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Anatomic Total Shoulder Arthroplasty Versus Reverse Total Shoulder Arthroplasty in Patients Aged Over 70 Without a Full-Thickness Rotator Cuff Tear: A Systematic Review and Meta-Analysis

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Abstract

***Introduction*:** This systematic review and meta-analysis compared the revision rates, complications, and outcomes in anatomic total shoulder arthroplasty (aTSA) and reverse TSA (rTSA) performed for primary glenohumeral osteoarthritis in patients aged over 70 years without a full-thickness rotator cuff tear.

***Materials and Methods*:** We performed a systematic literature search identifying comparative studies meeting the above patient criteria and published from January 2010 to May 2022 from 3 databases: MEDLINE, EMBASE, and Cochrane Library. We performed the systematic review in accordance with PRISMA guidelines and the study was prospectively registered on PROSPERO.

***Results*:** From the 1798 studies identified from the initial literature search, 4 met our inclusion criteria. Two thousand seven hundred thirty-one shoulder arthroplasties (1472 aTSA and 1259 rTSA) were evaluated with a minimum follow up of 2 years. A statistically significant lower revision rate was observed in rTSA compared to aTSA (odds ratio [OR] 0.50, 95% confidence interval [CI]: 0.30, 0.84, $p < .05$). No significant difference was noted between aTSA and rTSA in overall complication rate (OR 0.98, 95% CI 0.34, 2.86, $p = .97$) while aTSA displayed a statistically significant improved postoperative Constant-Murley score [aTSA: 80(75; 82), rTSA: 68(66; 76.5), $p < .001$].

***Conclusion*:** Higher revision rates were identified following aTSA in our study population, although admittedly this is within retrospective studies. aTSA displayed equal functional results and postoperative complications compared to rTSA in patients over 70 without a full-thickness rotator cuff tear. Given these similar results a shoulder surgeon must carefully consider each patient individually prior to deciding the optimal form of arthroplasty to offer.

Keywords

anatomic total shoulder arthroplasty, reverse total shoulder arthroplasty, glenohumeral osteoarthritis, shoulder replacement, intact rotator cuff, full-thickness rotator cuff tear, elderly, revision rate

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Introduction

The optimal surgical treatment option for patients aged over 70 with glenohumeral arthritis continues to be a disputable topic. Anatomic total shoulder arthroplasty (aTSA) and reverse TSA (rTSA) have displayed increasingly reliable results over the past decades while being widely established among surgeons as the prevailing surgical options in the treatment of end-stage glenohumeral osteoarthritis. However, since their inception

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and development, they have been quite different in their approach, indications, and outcomes.

There are numerous factors, indications, and parameters that affect clinical decision making regarding the type of optimal implant selection (aTSA or rTSA).[1,2] The most widespread indication for aTSA has been primary osteoarthritis with intact rotator cuff,[3,4] while on the other hand, rTSA has been traditionally reserved for patients with rotator cuff arthropathy.[3,5,6]

During the past few decades however, concerns in regard to rotator cuff failure following aTSA in older patients with primary glenohumeral osteoarthritis, have become more prevalent.[7] The reported rate of cuff failure following aTSA in patients aged over 70 has been reported around 1% according to certain studies,[8] while other studies note a higher rate of rotator cuff failure around 11% in patients aged over 80, which necessitates conversion to rTSA.[9] These concerns have led to an increased incidence of rTSA, with shoulder surgeons increasingly likely to council their elderly patients aged over 70 in favor of rTSA, irrespective of the state of their rotator cuff, due to the high rates of postoperative satisfaction achieved.[7,10–14]

Although rTSA has been the most prevalent surgical option in rotator cuff-deficient shoulders,[15] its effectiveness and role in shoulders without a full-thickness rotator cuff tear compared to aTSA may be more equivocal. This is particularly relevant since a number of studies have reported excellent outcomes for aTSA in patients older than 70.[7,8,16] In this systematic review and meta-analysis, we therefore assessed and compared the implant revision rate, clinical outcomes and complication rate in aTSA and rTSA performed for glenohumeral osteoarthritis in patients aged 70 years and over without a full-thickness rotator cuff tear. We aimed to help provide some clarity in optimal implant selection in this specific patient population.

Materials and Methods

This study was designed and executed in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and protocols. The eligibility criteria were established prior to commencing the search. The study was registered on PROSPERO.

