Early Follow-up of Reverse Total Shoulder Arthroplasty in Patients Sixty Years of Age or Younger

Stephanie J. Muh, MD, Jonathan J. Streit, MD, John Paul Wanner, BS, Christopher J. Lenarz, MD, Yousef Shishani, MD, Douglas Y. Rowland, PhD, Clay Riley, MD, Robert J. Nowinski, DO, T. Bradley Edwards, MD, and Reuben Gobezie, MD

Investigation performed at University Hospitals of Cleveland, Mayfield Heights, Ohio, Fondren Orthopaedic Group, Houston, Texas, and OrthoNeuro, New Albany, Ohio

Background: Reverse shoulder arthroplasty (RSA) is an accepted treatment that provides reproducible results in the treatment of shoulder arthritis and rotator cuff deficiency. Concerns over the longevity of the prosthesis have resulted in this procedure being reserved for the elderly. There are limited data in the literature with regard to outcomes in younger patients. We report on the early outcomes of RSA in a group of patients who were sixty years or younger and who were followed for a minimum of two years.

Methods: A retrospective multicenter review of sixty-six patients (sixty-seven RSAs) with a mean age of 52.2 years was performed. The indications included rotator cuff insufficiency (twenty-nine), massive rotator cuff disorder with osteoarthritis (eleven), failed primary shoulder arthroplasty (nine), rheumatoid arthritis (six), posttraumatic arthritis (four), and other diagnoses (eight). Forty-five shoulders (67%) had at least one prior surgical intervention, and thirty-one shoulders (46%) had multiple prior surgical procedures.

Results: At a mean follow-up time of 36.5 months, mean active forward elevation of the arm as measured at the shoulder improved from 54.6° to 134.0° and average active external rotation improved from 10.0° to 19.6°. A total of 81% of patients were either very satisfied or satisfied. The mean American Shoulder and Elbow Surgeons (ASES) score and visual analog scale (VAS) score for pain improved from 40.0 to 72.4 and 7.5 to 3.0, respectively. The ability to achieve postoperative forward arm elevation of at least 100° was the only significant predictor of overall patient satisfaction ($p < 0.05$) that was identified in this group. There was a 15% complication rate postoperatively, and twenty-nine shoulders (43%) had evidence of scapular notching at the time of the latest follow-up.

Conclusions: RSA as a reconstructive procedure improved function at the time of short-term follow-up in our young patients with glenohumeral arthritis and rotator cuff deficiency. Objective outcomes in our patient cohort were similar to those in previously reported studies. However, overall satisfaction was much lower in this patient population (81%) compared with that in the older patient population as reported in the literature (90% to 96%).

Level of Evidence: Therapeutic Level IV. See Instructions for Authors for a complete description of levels of evidence.

Since approval by the United States Food and Drug Administration (FDA) in 2004, reverse shoulder arthroplasty (RSA) has become a popular treatment for shoulder arthritis with rotator cuff insufficiency[1-15]. Short-term and midterm outcomes have generally been favorable despite relatively high complication rates and concerns over longevity of the results beyond the midterm. Guery et al. and others, for instance, recently reported that Constant scores, radiographic results, and survivorship deteriorated at a follow-up time of six to eight years[2,3,6,11,16]. While these studies report outcomes primarily in older patients, little is known about the outcomes of this procedure in a younger population. A decline in outcome after six to eight years would be an important concern in a younger population. The purpose of this study was to assess the early outcomes

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TABLE I Indications for Surgery

Indication	No of Shoulders (N = 67)
Rotator cuff insufficiency	29
Rotator cuff tear with osteoarthritis	11
Failed primary arthroplasty	9
Rheumatoid arthritis	6
Posttraumatic arthritis	4
Other diagnosis	8

following RSA in patients sixty years or younger for the purpose of characterizing these patients, evaluating their clinical outcomes, and assessing their subjective satisfaction. We hypothesized that the average functional outcome in our patient group would be similar to the reported outcome in older patients and that the average subjective satisfaction score in our group would be lower than that reported in the older population.

