

Reverse Shoulder Arthroplasty and Latissimus Dorsi Tendon Transfer

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Abstract

In a systematic review, we critically examined and synthesized the results of individual studies on reverse shoulder arthroplasty (RSA) with latissimus dorsi tendon transfer. Two electronic databases were searched. For each included study, 2 reviewers evaluated the quality of its methods and retrieved data. In cases in which outcomes data were similar between studies, data were pooled using frequency-weighted (FW) mean values to generate summary outcomes.

Seven studies met the inclusion and exclusion criteria, and 133 patient cases were reviewed. FW mean age was 69.5 years. Patients were followed up an FW mean of 39.9 months. FW mean Constant score improved from 28.7 before surgery to 64.4 afterward ($P = .0001$). External rotation improved from an FW mean of -4° to 25° ($P < .0001$). The overall complication rate was 22.8%.

RSA combined with latissimus dorsi tendon transfer can improve function and external rotation in patients with cuff tear arthropathy and teres minor dysfunction. Its overall complication rate appears to be similar to that of RSA alone, though the rate of neuropraxia may be increased.

Reverse shoulder arthroplasty (RSA) is a proven procedure that typically improves pain and function in patients with rotator cuff tear arthropathy.¹ Worse clinical outcomes are seen in patients with loss of teres minor function.^{2,3} The teres minor is often the last important external rotator of the shoulder left in cuff tear arthropathy.

When its function is lost, the ability to achieve active external rotation may become diminished. This phenomenon was termed *combined loss of active elevation and external rotation* (CLEER) by Boileau and colleagues.⁴ Patients with CLEER typically exhibit weakness with external rotation of the shoulder—most pronounced with the arm in an abducted position. Clinical examination may reveal a positive Hornblower test, and magnetic resonance imaging (MRI) of the shoulder often shows atrophy in the teres minor muscle.⁵

Patients with CLEER often do not exhibit the same degree of clinical improvement after RSA, largely because the external rotation strength deficit remains unchanged, causing persistent difficulty in completing activities of daily living (eg, combing hair, brushing teeth, eating).⁶ One option for treating patients with CLEER is to combine RSA with latissimus dorsi tendon transfer (LDTT) with or without teres major (TM) tendon transfer. In 1934, L'Episcopo⁷ was the first to describe performing LDTT with TM tendon transfer in an attempt to restore external rotation in patients with brachial plexus palsy. This procedure typically is used for irreparable posterior-superior rotator cuff tears in younger patients.⁸ Although the transfer was originally popularized with use of 2 incisions,⁹ Boileau and colleagues⁴ described a modified technique that allows the transfer to be performed through a single deltopectoral approach during RSA.

Although several authors have described the outcomes of RSA

Take-Home Points

- CTA with loss of teres minor has been associated with worse clinical outcomes.
- Combined RSA and LDTT has been proposed and studied as a solution to this problem.
- LD tendon can be transferred to native teres minor insertion or lateral bicipital groove.
- Published studies have shown significant improvements in various subjective values, active forward elevation, external rotation, and abduction strength.
- Overall complication rates appear similar to RSA alone, however rates of neuropraxia may be higher.

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with LD TT, the expected clinical outcomes and complication rates remain elusive because of the relatively small number of patients in each case series. In a systematic review, we critically examined and synthesized the results of individual studies on RSA with LD TT. We had 3 questions: What are the demographics of patients treated with RSA-LD TT? What outcomes are associated with this combined procedure? What are the associated complications, and how often do they occur?

Methods

PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines were followed. PubMed and Scopus computerized literature databases were searched through July 2015. Articles were identified with keyword searches (**Figure**). In our review, we included only studies that were reported in English, that included a minimum of 10 patients at baseline, and that had follow-up of at least 12 months; we excluded review papers, case reports, and technique papers

without patient data. Mr. Sheth performed the initial search, and he and Dr. Namdari reviewed the qualifying abstracts. If one of the authors selected a paper, it was moved to the next phase of the review process. At the final phase (full-text review), there were no disagreements about which articles ultimately would be included (**Figure**).

