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Functional results of bilateral reverse total shoulder arthroplasty

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Background: The purpose of this study was to analyze a population of patients with bilateral reverse total shoulder arthroplasty (RTSA) to evaluate their ability to perform activities of daily living and personal hygiene tasks.
Methods: At a minimum 2-year follow-up, we retrospectively reviewed 50 patients (100 shoulders) with a mean age of 72 years who underwent staged bilateral RTSA. The average follow-up period was 61 months (range, 24-121 months), with a minimum 2-year follow-up after the second surgical procedure. Functional outcomes were assessed with American Shoulder and Elbow Surgeons, Simple Shoulder Test, and Short Form 12 (SF-12) scores. In addition, a unique questionnaire regarding personal hygiene habits and activities of daily living reliant on shoulder rotation was administered to all patients.
Results: Patients showed significant improvements in pain (mean improvement in visual analog scale score from 5.7 to 1.0, $P < .001$) and forward elevation (mean improvement from 71° to 136°, $P < .001$). Clinical outcome scores showed significant improvements: The mean American Shoulder and Elbow Surgeons score improved from 35.8 to 76.5 ($P < .001$), Simple Shoulder Test score improved from 2.4 to 8.0 ($P < .001$), SF-12 mental component subscore improved from 51.9 to 54.1 ($P < .001$), and SF-12 physical component subscore improved from 30.5 to 39.7 ($P < .001$). Internal and external rotation showed significant improvements (from 33° to 53° [$P < .005$] and from 27° to 44° [$P < .001$], respectively). All patients retained independence with personal hygiene and activities of daily living. Complications included prosthetic instability (3%), acromial fracture (5%), and periprosthetic joint infection (1%). The overall reoperation rate was 5%.
Conclusions: Bilateral RTSA provides predictable pain relief and improved function. Hygiene practices are unaltered for most patients, and the other patients rapidly develop simple compensatory strategies and retain independence in activities of daily living.
Level of evidence: Level IV; Case Series; Treatment Study

Keywords: Reverse total shoulder arthroplasty; bilateral; shoulder replacement; activities of daily living; hygiene; rotator cuff tear arthropathy

This study has been approved under Rush University Medical Center Institutional Review Board protocol 14051202.

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Reverse total shoulder arthroplasty (RTSA) has been shown to have efficacy for a variety of indications including rotator cuff tear arthropathy (RCTA),[8,23] osteoarthritis (OA) in the setting of a rotator cuff tear,[8,23] irreparable massive rotator cuff

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tears with associated pseudoparalysis,[16] rheumatoid arthritis,[29] and sequelae of proximal humeral fractures,[4,14] as well as revision of a failed shoulder arthroplasty.[25] Although several large series have shown excellent short-term outcomes and restoration of painless active forward elevation (AFE),[5-7,12,18] active external rotation and internal rotation have less reliably been restored postoperatively.[1,26] External rotation and internal rotation movements are necessary for activities of daily living (ADLs), perineal care, and hygiene.[13,17,19]

Bilateral RTSA may be inadvisable, as patients may struggle with ADLs. This is especially true in patients who need to reach behind their back on the operative side, perform personal hygiene activities, or use the toilet. Other activities that can be difficult include washing behind the back, washing the contralateral shoulder, putting on a bra, and tucking in a back shirt-tail. In unilateral RTSA cases, the patients can compensate for these activities by learning to use the contralateral extremity. However, previous authors have been concerned that patients who undergo bilateral RTSA may not be able to adequately compensate.[2,18,27,28] Although a small number of previous series have shown good outcomes after bilateral RTSA, these studies have been limited by small sample sizes and few data were focused specifically on hygiene.[15,22,28]

To better understand the effect of bilateral RTSA on a patient's ADLs, we retrospectively reviewed our own series of bilateral RTSA cases with standardized functional outcome measures and a unique questionnaire on personal hygiene practices and ADLs. We hypothesized that bilateral RTSA would lead to significant functional improvements and that, although bilateral RTSA would alter a minority of patients' hygiene habits, patients would develop compensatory habits and thus these changes would have minimal overall impact on their lifestyle.