Materials and Methods

This study was a retrospective multicenter review of sixty-seven RSAs (sixty-six patients) performed at three institutions during the period from the beginning of 2004 through the end of 2010. Twenty-nine patients (thirty shoulders) were treated by one surgeon, six patients (six shoulders) were treated by a second surgeon, and thirty-one patients (thirty-one shoulders) were treated by a third surgeon. Radiographic imaging was performed on all patients preoperatively. Magnetic resonance imaging (MRI) or computed tomography (CT) was performed to assess rotator cuff status. Seventeen shoulders, or 25.4%, were the subject of Workers' Compensation claims. Postoperative radiographs were made at each visit and included anteroposterior, outlet, and axillary views. Scapular notching was classified according to the size of the defect on the anteroposterior radiograph, according to the classification system described by Sirveaux et al.[11]. Humeral loosening was detected through the evaluation of anteroposterior radiographs for the presence of radiolucent lines, as described by Boileau et al.[1].

Preoperative and postoperative outcome measures included active forward elevation, active external rotation, visual analog scale (VAS) pain score, and American Shoulder and Elbow Surgeons (ASES) score[17]. Additionally, patients rated their level of satisfaction through the use of a nonvalidated subjective scale following the procedure.

Surgical Technique

The deltopectoral surgical approach was used on all patients. A Grammont design reverse total shoulder prosthesis was implanted for all cases (Tornier, Saint-Ismier, France)[18,19]. No concomitant procedures were performed. Postoperative rehabilitation protocol was followed according to the surgeon's preference. Surgeon #1 used a sling for three to four weeks, then initiated aquatic therapy until the patient was able to reach 90° of active forward elevation (average six to twelve weeks). Surgeon #2 immobilized patients for one to two weeks and then allowed passive and active range of shoulder motion over the next six weeks. Surgeon #3 immobilized patients for six weeks and then allowed sedentary activity at two weeks, active motion at six weeks, and strengthening exercises at twelve weeks postoperatively.

Statistical Analysis

Quantitative data were summarized with use of parametric statistics (i.e., the mean and standard deviation) and nonparametric statistics (i.e., the median and interquartile range [25th through 75th percentiles]). The effect of surgery was ascertained by comparing the preoperative and postoperative levels for the various outcome measures in paired analyses of data before and after surgery. Two of the outcomes, active forward elevation and active external rotation, were measured by rotational angle in degrees (a continuous measure). The VAS pain score was determined by the patient as a point on a continuum from 0 to 10 (with 0 indicating no pain and 10 indicating the worst pain imaginable), and the ASES score is a total score on a 0 to 100 interval; both are continuous measures. The sample data for all four of these outcome measures were observed and have apparently normal distributions. The Student t test for paired data was utilized to compare the preoperative and postoperative levels for these outcome measures of treated shoulders. Doubly dichotomous categorical contingency table data were analyzed with the Fisher exact test. Bivariate correlations of each of these outcome measures compared with the number of prior surgeries were calculated with use of the Spearman rank correlation coefficient (the Spearman rho statistic), as the assumption of a linear relationship did not seem appropriate. The p value reported with the Spearman correlation coefficient is for the test of the null hypothesis, i.e., that the true correlation of ranks is zero. P values of less than 0.05 were considered significant.

Source of Funding

One author received financial support for the database that was used to collect results for the study.

