J Shoulder Elbow Surg (2020) 29, 2221–2228

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Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

Anatomic total shoulder arthroplasty after healed rotator cuff repair: a matched cohort

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Background: Rotator cuff tears are a common cause of failure after anatomic total shoulder arthroplasty (TSA). The purpose of this study was to evaluate the effect of a healed prior rotator cuff repair (RCR) on outcomes and complications after primary TSA. We hypothesized that patients with a prior healed RCR would have equivalent outcomes and complication rates compared with patients without prior surgery.

Methods: A retrospective review of all primary TSAs with a prior RCR was performed using a multicenter database between 2005 and 2017. Thirty shoulders with prior RCR were case matched on a 3:1 ratio with a minimum 2-year follow-up. Range of motion, strength, patient-reported outcome measures, complications, and reoperations were compared.

Results: Thirty shoulders with a prior RCR were compared with 90 control patients without prior surgery at a mean follow-up of 43 months (range, 24-109 months). Groups demonstrated similar preoperative range of motion and patient-reported outcome measures. Postoperatively, TSAs with a prior healed RCR demonstrated less forward flexion (132° vs. 143°, $P = .14$) and strength (5.7 vs. 6.4 kg, $P = .55$) compared with control shoulders with no prior surgery; however, these did not meet statistical significance. Complications were significantly more common in patients with a prior RCR (17% vs. 7%, $P = .01$). Postoperative rotator cuff tears were significantly more common in TSA with a healed prior RCR (13% vs. 1%, $P = .014$).

Conclusions: TSA after RCR results in similar functional improvements compared with shoulders without prior surgery. However, the risk of a postoperative rotator cuff tear is significantly higher after prior successful RCR. Surgeons should consider this potential complication when indicating these patients for primary TSA.

Level of evidence: Level III; Retrospective Cohort Comparison; Treatment Study

Keywords: Total shoulder arthroplasty; aTSA; rotator cuff repair; rotator cuff tear; revision; rcr; retear

Rotator cuff tears (RCTs) are a common cause of shoulder pain that are increasingly being treated with surgical repair over therapy and corticosteroid injections.[1,4,13] With radiographic confirmed healing, patients routinely return to full activity without restrictions.[11] In rare cases, these patients present at a later date for evaluation of primary osteoarthritis of the glenohumeral joint.[6] Biomechanical literature has documented decreased strength of a healed rotator cuff tendon compared with native tendon, and concern remains about the genetic

Institutional Review Board approval was received from the Medical University of South Carolina (IRB study no. Pro00030914).

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https://doi.org/10.1016/j.jse.2020.03.029