Study Selection

A thorough and detailed literature search was performed on 3 databases (Cochrane Library, EMBASE, and MEDLINE) for studies that were published from January 2010 to May 2022 that performed a direct comparison of aTSA and rTSA in patients over the age of 70 with glenohumeral osteoarthritis being the primary cause of surgery. The following search terms were utilized: (“aTSA” OR “TSA” OR “total shoulder arthroplasty” OR “total shoulder replacement” OR “shoulder arthroplasty” OR “rTSA” OR “reverse arthroplasty” OR “reverse shoulder arthroplasty” OR “reverse total shoulder arthroplasty” OR “reverse shoulder replacement”) AND (‘’arthritis’’ OR ‘’osteoarthritis’’). We only included studies that had English as Primary Language or were published in English.

Two independent reviewers evaluated the titles, abstracts, and full texts of the identified studies, following duplicates removal. Any differences and discrepancies that existed between the 2 reviewers were discussed and resolved prior to data extraction.

The κ value was calculated at each stage to determine level of agreement between reviewers regarding study selection. The level of agreement was categorized prior to commencing the literature search using the following κ values: $\kappa = 1$ indicated “perfect” agreement, $1.0 > \kappa \geq 0.8$ “almost perfect” agreement; $0.8 > \kappa \geq 0.6$ “substantial” agreement; $0.6 > \kappa \geq 0.4$ “moderate” agreement; $0.4 > \kappa \geq 0.2$ to “fair” agreement; and $\kappa < 0.2$ “slight” agreement.

The following inclusion criteria were used: (1) comparative studies that performed a direct comparison of aTSA versus rTSA, (2) patient population aged over 70 years old, and (3) no history of trauma (fracture, traumatic rotator cuff tear). We only included randomized controlled trials, cohort studies, case control studies, and registry reviews. Biomechanical studies, technical notes, letters to the editor, expert opinions, review articles, meta-analyses, conference abstracts, and case reports were excluded. We also excluded studies that: (1) included patients with full-thickness rotator cuff tears, (2) included patients undergoing revision shoulder replacement, (3) included patients younger than 70 years old, (4) included shoulder replacement performed secondary to fracture, malignancy, or chronic inflammatory conditions. We only included studies with a minimum follow-up duration of 2 years.

Our primary outcome measure was the reported revision rates for aTSA compared to rTSA. Secondary outcome measures included clinical outcomes (patient reported outcome measures and functional assessment) and complication rates. We sought to identify similar clinical outcomes reported within the studies that could facilitate a statistical comparison and meta-analysis. We only performed data analysis using validated clinical outcome scores which could include the following: Constant-Murley Shoulder (CS) score, Oxford Shoulder Score (OSS), American Shoulder and Elbow Surgeons (ASES) score, Visual Analog Scale (VAS) Pain Score, and Simple Shoulder Test score. Complication rates were extracted and complications were further subclassified depending on their type.

Quality Assessment of Included Studies

The Methodological Index for Non-Randomized Studies (MINORS) criteria were used to assess the quality of the included studies.[17] Each of the 12 items in the MINORS criteria is scored between zero (0) and two (2), with maximum scores of 12 and 24 for noncomparative and comparative studies, respectively.

Statistical Analysis

A meta-analysis was performed of revision rate, complications, and functional scores using Revman (Version 5.4, The Cochrane Collaboration). A random effects model was used. This dichotomous variable was expressed in terms of odds

ratio (OR), with 95% confidence interval (CI) stated. Graphical representation of this was performed using forest plots.

The primary outcome of this meta-analysis was defined as the comparison of revision rates among the patients who underwent aTSA and rTSA. Secondary outcomes were defined as the complication rate between the 2 groups, which also included radiological complications as well as functional outcome scores (CS Score).

Results

From the initial literature search, 1798 relevant studies were identified (Figure 1). Following the removal of 400 duplicate abstracts, and the further removal of 6 abstracts that were published before 2010, 1392 abstracts were screened. Out of these, 1306 were removed following abstract and title evaluation. As a result, 86 were submitted for full-text review. After appropriate evaluation and discussion between the 2 reviewers, 4 studies that met the inclusion criteria were selected as eligible,[1,10,12,18] with a total number of 2731 shoulder arthroplasties and a minimum follow up of 2 years (Table 1).

The agreement in study selection between the 2 reviewers was "substantial" at the abstract review stage ($\kappa = 0.725$), and "perfect" at the full-text review stage ($\kappa = 1.0$).

