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Latissimus dorsi and teres major transfer in reverse shoulder arthroplasty: A systematic review

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Background: This paper aims to conduct a systematic review of the current literature to evaluate the clinical outcomes of concurrent latissimus dorsi and teres major (LD/TM) tendon transfer in reverse shoulder arthroplasty (RSA), and to compare that to isolated RSA.

Methods: A comprehensive search on PubMeb, Web of Science, Embase and CINAHL was performed from inception up to January 20, 2023, in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analyses. Cohort studies, case-control studies, randomized controlled trials and case series that were written in English, which involved patients who underwent RSA with LD/TM transfer were included. Quality of studies was appraised using the Cochrane Risk Of Bias In Nonrandomized Studies of Interventions tool. Systematic review of Constant-Murley Score (CMS) and range of movement (ROM) was conducted.

Results: Eight studies with a total of 265 patients were included. The average mean follow-up time was 42.5 months, with a range of 6 months to 136 months. Of the studies that reported outcomes of RSA with LD/TM transfer, five reported the CMS, five reported external rotation (ER) ROM and six reported forward flexion ROM. Comparing postoperative to preoperative scores, there was an improvement above the minimal clinically important difference for CMS (mean difference (MD) range = 22.40 to 41.80), ER (MD range = 29° to 36°) and forward flexion (MD range = 50° to 75°). Three studies that compared postoperative ER between RSA with and without LD/TM reported no significant difference.

Conclusion: RSA with LD/TM transfer has good clinical outcomes postoperatively, but there is insufficient comparative data to suggest that it is superior or inferior to an isolated RSA.

Owing to its excellent outcomes in function and pain relief, reverse shoulder arthroplasty (RSA) is the most implanted shoulder arthroplasty worldwide, and is indicated for the treatment of cuff tear arthropathy.[18] Since the first commercially available RSA design by Grammont in 1985, many improvements continue to be made.

More recently, in 2010, Boileau et al performed the concurrent transfer of the latissimus dorsi and teres major (LD/TM) tendons for restoration of external rotation (ER) post-RSA.[8] This transfer is indicated in combined loss of elevation and external rotation (CLEER) and potentially improves patients' abilities to perform activities of daily living.[16]

With regards to this novel procedure, Wey et al have found that patients undergoing RSA with LD/TM transfer in the setting of loss of ER demonstrate reliable clinical improvements in shoulder function, with complication rates which are comparable to RSA alone.[28] However, it is unclear whether the addition of LD/TM transfer has significantly different outcomes compared to isolated RSA.

Therefore, this study aims to conduct a systematic review to evaluate the clinical outcomes of RSA with LD/TM transfer, and to compare them to that of RSA without concurrent LD/TM transfer.

Search design and methodology

This systematic review was planned, conducted, and reported in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analyses guidelines.

Institutional review board approval was not required for this systematic review.

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Search strategy

A comprehensive database search of PubMed, Web of Science, Embase and CINAHL from inception up to January 20, 2023, was conducted. The search strategy used consisted of the following terms: RSA AND ((latissimus dorsi transfer AND teres major transfer) OR L'Episcopo). In addition, a snowball strategy was applied, looking at references and citations of relevant articles with similar topics. A search of grey literature was also conducted (relevant websites, Google Scholar).

Eligibility criteria

Inclusion criteria

Studies that involved patients who underwent RSA with and without LD/TM transfer, of any age, gender and race were considered. Cohort studies, case-control studies, randomized controlled trials and case series were included. Only articles written in English were included.

Exclusion criteria

The authors excluded studies which included people who had not gone for any procedure, gone for only RSA without any tendon transfer or gone for RSA with only transfer of either one of the tendons. Systemic reviews, meta-analyses and case reports were also excluded.

In this review, data of RSA without any tendon transfer was extracted only from studies which reported results comparing RSA with LD/TM transfer to RSA without any tendon transfer.

Study selection and data extraction

The review process was completed using Covidence (Covidence systematic review software, Veritas Health Innovation, Melbourne, Australia).[14]

Two reviewers (A.T. and I.D.W.C.) independently screened through the titles and abstracts based on the inclusion and exclusion criteria. Following that, the full texts of shortlisted studies were retrieved. The two reviewers (A.T. and I.D.W.C.) then independently extracted data from these full texts. From each study, the authors extracted the study reference (author, year of publication, country of study, study design/duration/objectives), demographics of subjects (number of participants, gender, age range) and results of study (Range of Movement (ROM), Constant-Murley Score (CMS) and other relevant scores or measurements).