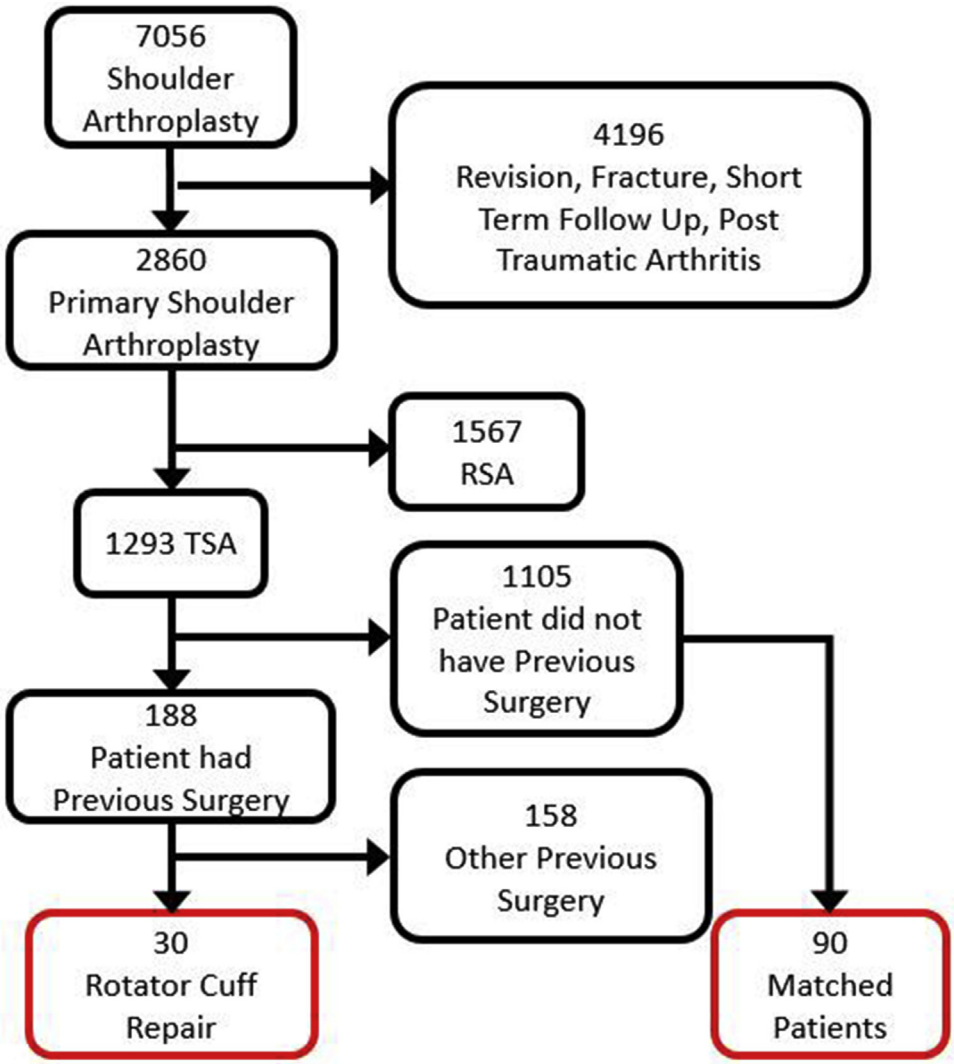

Figure 1 Flow diagram demonstrating selection of study patients. *RSA*, reverse shoulder arthroplasty; *TSA*, total shoulder arthroplasty.

predisposition to rotator cuff tearing in patients with an atraumatic RCT. Yamaguchi et al[27] previously showed that patients presenting with a full thickness RCT had a 50% chance of a full thickness tear on the contralateral side, which is often asymptomatic. This is in comparison with the 28% incidence of asymptomatic full thickness RCTs in the asymptomatic population older than 60 years of age, indicating that there are likely contributory genetic factors.[22] RCTs after anatomic total shoulder arthroplasty (TSA) are a common complication at midterm follow-up, and attempts to repair the rotator cuff after TSA are unreliable at restoring function.[10,21]

Prior studies have evaluated the effect of concurrent rotator cuff repair (RCR) on primary TSA.[15,24] Individual studies have shown a higher risk of radiographic failure when primary TSA is performed in conjunction with surgical repair of a large RCTs. However, functional results remain similar when comparing TSAs with no rotator cuff disease with those undergoing TSA with concurrent repair of small RCTs.[9,24] These studies remain limited by their small size and do not assess healing rates using any advanced imaging. In a larger study, Mahony et al[16] identified both prior shoulder surgery and an RCT requiring repair during anatomic TSA to be associated with a higher risk of failure to improve after surgery.

Because of concerns regarding outcomes after prior surgery, a reasonable case can be made to proceed directly to reverse shoulder arthroplasty (RSA) in patients with a healed RCR.[14,21] Although prior studies have evaluated the effect of prior surgery on TSA outcomes, we are unaware of any studies specifically evaluating the effect of a healed prior RCR on the outcomes of TSA. The purpose of this study is to evaluate the effect of a healed prior RCR on outcomes and complications after primary TSA. We

hypothesized that patients with a prior healed RCR would have equivalent outcomes and rate of complications compared with patients without a prior surgery.

Methods

A retrospective review of an international shoulder arthroplasty database was performed over a 12-year period (2005-2017). All primary anatomic shoulders with a documented prior RCR were identified and reviewed. Shoulders with a documented RCT at the time of surgery or undergoing simultaneous repair at the time of TSA were eliminated. Other exclusion criteria included revision surgery, post-traumatic arthritis, acute fractures, and a follow-up less than 2 years. Thirty shoulders ultimately met inclusion criteria and were evaluated. See Fig. 1.

