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EVIDENCE-BASED SYSTEMATIC REVIEWS

Long-Term Outcomes Following Reverse Total Shoulder Arthroplasty

A Systematic Review with a Minimum Follow-Up of 10 Years

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Background: Reverse total shoulder arthroplasty (rTSA) is a crucial intervention for restoring shoulder function and alleviating pain. The aim of this review was to evaluate long-term clinical and radiological outcomes of rTSA patients with a minimum follow-up of 10 years.

Methods: A systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines across PubMed, Web of Science, Embase, and Cochrane databases until September 2024. Studies in English or German with a minimum 10-year follow-up were included. Risk of bias was assessed using the Methodological Index for Non-Randomized Studies criteria. The study was registered with PROSPERO (CRD42024558828).

Results: Of 673 studies, 7 retrospective case series with Level IV evidence met the inclusion criteria, totaling 469 rTSA procedures in 460 patients. The weighted mean age was 71 years, with 63% female patients. The mean follow-up was 12 years, with a 63% lost to follow-up. Four studies conducted all follow-ups in a clinical setting, while 3 used either outpatient visits (20 to 41%) or phone/mail interviews. The weighted mean reported revision-free implant survivorship reported in 5 studies was 88% at 10 years. Overall, the complication rate was 36% with need for further revision in 23% of patients. The revisions were primarily due to infection (8%), instability (7%), and glenoidal complications (3%). Significant functional improvements were noted across all studies. The absolute Constant score (CS) improved from 27 to 62 across 5 studies, and the relative CS improved from 37% preoperatively to 81% across 3 studies. The American Shoulder and Elbow Surgeons Score improved from 35 to 74 ($p < 0.001$) and the Single Assessment Numeric Evaluation from 23 to 73 ($p < 0.001$), in 1 study each. The Subjective Shoulder Value increased from 28% to 79% ($p = 0.001$) in 2 studies. Weighted mean range of motion improvements included active abduction of 54°, active anterior elevation of 52°, and active external rotation of 8°. Longitudinal outcomes were reported to be stable in the due course in 5 studies and deteriorated in 1. Scapular notching varied widely, with Nerot-Sirveaux grades I and II in 15% to 59% of cases, and grades III and IV in 7% to 47%.

Conclusion: RTSA appears to provide substantial long-term improvements in shoulder function, clinical outcomes, and pain relief, albeit with significant complication and revision rates. However, caution is warranted when interpreting the data due to high lost-to-follow-up rates and limited data quality in the contemporary literature. Long-term registry data will be essential.

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

Introduction

Shoulder pain and dysfunction profoundly affect quality of life and functional independence. When patients face irreparable rotator cuff tears[1], severe cuff tear arthropathy[2], complex fractures[3], osteoarthritis with glenoid bone loss[4] or failed previous shoulder arthroplasty[5], traditional surgical options may be insufficient. In

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Disclosure: The **Disclosure of Potential Conflicts of Interest** forms are provided with the online version of the article (http://links.lww.com/JBJSOA/A806).

such cases, reverse total shoulder arthroplasty (rTSA) emerged as a revolutionary solution, restoring function and alleviating pain[6]. The demand for rTSA continues to rise globally, driven by demographic shifts toward an older population. Projections indicate that the number of rTSA procedures will nearly double by 2040[7]. In addition, Padegimas et al.[8] reported a projected 333% increase in rTSA utilization from 2011 to 2030 in patients younger than 55 years and a 755.4% increase in patients older than 55 years.

While many studies[1,6] have highlighted favorable initial and midterm clinical outcomes after rTSA, data on long-term outcomes remain scarce. Only a few studies[9-15] have examined clinical and radiological outcomes over periods exceeding a follow-up of 10 years. Guery et al.[16] identified progressive functional deterioration and increased pain beginning approximately 6 years postoperatively in rTSA patients. This pattern aligns with the findings of Sirveaux et al.[17] and Favard et al.[2], who observed similar declines around 6 to 8 years after surgery. These changes were often attributed to factors such as patient aging, implant loosening, and scapular notching, all of which can compromise long-term outcomes and implant stability.

Despite the growing use of rTSA, no systematic review has yet comprehensively summarized its long-term outcomes with a minimum 10-year follow-up. This review addressed this gap by examining patient demographics, follow-up duration, implant survivorship, complication rates, radiological and functional outcomes, and risk of bias. By doing so, it aimed to systematically clarify the long-term efficacy of rTSA, providing valuable insights that will help guide clinical decisions and improve patient care over the long term.

