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Anatomic Shoulder Arthroplasty in the Setting of Concurrent or Prior Rotator Cuff Repair: A Systematic Review

Zylyftar Gorica, MD[1], Kimberly McFarland, BS[2], Conor N. O'Neill, MD[1], Jennifer Vanderbeck, MD[1] and Alexander R. Vap, MD[1]

Abstract

Background: Reverse total shoulder arthroplasty (RSA) is the gold standard in management of osteoarthritis (OA) in the setting of rotator cuff pathology. However, there are significant complications associated with the procedure. An alternative option in the setting of a deficient rotator cuff may be to perform a repair prior to or concurrently with an anatomic total shoulder arthroplasty (aTSA).

Methods: A systematic review was performed utilizing Preferred Reporting Items for Systematic Meta-Analyses (PRISMA) guidelines to evaluate outcomes in aTSA with concomitant or prior rotator cuff repair (RCR). Key outcomes were complication rate and subjective outcome scores.

Results: Seven studies were included in the review. One study found a higher rate of total adverse events in the prior repair group (17% vs 7%, $P = .01$) while others found no significant difference. There was a nonstatistically significant increase in revision rates among patients with larger tears at time of repair. Prior repair groups were associated with a higher rate of re-tear in one study (13% vs 1%, $P = .014$). Concomitant repair was associated with a higher rate of loosening. In patients with prior repair, there was no statistical difference in strength, range of motion (ROM), simple shoulder test (SST), Single Assessment Numeric Evaluation (SANE), American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form (ASES), and visual analogue scale (VAS). In patients with concurrent repair, one study demonstrated a less drastic improvement in Hospital for Special Surgery (HSS) in "moderate" repairs as opposed to "good" repairs.

Conclusions: Anatomic TSA is an appropriate treatment for glenohumeral OA in patients with a prior successful RCR and in younger patients with concurrent repair of small or medium tears.

Level of Evidence: Level III.

Keywords

anatomic, shoulder arthroplasty, rotator cuff, repair, concomitant, prior

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Introduction

In the last decade, shoulder arthroplasty has increased dramatically.[21] A statistical analysis by Wagner et al. demonstrated that the yearly volume of primary shoulder arthroplasties increased by 103.7% between 2011 and 2017, with projection models showing an additional expected increase between 67.2% and 235% by 2025.[21]

Anatomic shoulder arthroplasty is typically regarded as the gold standard for treating glenohumeral osteoarthritis (OA).[15,18] However, concomitant unrepaired rotator cuff pathology is associated with poorer anatomic total shoulder arthroplasty (aTSA) outcomes due to eccentric loading and early failure of the glenoid component.[4] Therefore, disruption of the rotator cuff is considered a contraindication to aTSA. The reverse total shoulder arthroplasty (RSA) was introduced as a better alternative for the management of OA in the setting of rotator cuff pathology.[9] While RSA has been shown to consistently provide pain relief and improve functional range of motion (ROM), there have been drawbacks with reported

[1]Department of Orthopaedic Surgery, Virginia Commonwealth University, Richmond, VA, USA
[2]Department of Orthopaedic Surgery, Virginia Commonwealth University School of Medicine, Richmond, VA, USA

Corresponding Author:
Zylyftar Gorica, Department of Orthopaedic Surgery, Virginia Commonwealth University, 1200 E. Broad Street, 9th Floor, PO Box 980153, Richmond, VA 23298 USA.
Email: zylyftarg@gmail.com

complications including infection, periprosthetic fracture, scapular notching, and instability at unsatisfactory rates.[2,10,14] An alternative option in the setting of a deficient rotator cuff may be to perform a repair prior to or concurrently with aTSA.[11,19]

Numerous studies have examined the effects of prior shoulder surgery on the outcome of shoulder arthroplasty.[1,3–6,8,13,17,18,22,23] Less is known about the outcomes of aTSA in a patient with a healed prior rotator cuff repair (RCR) or those with a concurrently repaired rotator cuff tear (RCT).[11,13,19,23] This review examines differences in outcomes of anatomic shoulder arthroplasty in patients with prior or concurrent RCR versus patients without RCR.

Materials and Methods

Literature Search

Two independent reviewers (ZG and KM) performed a systematic review according to Preferred Reporting Items for Systematic Meta-Analyses (PRISMA) guidelines in December 2021 using PubMed (MEDLINE), Cochrane Central Register of Controlled Trials, and Embase database studies. A combination of the following search terms was used: "shoulder," "arthroplasty," "replacement," "anatomic," "total," "rotator cuff," "repair," "prior," "concurrent," and "outcomes." Articles of evidence levels 1 to 3 were screened for the inclusion criteria of elective primary anatomic shoulder arthroplasty, history of prior RCR versus concomitant RCR, and at least 1 documented outcome. Minimum follow-up was not included in the inclusion criteria to ensure studies were not left out. Studies written prior to 2000, in languages other than English, and case reports and series were excluded.