Demographic data were collected including age, sex, height, weight, body mass index (BMI), and diagnosis. Study patients were then matched on a 3:1 basis based on age, sex, height, weight, BMI, and follow-up duration. Match was performed using the Optimal method in the MatchIt algorithm with a logistic regression-based propensity score method using R (Vienna, Austria).[12] The Optimal algorithm is designed to minimize the measure of global error between the 2 datasets, which can result in sacrificing a match based on a single variable (ie, sex) to better match based on other available patient characteristics (height, weight, BMI, or diagnosis).[12] Before surgery, all patients were evaluated clinically with multiple patient-reported outcome measures (PROMs). Range of motion (ROM) was evaluated in 3 planes: forward elevation in the scapular plane (degrees), external rotation (degrees), and internal rotation measured by the level reached by the thumb according to the scale described by Flurin et al.[7] ROM was measured by the performing surgeon or research assistant with a goniometer. Maximum strength with the arm elevated in the scapular plane was measured in kilograms. PROMs included American Shoulder and Elbow Surgeons (ASES) score, Simple Shoulder Test (SST), and Shoulder Pain and Disability Index. The Constant score, a combination of patient-reported and objective measures, was also assessed. Pain was assessed using the visual analog scale. All patients were evaluated at a minimum 2 years using the same ROM measures and PROMs. At each follow-up visit, clinical complications and interval reoperations were recorded. TSAs with a prior healed RCR were then compared with the control group of TSA with no prior surgery to evaluate for differences in clinical outcomes, complications, and reoperation rates. Healing was evaluated at the time of surgery by direct visualization at the time of surgery. Postoperative RCTs were diagnosed at the discretion of the treating surgeon, and testing was not standardized across clinical practices.

All statistical analyses were performed using R. Ordinal variables were assessed using a chi-squared statistic or the Fisher exact test based on sample size. Continuous variables were assessed using a Wilcoxon rank-sum test. The alpha level for all tests was set at 0.05.

Results

Thirty TSAs (10 males, 20 females) with a healed prior RCR were compared with 90 control TSAs (29 males, 61 females) without prior surgery at a mean follow-up of 43 months (range, 24-109 months). Age, sex, and BMI were similar between groups. See Table I. Osteoarthritis was the most common diagnosis, representing 97% of study patients and 93% of control patients. A full list of diagnoses is provided in Table I.

Preoperatively, groups demonstrated similar ROM and PROMs. See Table II. Postoperatively, forward elevation was lower in the shoulders with a healed prior RCR (132 vs. 143, $P = .14$). Internal and external rotations were clinically similar between groups. See Table III for full details. Differences in postoperative pain and PROMs were similar between groups with all differences well below the minimally clinically important difference as described by Simovitch et al.[25] When evaluating improvements in outcomes from pre- to postoperatively, forward elevation demonstrated smaller improvements in patients with a prior healed RCR (33 vs. 45, $P = .14$). Improvements in maximum strength in forward elevation were also less in TSAs with a prior RCR (2.7 vs. 4.2, $P = .32$). See Table IV for full details.

Complications were more common in patients with a prior RCR (17% vs. 7%, $P = .01$; odds ratio [OR]: 2.8, 95% confidence interval [CI] = [0.788-9.95], $P = .121$). The most common postoperative complication in the prior RCR group was an RCT (n = 4, 13%), which was diagnosed at a mean follow-up of 48 months. One shoulder in the group with no prior surgery had a clinically documented RCT after TSA. The OR for developing an RCT after TSA with prior RCR vs. no prior RCR was 13.63, 95% CI = [1.46-127.9] ($P = .022$). The most common complication in the control group was aseptic glenoid loosening (n = 5, 6%). Full details of all complications are shown in Table V. One of the 4 TSAs with a prior RCR and a postoperative RCT underwent revision to an RSA. One additional patient in the TSA with the prior RCR group was revised for aseptic loosening. Five patients in the control group underwent revision surgery that was not found different from those with prior RCR (6% vs. 7%, $P = 1.0$, OR = 1.21, $P = .82$). Four of these were performed for aseptic glenoid loosening, and 1 was performed for aseptic humeral loosening.

Subgroup analysis

To evaluate the effect of clinically diagnosed rotator cuffs on the differences observed between groups, a subgroup analysis was performed removing all shoulders with a documented RCT after TSA. When comparing the control group with the remaining 26 TSAs with prior RCR, differences in overhead ROM and strength persisted. Similar to the entire study cohort, PROMs remained comparable. See Table VI for full details.