We obtained 36 articles from PubMed and 12 from Scopus (**Figure**). Of these 48 articles, 15 were removed on the basis of their titles (reviews or editorials), and 8 for being duplicates. The remaining 25 articles underwent abstract review, which eliminated 17: reviews, case reports, technique articles, instructional articles, and reports on small case series (<10 patients) or studies lacking the minimum 12-month follow-up. The remaining 8 articles underwent full-text review. Inclusion/exclusion criteria removed 1 article, leaving 7 qualifying articles for analysis.

None of the studies compared outcomes with those of a control (nonoperative) group or an alternative surgical treatment. One study reported outcomes of RSA with and without LD TT; in this

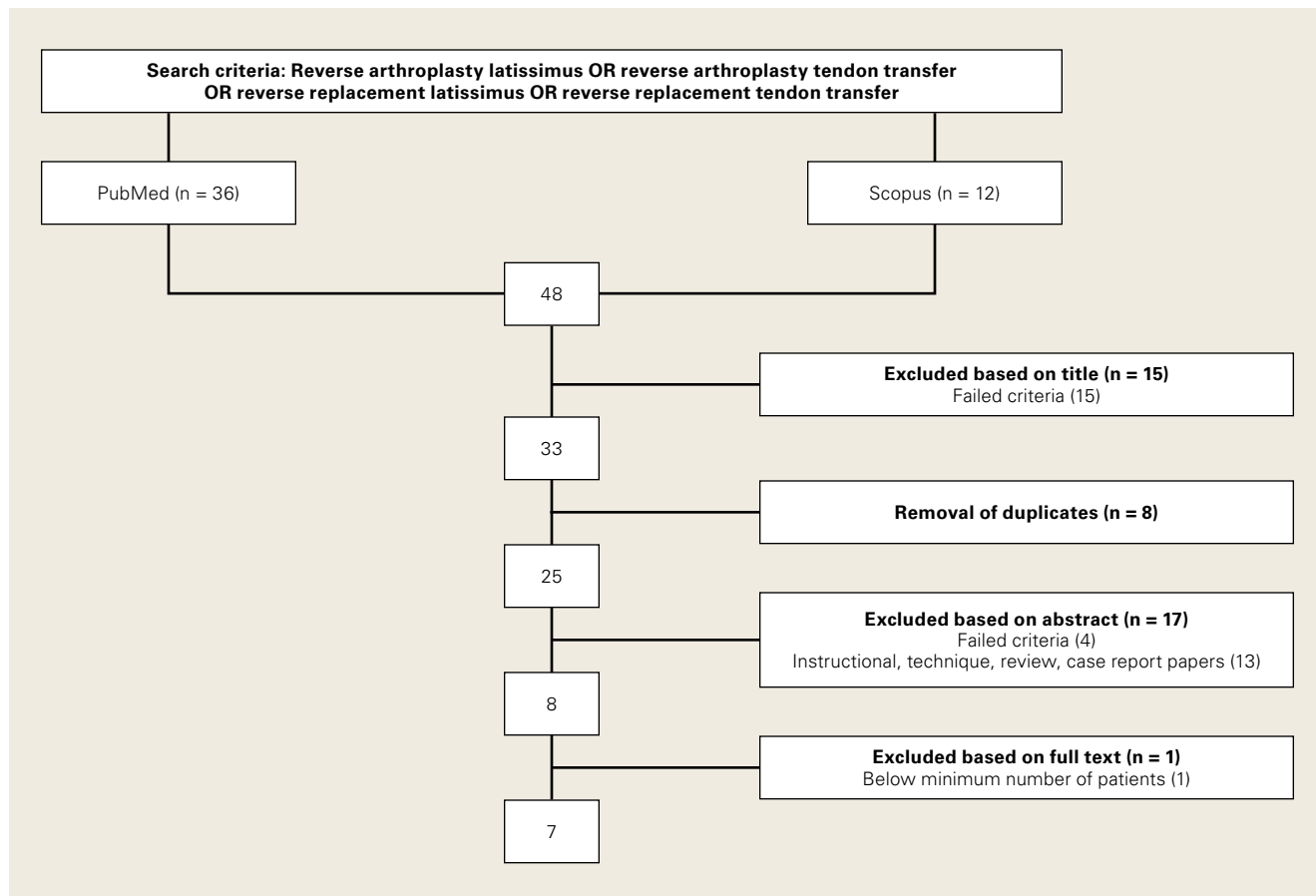


Figure. Flow chart representing the systematic review process used in this study.