Data Extraction

Data extraction for all studies meeting inclusion criteria was performed by 2 independent reviewers (ZG and KM). Study characteristics such as study design, number of patients included, length of follow-up, and exclusion criteria were recorded. Additional information such as primary surgical procedure, concomitant procedures, primary outcome, secondary outcomes, results, analysis methods, and study conclusions were also recorded. Pre- and postoperative assessments reported include American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form (ASES), Constant score, UCLA score, simple shoulder test (SST), visual analogue scale (VAS), ROM or strength exams, radiographs, 12-Item Short Form Health Survey (SF-12), and Single Assessment Numeric Evaluation (SANE).

Quality and Bias Assessment

The Risk of Bias in Non-randomized Studies of Interventions (ROBINS-I) tool for cohort studies was used to assess the quality and bias of studies included in this review (Table 1).[20]

Table 1. Study Characteristics.

First author, Year	Study type	ROBINS-I	No. of patients	M:F	Age	BMI	Follow-Up	Outcomes reported
	TSA with prior RCR versus TSA without prior RCR (TSA with prior RCR; TSA without prior RCR):							
Schiffman 2020	Retrospective Cohort	Moderatr	183; 462	42:30; 106:115	59; 68	30; 31	Min. 2 years	SST, MPI, SANE
Schoch 2020	Retrospective Cohort	Low	30; 90	10:20; 29:61	64; 64	29.9; 28.6	43 months	ROM, strength, ASES, SST, SPADI, Constant score, VAS
Erickson 2020	Retrospective Cohort	Moderate	14; 42	9:5; 27:15	65.1; 65.4	30.4; 28.5	Min. 2 years	ASES, SF-12, SAS, overall patient satisfaction
Frank 2018	Retrospective Cohort	Low	96; 362	215:238	66.4 avg	32.3; 30.9	Min. 2 years	ASES, SST, VAS, ROM
	TSA with concomitant RCR:							
Rozing 2010	Prospective Cohort	n/a	66	36:74	60	NR	6.5 years	HSS score
Livesey 2018	Retrospective Cohort	Moderate	45	23:22	68.9	NR	4.7 years	Acromiohumeral interval (AHI), ROM/ strength (active FF and ER); At 2 years: ASES, SANE, VAS, SF-12
Simone 2014	Retrospective Cohort	n/a	33	12:21	73	NR	4.7 years	Forward elevation, ER, radiographs, pain

Abbreviations: ASES, American Shoulder and Elbow Surgeons score; BMI, body mass index; ER, external rotation; FF, forward flexion; HSS score, Hospital for Special Surgery shoulder rating score; MPI, maximum possible improvement; NR, not reported; RCR, rotator cuff repair; ROM, range of motion; ROBINS-I, Risk of Bias in Non-randomized Studies of Interventions; SANE, Single Assessment Numeric Evaluation; SAS, shoulder activity scale; SF-12, 12-item short form survey; SPADI, shoulder pain and disability index; SST, simple shoulder test; TSA: total shoulder arthroplasty; VAS, visual analogue scale (pain rating scale).

This tool examines the internal validity of studies and assesses risk of bias within specified domains. The results are then qualified as low, moderate, serious, or critical risk of bias.

Results

Study Characteristics

The initial search of PubMed (MEDLINE), Cochrane Central Register of Controlled Trials, and Embase database studies yielded a total of 918 studies, of which 7 met the inclusion criteria and were included for further analysis.[4,6,11,16–18,19] See PRISMA flowchart (Figure 1). Included studies were prospective or retrospective cohort studies. For ease of comparison, the 7 included studies were divided into 2 study types: 4 studies (Schiffman, Schoch, Erickson, and Frank) examined total shoulder arthroplasty (TSA) with prior RCR versus TSA without prior RCR, with the other 3 studies (Rozing, Livesey, Simone) examining only TSA with concomitant RCR.