Methodological Quality Assessment

The mean MINORS score for methodological quality assessment was 18 of 24 (range 17-20). All studies lost points for the retrospective study design and prospective calculation

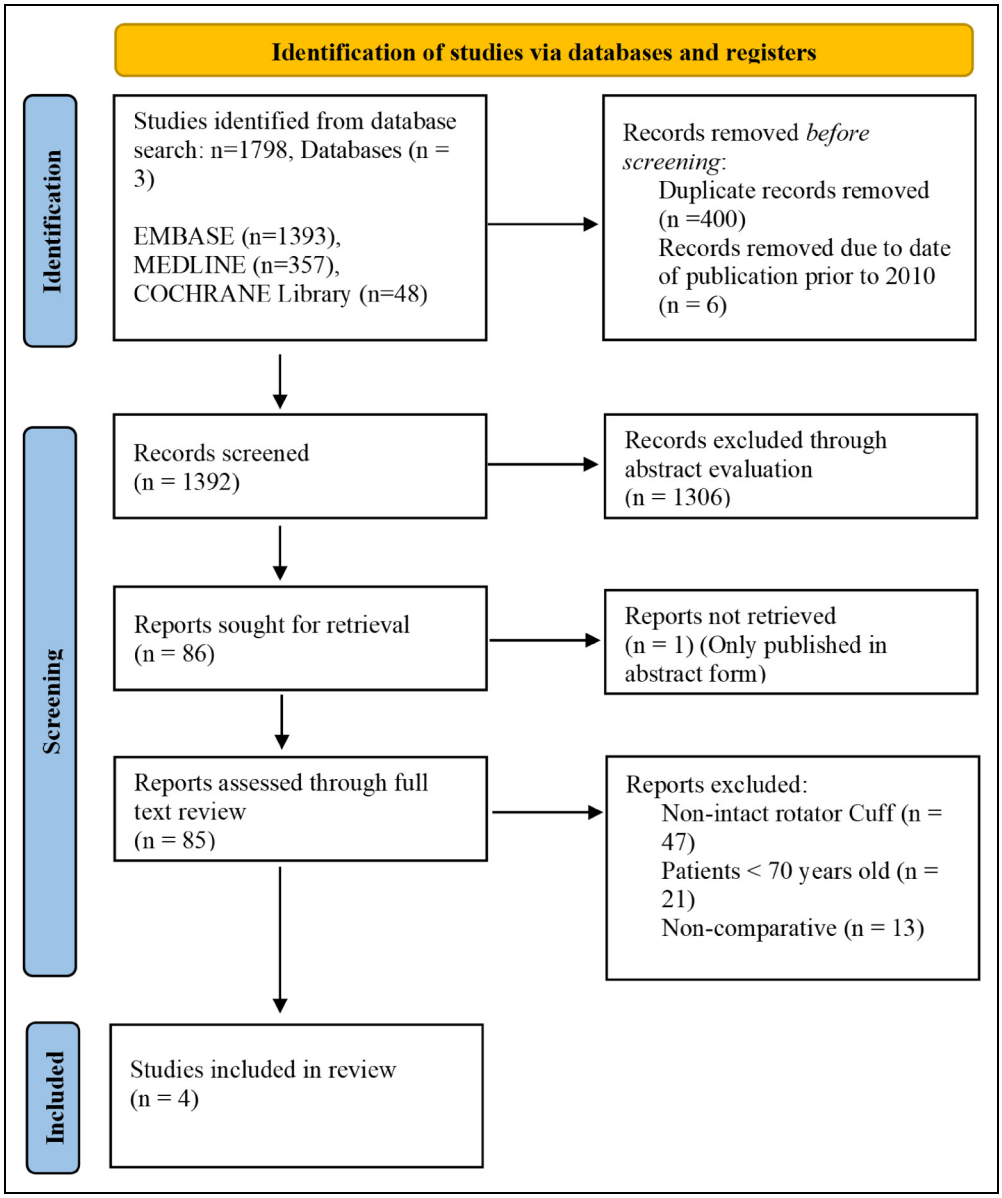

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) flow diagram.

Table 1. Studies Included in the Meta-Analysis.