Results

Clinical Analysis

There were thirty-seven women and twenty-nine men with a mean age of 52.2 years (twenty-three to sixty years.). Forty surgical procedures were on the dominant shoulder. The average follow-up was 36.5 months (twenty-four to seventy-seven months). Preoperative diagnoses included rotator cuff insufficiency without glenohumeral arthritis (n = 29), rotator cuff tear with arthritis (n = 11), failed primary shoulder arthroplasty (n = 9), rheumatoid arthritis (n = 6), posttraumatic arthritis (n = 4), and other diagnoses (n = 8) (Table I). Forty-five shoulders (67%) had at least one prior surgical procedure, and thirty-one shoulders (46%) had multiple prior surgical procedures. Of the twenty-two patients who had no history of prior surgery, nineteen had an irreparable rotator cuff tear with an unbalanced shoulder and preoperative diagnoses that included irreparable rotator cuff tears with pseudoparalysis (nine), posttraumatic arthritis (four), rheumatoid arthritis (one), rotator cuff tear with arthritis (four), and a four-part fracture-dislocation with a preexisting rotator cuff tear (one). The remaining three patients with no history of surgery had severe posttraumatic arthritis and proximal humeral nonunion with compromised rotator cuff function and pseudoparalysis.

Clinical evaluation was performed on all patients preoperatively and at each postoperative visit. Objective outcome measures are demonstrated in Table II. The average active forward elevation of the arm improved from 54.6° (range, 0° to 165°) to 134.0° (range, 0° to 180°) ($p < 0.05$), and the average active external rotation improved from 10.0° (range, −20° to 70°) to 19.6° (range, −10° to 70°) ($p < 0.05$). Patient subjective scores (and standard deviation) showed improvement, with the average ASES score increasing from 40.0 ± 16.71 to 72.4 ± 12.75) ($p < 0.05$); VAS pain scores decreased from 7.5 ± 2.0 to 3.0 ± 2.3 ($p < 0.05$) (see Appendix). Overall, 81% of the patients were either very satisfied or satisfied with the ultimate

TABLE II Outcomes at a Mean Follow-up Time of Thirty-Six Months

	Preoperative	Postoperative	P Value
Overall (n = 67)			
Forward elevation (active)	54.6° (range, 0° to 165°)	134.0° (range, 0° to 180°)	$p < 0.05$
External rotation (active)	10.0° (range, −20° to 70°)	19.6° (range, −10° to 70°)	$p < 0.05$
Visual analog scale pain score*	7.5 ± 2.0	3.0 ± 2.3	$p < 0.05$
American Shoulder and Elbow Surgeons score*	40.0 ± 16.71	72.4 ± 12.75	$p < 0.05$
History of prior surgery (n = 45)			
Forward elevation (active)	52.8° (range, 0° to 165°)	129.6° (range, 0° to 180°)	$p < 0.05$
External rotation (active)	10.9° (range, −20° to 70°)	18.9° (range, −10° to 70°)	$p < 0.05$
Visual analog scale pain score*	7.3 ± 2.4	3.4 ± 2.5	$p < 0.05$
American Shoulder and Elbow Surgeons score*	42.8 ± 16.6	70.2 ± 13.1	$p < 0.05$
History of no prior surgery (n = 22)			
Forward elevation (active)	57.8° (range, 0° to 100°)	142.6° (range, 30° to 175°)	$p < 0.05$
External rotation (active)	8.3° (range, –20° to 50°)	20.9° (range, 0° to 45°)	$p < 0.05$
Visual analog scale pain score*	7.7 ± 1.2	2.4 ± 1.8	$p < 0.05$
American Shoulder and Elbow Surgeons score*	34.8 ± 15.9	76.7 ± 11.2	$p < 0.05$

*The data are given as the mean value plus the standard deviation.

result and 19% of the patients were not satisfied, dissatisfied, or very dissatisfied with the outcome.

Patients with no history of prior surgery demonstrated significant improvements in active forward elevation, active external rotation, ASES scores, and VAS pain scores ($p < 0.05$). Patients with a history of prior surgery also showed significant improvements in active forward elevation, active external rotation, ASES scores, and VAS pain scores ($p < 0.05$). Analysis showed a negative correlation between increasing number of prior surgical procedures and change in ASES scores (Spearman rank correlation = −0.26, $p < 0.05$).