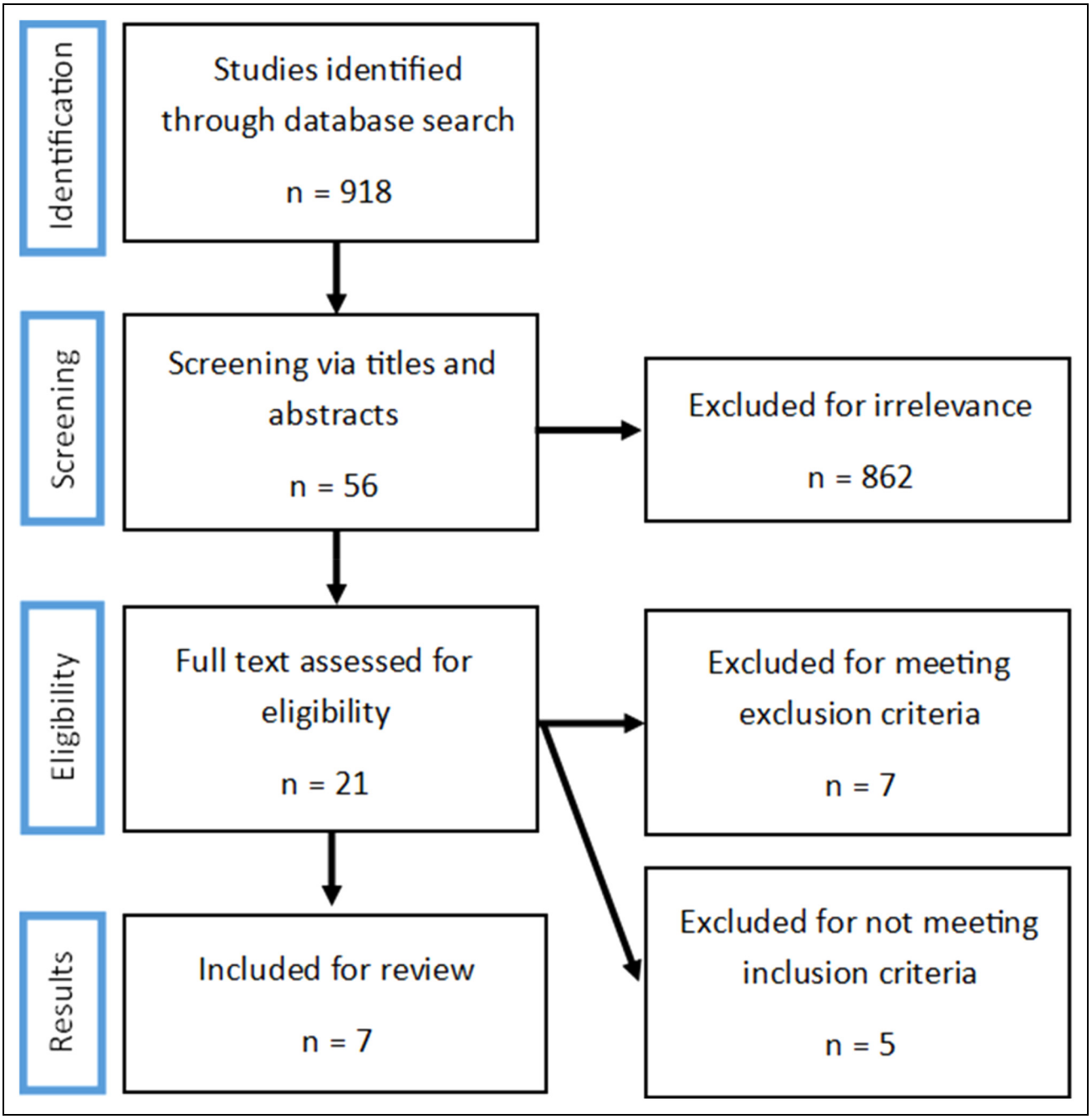

Figure 1. Preferred Reporting Items for Systematic Meta-Analyses (PRISMA) schema.

The studies by Frank et al. and Schiffman et al. examined patients undergoing anatomic TSA with no history of shoulder surgery versus those with prior nonarthroplasty shoulder surgery. Both performed subanalysis comparing RCR versus no RCR. Frank et al. reported that the prior surgery was RCR in 67% of their patients.[6] Schoch et al. and Erickson et al. looked at aTSA patients who had prior RCR versus those who did not.[4,6,17,18] The mean follow-up period for these 4 studies was 46.7 months.[4,6,17–18] The mean time interval between RCR and aTSA was not documented.

Studies by Livesey et al., Rozing et al., and Simone et al. evaluated outcomes in patients with concurrent RCR.[11,16,19] Rozing et al. compared patients undergoing aTSA with concomitant RCR versus aTSA alone. Rozing et al. evaluated patients with rheumatoid arthritis. Livesey et al. and Simone et al. examined the outcomes of patients with aTSA and concurrent RCR. The mean follow-up period for these 3 studies was 62.6 months. A summary of the study characteristics, including ROBINS-I score is shown in Table 1.