Disparities were resolved by discussion and consultation with the review team. The final included studies were decided in consultation with the senior authors (W.Q. and D.T.T.L.). Attempts were made to contact study authors for papers with missing or incomplete information. Each step of the selection process was outlined via Preferred Reporting Items for Systematic reviews and Meta-Analyses.

Scoring systems

Constant-Murley Score

The CMS is a multi-item scale validated for use in proximal humeral fractures, rotator cuff tears and postarthroplasty.[10] It is being widely used and the recommended score to assess shoulder function.[15] The score ranges from 0 to 100, including both objective and subjective components: pain (Visual Analog Scale), activities of daily living, ROM and strength of the affected shoulder.[25]

Range of movement

The ROM of the shoulder is a good measure of function.[26] The normal active ROM is 90° for ER with the arm at 0° abduction and 180° for forward flexion (FF).[13]

Other clinical scores utilized in the various studies are summarized in Table I.

Risk of bias assessment

The Cochrane Risk Of Bias In Nonrandomized Studies of Interventions tool was used for follow-up studies, comprising seven categories: bias due to confounding, in selection of participants, classification of interventions, deviations from intended interventions, missing data, measurement of outcome and selection of reported result.[24] The risk of bias for each domain was judged to be low, moderate, serious, critical or no information.

Statistical analysis

Review Manager 5.4 software (The Cochrane Collaboration, London, United Kingdom) was used for data analysis and synthesis.[20]

To evaluate the outcomes of RSA with LD/TM tendon transfer, a random-effects model was employed for the systematic review. The mean difference (MD) was used to assess the effect of the procedure on FF, ER and CMS.

A narrative synthesis (making use of structured narratives, summary tables or figures to aid in a descriptive summary or explanation of the primary study characteristics and findings) was undertaken to complement the quantitative analysis done.

Results

Systematic review

Study selection

Using the above developed search strategy, a total of 184 articles were found. After the removal of 51 duplicates, the remaining 133 titles and abstracts were screened, with 31 sought for full text retrieval. Eight articles were eventually included in this review (Fig. 1). Details of the search strategy and selection of the included studies are summarized in Figure 1.

Study characteristics

The eight studies included in this systematic review included four cohort studies, one case control, one case series, one randomized control test and one laboratory study, with a total of 265 patients (Table I). Three out of the eight studies compared between RSA with LD/TM and isolated RSA without tendon transfer. The average mean follow-up time was 42.5 months, with a range of 6 months to 136 months. The mean age across all the included studies was 71.1 years. The majority of the studies (87.5%) reported a higher number of females compared to males.

Risk of bias assessment

The risk of bias for all included studies was determined to be moderate (Supplementary Appendix S1). The inter-rater agreement percentage was 100% (Supplementary Appendix S2).

Outcomes of included studies

Amongst the three comparative studies (Flury 2018 et al, Young 2020 et al, Merolla 2021 et al), postoperation ER was the only common outcome presented. Due to a high heterogeneity between the three studies, we were unable to pool the data. All three studies individually report that there is no significant difference in postoperative ER between both procedures.

Table I
Summary of included studies.