Authors	Year	Total procedures	Number of aTSA and rTSA	Follow-up duration (months)	Mean age (years)	Type of study	Clinical outcome scores
Merolla et al [1]	2019	58	26 (aTSA) 32 (rTSA)	28.8 (27–30)	71.6	Retrospective cohort study	CS, VAS
Mowbray et al [18]	2021	2490	1307 (aTSA) 1183 (rTSA)	Over 3 years	Over 70	Registry review	OSS
Steen et al [10]	2015	48	37 (aTSA) 11 (rTSA)	Over 2 years	Over 80	Retrospective cohort study	ASES
Wright et al [12]	2019	135	102 (aTSA) 33 (rTSA)	85	77 (aTSA) 78 (rTSA)	Retrospective cohort study	ASES, VAS
Total		2731	1472 (aTSA) 1259 (rTSA)	-	-	-	-

Abbreviations: ASES, American Shoulder and Elbow Surgeons score; aTSA, anatomic total shoulder arthroplasty; CS, Constant-Murley Shoulder score; OSS, Oxford Shoulder Score; rTSA, reverse TSA; VAS, Visual Analog Scale score.

Table 2. Methodological Items for Non-Randomized Studies Score.

Methodological Items for Non-Randomized Studies	Merolla et al [1]	Mowbray et al [18]	Steen et al [10]	Wright et al [12]
1. A clearly stated aim	2	2	2	2
2. Inclusion of consecutive patients	2	2	2	2
3. Prospective collection of data	0	0	0	0
4. Endpoints appropriate to the aim of the study	2	2	2	2
5. Unbiased assessment of the study endpoint	2	0	0	0
6. Follow-up period appropriate to the aim of the study	2	2	2	2
7. Loss to follow up <5%	2	2	1	1
8. Prospective calculation of the study size	0	0	0	0
9. An adequate control group	2	2	2	2
10. Contemporary groups	2	2	2	2
11. Baseline equivalence of groups	2	2	2	2
12. Adequate statistical analysis	2	2	2	2
Total (out of 24)	20	18	17	17

The items are scored 0 (not reported), 1 (reported but inadequate), or 2 (reported and adequate). The global ideal score is 16 for noncomparative studies and 24 for comparative studies.

of the study size. Three out of 4 studies did not have an unbiased assessment of the study endpoint. Two studies lost 1 point each for as patients were lost to follow up (Table 2).

Outcome Measures

Four studies compared the overall revision rate between aTSR versus rTSA with the minimum of 2 year follow up. The overall revision rate for aTSA was 3.05% and for rTSA was 1.18%. Our analyses showed that there was a statistically significant difference in revision rate between rTSA and aTSR, with rTSA displaying a lower revision rate (OR 0.50, 95% CI: 0.30, 0.84, $p < .05$, $I^2 = 0\%$; Figure 2). We identified that the most common reason for revision rTSA was infection,[12,18] whereas the most common reason for revision following aTSA was rotator cuff tear.[1,12] We assessed the studies in regard to the overall complication rate in aTSA and rTSA.

Two studies[1,12] included complete data regarding types of complication and total complication rate. Reported complications included periprosthetic fracture, glenoid loosening, scapula notching, instability, deep infection, nerve palsy, vascular injury, secondary rotator cuff tear, deep venous thrombosis and hematoma (Table 3). The overall complication rate for aTSA was 7.9% and for rTSA was 8.8%. Our results showed that there was no statistical difference in the overall complication rate between the 2 systems (OR 0.98, 95% CI: 0.34, 2.86, $p = 0.97$, $I^2 = 0\%$; Figure 3).

Clinical outcome scores that were encountered included the following: CS Score, OSS, ASES, and VAS Pain score (Table 1). The postoperative VAS Pain Score was also extracted from 2 out of 4 studies.[1,12] Unfortunately, a direct comparison was not possible due to the absence of statistical data in the presented material [Lack of Standard Deviation (SD)]. As a result, a meta-analysis could not be performed. On the available data, both Merolla et al[1] [aTSA: 1(0; 1), rTSA: 1 (0; 2), $p = .393$] and Wright et al[12] (aTSA: 0.72 +/− 1.93, rTSA: 0.31 +/− 0.72, $p = .183$) reported no difference in postoperative VAS Pain score between the 2 systems.