Table I Demographic information

Study demographics	TSA no previous surgery	TSA with a healed prior RCR	*P* value
Group size	90	30	–
Postoperative follow-up (mo)	48.6 ± 24.1	49.9 ± 27.7	.82
Patient sex			
Female	61	20	.91
Male	29	10	
Patient age (yr)	64 ± 9.3	64 ± 7.6	.36
Demographic characteristics			
Height (in)	66.2 ± 4.8	66.2 ± 4.3	.99
Weight (lbs)	177.6 ± 38.1	186.1 ± 40.0	.31
BMI	28.6 ± 6.0	29.9 ± 5.9	.30
Diagnosis			
Osteoarthritis	84	29	.50
Osteonecrosis	1	1	
Rheumatoid arthritis	3	0	
Rotator cuff arthropathy	2	0	

TSA, total shoulder arthroplasty; *RCR*, rotator cuff repair; *BMI*, body mass index.
Follow-up, age, and demographic characteristics are listed as mean ± standard deviation.

Table II Preoperative clinical comparison between groups

	TSA no previous surgery (90)	TSA with a healed prior RCR (30)	*P* value
Range of motion			
Active abduction (°)	83 ± 28.1	93 ± 26.9	.12
Active forward elevation (°)	100 ± 30.8	102 ± 31.6	.70
IR score	3.2 ± 1.4	3.5 ± 1.5	.25
Active external rotation (°)	21 ± 17.0	25 ± 19.7	.45
Strength			
Forward elevation (kg)	2.4 ± 3.5	2.3 ± 4.2	.92
Quality of life			
Pain	6.1 ± 2.1	6.6 ± 1.7	.30
Shoulder function	4.1 ± 2.1	4.1 ± 1.9	.95
Clinical metrics			
SST	4.0 ± 2.7	4.7 ± 3.5	.35
Constant	38.5 ± 12.2	41.3 ± 16.0	.44
ASES	35.8 ± 16.5	37.2 ± 14.3	.73
UCLA	14.8 ± 4.2	13.8 ± 3.8	.31
SPADI	81.8 ± 24.4	76.4 ± 28.6	.42

TSA, total shoulder arthroplasty; *RCR*, rotator cuff repair; *IR*, internal rotation; *SST*, Simple Shoulder Test; *ASES*, American Shoulder and Elbow Surgeons; *UCLA*, University of California, Los Angeles Shoulder Score; *SPADI*, Shoulder Pain and Disability Index.
Outcomes are reported as mean ± standard deviation.

Discussion

RCTs after TSA remain a common complication leading to revision surgery at midterm follow-up.[21] Given that patients with prior RCTs are at increased risk for recurrent tears compared with the population, concern remains about the development of postoperative RCTs after TSA in patients with a history of a healed RCR. Based on the results of this study, this concern appears to be appropriate. Postoperative RCTs were significantly more common in patients with a prior healed RCR compared with matched controls (13% vs. 1%). Although no differences were shown in PROMs or the rate of revision, concern remains about the long-term effects of RCTs and the risk of progressive glenoid component loosening.[8]

The incidence of postoperative RCTs was significantly higher in the study cohort (13%) compared with the

Table III Postoperative clinical comparison between groups

	TSA no previous surgery	TSA with a healed prior RCR	*P* value
Range of motion			
Active abduction (°)	122 ± 33.3	117 ± 35.9	.47
Active forward elevation (°)	143 ± 32.6	132 ± 38.5	.14
IR score	5.0 ± 1.4	4.9 ± 1.6	.66
Active external rotation (°)	50 ± 22.9	55 ± 22.2	.28
Strength			
Forward elevation (kg)	6.4 ± 5.2	5.7 ± 5.6	.55
Quality of life			
Pain	1.3 ± 2.3	2.0 ± 2.6	.18
Shoulder function	8.2 ± 2.2	7.7 ± 2.6	.27
Clinical metrics			
SST	10.2 ± 2.6	9.7 ± 3.0	.45
Constant	70.0 ± 17.6	64.3 ± 19.8	.26
ASES	82.7 ± 22.2	77.1 ± 24.7	.26
UCLA	30.5 ± 6.0	28.3 ± 7.2	.11
SPADI	20.5 ± 28.2	25.5 ± 29.2	.42

TSA, total shoulder arthroplasty; *RCR*, rotator cuff repair; *IR*, internal rotation; *SST*, Simple Shoulder Test; *ASES*, American Shoulder and Elbow Surgeons; *UCLA*, University of California, Los Angeles Shoulder Score; *SPADI*, Shoulder Pain and Disability Index.
Outcomes are reported as mean ± standard deviation.

control group (1%) at a mean follow-up of 43 months. The incidence of tears in TSAs with a prior RCR is also higher than the historical rate of RCTs after TSA as reported by Chin et al[3] (4%) at a similar follow-up of 4.2 years ($P = .045$). In their study of 419 TSAs, Chin et al reported 17 clinically diagnosed RCTs after TSA, with 6 undergoing reoperation. However, only 1 of the 4 TSAs with a prior RCR and a postoperative RCT underwent revision surgery.