Patients who achieved a postoperative active forward elevation of at least 100° (Table III) showed improvements in ASES ($p < 0.05$) and VAS pain scores ($p < 0.05$) compared with those who did not reach 100°. Patients with <100° of postoperative forward elevation also had significant improvements in VAS pain scores ($p < 0.05$). However, subjective postoperative satisfaction scores showed that 92.7% of patients who had forward elevation of at least 100° were either satisfied or very satisfied with the outcome, whereas only 25% of patients who had <100° of forward elevation were satisfied or very satisfied with the outcome (Table IV).

Four patients had a preoperative active forward arm elevation of >90°. Two of these patients had rotator cuff insufficiency and multiple prior rotator cuff repairs with recurrent tears and >50% fatty atrophy of the muscle on MRI or CT. One patient had rotator cuff insufficiency with >50% fatty atrophy, and the final patient had Ehlers-Danlos syndrome with recurrent instability and multiple prior failed stabilization procedures. All four patients demonstrated improvements in active forward elevation, VAS pain scores, and ASES scores.

Radiographic Analysis

Preoperative MRI or CT Findings

Preoperative MRI or CT was performed to assess rotator cuff status and muscle quality. The number of full-thickness tears of the rotator cuff and the number of tendons involved are described in the Appendix. Sixteen patients had either

TABLE III Descriptive Statistics Depending on Postoperative Active Forward Elevation*

	Change in Forward Elevation (Range)	Change in External Rotation (Range)	Change in VAS Score *(Mean and Standard Deviation)*	Change in ASES Score *(Mean and Standard Deviation)*
Active forward elevation ≥100° (n = 55)	92.4° (15° to 175°)†	10.6° (−20° to 50°)†	−4.83 ± 2.1†	38.20 ± 20.3†
Active forward elevation <100° (n = 12)	20.4° (−50° to 60°)	5.4° (−20° to 30°)	−2.58 ± 3.7†	5.75 ± 16.4

*VAS = visual analog scale, and ASES = Association of Shoulder and Elbow Surgeons. †$P < 0.05$.

TABLE IV Postoperative Subjective Satisfaction

	Overall Satisfaction (N = 67 shoulders)	Active Forward Elevation (N = 67 Shoulders)	
		≥100° (N = 55 Shoulders)	<100° (N = 12 Shoulders)
Very dissatisfied	6 (9%)	1 (1.8%)	5 (41.7%)
Dissatisfied	4 (6%)	2 (3.6%)	2 (16.7%)
Not satisfied	3 (4.5%)	1 (1.8%)	2 (16.7%)
Satisfied	35 (52.2%)	33 (60%)	2 (16.7%)
Very satisfied	19 (28.4%)	18 (32.7%)	1 (8.3%)

an intact cuff or single-tendon involvement. The preoperative diagnoses for these patients included failed arthroplasties (seven), posttraumatic osteoarthritis (three), recurrent instability with multiple prior surgical procedures (one), rotator cuff tear insufficiency with multiple prior surgeries (one), instability with glenohumeral arthritis with multiple prior surgical procedures (one), rotator cuff tear with severe arthritis (one), fracture (one), and rheumatoid arthritis with a single tendon tear and attenuation of the remaining three tendons (one).

Fatty infiltration of the rotator cuff muscles was classified according to a modified method described by Goutallier et al.[20]. In patients with full-thickness tears of the supraspinatus, eleven shoulders were at Goutallier stage II or less, and forty shoulders demonstrated Goutallier stage III or higher. Full-thickness tears involving the infraspinatus tendon showed fifteen with Goutallier stage II or less, and twenty-seven with Goutallier stage III or higher. Nine patients had Goutallier stage II or less of subscapularis tears, and 16 patients were at Goutallier stage III or higher. There were five tears involving the teres minor that were at Goutallier stage II or less and one that was at Goutallier stage III or higher. Overall, twenty-two patients had Goutallier stage II or less fatty infiltration in all four tendons. Of these patients, the indication for RSA was failed arthroplasty (five), posttraumatic osteoarthritis (four), rotator cuff tear with arthritis (four), irreparable rotator cuff tear with pseudoparalysis (four), recurrent instability with multiple prior surgeries (two), four-part fracture-dislocation with preexisting rotator cuff tear (one), rheumatoid arthritis (one), and instability with arthritis and multiple prior surgeries (one).