Materials and methods

This study was a retrospective case series. Between 2004 and 2013, the operative databases of the 2 senior authors (G.P.N. and A.A.R.) were reviewed. Patients who underwent staged bilateral RTSA were included. The exclusion criteria were patients with incomplete medical records and patients with less than 2 years of follow-up. Three patients with incomplete preoperative data from 2005 were excluded from the study. All patients were then contacted by phone to respond to a questionnaire that included questions regarding hygiene.

Data collection

Data were recorded in Excel X (Microsoft, Redmond, WA, USA). Preoperative, perioperative, and postoperative records were reviewed. Preoperative data collected from the chart for each shoulder included age at the time of RTSA, sex, body mass index (BMI), time between right and left RTSA, diagnosis (divided into OA, RCTA, irreparable massive cuff tear [MCT], and revision from a prior shoulder arthroplasty), and whether previous surgery on the ipsilateral shoulder had been performed. Preoperative radiographs were reviewed by an orthopedic shoulder and elbow fellow (C.R.M.) to include Walch grading for those patients with OA[24] and Favard grading for those patients with RCTA.[21] Operative data included whether glenoid bone grafting was required, the prosthesis used, the degree of retroversion of the humeral component, the glenosphere size, and the need for adjunctive procedures at the time of RTSA.

The incidence of surgical complications including the need for revision surgery was obtained from existing clinical data and confirmed with a phone call from an independent observer. The following outcome measures were collected preoperatively and at final follow-up for both sides for each patient: visual analog scale score for pain, Simple Shoulder Test (SST) score, American Shoulder and Elbow Surgeons (ASES) score, functional portion of the ASES score (ASES-Functional), and Short Form 12 (SF-12) quality-of-life physical component subscore (PCS) and mental component subscore (MCS). Range-of-motion measurements, including AFE, abduction, active internal rotation at 90° of abduction (AIR), and active external rotation at the side (AER), were taken by an independent observer with a goniometer preoperatively and at final follow-up for both sides for each patient. Radiographs were evaluated at final follow-up for evidence of loosening as well as scapular notching, which was graded by the Nerot-Sirveaux system.[21]

Several specific outcomes related to hygiene habits were collected via a questionnaire administered over the phone or in the office (Fig. 1). The questionnaire was developed through discussion with patients over the years to determine the tasks of personal hygiene with which they may struggle. It was not validated to any standard. The questionnaire was designed to allow the patients to compare their abilities after bilateral RTSA with their preoperative status. It was not administered preoperatively. Patients were asked if they were able to wash the contralateral shoulder with each extremity, if they were able to tuck a shirt-tail into the back of their pants with each shoulder, if they were able to use the same hand while toileting as before surgery, whether their overall hygiene habits had changed, and if they required the use of assistive devices in the shower or during toileting.

Statistical analyses

Statistical analyses were performed by use of SPSS software (version 21; IBM, Armonk, NY, USA). Descriptive statistics and frequencies were calculated and are reported. All comparisons were planned a priori. Continuous variables were evaluated for normality with the Kolmogorov-Smirnov test, and preoperative and postoperative data were then compared by use of paired Student *t* tests or Wilcoxon signed rank tests as appropriate. Post hoc analyses were performed comparing changes in outcomes from preoperatively to postoperatively in subgroups to better understand the determinants of outcomes. Specifically, laterality was compared, patients older than 70 years were compared with those younger than 70 years, patients with a history of rotator cuff surgery were compared with those with no history of rotator cuff surgery, patients with RCTA were compared with those with OA, and patients with RCTA were compared with those with MCT by use of independent-samples *t* tests or Mann-Whitney *U* tests as appropriate based on data normality. Pearson correlation coefficients were calculated to determine whether humeral version correlated with internal rotation or external rotation at final follow-up or the change in these measurements.

For questions involving a 0-3 scale, 0 = unable to do; 1 = very difficult to do; 2 = somewhat difficult; 3 = not difficult. Please circle the most accurate response.