Table 1. Patient Demographics

Study	Year	Level of Evidence	Type of Study	Patients, n		Mean Age, y	Female/Male	Dominant/Nondominant/Bilateral	Mean Follow-Up, mo
				Baseline	Final				
Gerber et al ¹¹	2007	4	Retrospective	11	9	73	NR	NR/NR/1	18
Boileau et al ⁵	2008	4	Prospective	11	11	70	7/4	8/3/0	19.5
Boileau et al ⁶	2010	4	Prospective	23	17	71	10/7	13/4/0	23
Boughebri et al ¹⁰	2013	4	Retrospective	14	14	68	10/4	9/6/1	33.2
Ortmaier et al ¹²	2014	4	Retrospective	13	13	71	9/4	10/3/0	65.4
Puskas et al ¹³	2014	4	Retrospective	40	31	70	18/13	NR/NR/1	53
Shi et al ¹⁴	2015	4	Retrospective	21	21	66	17/4	NR/NR/NR	44
Total				133	116	69.5 ^a	71/36	73% dominant 25% nondominant	39.9 ^a

^aFrequency-weighted mean.
Abbreviation: NR, not recorded.

instance, we included only the data specific to the RSA-with-LDTT cases. Data from the individual studies were compiled to obtain demographic statistics. In cases in which outcomes data were consistently reported between studies, results were pooled for calculation of percentages and frequency-weighted (FW) means. FW means and grouped standard deviations were used to generate *P* values, using the number of “subjects” as the number of studies. As a result, comparative statistics for each variable were reported as means that 95% of the studies would report.

Results

Seven studies met the inclusion/exclusion criteria and were included in this systematic review. Five were retrospective,¹⁰⁻¹⁴ and 2 were prospective.^{5,6} All were published between 2007 and 2015.

Table 1 lists the full study characteristics between groups.

Demographics

All 7 studies reported number of patients at baseline (Table 1); 133 patients (study range, 11-40) underwent RSA with LDTT.^{5,6,10-14} All 7 studies reported patient ages; FW mean age was 69.5 years (range, 66-73 years).^{5,6,10-14} Six studies reported sex at follow-up; there were 36 men (33.6%) and 71 women (66.4%).^{5,6,10,12-14} Four studies reported side of surgery; of 55 cases, 40 (68%) were on the dominant side, 16 (27%) were on the nondominant side, and 3 (5%) was bilateral.^{5,6,10,12} Six studies reported implant type; the Delta III Total Shoulder prosthesis

(DePuy Synthes) was used in 23.9% of the 109 cases, the Aequalis Reverse System (Tornier) in 25.7%, the Arrow prosthesis (FH Orthopedics) in 13.8%, and the Anatomical Reverse Total Shoulder prosthesis (Zimmer Biomet) in 37.0%.^{5,6,10,12-14}

Surgical Indications and Technique

All patients underwent RSA with LDTT with or without TM tendon transfer for the indications of cuff tear arthropathy and CLEER. All 7 studies assessed loss of elevation as active forward elevation of <80° or <90° and loss of external rotation as active external rotation of <0°, inability to maintain abducted arm at 0°, or external rotation lag sign of >30°. All surgeries were performed with the deltopectoral approach. Combined LD/TM tendons were transferred in 6 studies^{5,6,10,12-14} and only the LD tendon in the seventh.¹¹ Of the 6 studies that indicated tendon transfer location, 4 reported attaching to the posterolateral aspect of the greater tuberosity at the level of the original teres minor insertion^{5,6,11,12} and 2 reported attaching to the lateral aspect of the bicipital groove at the level of the LD insertion.^{10,14} Six studies reported use of a sling or brace for 6 weeks after surgery.^{5,6,10,12,14}