Material and Methods

Data Collection

A systematic review was performed based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses criteria[18]. The databases used were PubMed, Web of Science, Embase, and Cochrane. The search was conducted using a combination of the following search terms: "(reverse OR inverse) total shoulder arthroplasty (long-term OR longer or 10[title]) outcome". The systematic review was prospectively registered with PROSPERO, the international prospective register of systematic reviews (CRD42024558828)[19]. Studies meeting the criteria for long-term results of rTSA were selected based on described criteria and were independently and blindly screened by 2 authors (M.B., S.K.) using Covidence (Melbourne, Australia)[20]. When there were differences in scores, a third reviewer (P.K.) assisted in reaching a consensus.

The inclusion criteria were the following: (1) full-text human studies in English or German language, (2) a minimum evidence level of IV according to the Oxford level of evidence[21], (3) a minimum follow-up of 10 years following implantation of rTSA, and (4) at least one of any previously mentioned clinical or radiological outcomes reported.

The exclusion criteria were the following: (1) nonhuman studies, (2) studies not in English or German, (3) follow-up of less than 10 years, and (4) review articles.

Evaluated Parameters

The outcome parameters were assessed in sequence, covering patient demographics, follow-up duration including lost to follow-up, implant survivorship, overall complications, complications leading to revisions, functional outcomes, radiological outcomes, and risk of bias. Data collection for clinical scores included the absolute Constant score (aCS), auto Constant score (autoCS), which is a self-administered version of the CS, showing good correlation with the aCS[22], or relative Constant score (rCS)[23]; the American Shoulder and Elbow Surgeons score (ASES)[24]; Single Assessment Numeric Evaluation (SANE)[25]; the visual analog scale[26]; and the Subjective Shoulder Value (SSV)[27]. Glenoidal or humeral radiolucency and scapular notching were assessed according to the classification by Sirveaux et al.[17] The bias risk assessment used the Methodological Index for Non-Randomized Studies (MINORS) criteria[28], customized for each study design. This index evaluates 8 key elements in noncomparative clinical studies and adds 4 more for comparative

TABLE I Demographics

Study	Bacle et al.[9]	Cuff et al.[12]	Gerber et al.[11]	Sheth et al.[10]	Castricini et al.[15]	Lafosse et al.[13]	Kriechling et al.[14]	Weighted Overall
Journal	JBJS	JBJS	JSES	JSES	JSES	JSES	JBJS OA	
Year	2017	2017	2018	2022	2024	2024	2024	
Nr RTSA (patients) at 10 years	87 (84)	42 (40)	22 (22)	93 (93)	27 (27)	63 (61)	135 (133)	
Patients assessed clinically (%)	84 (100%)	8 (20%)*	22 (100%)	25 (27%)	27 (100%)	25 (41%)*	133 (100%)	70% (20-100%)
Follow-Up mean (range), years	12.5 (10.1-20.1)	11 (10-12.3)	16.1 (15-19)	11.4 (10-15.7)	12.5 (11.3-16.8)	11.8† (10.5-13.2‡)	10.9 (±1.6)	11.8 (10.9-16.1)
Lost to follow-up	54.8%	64.3%	57.7%	80.3%	66%	47.1%	64.5%	63.3% (47%-80%)
Age	72.7 (23-86)	78 (62-99)	68 (54-77)	66 (±10)	71.4 (63-78)	72.6† (69-76‡)	69 (±8)	70.5 (23-99)
Female	n/r	22 (55%)	15 (68.2%)	60 (63%)	23 (85.2%)	44 (72.1%)	76 (56%)	63% (55-85.2%)
Survivorship	93%	91%	73%	81%	n/r	94%	n/r	87.9% (73%-94%)

F = female, JBJS = *Journal of Bone and Joint Surgery*, JSES = *Journal of Shoulder and Elbow Surgery*, and n/r: not reported. *Radiographic follow-up. †Estimated mean. ‡Interquartile range.

studies. Scores are 0 if information is missing, 1 if inadequate, and 2 if adequate. The maximum scores are 16 for noncomparative studies and 24 for comparative studies.