Patient Demographics

The 4 studies with prior RCR evaluated a total of 1327 patients. Average patient age was 63.9 years for those with prior RCR and 65.9 for the control group (no prior RCR). Four hundred eighty-four patients were female and 438 patients were male. Four of these studies reported body mass index (BMI), of which the average was 30.65 for the prior RCR group and 29.75 for the control group.[4,6,17–18] Matched controls were selected based on age and sex in 3 studies. Erickson et al. also matched by preop ASES scores and Schoch et al. also matched by BMI and follow-up duration.[4,18] Schiffman et al. used additional factors for matching which were shoulder laterality, primary insurance, ASA class, tobacco use, alcohol use, narcotic use, type 1 diabetes, type 2 diabetes, preop pain score, preop SST score, and preop SANE score.[17] Matching methods were not reported in the study by Frank et al.[6]

The 3 studies evaluating aTSA with concurrent RCR included a total of 144 patients, with an average patient age of 67.3 years, with 117 female patients and 71 males. BMI was not reported in any of these studies.[11,16,19]

TSA Surgical Technique

Studies describe multiple approaches and implants for aTSA with concurrent RCR. Rozing et al. did not describe the approach or technique; however, they report primarily using the Biomet prosthesis.[16] Livesey et al. used a subscapularis take down technique (most often lesser tuberosity osteotomy) and implant type (most often DePuy).[11] Simone et al. utilized a deltopectoral approach for all their procedures. Erickson et al. also reported a deltopectoral approach with cemented, pegged, polyethylene glenoid but prosthetic brand was not noted.[4] Frank et al. Schiffman et al. and Schoch et al. did not report the surgical technique or type of prosthetic used.[6,18] The most popular prosthetic components were the Cofield all-polyethylene glenoid component and the Cofield stems.[19]

RCR Surgical Technique

Only 2 studies reported on the RCR surgical technique. Livesey et al. performed 44 bone tunnel and 1 anchor RCR. Simone et al. performed a side-to-side suture repair in 23 patients and both tendon-to-tendon and tendon-to-bone sutures in 10 patients.[11,19] Rozing et al. did not report RCR technique.[16] Surgical techniques for aTSA and RCR as well as intraoperative findings are presented in Table 2.

Intraoperative Measures

Of the 4 studies of aTSA with no concurrent procedures, there was limited data of intraoperative measures, with only Erickson et al. noting the integrity of the rotator cuff at the time of aTSA to confirm imaging findings and ensure competence.[4]

All 3 studies reported operative details for the aTSA with RCR procedures. Rozing et al. reported that 75 were converted to hemiarthroplasty due to glenoid bone loss or insufficient glenoid exposure (these hemi conversions were not included in this review). Additionally, they inspected the rotator cuff intraoperatively and found 48 normal cuffs, 20 thin or attenuated but intact cuffs, 21 small tears, 49 large tears, and 3 cuffs that could not be reliably inspected.[16] Simone and Livesey also reported intraoperative RCT assessment which included cuff tear size.[11,19]

Radiographic Findings

The study by Erickson ensured the integrity of the rotator cuff preoperatively with magnetic resonance imaging or computerized tomography but did not report any specific results except that all included patients had radiographically intact rotator cuffs.[4] The studies by Schiffman et al, Schoch et al., and Frank et al. did not report any radiographic findings.[6,17,18]

More radiographic findings were reported for the studies with concurrent RCR such as measurement of superior humeral head migration, acromiohumeral interval (AHI), AC joint evaluation, and postoperative evaluation for glenoid component loosening. Rozing et al. reviewed improvement in proximal migration of the humeral head in aTSA, measured by AHI, and found improvement more frequently in those with "good" repair of the cuff than those with "moderate repair of the cuff ($P = .027$). Rozing et al. also found that preoperative status of the rotator cuff was significantly related to the presence of radiolucency and loosening of the cemented glenoid components ($P = .002$). This was an issue even with good repairs of the cuff when compared to intact cuff.

Livesey et al. measured AHI as well as the Lazarus radiolucency score with 0 indicating no lucency and 5 indicating gross loosening. The Lazarus score was 0 for 20 patients, 1 for 11 patients, and 3 for 3 patients with a mean of 0.6.[11] Mean AHI measurements were 9.0 mm preoperatively,

Table 2. Surgical Technique and Intraoperative Findings.