Outcomes

The 7 studies reported outcomes data for 116 (87%) of their 133 baseline patients (**Table 2**). Patients were followed up an FW mean of 39.9 months (range, 18-65 months). Six studies reported postoperative Constant scores; FW mean Constant score was 28.7 before surgery and 64.4

Table 2. Subjective and Objective Outcomes

Study	Year	Pre/Post Constant	Pre/Post VAS Pain	Satisfaction ^a	Pre/Post SSV	Pre/Post UCLA	Pre/Post SST	Pre/Post Pain ^b	Pre/Post Active Forward Elevation	Pre/Post Active External Rotation	Pre/Post Abduction	Pre/Post Abduction Strength, kg
Gerber et al ¹¹	2007	34/70	NR	NR	23/64	NR	0	6.1/10.9	70/148	-18/18	NR	NR
Boileau et al ⁵	2008	28/63	NR	VS = 8, S = 3	27/76	NR	0	NR	64.7/126	-8.7/27.3	NR	NR
Boileau et al ⁶	2010	27/62	NR	VS = 9, S = 8	24/71	NR	0	NR	94/139	12/19	87/145	0.25/4.12
Boughebri et al ¹⁰	2013	23.7/61.1	NR	VS = 6, S = 6, US = 2	NR	NR	1.9/7.6	NR	55/138	-16/21	45/129	NR
Ortmaier et al ¹²	2014	20.4/64.3	6.8/1.1	VS = 8, S = 3, US = 2	NR	7.9/26.4	2.3/7.9	NR	74/148	-21/13	NR	NR
Puskas et al ¹³	2014	34/66	NR	E = 23, G = 4, F = 2, P = 2	33/75	NR	0	6.3/13.1	82/138	4/27	79/137	0.4/3.2
Shi et al ¹⁴	2015	NR	8.4/1.6	NR	NR	NR/27	NR	NR	56/120	6/38	NR	NR
Total		28.7/64.4 ^c	7.8/1.4 ^c	—	28.4/72.6 ^c	7.9 ^d /26.8 ^c	2.1/7.7 ^c	6.3/12.6 ^c	71/136 ^c	-4/25 ^c	72/137 ^c	0.4/3.4 ^c

^aRatings: VS, very satisfied; S, satisfied; US, unsatisfied; E, excellent; G, good; F, fair; P, poor.

^bRated on scale ranging from 0 to 15 (no pain).

^cFrequency-weighted mean.

^dDoes not represent average, as only 1 preoperative UCLA value was reported.

Abbreviations: NR, not recorded; SST, Simple Shoulder Test; SSV, subjective shoulder value; UCLA, University of California Los Angeles; VAS, visual analog scale.

afterward ($P = .0001$).^{5,6,10-13} Four studies reported subjective shoulder values (SSVs); FW mean SSV was 28.4 before surgery and 72.6 afterward ($P = .0001$).^{5,6,11,13}

With regard to functional evaluation on physical examination, all 7 studies reported preoperative and postoperative active forward elevation and external rotation.^{5,6,10-14} Active forward elevation improved to an FW mean of 136°, from 71° ($P < .0001$), and external rotation improved to an FW mean of 25°, from -4° ($P < .0001$). Three studies reported preoperative and postoperative abduction; abduction improved to an FW mean of 137°, from 72° ($P = .003$).^{6,10,13}

Complications and Reoperations

The 7 studies reported 31 complications, for an overall complication rate of 22.8% (31/126).^{5,6,10-14} There were 9 cases of neuropraxia (7.1%), 7 infections (6.0%), 4 dislocations or subluxations (3.4%), 2 cases of aseptic loosening (1.7%), 2 deltoid separations (1.7%), 2 periprosthetic fractures (1.7%), 1 acromion fracture (0.9%), 1 hematoma (0.9%), 1

LD/TM tendon rupture (0.9%), 1 intraoperative metaphyseal fracture (0.9%), and 1 painful baseplate screw (prominent where it penetrated the scapular spine)⁷ (0.9%).