Statistical Analysis

Weighted means were calculated to ensure each study's contribution reflected its size and relevance. Continuous variables were summarized as means and ranges, while categorical variables were reported as percentages and absolute numbers[29]. Higgins and Thompson I^2 statistic and Cochran Q test were used to measure heterogeneity[30]. Given the intrinsic limitations of Cochran Q test and the I^2 statistic, prediction intervals were also included to provide a range in which the effect size of future studies can be expected to fall. The forest plots were generated using a random-effects model and the inverse-variance weighting method, which are techniques available in the 'metafor' package in R/RStudio[31]. When the standard deviation needed to be estimated from the mean, sample size, or median, the Wan et al.[32] estimator was used. Pooled standard deviations were computed by combining variances across studies, based on the methodology described by Deeks et al.[29]. To standardize the reported data, means were

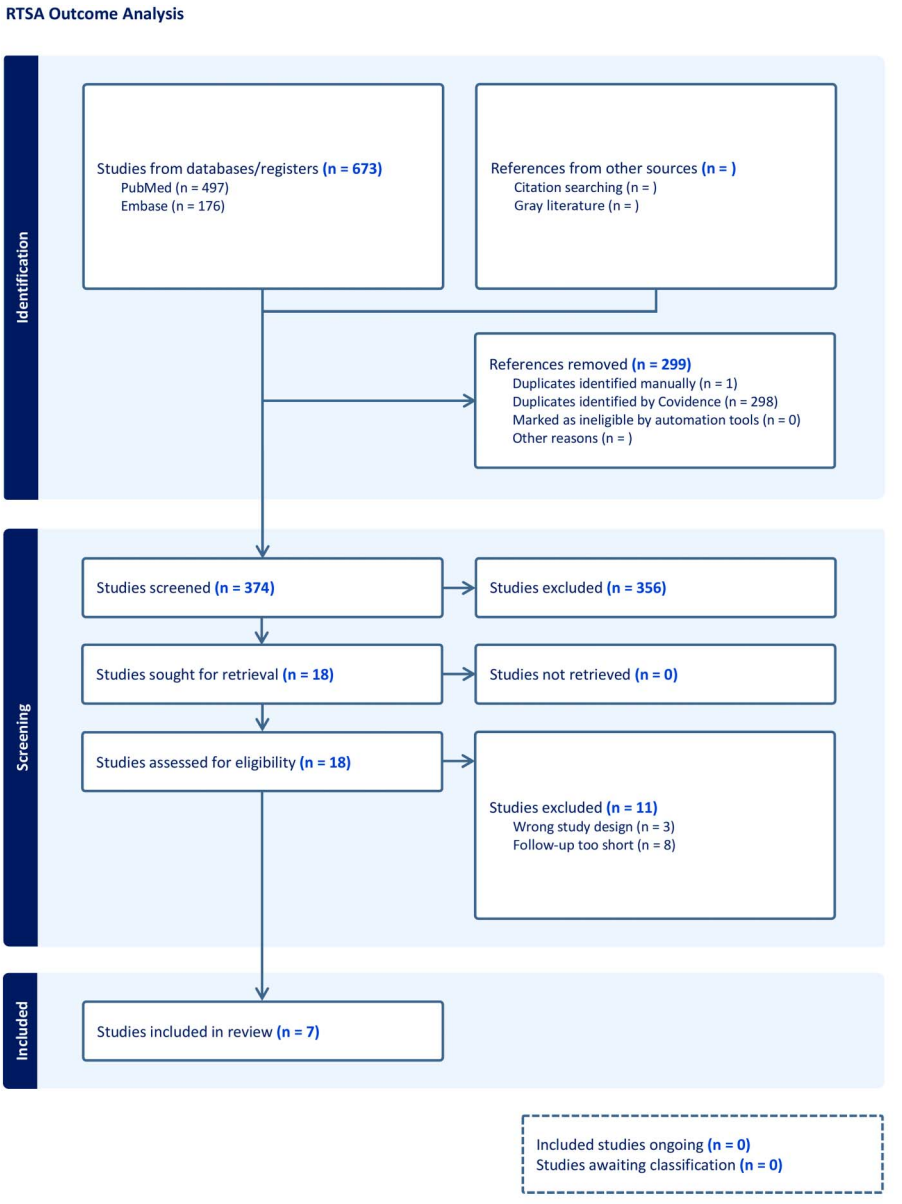

Fig. 1

Flow chart of research process

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estimated for studies that reported medians using the method proposed by Luo et al.[33] and Chi et al.[34]. Heterogeneity values above 40% were considered moderate, and those above 75% were considered highly heterogeneous[30].