TABLE V Postoperative Complications

Complication	Number	Treatment
Dislocation	5	Revision (3)
		Closed reduction (2)
Infection	3	Resection arthroplasty final treatment (2)
		Two-stage revision (1)
Humeral stress fracture	1	Revision to long-stemmed component
Nerve palsy	1	Nonoperative management

Postoperative Radiographs

At an average of 36.5 months (range, twenty-four to seventy-seven months) follow-up, scapular notching was present in twenty-nine shoulders (43%). Twenty-two (32.8%) of these were judged to be grade 1; five (7.5%), grade 2; and two (3%), grade 3. There was no evidence of humeral loosening at the time of final radiographic analysis.

Complications

Ten complications (15%) were identified among nine shoulders (Table V). No intraoperative complications occurred. Of the postoperative complications, five were dislocations. The shoulder required revision in two of these patients (polyethylene exchange in one and revision RSA in the other), and two patients were treated with closed reduction. The fifth patient also had a postoperative dislocation that required revision; subsequently, an infection developed requiring the performance of a resection arthroplasty. Two other patients also developed postoperative infection that required resection arthroplasty (one patient underwent a two-stage revision with reimplantation once the infection was eradicated, and the other had a resection arthroplasty as the final treatment). Another patient sustained a humeral stress fracture at the distal tip of the stem secondary to a remote healed fracture, requiring revision to a long-stemmed component. Finally, one patient had a postoperative radial and ulnar nerve palsy that was improving spontaneously but had not fully resolved at the time of the most recent follow-up (thirty months). Postoperatively, five of these patients were not satisfied, were dissatisfied, or were very dissatisfied, and four patients were either very satisfied or satisfied.

Discussion

This study reports on outcomes following RSA in patients who were sixty years of age or younger at the time of the operation. Our study demonstrates that RSA can improve function and restore some active arm elevation, and these results are similar to those reported previously from studies that followed older populations of patients who underwent RSA[2,6,11-14,21,22].While postoperative motion was comparable with results reported previously in older patients, subjective

TABLE VI Published Results of Reverse Shoulder Arthroplasty (RSA) Outcomes*

	Age	No. with Prior Surgery/Total No. of Patients	Functional Score		Active Forward Elevation		Subjective Outcomes
			Preop	Postop	Preop	Postop	
Wall et al.[12] (2007)	75.3	45/196	22.8 (Constant)	59.7 (Constant)	86	137	93% very satisfied or satisfied
Frankle et al.[6] (2005)	71	25/60	34.3 (ASES)	68.2 (ASES)	55	105.1	68% good to excellent
Boileau et al.[2] (2006)	72	19/45	17 (Constant)	58 (Constant)	55	121	82% very satisfied or satisfied
Werner et al.[13] (2005)	68	41/58	29 (Constant)	64 (Constant)	42	100	improvement from 18% to 56% in subjective shoulder score
Sirveaux et al.[11] (2004)	73	12/80	22.6 (Constant)	65.6 (Constant)	73	138	96% very satisfied or satisfied
Molé and Favard[21] (2007)	NR	NR	NR	62 (Constant)	NR	130	90% very satisfied or satisfied
Young et al.[14] (2009)	79	4/49	NR	70 (ASES)	NR	122	89% good to excellent

*Constant = Constant score, and ASES = American Shoulder and Elbow Surgeons score.

outcomes following RSA in this younger patient population were less favorable. Satisfaction rates following RSA have traditionally been high in the literature regarding RSA (Table VI). Molé and Favard reported on 484 arthroplasties performed in a primarily older-age cohort at a mean follow-up of fifty-two months, and 90% of patients were satisfied with their outcome[21]. In another study, Sirveaux et al. reported that 96% of 80 patients (mean age, seventy-three years) had little or no pain, with a mean Constant score of 65.6, at a mean follow-up of forty-four months[11]. Frankle et al. similarly reported that 95% of patients (mean age, seventy-one years) were at least satisfied at a mean follow-up time of thirty-three months[6]. In an analysis of 58 consecutive patients (mean age, sixty-eight years) undergoing the procedure for indications that included revision surgery in 70.1% of patients, Werner et al. found that the subjective shoulder score increased from a mean of 18% to 56%[13].