First author, Year	TSA technique	TSA prosthesis	Concomitant procedures	RCR technique	Intraop findings
	TSA with prior RCR versus. TSA without prior RCR:				
Schiffman 2020	Deltopectoral approach, subscapularis peel, retention of intact long head tendon of biceps, humeral head cut in 30°. Retroversion, conservative glenoid reaming (345 TSAs, 295 ream-and-run)	Anchor Peg Glenoid prosthesis (DePuy Synthes)	NR	n/a	NR
Schoch 2020	NR	NR	NR	n/a	NR
Erickson 2020	Deltopectoral with cemented, pegged, polyethylene glenoid	NR	NR	n/a	Examined RC integrity by direct visualization
Frank 2018	NR	NR	NR	n/a	NR
	TSA with Concomitant RCR:				
Rozing 2010	Biomodular glenoid component – 18 uncemented metal backed, 48 cemented polyethylene	83 Biomet, 58 ESKA	RCR	NR	75 converted to hemiarthroplasty due to glenoid bone loss or insufficient glenoid exposure. Inspected RC intraop: 48 normal cuffs, 20 thin/attenuated but intact, 21 small tears, 49 large tears, 3 could not be reliably inspected
Livesey 2018	34 lesser tuberosity osteotomy, 7 subscapularis tenotomy, 3 subscapularis peel	31 DePuy, 11 Tornier, 1 Stryker, 1 Zimmer, 1 Integra	RCR	44 bone tunnel, 1 anchor	Intraoperative RCT assessment, cuff tear size, subscapularis takedown method
Simone 2014	Deltopectoral	24 Cofield all-poyethylene glenoid component, 1 Cofield metal-backed noncemented component, 6 Biomet, 2 Aequalis	RCR	23 side-to-side suture, 10 TTT and TTB suture	NR

Abbreviations: NR, not reported; RC, rotator cuff; RCR, rotator cuff repair; RCT, rotator cuff tear; TSA, total shoulder arthroplasty.

12.4 mm immediately postop ($P = .013$), and 8.4 mm at an average of 43 weeks out ($P = .86$)[11].

Simone et al. measured humeral head subluxation relative to the center of the glenoid (graded as mild = <25%, moderate = 25%-50%, severe >50%), AHI (classified as < 6 mm or >/ = 6 mm), and peri-prosthetic glenoid lucency (graded on depth and completeness around the component). With regard to humeral head subluxation, preoperatively, 17 patients had no subluxation, 9 patients had mild subluxation, and 1 had moderate subluxation. Postoperatively, there was no superior translation in 13 patients, mild translation in 9, moderate translation in 3 (preop tears: 2 large, 1 medium), and severe translation in 2 (both with medium preop tears). Based on glenoid lucency, 6 shoulders were judged to have radiographic risk of loosening.[19]

Postoperative Complications and Reoperations

The reported complications varied by study, with overall complication rate, repeat RCT, glenoid loosening, and reoperation among the most commonly cited.

Overall complication rate. Schoch et al. found a higher rate of total adverse events in the prior RCR group (17% vs 7%, $P = .01$). The most common postoperative complications were RCT (in the prior RCR group) and aseptic glenoid loosening (in the control group). There was no statistical difference in aseptic glenoid loosening between the groups (3% for prior RCR vs 6% for control, $P = .53$). Two patients in the study by Erickson et al. required early reoperation, however, there were no significant differences in complication rates at 2 or 5 years when matched with the control group.[4] This was corroborated by Frank et al. who report no difference in complications between anatomic TSA patients with and without prior RCR. Contrary, Livesey et al. showed poor clinical result in 31% of patients which was found to be predicted by a preoperative AHI of <8 mm ($P = .003$).[11]

Reoperation. Reoperation was indicated for varied diagnoses, most commonly re-tear of the rotator cuff, glenoid loosening, or instability. Schiffman et al. found significantly higher rates of reoperation in those with prior surgery. The difference becomes statistically insignificant, however, when specifying prior surgery as RCR, with difference in revision rates of 2.05 ($P = .370$).[17] Erickson et al. had 2 prior RCR patients (14%) develop complications requiring reoperation. One patient with persistent anterior instability, and another with postop infection resulting in revision and 2-stage exchange, respectively.[4] Livesey et al. reported 8 reoperations (57%) of which 5 were for rotator cuff insufficiency (3 converted to RSA, 2 revision RCR), 2 frozen shoulders, and 1 periprosthetic fracture. Of these, 4 reoperations were done on patients with large tears and 4 had high-grade partial tears at the index procedure. There were 11 revisions in the study by Rozing et al. with 3 for symptomatic glenoid loosening, 1 for painful medial migration, 3 for acute cuff rupture, 1 for internal rotation contracture release, and 2 for painful AC joint.[16] Simone et al. reported complications in 5 patients, all who had medium or large tears, which were symptomatic instability in 4 and 1 late periprosthetic fracture. Four of these patients underwent revision surgery (12%; 3 for instability, 1 for periprosthetic fracture); the fifth refused further intervention. Those with instability were found to have medium to large tears and 2 underwent revision to reverse TSA; the other underwent unsatisfactory repeat repair. None of the patients with a small tear had instability or further operation and all reported satisfactory results.[19] Schoch et al. found 2 (7%) of the patients in the prior RCR group underwent revision surgery, one for revision to RSA due to postoperative RCT and one for aseptic loosening. Five (6%) of the patients in the control group underwent revision surgery, all for aseptic loosening. There was no statistically significant difference in revision rates.