Results

The systematic review identified a total of 673 studies, from which 299 duplicates were removed. Subsequently, titles and abstracts of the remaining 374 studies were screened and the full texts of 18 studies were analyzed in detail, and the reasons for exclusion were carefully documented, leaving 7 publications[9-15] for final analysis (Fig. 1). Each of these were retrospective single-institution case series and reported a level of evidence IV according to Oxford Centre for Evidence-Based Medicine[21]. Solely 4 studies[9,11,14,15] conducted all follow-ups in a clinical setting. The other studies[10,12,13] conducted follow-ups either in a clinical setting (20-41%) or through telephone/mail interviews. The combined mean follow-up period was 12 years (range 11-16 years) with a weighted mean lost to follow-up of 63% (47%-80%). There were 460 patients who underwent a total of 469 rTSA procedures. The sample size per study ranged from 22 to 135 shoulders. The weighted mean age was 71 years (range, 23-99) with a weighted proportion of 63% female patients. Demographics were summarized in Table I, and details on the indications, original

TABLE II Indications and Implants

Study	Indications for RTSA	Original Nr Patients	Implant Type
Bacle et al.[9]	Cuff tear arthropathy Revision Massive rotator cuff tear without arthritis Post-traumatic osteoarthritis with rotator cuff deficiency Primary osteoarthritis with rotator cuff deficiency (no numbers reported)	186	Delta Xtend RSP (DePuy)
Cuff et al.[12]	Rotator cuff deficiency with osteoarthritis: 45% Failed rotator cuff repair: 31% Revision: 24%	112	Delta III RSP (DePuy)
Gerber et al.[11]	Irreparable rotator cuff dysfunction: 100%	52	Delta III RSP (DePuy) Aequalis (Tornier, Wright Medical)
Sheth et al.[10]	Cuff tear arthropathy: 77% Proximal humerus fracture: 13% Instability or fixed dislocation: 6% Postinfection: 3% Biconcave deformity: 1%	471	Aequalis Legacy RSP (Tornier, Wright Medical) Aequalis Legacy Long RSP (Tornier, Wright Medical)
Castricini et al.[15] 2024	Massive rotator cuff tear: 14 51.9% Eccentric Osteoarthritis: 14.8% Concentric osteoarthritis: 33.3%	80	Delta III implant (DePuy)
Lafosse et al.[13] 2024	Cuff tear arthropathy: 44% Primary osteoarthritis or unknown: 42% Revision: 3% Rheumatoid arthritis: 3% Fracture sequelae: 3% Cuff arthropathy: 2% Acute fracture: 2%	116	Delta Xtend prosthesis (DePuy Synthes)
Kriechling et al.[14] 2024	Rotator cuff tear without osteoarthritis—34% RCT with osteoarthritis: 29% Cuff tear arthropathy: 10% Fracture, acute: 5% Fracture, conversion from plate Instability: 4% Osteoarthritis: 5% Osteonecrosis: 5%	375	RTSA prosthesis (Zimmer Biomet Anatomical Shoul- der Inverse/Reverse) with a neck-shaft angle of 155°

number of rTSA, and implants were provided in Table II. The weighted mean reported survivorship free of revision at the 10-year follow-up was 88% in 5 studies[9-13].

All 7 studies assessed function preoperatively and postoperatively, showing statistically significant improvements in the autoCS/aCS (n = 5 studies: [9,11,13-15]) and the rCS (n = 3 studies: [9,11,14]) (Table III).

The ASES, SANE, and SSV scores were reported in the following studies: ASES score improved from 35 (0-65) to 74 (45-90) ($p < 0.001$; n = 1 study: [12]), SANE score improved from 22.5 (±24.5) to 73.3 (±28.2) ($p < 0.001$; n = 1 study: [10]), and SSV score improved from 27% (±18) to 78% (±26) ($p = 0.001$; n = 1 study: [11]) and from 28% (±18) to 79% (±21) ($p < 0.01$; n = 1 study: [14]).