First author, year, country	Study design, level of evidence	Number of patients/ number of shoulders in intervention group	Number of patients/ number of shoulders in control group	Mean age (years) (range)	Gender (M: F)	Follow-up period (months) (range)	Implant used (lateralising [Y/N])	Reported clinical scores	Indications for operation
Merolla, 2021, Italy[19]	Retrospective laboratory study	13/13	12/12	74.4 (65-84)	4:21	34.1 (NA)	Grammont-style prosthesis (N)	Constant-Murley Score, DASH, active shoulder ROM (forward flexion, abduction, ER, IR)	Cuff tear arthropathy, pseudoparalysis, and a positive dropping sign
Young, 2020, USA[29]	Prospective randomised controlled trial, Level I	RSA with transfer: 16	RSA without transfer: 12	67.7 (NA)	13:15	24 (24-39)	Zimmer Trabecular Metal Reverse Shoulder System and Biomet Comprehensive Reverse Arthroplasty System[30] (Y)	DASH, ASES, ADLER, SST scores	CLEER
Flury, 2018, Switzerland[11]	Retrospective cohort study, Level III	13/13	Control 1 ER deficit, no LDTM: 13/13 Control 2 no ER deficit, no LDTM: 88/88	73.3 (NA)	33:81	60 (N.A.)	Promos Reverse prosthesis (Y)	Constant-Murley Score, Shoulder Pain and Disability Index (SPADI) score	Active external rotation deficit, control group 2 no ER deficit
Piedra, 2022, Spain[4]	Cross-sectional case-control study, Level IV	10/10	10/10	66.6 (55-81)	2:8	80.8 (42-136)	4x Delta Extend[5] (Y) 6x Comprehensive Shoulder System (Y)	Constant-Murley Score	CLEER
Kazum, 2022, France[17]	Retrospective cohort study	21/21	15/15	69.8 (52-86)	22:14	40.8 (6-98)	RSA Arrow System[27] (Y)	ROM (forward flexion, abduction, ER in adduction, ER in abduction, internal rotation), Constant-Murley Score, VAS, SSV	Painful shoulder CLEER Limitation in forward elevation or pseudoparalysis related to massive posterosuperior cuff tear
Shi, 2015, USA[22]	Retrospective cohort study, Level IV	21/21	N.A.	66 (58-82)	4:17	44 (26-81)	Zimmer Anatomical Inverse system (Y)	ROM (forward flexion, ER in adduction, ER in abduction, ER lag), VAS, UCLA, ASES, SANE	Combined loss of active shoulder elevation and external rotation External rotation lag >30 with arm in either adduction or abduction
Boughebri, 2012, France[9]	Retrospective cohort study, Level IV	14/15	N.A.	67.5 (N.A.)	4:10	33.2 (24-60)	Arrow reverse shoulder prosthesis (Y)	Constant-Murley Score, Simple Shoulder Test (SST)	Irreparable posterosuperior cuff tears
Boileau, 2010, France[8]	Case series, Level IV	17/17	N.A.	71 (N.A.)	7:10	23 (12-54)	Aequalis Reverse System[7] (Y)	ROM (elevation, ER, IR), Constant-Murley Score, ADLER score, SSV	CLEER

VAS, Visual Analog Scale; *LDTM*, latissimus dorsi and teres major; *CLEER*, combined loss of elevation and external rotation; *DASH*, disabilities of the arm shoulder and hand; *ASES*, American Shoulder and Elbow Surgeons; *ROM*, range of motion; *ER*, external rotation; *IR*, internal rotation; *UCLA*, University of California Los Angeles; *SANE*, single assessment numeric evaluation.