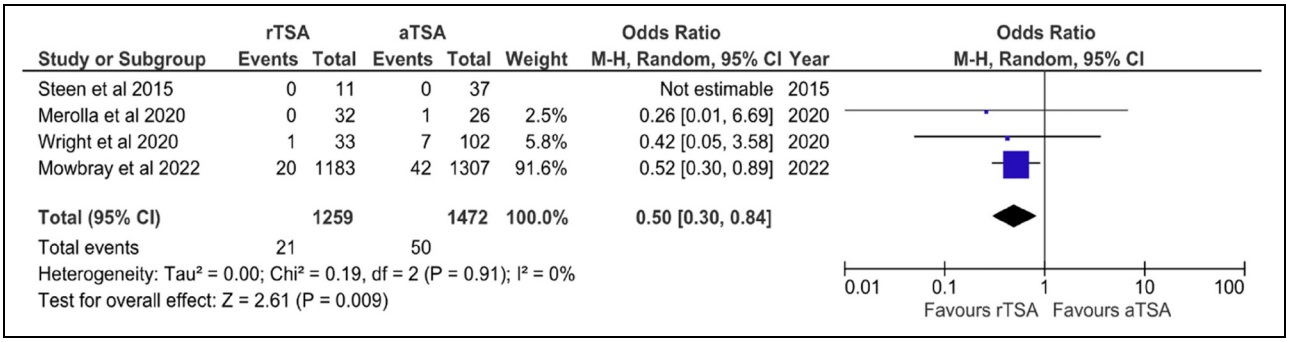

Figure 2. Forest plot displaying the odds ratios of revision rate due to reverse total shoulder arthroplasty and anatomic total shoulder arthroplasty.

Table 3. Postoperative Complications Included in the Meta-Analysis.

Complications	aTSA	rTSA
Rotator Cuff tear	3.8% (1/26)[a]	0%[a]
	10.7% (11/102)[a]	0%[a]
Intra-operative fracture	0%[a]	3.1% (1/32)[a]
	0%[a]	0%[a]
Instability	0%[a]	0%[a]
	0.98% (1/102)[a]	0%[a]
Periprosthetic fracture	0%[a]	3.1% (1/32)[a]
	1.9% (2/102)[a]	3% (1/33)[a]
Deep infection	0%[a]	0%[a]
	0%[a]	3% (1/33)[a]
Nerve palsy	0%[a]	0%[a]
	0%[a]	3% (1/33)[a]
Vascular injury	0%[a]	0%[a]
	0%[a]	3% (1/33)[a]
Total complications	3.8% (1/26)[a]	6.25% (2/32)[a]
	13.7% (14/102)[a]	1.2% (4/33)[a]

[a] Merolla et al.[1]
[b] Wright et al.[12]
Abbreviations: aTSA, anatomic total shoulder arthroplasty; rTSA, reverse TSA.

Only 1 of the studies included data on CS.[1] On the available data, Merolla et al[1] reported a statistically significant improved postoperative CS [aTSA: 80(75; 82), rTSA: 68(66; 76.5), $p < .001$], in patients who underwent aTSA.[1]

Discussion

While there are theoretical advantages of rTSA over aTSA in patients over the age of 70, the literature is sparse, with little data available to guide surgeons on implant selection in the aforementioned population.

To our knowledge, this is the first systematic review to directly compare the outcomes of the 2 surgical procedures in the case of primary osteoarthritis tear in patients over the age of 70 without a full-thickness rotator cuff tear.

The results of this study indicate that when a rTSA is performed for cases of osteoarthritis, the revision rate is better than when an aTSA is performed. Furthermore, there is no statistical difference between the 2 procedures in terms of overall complication rate or functional outcomes.

It is estimated that following shoulder arthroplasty, the lifetime risk of implant revision can be as high as 24% for patients aged 60 and younger, while for those aged 85 and older, the lifetime risk of revision is significantly lower, estimated at only 4%.[19] In regard to the revision rate in all our studies, there was a mean follow up of more than 2 years (Table 1). The most common cause of revision in aTSA was rotator cuff tear, while the most common cause of revision in rTSA was infection.

Regarding the revision rates between rTSA and aTSA systems, current literature has largely shown either no difference or a better revision rate for rTSA.[20] Our study has identified a statistically significant lower revision rate for rTSA compared to aTSA. This suggests that rTSA may be a viable option for treating osteoarthritis in our specific study population with more favorable revision rates. However, we believe that the low revision rate could be attributed to the fact that revising an rTSA system is more challenging than revising an aTSA system.[21,22] Given the retrospective nature of our included studies, we realize that there is no randomization between the 2 groups (aTSA and rTSA) that were compared. It is well established at this point that patients who are offered rTSA are typically older and have a lower activity level than those offered aTSA.[3,5,15] As a result, they are less likely to be offered or to accept a revision shoulder arthroplasty procedure, with evidence having previously shown lower revision rates in lower demand patients.[21,22] This could indicate a degree of selection bias which we are unable to eliminate, due to the nature of the studies included in our review and the lack of randomized studies in current literature.