Active anterior elevation improved by a weighted mean of 52° (40°-78°) across 6 studies[9,11-15], active external rotation improved by 8° (−2° to 29°) across 6 studies[9,11-15], and active abduction showed a weighted mean improvement of 54° (31°-62°) across 5 studies[11-15]. Active internal rotation changes were variable, with Bacle et al.[9] reporting a decrease from L5 to sacrum, and Lafosse et al.[13] showing an improvement from sacrum to L5 and Kriechling et al.[14] remaining unchanged. Castricini et al.[15] showed a significant increase from 49° to 72° (Supplemental Table 1). Overall, the outcome was stable from midterm to long-term follow-up in the studies of Cuff et al., Gerber et al., Sheth et al., Castricini et al., and Kriechling et al.[10-12,14,15], but deteriorated according to Bacle et al.[9], and was not applicable over time in Lafosse et al.[13] (Supplemental Tables 3 and 4). Six[9,11-15] of 7 studies reported radiographic analyses with a minimum follow-up of 10 years, covering 64% of the rTSA analyzed in their cohorts. Humeral radiolucency was noted in 4 studies, ranging from 2%[12] to 96%[13]. Glenoid radiolucency was observed in 5 studies, with rates ranging from 0%[12] to 52%[13]. Scapular notching, classified by the Nerot-Sirveaux system[17], varied widely across studies (Supplemental Table 2). Grades I and II were most frequent, with rates ranging from 8% to 59%. Bacle et al.[9] reported 45% grade I and II in 67 cases, while Kriechling et al.[14] observed 28% grade I and 22% grade II in 130 cases. Castricini et al.[15] found 33.3% grade I and 25.9% grade II in 27 cases, and Lafosse et al.[13] reported lower rates of 8% and 16%, respectively. Cuff et al.[12] identified 15% grade I but no data on higher grades. Grades III and IV were less common, ranging from 3.7% to 47%. Gerber et al.[11] reported the highest rates, with 40% grade III and 7% grade IV in 15 cases. Kriechling et al.[14] found 21% and 11% for grades III and IV, while Lafosse et al.[13] reported 4% and 12%, and Castricini et al.[15] observed 3.7% for both grades. Cuff et al.[12] analyzed 20% of its cohort radiologically and had a minimum radiographic follow-up of 2 years, limiting the detection of new or progressive scapular notching after the last clinical follow-up.

Overall, any complication occurred in 36% of patients, with instability (9%), infections (9%), and glenoidal complications (6%) being the most frequent of cases (Table IV). Complications leading to revisions included infection (8%), instability (7%), and glenoidal complications (3%), which were the 3 main causes (Table IV). Heterogeneity across studies was very high with a I^2 of 93%. The random-effects model estimated a complication proportion of 0.31 (95% CI, 0.14-0.56) (Fig. 2) and a revision proportion of 0.18 (95% CI, 0.07-0.38) (Fig. 3). Individuals risk-of-bias assessment using MINORS criteria are summarized in (Table V). Gerber et al.[11] and Kriechling et al.[14] received the highest score with 12 of 16 points (75%).

Discussion

This study was the first to systematically review available research on the clinical, radiological, and functional outcomes of rTSA with at least 10 years of follow-up. Including 7 comprehensive studies[9-15], it explored the long-term impacts on patients in 469 shoulders. The main finding was that long-term

TABLE III Constant Score at the Final Follow-Up

Study	Nr RTSA	aCS Preop	aCS Postop	rCS Preop	rCS Postop
Bacle et al.[9]	87	23 (±12)	55 (±16)	33 (±17)	86 (±26)
Improvement Yes/No (p-value)		Yes ($p < 0.05$)		Yes ($p < 0.05$)	
Gerber et al.[11]	16	23 (±11)	58 (±19)	30 (±13)	73 (±23)
Improvement yes/no (p-value)		Yes ($p < 0.001$)		Yes ($p < 0.001$)	
Castricini et al.[15]	27	23.2 (±6.9) (6-33)	69.7 (±7.9) (50-81)	n/r	n/r
Improvement yes/no (p-value)		Yes ($p < 0.001$)		n/r	
Lafosse et al.[13]	47	25.71* (±13.33)† (17-35)‡ autoCS	66.23* (±18.52)† (53-78)‡ autoCS	n/r	n/r
Improvement yes/no (p-value)		Yes ($p < 0.001$)		n/r	
Kriechling et al.[14]	135	32 (±14)	64 (±16)	40 (±17)	79 (±18)
Improvement yes/no (p-value)		Yes ($p < 0.01$)		Yes ($p < 0.01$)	
Weighted mean and pooled SD	Total	27.32 (±12.75)	62.02 (±16.06)	36.74 (±15.11)	81.16 (±21.58)

aCS = Absolute Constant Score, autoCS = Auto Constant Score, n/r = not reported, preop/postop = preoperatively/postoperatively, and rCS = Relative Constant Score. *Estimated mean. †Estimated SD. ‡Interquartile range.