Re-tear. Schoch et al. found a higher rate of postoperative RCTs in the prior RCR group (13% vs 1%, $P = .014$). Rozing et al. had 3 (5%) acute cuff ruptures in the postoperative period.

Glenoid loosening. Complications were more common in aTSA with concurrent RCR and instability was reported most often. A preoperatively attenuated cuff, defined as degenerated or torn, was associated with more loosening ($P = .004$)[16].

Subjective Outcomes Scores and Clinical Measurements

Clinical outcomes by most studies included strength, ROM, percentage of maximal improvement (% MPI), and subjective scores, such as SST, SANE, ASES, Shoulder Arthroplasty Smart Score (SAS), VAS, Short Form health summary (SF-12), and Constant score. These findings are summarized in (Tables 3 and 4).

For the 3 studies of aTSA patients with or without prior RCR, there were varied findings. Schiffman et al. reported

Table 3. Measured Objective Outcome Results.

First Author, Year	Preop AFF	Postop AFF	Preop AER	Postop AER	Preop AIR	Postop AIR	Preop strength	Postop strength
	TSA with prior RCR versus TSA without prior RCR:							
Schoch 2020	102 versus 100 ($P = .7$)	132 versus 142 ($P = .14$)	-	-	-	-	2.3, 2.4 ($P = .92$)	5.7, 6.4 ($P = .55$)
Frank 2018	91.2	140.1 (**P<.001**)	27.4	51.6 (**P<.001**)	-	-	-	-
	TSA with concurrent RCR:							
Livesey 2018	101	139 (**P<.00001** 95% CI 26 to 50)	20	40 (**P<.0001** 95% CI 14-27)	-	-	-	-
Simone 2014	99	139 (**P<.0001**)	20	49 (**P<.0001**)	Sacrum	First lumbar spinous process (**P<.0001**)	4.3 (FF), 4.2 (ER), 4.4 (IR)	4.6 (FF), 4.7 (ER), 4.8 (IR)

Abbreviations: AEF, active external rotation; AFF, active forward flexion; AIR, active internal rotation; ER, external rotation; FF, forward flexion; IR, internal rotation; RCR, rotator cuff repair; TSA, total shoulder arthroplasty.

Table 4. Subjective Outcome Results.

First author, Year	2-year SST score Diff. (95% CI)	% MPI Diff. (95% CI)	2-year SANE score Diff. (95% CI)	Other	Findings
Schiffman 2020	−0.7 (95% CI −3.6 to 2.2), $P = .656$[a]	−4 (95% CI −38 to 30), $P = 7.99$[a]	9 (−11 to 29), $P = .377$[a]	-	No significant difference in 2-year SST, % MPI, 2-year SANE score, and revision risk.
Schoch 2020	5.1 versus 6.5 (p = 0.11)	-	-	-	No differences in PROM or revision rate but higher rates of later RCT in study group versus control (13% vs 1%, OR 13.6, 95% CI 1.46 to 127.9, $P = .022$).
Erickson 2020	-	-	-	ASES Diff.[a]: -0.6 at baseline ($P = .91$), -6.8 at 2 years post-op ($P = .19$), -4.3 at 5 years post-op ($P = .72$)	No significant differences in any baseline, 2-year, or 5-year follow-up scores.
Frank 2018	3.5 to 8.9, ***P*<.002**	-	-	ASES improvement: 40.4 to 81.7, ***P*<.001**	No difference in patient-reported outcomes or reoperation rates. Differences in SST scores did not reach MCID. Worse postop VAS, SST, and ASES for study group. Worse post-op AFF for study group but no difference in AER.
Rozing 2010	-	-	-	Overall HSS[b]: 70.0, 69.2, 66.0 (trend ***P* = .045**). By RCR quality: Moderate: 57.0, 54.5, 56.2 (trend $P = .859$); Good: 73.8, 76.2, 59.5 (trend ***P* = .003**), Intact 73.6, 72.0, 70.1 $P = .122$)	Stratified by quality of RCR. Moderate repair: worse outcomes (HSS) at 2 years versus good repair or intact cuff ($P = .006$). Good repair: improvement (HSS) initially comparable to shoulders w/ intact cuff, but statistically significantly declines at avg. of 1.3 points/year ($P = .003$). Similar decline in HSS was not significant for intact cuff group (0.4 points/year, $P = .122$). Shoulders with preoperative proximal migration had less flexion ($P = .009$) and abduction ($P = .021$) at 2-year follow up.
Livesey 2018	-	-	-	AHI pre versus post: 9.0 mm, 12.3 mm (***P* = .013**) immediate, 8.4 mm ($P = .86$) avg 43 weeks out)	68% had good or excellent outcome. Subscapularis involvement negatively predicted poor ASES and VAS; infraspinatus negatively predicted poor VAS pain score. Pre-op AFF and AER predictive of poor functional outcomes scores. Pre-op AHI <8mm had statistically significant increase in cuff-related reoperations.
Simone 2014	-	-	-	AHI: <6 mm in 2 pts pre-op, <6 mm in 7 pts post-op	Significant improvements in pain, FF, ER at mean 4.7 years post-op; worse results with larger tears and older patients.