Elderly patients are at a high risk when undergoing shoulder replacement, as it has been reported that shoulder arthroplasty for patients over 75 years old can increase hospital mortality, 1-year mortality, the length of stay in the hospital, and the readmission rate.[23,24] The majority of papers in the current literature show that there is no difference in overall complication rate between aTSA and rTSA, although the nature of the complication is different.[15,25–27] However, other studies demonstrate that rTSA has a higher complication rate compared to aTSA, as it can increase mechanical complications, blood loss, postoperative pain, and the length of stay.[28]

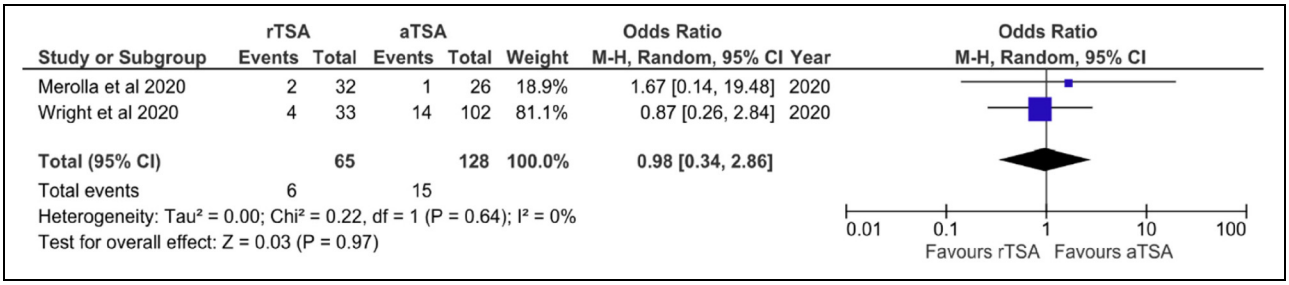

Figure 3. Forest plot displaying the odds ratios of complication rate due to reverse total shoulder arthroplasty and anatomic total shoulder arthroplasty.

The most common complication found in our study following aTSA is rotator cuff tear. This is followed by periprosthetic fracture and instability in the postoperative period. The most common complications encountered with rTSA were intra-operative or postoperative periprosthetic fracture followed by deep infection, nerve palsy, and vascular injury.

There is controversy in the literature regarding the functional outcomes between aTSA and rTSA for patients over 70 years old without a full-thickness rotator cuff tear. While some studies have reported that aTSA has better functional outcomes, others have concluded that it has worse outcomes.[3,29] Additionally, other studies report no difference in the functional outcome between aTSA and rTSA.[1,11,25,26] Mowbray et al[18] included 2490 patients for their functional outcomes (OSS), where they reported that for elderly population aged over 70 with osteoarthritis as primary diagnosis and intact rotator cuff, aTSA was associated with an improved OSS compared to primary rTSA.[18] We were unable to include this clinical outcome in our meta-analysis as Mowbray et al[18] was the only study using OSS. Furthermore, the study conducted by Merolla et al[1] involved 58 patients and reported an improved postoperative CS in favor of the aTSA system. However, the CS delta scores achieved by the patients in the rTSA subgroup were similar to those of the aTSA subgroup, a finding that indicates the excellent pain relief and recovery of shoulder function provided by the rTSA system.[1] Our results are derived from studies with a minimum of 2-year follow up. However, there could be a further decline of function in patients with rTSA 6 to 8 years postoperatively that our study is not able to comment on.[30]

Therefore, when deciding the best treatment option for glenohumeral osteoarthritis in patients without a full-thickness cuff tear, we suggest that functional outcome should be considered in addition to variables such as age, patient activity, and dominant hand. This comprehensive approach will ensure that the best possible treatment is chosen for each individual patient.

Limitations

Our study had a few limitations. The number of our studies was small as we wanted to perform a direct comparison between aTSA and rTSA patients, which may lead to the results being misrepresentative of a larger population. Furthermore, the data was collected from different sites, and this could lead to differences in the functional outcome scores used. We attempted to minimize this by including only comparable scores. Additionally, we did not evaluate the risk of bias arising from the variable quality of different arthroplasty systems, concepts, and patient demographics, which is unavoidable in a systematic review study. Also, in 1 of the studies that we included, there could be an underlining difference in patient characteristics between rTSA and aTSA, as there was a conversion from aTSA to rTSA due to intraoperative difficulties.[10] Lastly, our study did not have long-term follow up, so further research with long-term follow up is necessary to confirm which system is superior in the elderly populations.