TABLE IV Complications and Complications that Lead to Revisions

Complications	Bacle et al.[9]	Cuff et al.[12]	Gerber et al.[11]	Sheth et al.[10]	Castricini et al.[15]	Lafosse et al.[13]	Kriechling et al.[14]	Weighted Complications (%)
Instability		n/r	3 (13.6%)	21 (22.6%)	1 (3.7%)	4 (6.3%)	2 (1.5%)	9.1
Infections		n/r	6 (27.3%)	21 (22.6%)	0	1 (1.6%)	4 (3.0%)	9.4
Neurological Complications		n/r	0	1 (1.4%)	0	2 (3.2%)	4 (3.0%)	2.1
Glenoidal Complications		n/r	2 (9.1%)	7 (7.5%)	0	0 *	11 (8.1%)	5.9
Humeral Complications		n/r	2 (9.1%)	1 (1.1%)	0	1 (1.6%)†	3 (2.2%)	2.1
Periprosthetic Fracture		n/r	1 (4.5%)	9 (9.7%)	0	2 (3.2%)	2 (1.5%)	4.1
Scapula Fracture		n/r	3 (13.6%)	5 (5.4%)	0	0	6 (4.4%)	4.1
Others		n/r	2 (9%) 1 Polyethylene wear, 1 mechanical block	2 (2.2%) 1 Hematoma, 1 Painful intraarticular loose body	1 (3.7%) hematoma	0	6 (4.4%)	3.2
Overall number of patients (%)	n/r	n/r	13 (59.1%)	60 (64.5%)	2 (7.4%)	10 (16.4%)	38 (28.6%)	36
Complications that lead to revisions								
Instability		1 (2.4%)	3 (13.6%)	17 (18.3%)	1 (3.7%)	4 (6.3%)	1 (0.74%)	7.1
Infections		0	6 (27.3%)	19 (20.4%)	0	1 (1.6%)	4 (3.0%)	7.8
Neurological Complications		0	0	0	0	0	0	0
Glenoidal Complications		0	2 (9.1%)	6 (6.5%)	0	0	4 (3.0%)	3.2
Humeral Complications		0	2 (9.1%)	1 (1.1%)	0	1 (1.6%)	2 (1.5%)	1.6
Periprosthetic Fracture		1 (2.4%)	1 (4.5%)	6 (6.5%)	0	1 (1.6%)	3 (2.2%)	3.1
Scapula Fracture		n/r	2 (9.1%)	0	0	0	4 (3%)	1.8
Others		2 (4.8%) not specified	2 (9%) 1 Polyethylene wear, 1 mechanical block	1 (1.1%) Painful intraarticular loose body	0	0	7 (5.2%) 1 External rotation deficit 6 Pain and/or scarring	3.2
Overall number of patients	n/r	4 (10%)	12 (54.5%)	48 (51.6%)	1 (3.7%)	7 (11.5%)	15 (11.3%)	23.2

*Six Glenoid Loosening and 6 not seated. †Four at risk of loosening (16%).

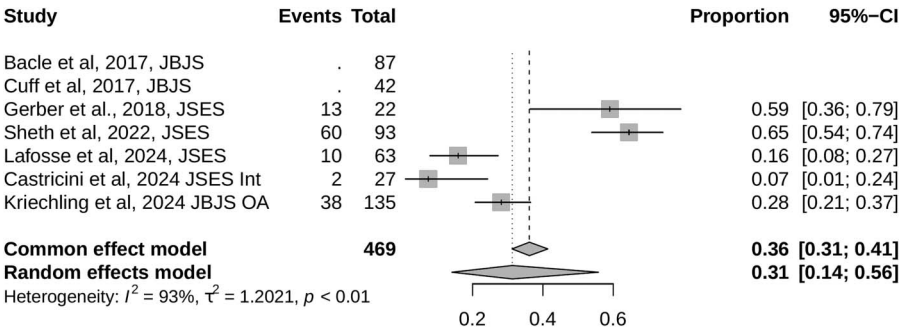

Fig. 2

The forest plot presents overall complications analysis using a common-effect and a random-effects model.