[a]Compares TSA with prior RCR versus TSA without prior RCR

[b]Values listed are at 2 years post-op, 5 years post-op, and 10-years post-op.

Abbreviations: AER, active external rotation; AHI, acromiohumeral interval; ASES, American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form; ER, external rotation; FF, forward flexion; %MPI, percentage of maximum possible improvement; RCR, rotator cuff repair; SST, simple shoulder test; VAS, visual analog scale.

no statistically significant difference in 2-year SST Score, % MPI, and 2-year SANE Score for prior RCR versus control.[17] The difference in ASES, SF-12 PCS, and MCS and SAS score for Erickson et al. was not statistically significant at baseline, 2-year follow-up, and at 5-year follow-up.[7] Frank et al. reported no significant difference in patient-reported outcomes or ROM between patients with prior RCR and those without.[6] Schoch et al. also reported nonstatistically significant differences in improvements of ROM and strength. The improvement between preoperative and postoperative active forward flexion (AFF) was 33.2° for the prior RCR group and 45.0° for the control group ($P = .14$). The differences in improvements in active abduction, active external rotation (AER), and internal rotation were also not significantly different ($P = .10$, .67, and .41, respectively). Similar nonsignificant findings were noted for improvements in strength ($P = .32$), pain ($P = .62$), subjective shoulder function ($P = .41$), SST ($P = .07$), Constant score ($P = .09$), ASES ($P = .12$), UCLA shoulder score ($P = .23$), and the Shoulder Pain And Disability Index/SPADI ($P = .03$)[18].

For aTSA patients with concurrent RCR, the study by Rozing et al. evaluated patients by Hospital for Special Surgery (HSS) 100 scoring system which gives 30 points to pain, 25 to power, 25 to motion, and 20 to function. At 2-year follow-up, patients with "moderate" repairs had statistically less improvement in HSS score. "Good" repairs had comparable scores to those with intact cuff. At 2 years, however, after the initial improvement, the HSS score decreased on average by 1.3 points per year ($P = .003$). HSS score improved in younger patients ($P<.001$) and those with a rotator cuff prothesis ($P = .006$).[16] Livesey et al., measuring active ROM, ASES, SANE, VAS, and SF-12, found that AFF improved from an average of 101° to 139° ($P<00001$). AER improved from an average of 20° s to 40° ($P<.0001$). Subjective outcome scores were collected only postoperatively and the averages were ASES of 85.4 (range: 48.33-100), SANE score of 84.9 (range: 50-100), VAS pain score of 0.9 (range: 0-5), SF-12 physical score of 44.9 (range: 22.4-60.4), and SF-12 mental score of 53.4 (range: 29-68.3). Using linear regression analysis they found that predictors of low ASES score were low preoperative AFF ($P = .28$), active external rotation (ER) ($P = .009$), and subscapularis tear ($P = .009$). Low SANE score predictors were also low preoperative AFF ($p = 0.044$) and active ER ($p = 0.031$). Greater pain on the VAS scale was predicted by low AFF ($P = .031$), active ER ($P = .003$), and subscapularis tear ($P<.001$).[11] Simone et al. reported improvements in pain levels, ROM, motor strength, and Neer ratings. They found that AFF improved from an average of 99° to 139° ($P<.0001$), active ER improved on average 20° to 49° ($P<.0001$), and ER improved at the level of the sacrum to the level of L1 ($P<.0001$). Strength was also compared pre- and postoperatively, with averages of 4.3 for forward flexion (FF), 4.2 for ER, and 4.4 internal rotation (IR) which improved to 4.6 (FF), 4.7 (ER), and 4.8 (IR). Statistical significance, however, was not reported. Neer ratings were also used; 28 patients reported their shoulder as "better" or "much better" and 5 reported "same" or "worse".[19] The study found that patients with smaller tears had the greatest improvement in elevation, and medium or large tears were associated with instability and loosening.