•Are you able to use the toilet with your right/left arm?
(RIGHT: 0 1 2 3) (LEFT: 0 1 2 3)

•Can you reach around to hook a bra or wash your back with your right/left arm?
(RIGHT: 0 1 2 3) (LEFT: 0 1 2 3)

•Can you wash your opposite shoulder with your right/left arm?
(RIGHT: 0 1 2 3) (LEFT: 0 1 2 3)

•Can reach the small of your back to tuck in your shirt with your right/left arm?
(RIGHT: 0 1 2 3) (LEFT: 0 1 2 3)

•Do you still use the same hand as before the surgery when toileting? (Y / N)

•Have your hygiene habits changed? For example, taking a bath instead of a shower, clipping bra in front and pulling around, stepping into bra, etc. (Y / N)

•Do you use assistive devices for the toilet? (Y / N)

•Do you use assistive devices for the shower? (Y / N)

Figure 1 Hygiene questionnaire.

Results

Demographic characteristics

Fifty patients who underwent staged bilateral RTSA with a minimum follow-up of 2 years were eligible for inclusion in this study. These patients were followed up for 61 ± 25 months (mean ± standard deviation; range, 24-121 months) after the second RTSA implantation. The mean time between right and left RTSA was 15 ± 13 months (range, 2-63 months). The mean patient age was 71.8 years. Of these patients, 62% were female patients, and the mean BMI was 29.0 ± 5.4. Among these patients, 30% underwent prior rotator cuff surgery and 66% underwent RTSA for the indication of RCTA, 20% for the indication of MCT, 13% for the indication of OA, and 2% for the indication of a prior failed hemiarthroplasty. Preoperatively, among the patients with a diagnosis of OA, 5 (33%) had type A1 glenoids, 2 (13%) had type A2 glenoids, 3 (20%) had type B1 glenoids, and 5 (33%) had type B2 glenoids. Preoperatively, among the patients with a diagnosis of RCTA, 32 (40%) had type E0 glenoids, 33 (41%) had type E1 glenoids, 11 (14%) had type E2 glenoids, and 4 (5%) had type E3 glenoids.

All surgical procedures were performed through a deltopectoral exposure with a subscapularis tenotomy technique. The subscapularis was repaired back to the humerus in all cases when a sufficient tendon was found. The prosthesis used in each case was dependent on surgeon preference. Eighty-five percent of patients underwent placement of a medialized center of rotation (MCOR)–style (Grammont-style[3]) implant: 70% with the Trabecular Metal Reverse Shoulder System (Zimmer, Warsaw, IN, USA; 150° neck-shaft angle implant), 13% with the Aequalis Reversed II Shoulder System (Tornier, Bloomington, MN, USA; 155° neck-shaft angle implant), and 1% with the Delta III (DePuy, Paoli, PA, USA; 155° neck-shaft angle implant). Fifteen percent of patients underwent placement of a lateralized center-of-rotation (LCOR) implant with a 135° neck-shaft angle humeral component (Encore Reverse Shoulder Prosthesis; DJO Surgical, Vista, CA, USA). The glenosphere size also varied: In 15% of patients, a 32-mm glenosphere was placed; in 62% of patients, a 36-mm glenosphere was placed; and in 18% of patients, a 40-mm glenosphere was placed. The humeral component was routinely placed in 20° of retroversion. No adjustments to version were performed because of the bilateral nature of the implants. In 2 shoulders (2% of all shoulders), a concomitant latissimus transfer was performed for a preoperative positive lag sign from posterior rotator cuff insufficiency. Although most patients did not require intraoperative bone grafting, 36% of patients required humeral head autograft and 1% required the use of freeze-dried allograft bone for glenoid reconstruction of superior or posterosuperior defects typically seen in rotator cuff–deficient glenoid wear patterns.

Complications were infrequent postoperatively. Instability occurred in 3 shoulders (3%), one of which resolved with closed reduction; another patient required surgical revision of the humeral insert and placement of a larger glenosphere;

and in the third patient, all attempts at stabilization failed and conversion to a hemiarthroplasty was required. In 1 shoulder (1%) a periprosthetic joint infection occurred requiring a 2-stage exchange revision. Acromial fractures were sustained in 5 shoulders (5%), only one of which required open reduction–internal fixation. Radiographically, 62% of patients had no notching, 30% had grade 1 notching, 7% had grade 2 notching, and 1% had grade 3 notching. Overall, 95% of patients were free from reoperation and 98% of patients retained the implants.

