid detachments in patients exposed through the superior approach. Both required open deltoid repair. There was also one dislocation in a patient operated on through the deltopectoral approach. He required open reduction. The complication and reoperation rates in the study group are relatively low compared with other series (Table 4). The complication and reoperation rates were slightly elevated in the control group (17.9%) compared with other series. Our control group included five (17.8%) patients undergoing RSA for fracture sequelae, an etiology known to have higher complication and reoperation rates [1, 2, 7, 8]. Our findings correspond to a declining trend in overall major complications after RSA and support a similar conclusion in a recent study by Cuff et al. [2].

We further evaluated a series of patient-specific factors other than indication for surgery and analyzed them for trends in shoulder outcomes measures and complication rates (Table 3). These patient-specific factors did not affect

Table 4. Extrapolated results from the literature of RSA for failed arthroplasty

Publication	Number	Prosthesis	Active elevation (preoperative/postoperative)	Constant score (preoperative/postoperative)	ASES score (preoperative/postoperative)	PENN score (preoperative/postoperative)	SANE score (percent of normal shoulder)	Complication rate (%)	Reoperation rate (%)
Werner et al. (2005) [8]	21	Delta III (DePuy)	39/96	25/55	NA	NA	NA	62	38
Boileau et al. (2006) [1]	19	Delta III (DePuy)	56/113	15/46	NA/50	NA	NA	47	45
Wall et al. (2007) [7]	54	Delta III (DePuy)/Aequalis (Tornier)	58/118	19.7/52.2	NA	NA	NA	36.7	NA
Cuff et al. (2008) [2]	23	Reverse TSA (Encore Medical)	46.4/90	NA	25/67.7	NA	NA	NA	NA
Our cohort (2010)	28	Delta III, Delta Extend (DePuy)	47.2/83.1	NA	NA/50.4	NA/56.3	48.8	35.7	7.1

ASES = American Shoulder and Elbow Surgeons; PENN = Penn Shoulder Score; SANE = Single Assessment Numeric Evaluation; NA = not available.

the results of RSA in our study. This may be the result of a lack of power.

Limitations notwithstanding, our data and that of the literature suggest the following conclusions. RSA for failed arthroplasty has inferior results compared with RSA as the primary arthroplasty. Despite this, RSA is an acceptable treatment for failed arthroplasty in severely debilitated patients who perceive their shoulder to be less than 50% of a normal shoulder. Patients can expect improvements in function and clinical outcomes measures but must also be willing to accept a higher complication rate than with primary RSA. However, complication and reoperation rates appear to be declining and may decline further with experience.

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