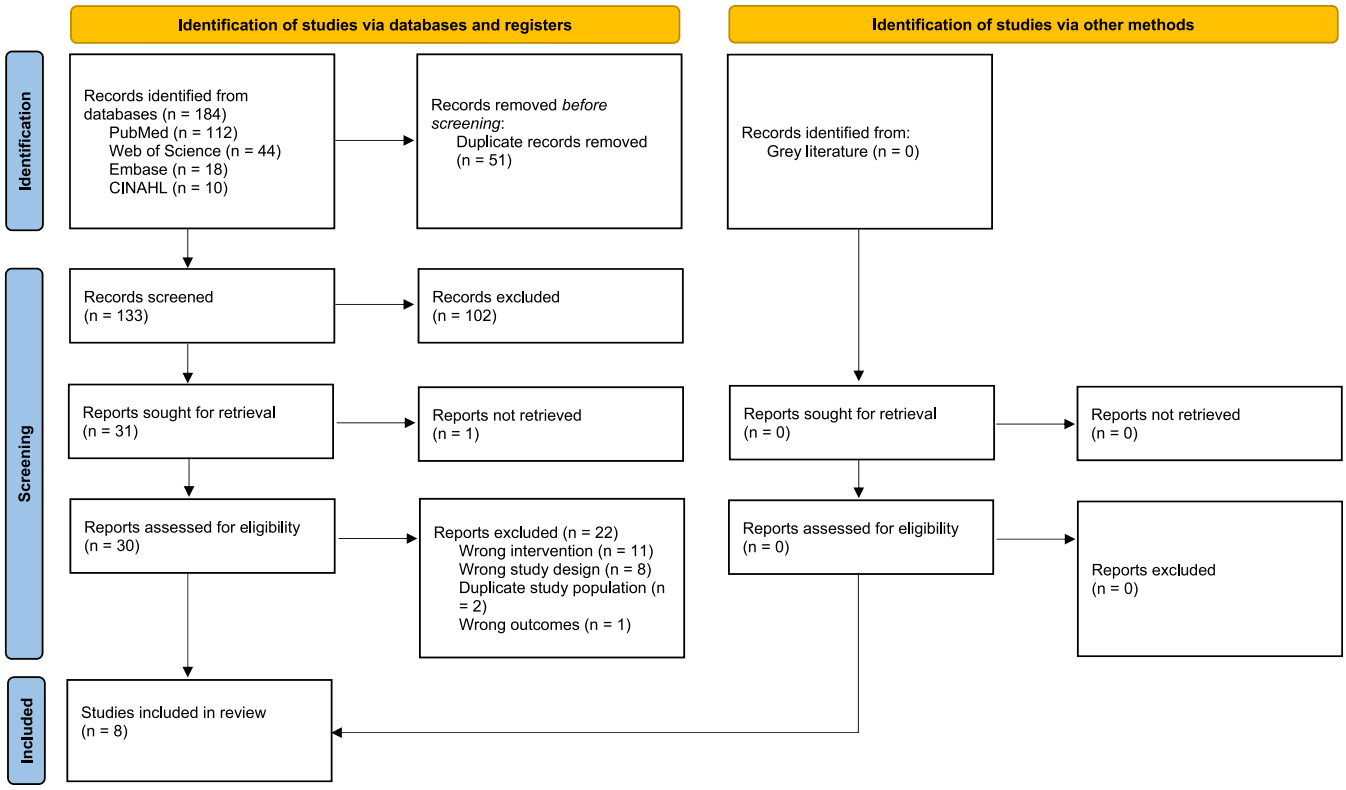

Figure 1 PRISMA 2020 flow diagram for new systematic reviews which included searches of databases, registers and other sources. *PRISMA*, Preferred Reporting Items for Systematic reviews and Meta-Analyses.

Table II
Summary of external rotation of included studies.

Study or subgroup	Follow-up			Preop			Mean difference	Minimal clinically important difference
	Mean	SD	Total	Mean	SD	Total		
Boileau 2010[8]	13	15	17	−21	8	17	34.00	>3
Boughebri 2012[9]	27.3	12.2	15	−8.7	21.3	15	36.00	
Shi 2015[22]	38	14	21	6	16	21	32.00	
Flury 2018[11]	18	13	10	−12	12	13	30.00	
Kazum 2022[17]	17.1	13.8	21	−11.9	19.4	21	29.00	

SD, standard deviation.

Table III
Summary of forward flexion of included studies.

Study or subgroup	Follow-up			Preop			Mean difference	Minimal clinically important difference
	Mean	SD	Total	Mean	SD	Total		
Boileau 2010[8]	149	18	17	74	34	17	75.00	>12
Boughebri 2012[9]	126	34.4	15	64.7	35.6	15	61.30	
Shi 2015[22]	120	38	21	56	36	21	64.00	
Flury 2018[11]	137	17	10	87	52	13	50.00	
Young 2020[29]	140	25.9	16	85	40.7	16	55.00	
Kazum 2022[17]	141.4	28.5	21	68.5	32.6	21	72.90	

SD, standard deviation.

The included studies show good postoperation outcomes for RSA with LD/TM transfer. Study outcomes for the same scoring tool were compiled and presented in Tables II-IV.

A total of five studies reported the range of ER at 0 degrees abduction before and after RSA with LD/TM transfer. The results show that there was an increase of ER ROM postoperation for all the studies with the MD ranging from 29° to 36° (Table II). This is greater than the MCID (>3°).[23]

A total of six studies reported the FF range before and after the procedure. Results from the analysis showed that there was an improvement in FF ROM postoperation for all the studies with the MD ranging from 50° to 75° (Table III). The MD of all the studies were greater than the MCID for FF (>12°).[23]

A total of five studies were used to analyze the difference in CMS before and after the procedure. Results from the analysis showed that there was an increase in CMS postoperation for all studies with

Table IV
Summary of CMS of included studies.