Patients with a history of a full-thickness RCT are known to be at increased risk of rotator cuff tearing in both the affected and nonaffected shoulder.[27] The long-term implications of TSA in patients at increased risk of rotator cuff disease remain poorly defined. Norris and Iannotti[18]

Table IV Clinical improvements from pre- to postoperatively

	TSA no previous surgery	TSA with a healed prior RCR	*P* value
Range of motion			
Active abduction (°)	41 ± 39.5	26 ± 37.0	.10
Active forward elevation (°)	45 ± 38.3	33 ± 33.1	.14
IR score	2.0 ± 1.9	1.6 ± 1.8	.41
Active external rotation (°)	30 ± 24.4	32 ± 23.5	.67
Strength			
Forward elevation (kg)	4.2 ± 5.8	2.7 ± 5.5	.32
Quality of life			
Pain	−5.1 ± 3.1	−4.8 ± 3.2	.62
Shoulder function	4.5 ± 3.0	3.9 ± 3.2	.41
Clinical metrics			
SST	6.4 ± 3.4	4.8 ± 3.6	.07
Constant	32.8 ± 19.2	24.2 ± 15.1	.09
ASES	50.5 ± 23.9	41.1 ± 24.9	.12
UCLA	17.0 ± 6.1	15.1 ± 7.3	.23
SPADI	−65.5 ± 32.7	−53.4 ± 38.3	.19

TSA, total shoulder arthroplasty; *RCR*, rotator cuff repair; *IR*, internal rotation; *SST*, Simple Shoulder Test; *ASES*, American Shoulder and Elbow Surgeons; *UCLA*, University of California, Los Angeles Shoulder Score; *SPADI*, Shoulder Pain and Disability Index; *PROM*, patient-reported outcome measure.
Range of motion and PROM reported as mean ± standard deviation.

Table V Complications

	TSA no previous surgery	TSA with a healed prior RCR	Chi-squared *P* value
Rotator cuff tear	1 (1%)	4 (13%)	.014
Aseptic glenoid loosening	5 (6%)	1 (3%)	.53
Total adverse events	6 (7%)	5 (17%)	.01

TSA, total shoulder arthroplasty; *RCR*, rotator cuff repair.

reported on a cohort of patients treated with hemiarthroplasty and TSA at a mean follow-up of 46 months. In their analysis, shoulders with a repairable supraspinatus had similar postoperative SST and ASES scores compared with the group without rotator cuff tearing. The mean ASES (83.9) and SST (8.5) scores of their cohort were clinically similar to both this study cohort with a healed RCR and those without any previous surgery.

In this small series, no detrimental effect on PROMs was identified in patients with a prior RCR compared with the control group. Previous studies have shown poorer clinical outcomes in patients undergoing TSA after prior surgery. Mahony et al evaluated 459 TSAs performed for primary osteoarthritis. Shoulders with a history of prior surgery were 3 times less likely to achieve a successful outcome, where failure was defined as reoperation before 2 years or improvement in the ASES score below the minimal clinically important difference.[16,26] The authors did not evaluate the type of prior surgery, so a direct comparison with our study cohort cannot be evaluated. Specifically, prior rotator cuff surgery has previously been associated with worse visual analog scale pain and ASES scores compared with shoulders without prior surgery in RSA.[23] However, other studies have challenged these results showing no difference in outcomes when stratified by prior RCR.[5,20] Similar to the RSA study by Shields et al, the results of this study did demonstrate lower ASES scores in shoulders with prior RCR, but this was below the MCID for TSA (MCID 23).[23,25]