Outcomes

Validated scoring and range of motion

Significant improvements were seen in almost all measured outcome variables, including visual analog scale score for pain ($P < .001$), SST score ($P < .001$), ASES score ($P < .001$), ASES-Functional score ($P < .001$), and SF-12 PCS ($P < .001$), with SF-12 MCS being the only variable without a significant change from preoperatively to postoperatively ($P = .455$). Mean preoperative and postoperative values, as well as the change between these values, are shown in Table I.

Significant improvements were seen between preoperative and postoperative values in all measured planes of range of motion including AFE ($P < .001$), abduction ($P = .001$), AIR ($P = .005$), and AER ($P < .001$). Mean preoperative and postoperative values, as well as the change between these values, are shown in Table II.

Personal hygiene and ADL questionnaire

Overall, most patients noted no changes to their personal hygiene habits and ADLs as a consequence of bilateral RTSA. Among the cohort, 94% noted that they used the same hand when using the toilet, 67% noted no change in their hygiene habits, 50% did not require an assistive device in the shower, and 97% did not require an assistive device on the toilet. Furthermore, 66% of patients were able to wash the opposite shoulder with the contralateral hand, and 83% were able to tuck a shirt-tail into the back of their pants. Among the minority of patients who did require changes to their hygiene habits, patients used a variety of techniques. For those female patients who had difficulty fastening a bra, strategies included fastening the bra in the front, switching to a sports bra, and fastening the bra and subsequently stepping into it and bringing it up the body. For those patients who had difficulty in the shower, the most frequently used strategies included using a long scrubber, using a long washcloth, and switching to baths instead of showers.

When asked whether it was difficult for patients to manage toileting, 77% of patients stated that it was not difficult, 17% stated that it was somewhat difficult, 2% stated that it was very difficult, and 4% stated that they were unable to do this task. When asked whether it was difficult for patients to wash the back or secure a bra, 27% of patients stated that it was not difficult, 17% stated that it was somewhat difficult, 16%

Table I Preoperative and postoperative functional outcome scores and change between scores

Variable	Preoperative	Postoperative	Change	*P* value for preoperative vs postoperative	MCOR	LCOR	*P* value for MCOR vs LCOR
ASES	37.5 ± 16.8	76.7 ± 19.6	39.2 ± 22.7	<.001*	42 ± 22	29 ± 22	.014*
Functional portion of ASES	9.0 ± 5.1	19.9 ± 6.5	10.9 ± 7.6	<.001*	12 ± 8	7 ± 6	.011*
SST	2.5 ± 2.5	8.9 ± 2.4	6.3 ± 3.2	<.001*	7 ± 3	4 ± 4	.013*
VAS	5.5 ± 2.6	0.7 ± 1.5	−4.8 ± 2.8	<.001*	5 ± 3	4 ± 3	.310
SF-12 MCS	53.6 ± 10.2	54.7 ± 7.4	1.1 ± 12.3	.455	2 ± 11	0 ± 16	.537
SF-12 PCS	31.2 ± 8.7	41.8 ± 13.3	10.6 ± 14.4	<.001*	10 ± 14	12 ± 16	.571

Data are presented as mean ± standard deviation.

ASES, American Shoulder and Elbow Surgeons score; LCOR, change from preoperatively to postoperatively for patients with lateralized center of rotation–style implant; MCOR, change from preoperatively to postoperatively for patients with medialized center of rotation–style implant; SF-12 MCS, Short Form 12 quality-of-life mental component score; SF-12 PCS, Short Form 12 quality-of-life physical component score; SST, Simple Shoulder Test; VAS, visual analog scale score for pain.

* Statistically significant.