Recently, Ek et al. reported on significant subjective improvement and substantial gain in overall function in their cohort of patients under the age of sixty-five years, with subjective shoulder values improving from 23% to 66%[23]. The overall satisfaction rate of 81% achieved in our study cohort is somewhat lower than that reported in previous reports; however, our cohort differs from the majority of those reported in the literature with respect to age as well as the complexity of the diagnosis. The mean age of our patient population was 52.2 years as compared with an average age of about seventy years in the aforementioned studies, and the majority of our patients presented with complex shoulder problems, often after undergoing prior failed surgical interventions. Finally, while numerous factors may contribute to the observed decrease in subjective satisfaction in this patient demographic, greater expectation of functional outcome may also be a factor.

It is also important that almost 50% of our patients had multiple failed shoulder surgical procedures prior to primary RSA. Our study demonstrates that while these patients have improvements in forward arm elevation at the shoulder, VAS pain scores, and ASES scores postoperatively, there is a negative correlation between a change in postoperative ASES scores and an increasing number of prior surgical procedures. This differs from the results reported by Ek et al., who found no significant difference in outcomes (in a similar cohort of patients) between patients who had no prior surgery and those who had at least one prior surgical intervention[23]. In a cohort of older patients, Werner et al. reported improved functional forward elevation in those who underwent RSA after prior surgery[13]. However, the average forward elevation in the subgroup of patients who had prior surgery was not above 100°. Our results are more similar to those of previous studies on RSA after failed rotator cuff surgery; for example, those of Boileau et al., who reported a postoperative forward elevation of 123°[1]. These results have been supported by several other studies, which found that patients without a history of previous shoulder surgery had better outcomes than those who had a history of previous shoulder surgery[6,12,13]. While these studies support our observations, a larger sample size is needed to confirm these findings.

Our series also shows that there is a significant association between postoperative active forward elevation dichotomized at 100° and patient satisfaction pooled to yield a dichotomy (satisfied versus less than satisfied), with greater

satisfaction occurring more frequently with greater elevation ($p < 0.05$).

The longevity of the prosthesis and functional results are major concerns, especially in the younger population. Recently, Cazeneuve and Cristofari reported on long-term functional outcomes in elderly patients who were managed with a Grammont-style reverse shoulder prosthesis as treatment for trauma[24]. The authors found that Constant-Murley scores decreased between postoperative year one and the time of the most recent follow-up (mean follow-up, eighty-six months) due to increased pain and loss of strength. Guery et al. also described a deterioration of functional results and pain in patients six to eight years after RSA was performed[16]. Long-term decline in function is a major concern, especially for our cohort, and should be closely followed.

In addition to its use in the treatment of rotator cuff tear arthropathy and massive rotator cuff tears with or without arthrosis, RSA has been used to treat problems requiring complex reconstruction, such as revision arthroplasty, tumor resection, and rheumatoid arthritis[10,12]. However, these patients are sometimes excluded from outcomes analyses because of the small numbers of patients undergoing the procedure for these indications. In an analysis of outcomes based on surgical indication, Wall et al. found that patients undergoing RSA for a diagnosis of posttraumatic arthritis had worse outcomes and were less satisfied compared with patients undergoing the procedure for rotator cuff tear arthropathy, primary osteoarthritis with rotator cuff tear, or massive rotator cuff tear[12]. Due to the relatively small sample size in our cohort, we were not able to identify any correlation between outcome and presenting diagnosis. However, our analysis shows that patients undergoing RSA for rotator cuff insufficiency seemed to have the most reproducible change in active forward elevation. Additionally, patients with a prior failed primary arthroplasty had the least improvement with regard to ASES scores. This information could prove valuable in managing patient expectations prior to total shoulder arthroplasty.