In addition to differences in PROMs, overhead ROM and maximum strength were also less in the study cohort. These differences persisted even after eliminating patients with a known RCT after TSA, possibly indicating a greater prevalence of silent rotator cuff disease in the cohort of TSAs with a healed prior RCR. Moosmayer et al[17] showed significantly decreased strength in forward flexion in a group of patients with asymptomatic full-thickness RCTs in their native shoulder diagnosed by ultrasound. In shoulders with a full-thickness RCT, the mean force of forward flexion was 6.5 kg, compared with 7.5 kg in shoulders with no RCT.[17] This effect may potentially explain some of the strength differences seen between groups in this study,

Table VI Comparison of improvement in outcomes in shoulders with prior RCR and no documented postoperative RCT compared with the control group

	TSA no previous surgery (n = 89)	TSA with a healed prior RCR (n = 26)	*P* value
Range of motion			
Active abduction (°)	41.4 ± 39.3	27.7 ± 39.1	.14
Active forward elevation (°)	46.0 ± 38.2	37.2 ± 32.8	.32
IR score	2.0 ± 1.9	1.6 ± 1.8	.43
Active external rotation (°)	29.4 ± 24.5	33.9 ± 23.5	.44
Strength			
Forward elevation (kg)	4.5 ± 5.7	3.0 ± 5.9	.38
Quality of life			
Pain	−5.1 ± 3.1	−5.1 ± 2.9	.99
Shoulder function	4.6 ± 3.0	4.3 ± 2.9	.72
Clinical metrics			
SST	6.5 ± 3.3	5.1 ± 3.7	.11
Constant	33.3 ± 19.0	25.8 ± 15.0	.16
ASES	50.8 ± 23.9	44.3 ± 23.1	.30
UCLA	17.2 ± 5.9	16.2 ± 6.8	.52
SPADI	−66.3 ± 32.4	−56.8 ± 36.3	.30

RCR, rotator cuff repair; *RCT*, rotator cuff tear; *TSA*, total shoulder arthroplasty; *IR*, internal rotation; *SST*, Simple Shoulder Test; *ASES*, American Shoulder and Elbow Surgeons; *UCLA*, University of California, Los Angeles Shoulder Score; *SPADI*, Shoulder Pain and Disability Index.
Outcomes are reported as mean ± standard deviation.

which persisted even after removal of shoulders with known postoperative RCTs. However, the observed differences did not reach statistical significance, that may be related to sample size, as this study was underpowered to evaluate for differences in both forward elevation and strength. In addition, patients did not routinely undergo postoperative advanced imaging as part of standard follow-up, and a definitive correlation cannot be made.

This is the first study to evaluate the effect of a healed prior RCR on the outcomes of primary TSA. The study remains limited by its retrospective nature and the information available within the database. Given these limitations, we were unable to assess if the prior RCR was performed in an open or arthroscopic fashion. However, prior studies have shown similar rates of healing after both procedures.[2] Furthermore, we were unable to assess the characteristics of the healed tear in regard to injury, chronicity, and size at the time of primary RCR. It is possible that the long-term recurrence rate in traumatic RCTs may be different than that of healed chronic tears, as healing rates have been shown to be greater in acute traumatic tears fixed early after injury.[19] Given that the performing surgeon evaluated these patients postoperatively, the study is also subject to self-evaluation bias. The diagnosis of a postoperative RCT was also made by the performing surgeon, and no attempt was made to standardize diagnostic tests. Furthermore, advanced imaging was not performed routinely on all patients, leaving the possibility of asymptomatic tears in both groups. However, given that both groups were evaluated in a similar matter, the differences identified between groups likely represent meaningful differences in overhead motion and strength between groups. Lastly, we were underpowered to evaluate for differences in both complications and revision surgery. However, the OR for developing a postoperative RCT did reach statistical significance (OR, 13.6; 95% CI = [1.46-127.9], $P = .022$).

Conclusion

Anatomic TSA after a healed RCR can improve both pain and function. Although functional improvements appear similar, gains in forward elevation and overhead strength were less compared with patients without prior surgery but did not reach statistical significance. Concern remains about the quality of the rotator cuff tissue in these patients, with 13% of patients sustaining clinically identified postoperative RCTs after TSA.

Disclaimer

Bradley Schoch is a paid consultant for and received royalties from Exactech. Carl Tams is an employee of Exactech. Josef Eichinger, Jay King, and Richard J. Friedman are paid consultants for Exactech. Thomas Wright receives royalties from Exactech and Wolters Kluwer Health – Lippincott Williams & Wilkins and is a paid consultant for Exactech.

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