Study or subgroup	Follow-up			Preop			Mean difference	Minimal clinically important difference
	Mean	SD	Total	Mean	SD	Total		
Boileau 2010[8]	62	13	17	27	9	17	35.00	>12
Boughebri 2012[9]	61.1	11.9	15	23.7	11.5	15	37.40	
Flury 2018[11]	67	15	9	37	14	13	30.00	
Merolla 2021[20]	53.2	12.7	13	30.8	12.4	13	22.40	
Kazum 2022[17]	64.9	9	21	23.1	8.5	21	41.80	

SD, standard deviation.

the MD ranging 22.40 to 41.80 (Table IV). The MD of all the studies were greater than the MCID for CMS (>5.7).[23]

Discussion

Our study found that RSA with LD/TM transfer had positive clinical outcomes. There was improvement in ROM (ER and FF) and CMS above the MCID postoperatively. This is supportive of Wey 2017, a systematic review of the same topic which reported that patients who underwent RSA with LD/TM transfer demonstrated clinical improvements in shoulder function (CMS/ER).[28] Wey 2017 also reported that complication rates of the procedure were comparable to that of isolated RSA. Despite this, the authors acknowledge that the added LD/TM transfer adds on to the operation time. However, the paper did not compare between outcomes of RSA with and without LD/TM transfer as no available studies were present previously. This study includes five additional studies published between 2017 and 2023, where three of them compared the outcomes of the two procedures. However, two studies that were included by Wey 2017 were excluded as they did not meet this paper's inclusion criteria (Boughebri 2013 and Puskas 2014).

Apart from CMS, the included studies also reported other patient reported outcomes - the Simple Shoulder Test (SST),[9,29] Visual Analog Scale (VAS),[17,22] Activities of Daily Living requiring active External Rotation (ADLER),[8,29] American Shoulder and Elbow Surgeons (ASES),[22,29] Disabilities of the Arm, Shoulder and Hand (DASH)[19,29] and Subjective Shoulder Value (SSV).[8,17] A meta-analysis for these outcomes could not be performed as there was heterogeneity in the reporting (n = 2 for all). Even so, there was significant improvement postoperatively for all the mentioned scores, although no significant differences were found when comparing between RSA with and without concurrent LD/TM tendon transfer.

The key finding of this study is that there is presently insufficient evidence to conclude whether concurrent LD/TM tendon transfer in RSA confers any significant benefit over an isolated RSA. Three included studies report no significant difference in ER postoperatively between the two procedures. This could be attributed to newer implants being used that confer mechanical advantage.[1,6] Older implants (eg, traditional Grammont-style Delta prosthesis) shift the joint center of rotation medially and inferiorly in order to better make use of the deltoid for abduction.[3] However, this comes at a cost of reduced ER due to shortening of the ER moment arm of the teres minor.[2] Newer lateralizing implants aim to maintain tension in residual rotator cuff tendons and optimize the wrapping of the deltoid.[21] Recent studies have shown that lateralizing implants better preserve ER.[12] In this study, seven out of eight studies made use of lateralizing implants. Out of the three studies that compared RSA with and without LD/TM, two used of lateralizing implants. Hence, more studies need to be done to investigate whether these newer implants eliminate the need for LD/TM tendon transfer.

The authors acknowledge several limitations of this study. Firstly, the small number of studies (n=8) included in the paper limits the power of conclusions. Secondly, there is a risk of bias due to the retrospective nature of the included studies, namely selection bias of included participants. Next, only three out of eight of the included studies compared RSA to RSA with LD/TM transfer. Among those studies, only ER was compared, while other variables were either not reported or had missing data. Even for ER, only one out of the three studies presented both preoperative and postoperative data (the other two only presented postoperation data), hence a comparison of the mean improvement between studies could not be performed. Lastly, there is a large heterogeneity in the included studies (Table I). This included the type of implants used, definition of CLEER patients and inconsistent reporting of preoperative rotator cuff injuries and fatty infiltration.

The authors present several suggestions for future work regarding this topic. Given the small number of studies present, it is crucial that more prospective comparative studies that consist of a larger population size should be carried out. These studies should not only compare preoperative versus postoperative outcomes over a longer follow-up beyond 60 months (current mean = 42.5 months), but also compare the need for LD/TM transfer in view of newer implants. The relationship between outcomes and exact site of tendon fixation could also be further assessed. Further studies should also consider having standardized inclusion criteria for the procedure and conform to the accurate definition of CLEER patients. Including common validated scores for shoulder function would aid future reviews to compare these outcomes across studies to come to more definitive conclusions. It is also crucial that preoperative parameters are sufficiently documented.

Conclusion

While the use of LD/TM transfer concurrently during an RSA has been shown to have good clinical outcomes, there is insufficient comparative data to suggest that RSA with LD/TM transfer is superior or inferior to isolated RSA. Further comparative studies with sufficiently reported data are needed in order to derive definitive conclusions on this topic.

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Supplementary Data

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