Discussion

The results of this review suggest that aTSA patients with a prior RCR or concurrent RCR have overall similar functional and patient-reported outcomes to those without history of RCR, though potentially with higher rates of complication or reoperation. Based on the included studies, this is most applicable to healed prior repairs or concomitant well-repaired smaller tears. ROM, strength, and subjective outcome measures were not significantly different between study and control groups in most studies, especially those comparing prior RCR to control. Frank et al. did not analyze the pre- to postop improvement between the 2 groups, but the prior RCR group did not have a statistically significant difference in postop VAS, SST, and ASES scores than the control[6]. Studies by Schiffman, Schoh, and Erikson also found no statistically significant difference between RCR and control group with regards to objective and subjective outcomes.

For aTSA with concurrent RCR, a good RCR (defined as closure without tension and strong tendon tissue) had similar functional outcomes when compared to a patient with no RCR, although Rozing et al. shows a significant decline years later[16]. This suggests that even well-healed concomitant repairs may go on to develop rotator cuff attenuation and ultimately failure of the arthroplasty. Outcomes for moderate repair were not as successful. They also found preoperative proximal migration to be associated with worse flexion and abduction at 2 years[16].

Studies comparing prior RCR to control did show a difference in revision rates and complications. Frank et al. found higher complications in patients with prior shoulder surgery which includes RCR[6]. Schoh et al. found a higher rate of total adverse events and postop tears in the prior RCR group. This may be in agreement with the concurrent repair studies which show a drop off in outcomes after 2 years despite a well-done repair. The studies by Schiffman et al.or Erikson et al., however, did not show significantly higher revision rates.

Studies comparing concurrent RCR with control offered significant evidence that larger and higher-grade tears had a higher rate of loosening and instability. Rozing et al. showed a preoperatively attenuated rotator cuff was associated with postop radiographic loosening. Subscapularis or infraspinatus tear and preoperative AHI < 8 mm also predicted poor outcomes[11]. Livesey et al. reported reoperations only in patients with large or high-grade partial tears at the time of surgery. Simone et al. reported complications only in patients with medium or large tears at the time of surgery, most of them requiring revision surgery for instability.

These findings suggest that in patients undergoing anatomic TSA with a history of prior healed rotator cuff or concomitant repair of small tears, we can expect similar early improvements in postoperative ROM, strength, and patient satisfaction when compared to patients without a history of RCR. However, when deciding between an anatomic and reverse total shoulder in this scenario, one must consider that there is some evidence that results do not hold up after 2 years. Any history of RCR could suggest the inevitable development of tendinopathy and ultimately poorer outcomes in anatomic TSA. Patients with larger and higher-grade tears are more likely to experience complications and require reoperation despite repair at time of surgery, therefore, a reserve total shoulder should be the preferred treatment.

There are limitations with this systematic review. First, some of these studies had relatively small sample sizes. Those evaluating prior RCR were unable to consistently report the severity of the prior tear. Another potential limitation is the wide variation in subjective outcome measurements utilized. Comparisons in ROM and strength could not largely be made between studies since many of them did not report much of these measures. Lastly, the time interval between RCR and subsequent aTSA was not studied and could play a role in outcomes. Only one of these studies was prospective, thus additional studies could be performed with a higher level of evidence and more standardization between measurement of outcomes and analysis of patient factors such as time between surgeries.

Conclusion

Though traditionally reserved for patients with intact, native rotator cuffs, aTSA is known to preserve shoulder function more so than reverse TSA and thus offers enough benefit to be worth considering for patients with rotator cuff pathology. This systematic review supports the conclusion that patients with a prior successful RCR tend to have similar outcomes as those without prior RCR. Caution should remain in patients with repairs that are inadequate, given that these patients had significantly worse outcomes.

In patients undergoing aTSA and concurrent RCR, outcomes were worse for older patients or those with medium to large tears. In such cases, rTSA likely remains the better choice, though patients with small or some medium tears could be good candidates for aTSA with concurrent RCR. Patients with structural changes of the shoulder such proximal humeral head migration should likely be considered for rTSA[19].

In both cases, proper patient selection and counseling remain key. Older patients appear to be more likely to have a successful outcome with rTSA, though patients with easily repairable, mild, or functionally insignificant RCTs are likely to have good outcomes with aTSA.

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ORCID iDs

Zylyftar Gorica https://orcid.org/0000-0001-5051-426X
Kimberly McFarland https://orcid.org/0000-0003-4265-8890
Conor N. O'Neill https://orcid.org/0000-0003-4456-9445

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