Conclusion

Based on the results of our meta-analyses, it was found that utilizing rTSA as the implant of choice results in a lower revision rate compared to aTSA. However, there was no significant difference in the complication rate or functional scores among the various systems evaluated.

Therefore, when selecting an appropriate implant, a surgeon must take into account various patient factors such as their individual needs, activity level, specific activities the patient desires to perform, age, as well as the condition of the cuff tissue. It is essential to take all of these factors into account in order to ensure the best possible outcome for the patient.

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Declaration of Conflicting Interests

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References

1. Merolla G, De Cupis M, Walch G, et al. Pre-operative factors affecting the indications for anatomical and reverse total shoulder arthroplasty in primary osteoarthritis and outcome comparison in patients aged seventy years and older. *Int Orthop*. 2020;44(6):1131–1141. DOI:10.1007/s00264-020-04501-4
2. Flurin PH, Roche CP, Wright TW, et al. A comparison and correlation of clinical outcome metrics in anatomic and reverse total shoulder arthroplasty. *Bull Hosp Jt Dis (2013)*. 2015;73(Suppl 1):S118–S123.
3. Simon MJK, Coghlan JA, Bell SN. Shoulder replacement in the elderly with anatomic versus reverse total prosthesis? A prospective 2-year follow-up study. *J Clin Med*. 2022;11(3):540. DOI:10.3390/jcm11030540
4. Barret H, Bonnevialle N, Azoulay V, et al. Short-stem uncemented anatomical shoulder replacement for osteoarthritis in patients older than 70 years: is it appropriate? *JSES Int*. 2021;5(4):656–662. DOI:10.1016/j.jseint.2021.02.014
5. Cuff D, Pupello D, Virani N, et al. Reverse shoulder arthroplasty for the treatment of rotator cuff deficiency. *JBJS*. 2008;90(6):1244–1251. DOI:10.2106/jbjs.G.00775
6. Rugg CM, Gallo RA, Craig EV, et al. The pathogenesis and management of cuff tear arthropathy. *J Shoulder Elbow Surg*. 2018;27(12):2271–2283. DOI:10.1016/j.jse.2018.07.020
7. Iriberri I, Candrian C, Freehill MT, et al. Anatomic shoulder replacement for primary osteoarthritis in patients over 80 years: outcome is as good as in younger patients. *Acta Orthop*. 2015;86(3):298–302. DOI:10.3109/17453674.2015.1006036
8. Poondla RK, Sheth MM, Heldt BL, et al. Anatomic and reverse shoulder arthroplasty in patients 70 years of age and older: a comparison cohort at early to midterm follow-up. *J Shoulder Elbow Surg*. 2021;30(6):1336–1343. DOI:10.1016/j.jse.2020.08.030
9. Foruria AM, Sperling JW, Ankem HK, et al. Total shoulder replacement for osteoarthritis in patients 80 years of age and older. *J Bone Joint Surg Br*. 2010;92(7):970–974. DOI:10.1302/0301-620x.92b7.23671
10. Steen BM, Cabezas AF, Santoni BG, et al. Outcome and value of reverse shoulder arthroplasty for treatment of glenohumeral osteoarthritis: a matched cohort. *J Shoulder Elbow Surg*. 2015;24(9):1433–1441. DOI:10.1016/j.jse.2015.01.005
11. Triplet JJ, Everding NG, Levy JC, et al. Anatomic and reverse total shoulder arthroplasty in patients older than 80 years. *Orthopedics*. 2015;38(10):e904–e910. DOI:10.3928/01477447-20151002-58
12. Wright MA, Keener JD, Chamberlain AM. Comparison of clinical outcomes after anatomic total shoulder arthroplasty and reverse shoulder arthroplasty in patients 70 years and older with glenohumeral osteoarthritis and an intact rotator cuff. *J Am Acad Orthop Surg*. 2020;28(5):e222–e229. DOI:10.5435/jaaos-d-19-00166
13. Young AA, Walch G, Pape G, et al. Secondary rotator cuff dysfunction following total shoulder arthroplasty for primary glenohumeral osteoarthritis: results of a multicenter study with more than five years of follow-up. *J Bone Joint Surg Am*. 2012;94(8):685–693. DOI:10.2106/jbjs.J.00727