implant survival rates were generally favorable, with a reported weighted mean revision-free survivorship of 88% in 5 studies[9-13], ranging from 73% to 93% with satisfactory clinical results. However, all data need to be interpreted with caution because of a mean lost-to-follow-up rate of 63% and only 70% of those patients were seen in clinic. This is primarily attributable to the elderly population undergoing rTSA, who often face health issues, limited lifespans, and challenges traveling for follow-up.

The study revealed significant long-term improvements in clinical and functional outcomes, as well as most range of motion parameters. Clinical scores such as the CS, ASES, SANE score, and SSV and the pain scores showed notable enhancements. Specifically, the mean weighted a/autoCS[9,11,13-15] improved from 27 (±13) preoperatively to 62 (±16) postoperatively, while the rCS improved from 37% (±15%) preoperatively to 81% (±22%) postoperatively across 3 studies[9,11,14]. Six[9,11-15] of the 7 studies examined preoperative and postoperative ROM, demonstrating relevant gains in active anterior elevation and active abduction. Yet, active external rotation results were mixed. Cuff et al.[12] and Castricini et al.[15] reported a significant increase, while Lafosse et al.[13] and Kriechling et al.[14] observed no statistically significant difference. The 2 other studies indicated stagnation[9] or even a decrease[11] in external rotation, suggesting that some types of rTSAs often struggle to restore external rotation adequately, possibly due to the medialization and distalization of its center of rotation[6].

Despite the overall satisfactory clinical outcomes, complications were still a significant concern. The analyses revealed an overall complication rate of 36% with instability being the second most frequent complication reaching a weighted incidence of 9% but significant variation across the studies (from 2% to 23%). One main reason for the high number of complications might be that some developments need to be termed complication without affecting the clinical outcome itself. For instance, glenoid loosening does significantly increase over time but might not need to affect the function[35]. Furthermore, another risk of higher complication and revision rates might have been the inclusion of revision rTSA in some of the studies. The risk of instability is higher for revision surgery and proximal humerus fractures, and subscapularis repair appeared to be a protective factor in 1 recent study[36]. In addition, the exchange to a thicker polyethylene alone carried a higher risk of recurrent instability, particularly in cases of revision surgery or post-traumatic settings[37]. Furthermore, only 3 studies mentioned how they handled the subscapularis tendon: Kriechling et al.[14] reported refixation in 53% of shoulders, while Castricini et al.[15] and Lafosse et al.[13] performed no repairs in their cohorts.

Infections were the most common complications ranging from 0% to 27%, which indicated a certain amount of variability in patient management and infection control practices, as well as heterogeneity of patients. As common in systematic reviews, the heterogeneity was very high (I^2 = 93%), indicating significant variability among the included studies. Chelli et al.[38] reported 91% 10-year survivorship with lower complication (16.5%) and revision rates (6.8%) compared with our findings (88%, 36%, and 23%, respectively) but with a shorter mean follow-up of 5.6 years. However, infection and instability were

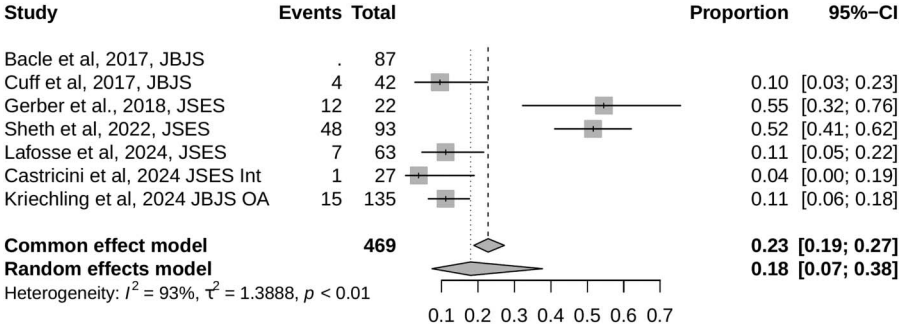

Fig. 3

The forest plot presents complications that lead to revisions analysis using a common-effect and a random-effects model.