The high complication rate (15%) observed in our study was concerning, especially because of the serious and debilitating nature of the complications. Of the nine patients with complications, two patients required resection arthroplasty as the final treatment. Surgeons considering RSA for the treatment of a shoulder disorder in the young patient should use the results of this study to better counsel their patients and manage expectations preoperatively.

Careful patient selection is of paramount importance, as some patients will not be candidates for the procedure due to the complex pathology that sometimes presents in the younger population. Taking into account the fact that over 50% of patients in our study group were either not satisfied, dissatisfied, or very dissatisfied with the final outcome, a frank discussion regarding the expectations, alternatives, risks, and benefits of the procedure must take place before the patient undergoes surgery.

The incidence of scapular notching (43%) in our cohort is comparable with what has been previously reported in the literature[2,12,13,25,26]. Recently, Lévigne et al. noted notch progression postoperatively, with an incidence of 48% at one year, 60% at two years, and 68% at three years[26]. The authors also found an increased incidence of grade-3 and grade-4 notches with longer postoperative follow-up. Additionally, several authors described a negative correlation between scapular notching and lower Constant-Murley score, subjective shoulder score, and motion[11,26,27]. While the majority of our patients had either grade-1 or grade-2 notching, two patients (3%) had evidence of grade-3 notching. Due to the possible long-term implications of scapular notching, this requires close monitoring.

The limitations of this study include those associated with the retrospective and multicenter design. The multicenter nature of this study introduces several variables, including patient selection bias, operator bias, surgical technique, postoperative rehabilitation protocol, and clinical follow-up. Second, the mean follow-up of 36.5 months is short in terms of prosthesis and functional survivorship. Finally, due to the small sample size, other significant clinical outcomes in this cohort of patients may have been missed. Additional prospective long-term studies need to be performed to assess the performance of this prosthesis in the younger patient population.

Conclusion

Reverse total shoulder arthroplasty can improve function in young patients. Despite improved functional outcomes that were similar to those reported in the literature, patient satisfaction is lower for the younger patient after undergoing RSA. Young patients who are candidates for RSA require preoperative counseling for a full understanding of their postoperative limitations and functional capacities.

Appendix

(eA) A table showing the incidence of complete tendon tears preoperatively and figures demonstrating the changes in forward elevation, VAS score, external rotation, and ASES score as compared with the preoperative data are available with the online version of this article as a data supplement at jbjs.org. ■

Stephanie J. Muh, MD
Jonathan J. Streit, MD
Christopher J. Lenarz, MD
Douglas Y. Rowland, PhD
Case Shoulder and Elbow Service (S.J.M. and C.J.L.), and the
Departments of Orthopaedics (J.J.S.) and
Epidemiology & Biostatistics (D.Y.R.),
Case Western Reserve University School of Medicine,
University Hospitals of Cleveland,
11100 Euclid Avenue,
Cleveland, OH 44106

John Paul Wanner, BS
Yousef Shishani, MD
Reuben Gobezie, MD

Cleveland Shoulder Institute,
University Hospitals of Cleveland,
5885 Landerbrook Drive, Suite 150,
Mayfield Heights, OH 44124.

Clay Riley, MD
T. Bradley Edwards, MD

Fondren Orthopedic Group,
7401 South Main Street,
Houston, TX 77030

Robert J. Nowinski, DO
OrthoNeuro, 5040 Forest Drive, Suite 300,
New Albany, Ohio 43054

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Update

The print version of this article has an error that has been corrected. The doi number for the paper, which was given as "doi:10.2106/JBJS.L.00005," has been corrected and is now given as "doi:10.2106/JBJS.L.10005."