14. Heifner JJ, Kumar AD, Wagner ER. Glenohumeral osteoarthritis with intact rotator cuff treated with reverse shoulder arthroplasty: a systematic review. *J Shoulder Elbow Surg*. 2021;30(12):2895–2903. DOI:10.1016/j.jse.2021.06.010
15. Crum RJ, de Sa DL, Su FL, et al. Decreased complication profile and improved clinical outcomes of primary reverse total shoulder arthroplasty after 2010: a systematic review. *Shoulder Elbow*. 2021;13(2):154–167. DOI:10.1177/1758573219852977
16. Churchill RS. Elective shoulder arthroplasty in patients older than ninety years of age. *J Shoulder Elbow Surg*. 2008;17(3):376–379. DOI:10.1016/j.jse.2007.09.005
17. Slim K, Nini E, Forestier D, et al. Methodological index for non-randomized studies (minors): development and validation of a new instrument. *ANZ J Surg*. 2003;73(9):712–716. DOI:10.1046/j.1445-2197.2003.02748.x
18. Mowbray J, Van Niekerk M, Frampton C, et al. The outcomes of shoulder arthroplasty in those aged ≥70 years with glenohumeral arthritis: a New Zealand Joint Registry study. *J Shoulder Elbow Surg*. 2022;31(4):799–805. DOI:10.1016/j.jse.2021.09.006
19. Craig RS, Lane JCE, Carr AJ, et al. Serious adverse events and lifetime risk of reoperation after elective shoulder replacement: population based cohort study using hospital episode statistics for England. *BMJ (Clin Res ed)*. 2019;364(8188):l298. DOI:10.1136/bmj.l298
20. Schoch BS, King JJ, Zuckerman J, et al. Anatomic versus reverse shoulder arthroplasty: a mid-term follow-up comparison. *Shoulder Elbow*. 2021;13(5):518–526. DOI:10.1177/1758573220921150
21. Chalmers PN, Boileau P, Romeo AA, et al. Revision reverse shoulder arthroplasty. *J Am Acad Orthop Surg*. 2019;27(12):426–436. DOI:10.5435/jaaos-d-17-00535
22. Black EM, Roberts SM, Siegel E, et al. Failure after reverse total shoulder arthroplasty: what is the success of component revision? *J Shoulder Elbow Surg*. 2015;24(12):1908–1914. DOI:10.1016/j.jse.2015.05.029
23. Anakwenze OA, Yehyawi T, Dillon MT, et al. Effect of age on outcomes of shoulder arthroplasty. *Perm J*. 2017;21(3):16–056. DOI:10.7812/tpp/16-056
24. Griffin JW, Hadeed MM, Novicoff WM, et al. Patient age is a factor in early outcomes after shoulder arthroplasty. *J Shoulder Elbow Surg*. 2014;23(12):1867–1871. DOI:10.1016/j.jse.2014.04.004
25. Kirsch JM, Puzzitiello RN, Swanson D, et al. Outcomes after anatomic and reverse shoulder arthroplasty for the treatment of glenohumeral osteoarthritis: a propensity score-matched analysis. *JBJS*. 2022;104(15):1362–1369. DOI:10.2106/jbjs.21.00982
26. Kim H, Kim CH, Kim M, et al. Is reverse total shoulder arthroplasty (rTSA) more advantageous than anatomic TSA (aTSA) for osteoarthritis with intact cuff tendon? A systematic review and meta-analysis. *J Orthop Traumatol*. 2022;23(1):3. DOI:10.1186/s10195-022-00625-y
27. Parada SA, Flurin PH, Wright TW, et al. Comparison of complication types and rates associated with anatomic and reverse total shoulder arthroplasty. *J Shoulder Elbow Surg*. 2021;30(4):811–818. DOI:10.1016/j.jse.2020.07.028
28. Liu H, Huang TC-T, Yu H, et al. Total shoulder arthroplasty versus reverse total shoulder arthroplasty: outcome comparison in osteoarthritis patients with or without concurrent rotator cuff deficiency. *Medicine* 2022;101(32):e29896. DOI:10.1097/md.0000000000029896
29. Friedman RJ, Cheung EV, Flurin PH, et al. Are age and patient gender associated with different rates and magnitudes of clinical improvement after reverse shoulder arthroplasty? *Clin Orthop Relat Res*. 2018;476(6):1264–1273. DOI:10.1007/s11999.0000000000000270
30. Boileau P. Reverse shoulder arthroplasty: indications and results of the French multicenter study. *Orthopaedic Proc*. 2010;92-B(2):343–343. DOI:10.1302/0301-620x.92bsupp_ii.0920343