TABLE V Individual Risk of Bias Assessment Using the MINORS Criteria

MINORS Criteria	Bacle et al.[9]	Cuff et al.[12]	Gerber et al.[11]	Sheth et al.[10]	Castricini et al.[15]	Lafosse et al.[13]	Kriechling et al.[14]
1. A clearly stated aim	2	2	2	2	2	2	2
2. Inclusion of consecutive patients	2	2	2	2	1	2	2
3. Prospective collection of data	1	2	2	2	2	1	2
4. End Points appropriate to the aim of the study	2	1	2	1	2	2	2
5. Unbiased assessment of the study end point	1	0	1	0	1	1	1
6. Follow-up period appropriate to aim	2	2	2	2	2	2	2
7. Loss to follow up less than 5%	1	1	1	1	1	1	1
8. Prospective calculation of the study size	0	0	0	0	0	0	0
Total score (%)	11 (69)	10 (63)	12 (75)	10 (63)	11 (69)	11 (69)	12 (75)

also the main complications in their study. Similarly, Smith et al.[39] found lower midterm complication rates of 14.7%, with implant loosening and instability each accounting for 3.3%.

Glenoidal complications, especially loosening, occurred with a weighted mean of 6%, with varying rates among studies. This was in strong contrast to short-term studies indicating much lower rates at medium-term follow-up[40]. A possible explanation might be that scapular notching is associated with glenoid loosening[41]. This review identified Nerot-Sirveaux Classification grade I and II ranging from 15%[12] to 59%[15], and grades III and IV from 7%[15] to 47%[11] across 4 studies. These variations likely reflect differences in surgical techniques and patient anatomy, emphasizing opportunities for improvement in managing long-term outcomes. High rates of notching might be linked to poorer clinical outcomes and impaired range of motion[42], which is why various techniques have been proposed to reduce notching, including inferior placement of the glenoid baseplate, lateralization, and ensuring the glenosphere is sufficiently large[13,43,44].

Further analysis of the available data revealed that infection and instability were the main causes of complications leading to revision surgery, with weighted mean incidences of 8% and 7%, respectively. They showed a proportion of 0.18 (95% CI, 0.7-0.38), indicating significant variability among studies. Standardizing outcome measures are crucial to improve evidence quality and comparability between studies. Recent Delphi consensus efforts highlight the importance of structured radiographic parameters and standardized reporting of complications in shoulder arthroplasty, including demographics, complications, revisions, survivorship, lost-to-follow-up rates, and radiographic outcomes such as implant loosening and migration[45,46]. Incorporating validated PROMs and functional outcomes, alongside data from registries such as the National Joint Registry, American Joint Replacement Registry, and Australian Orthopaedic Association National Joint Replacement Registry, enhances patient care, and it is crucial to provide critical insights into implant performance[47-49]. However, apart from the recommendation to collect data in a large scale, it remains debatable if the commonly used scoring system are properly measuring the outcome[50]. Further research into surgical techniques and implants designed to address scapular notching, glenoidal loosening, and stability, such as lateralized center of rotation[51], is crucial. Although rTSA improves shoulder function and satisfaction, ongoing research is vital to refine this important procedure and reduce long-term complications and revision rates.

Limitations

This systematic review had several limitations, primarily due to the constraints of the included studies. Only 7 retrospective studies met the inclusion criteria, limiting the level of evidence. The high lost-to-follow-up rate of 63% and limited clinical follow-up further complicated the analysis. In addition, significant heterogeneity among studies due to variability in patient demographics, implant designs, surgical techniques, subscapularis reattachment methods, and data collection approaches posed a challenge, as is common in systematic reviews.

Conclusion

RTSA can provide satisfactory improvement of pain and function at long-term follow-up mean revision-free survivorship of 88% after 10 years. However, due to high lost-to-follow-up rates and limited data quality in the available literature, more research is necessary to provide the surgeon and patient with more robust data. Nevertheless, the available literature suggested a variable but considerable complication and revision rate.

Appendix

eA Supporting material provided by the author is posted with the online version of this article as a data supplement at jbjs.org (http://links.lww.com/JBJSOA/A807). This content has not been copyedited or verified. ■

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