Table II Mean preoperative and postoperative range-of-motion measurements and change between measurements

Variable	Preoperative, °	Postoperative, °	Change, °	*P* value for preoperative vs postoperative	MCOR, °	LCOR, °	*P* value for MCOR vs LCOR
Active forward elevation	72 ± 32	136 ± 22	67 ± 35	<.001*	74 ± 31	37 ± 31	<.001*
Active abduction	84 ± 37	121 ± 32	37 ± 42	.001*	55 ± 29	24 ± 46	.086
Active external rotation in adduction	26 ± 20	45 ± 15	19 ± 22	.005*	23 ± 22	9 ± 21	.017*
Active internal rotation in abduction	39 ± 17	58 ± 18	19 ± 24	<.001*	27 ± 20	−5 ± 24	.023*

Data are presented as mean ± standard deviation.
LCOR, change from preoperatively to postoperatively for patients with lateralized center of rotation–style implant; MCOR, change from preoperatively to postoperatively for patients with medialized center of rotation–style implant.
* Statistically significant.

stated that it was very difficult, and 39% stated that they were unable to do this task.

Subgroup analysis

Although most subgroup analyses showed no or minimal significant differences, when patients with MCOR implants were compared with those with LCOR implants, significantly better outcomes were seen for MCOR implants (SST score, $P = .013$; ASES score, $P = .014$; ASES-Functional score, $P = .011$; AFE, $P < .001$; AIR, $P = .017$; AER, $P = .023$) (Tables I and II). Notching rates were not significantly different between MCOR and LCOR implants (8% vs 14%, $P > .05$). When patients older than 70 years were compared with those younger than 70 years, patients older than 70 years had significantly greater gains in AER (23° ± 21° vs 9° ± 22°, $P = .018$); otherwise, no significant differences were seen ($P > .097$). When patients with previous rotator cuff surgery were compared with those without previous rotator cuff surgery, those with previous surgery had significantly greater gains in SF-12 MCS (6.9 ± 14.9 vs −1.4 ± 10.2, $P = .009$); otherwise, no significant differences were seen ($P > .097$). Latissimus transfer patients did not have differing outcome values compared with the population.

When patients with RCTA were compared with those with OA, patients with OA had significantly greater gains in AER (33° ± 21° vs 16° ± 21°, $P = .021$). When patients with RCTA were compared with those with MCT, significantly greater gains in ASES scores were seen for those with RCTA (41 ± 21 vs 29 ± 27, $P = .034$); otherwise, no significant differences were seen ($P > .054$). When patients who noted that they have had a change in their hygiene habits were compared with patients without a change in their hygiene habits, those patients without any change had significantly greater improvements in the ASES-Functional score (13 ± 8 vs 8 ± 7, $P = .026$) but significantly less change in the SF-12 MSC (7 ± 16 vs −1 ± 9, $P = .015$).

Regarding BMI, there was no correlation between BMI and range of motion or clinical outcome scores for either the right or left shoulder. BMI also did not significantly correlate with the patients' ability to perform their personal hygiene. Regarding glenosphere size, although there was a trend toward improved ASES scores for the left shoulder in patients with an increased glenosphere size ($r = 0.285$, $P = .061$), this was not true for the right shoulder ($r = 0.003$, $P = .986$). Furthermore, glenosphere size had no correlation with final range of motion, nor did glenosphere size correlate with a patient's ability to perform personal hygiene. Improved hygiene, however, was correlated with increased ASES scores ($r = 0.629$, $P < .0001$).

Discussion

Although RTSA has shown excellent outcomes for a variety of indications,[4-8,12,14,16,18,23,25,29] restoration of active internal and external rotation has been unreliable in past series.[1,26] Because rotational movements are necessary for ADLs, toilet care, and hygiene,[13,17,19] several authors recommend caution with bilateral RTSA.[2,18,27,28] Although a small number of previous series have shown good outcomes after bilateral RTSA, these studies have been limited by small sample sizes and few data focused specifically on hygiene.[15,22,28] We thus performed a retrospective case series to determine the effect of staged bilateral RTSA on functional outcome measures and specifically on hygiene and toileting. In our series, significant improvements were seen in range of motion in all planes including external and internal rotation ($P < .005$ in all cases), as well as in all functional outcome scores ($P < .001$ in all cases). Bilateral RTSA is thus a highly efficacious surgical intervention.

The specific ADLs that bilateral RTSA could complicate for patients include toilet use, washing the back, washing the contralateral shoulder, putting on a bra, and tucking in a back shirt-tail. In our series, most patients noted no change in their habits: 94% of patients noted that they used the same hand when using the toilet, and 67% of patients noted no change in their hygiene habits. In addition, of the minority of patients who did note a change in their habits, all developed successful compensatory habits. For instance, although 50% of patients required an assistive device in the shower, strategies such as using a long scrubber brush, using a long wash cloth, and switching to baths instead of showers allowed patients independence in their bathing. Similarly, although 17% of female patients were unable to fasten a back bra strap, strategies such as fastening the bra in the front, switching to a sports bra, and fastening the bra and then stepping into it and bringing it up the body allowed patients independence in these activities. Similarly, 4% of patients were unable to manage toileting independently but were able to retain independence with the use of an assistive device.

Our results confirm those of the previously published series. In a case-control study with 11 patients who underwent bilateral RTSA, Morris et al[15] showed significantly improved outcome scores and range of motion for both the first and second RTSA and showed no differences as compared with a control group of patients who underwent unilateral RTSA. In a retrospective case series of 15 patients who underwent bilateral RTSA, Stevens et al[22] showed significant improvements in functional outcome scores and AFE but no significant improvements in SF-12 quality-of-life scores, AER, or AIR. Although all patients retained the ability to perform toilet hygiene, the authors suggested caution with use of bilateral RTSA given the lack of improvement in rotation motion. In a case-control study of 16 patients who underwent bilateral RTSA, Wiater et al[28] concluded that although significant improvements were seen between preoperatively and postoperatively for functional outcome scores and pain, there were no significant improvements in either AER or AIR. They also concluded that the first shoulder offered more benefit to the patient than the second shoulder. Our study confirms the improvement in functional outcome scores as well as the improvement in rotation found by Morris et al. The reason for the differential between studies is unclear, although differences in implant design, integrity of the posterior rotator cuff, repair of the subscapularis, postoperative rehabilitation, and patient demand may all play a role.

Our study identified significantly better functional outcome scores and significantly better range of motion in the MCOR cohort compared with the LCOR cohort. Several previous studies have identified potential differences between these implant designs, with benefits of the MCOR design including reduced shear and rotational forces placed on the baseplate and reduced deltoid forces necessary for elevation and abduction[9,10] and benefits of the LCOR design including reduced impingement, potentially reduced dislocation rates,[9,10] and reduced scapular notching.[11] Our study did not show a significant difference in scapular notching between the MCOR and LCOR implants (8% and 14%, respectively). Previous studies have shown that these 2 designs do result in different radiographic centers of rotation.[20] However, to our knowledge, no comparative studies exist to compare the LCOR and MCOR implant options available in the United States and thus the clinical effect of these implant designs remains largely unknown. Given the wide disparity in use of MCOR implants in our study (85% of patients), no definitive conclusions can be made regarding outcomes when comparing these 2 implant designs.

Our study has several limitations. The relatively small sample size, the lack of a control group of unilateral RTSA patients, and the inclusion of multiple surgeons and multiple implants—and thus significant heterogeneity within the included patient cohort—all limit the conclusions that can be drawn. The strengths of the study include a larger sample size than any previous study on the subject even with the inclusion of control groups from previous studies and the inclusion of specific custom outcome measures regarding hygiene and rotational movements.

Conclusion

Bilateral RTSA provides predictable pain relief and improved function, particularly improved forward elevation. Internal and external rotation improvements were less dramatic from preoperative levels. Despite the modest improvements in internal and external rotation, most patients did not have difficulty with ADLs requiring shoulder rotation including bathing and toileting. In our cohort, all patients were able to independently perform ADLs, though some required simple compensatory strategies to be successful. Thus patients who are candidates for bilateral RTSA must be appropriately counseled that (1) it is more likely than not that their hygiene habits will not change and (2) if their hygiene habits do change, they will develop compensatory habits with the use of assistive devices such that they will retain independence.

Disclaimer

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