The 7 studies also reported 19 reoperations, for an overall reoperation rate of 15.1% (19/126).^{5,6,10-14} There were 4 wound revisions, 3 revision RSAs, 3 open reduction and internal fixations, 2 deltoid repairs, 2 irrigation and débridements, 1 revision to hemiarthroplasty, 1 acromioclavicular resection, 1 procedure for a shoulder dislocation, 1 cerclage wire fixation to correct an intraoperative metaphyseal fracture, and 1 procedure to burr down a protruding baseplate screw.

Discussion

RSA with LDTT improves postoperative function in patients with cuff tear arthropathy associated with profound external rotation weakness caused by loss of a functional teres minor muscle. That statement is consistent with the findings of our systematic review, as all 7 reviewed studies found functional improvements, particularly in active

external rotation (~30° improvement). In addition, there were consistent reductions in pain and improvements in forward elevation.

Our review found a mean patient age of 69.5 years, similar to the 72.7 years reported in a recent population-based study on RSA utilization.¹⁵ Likewise, our percentage of women who underwent RSA with LD TT, 66.4%, is similar to the overall rate of 63.6%.¹⁵ It appears that the RSA-with-LD TT population and the traditional RSA population are not dramatically different.

The improvements we found in subjective outcome scores and range of motion can be compared with those found in RSA-only treatment of rotator cuff tear arthropathy. Wall and colleagues¹⁶ found an approximate 44-point Constant score improvement, to 65.1 from 21.7, which is similar to our 36-point improvement for RSA with LD TT. They also found an approximate 10-point increase in pain relief; ours was about 6 points. Regarding range of motion, they found 66° improvement in active forward elevation and 2° in active external rotation, and we found 65° and 29° improvement, respectively. Thus, the outcomes of RSA with LD TT and RSA alone appear to be comparable. Simovitch and colleagues¹⁷ evaluated RSA outcomes as a function of teres minor muscle atrophy and found that, compared with patients with stage 3 or 4 fatty infiltration, patients with stage 0, 1, or 2 infiltration had significantly better ultimate Constant scores, significantly better SSVs, and significantly more preoperative-to-postoperative improvement. On average, Constant scores and SSVs increased 32% and 25%, respectively, in patients with more extensive fatty atrophy, and these patients experienced an average net loss of 7° in external rotation. It appears that, whereas RSA-with-LD TT outcomes are similar to outcomes in a nonspecific group of cuff tear arthropathy patients treated with RSA alone, adding LD TT to RSA may substantially improve outcomes in cases in which the teres minor is of poor quality.

We found no differences in implant types. However, with the exception of the Arrow prosthesis, which had 8.5 mm of lateralization, all implants had a traditional Grammont design. Greiner and colleagues² recently found a trend toward improved external rotation in lateralized RSA designs, and a statistically significant improvement in external rotation in patients with an intact teres minor. The impact of LD TT with use of a lateralized design is unknown.

Our review found a relatively high rate of complications, 22.8%, and a reoperation rate of

15.1%. These are not dramatically different from the historical rates of complications (21%) and reoperations (13.4%).¹⁸ Although RSA with LD TT appears to have a higher rate of a specific complication, nerve-related injury, this is not necessarily surprising given the proximity of the axillary and radial nerves, the operative field, and the tendons transferred. This review's rate of neuropraxia, 7.1%, is higher than the historical rate of 1.2% reported for RSA alone.¹⁸

This systematic review was limited by the quality of the studies available for inclusion. Although we followed PRISMA guidelines, none of the reviewed studies reported methods for controlling bias, confounding, and chance. In addition, the number of patients included and the relatively short follow-up period limit the impact of our findings. Finally, the individual studies used different outcome measures and did not report raw patient data, which limited our ability to perform more advanced statistical analysis.

Conclusion

This systematic review describes the demographics and outcomes of patients who underwent RSA with LD TT. Compiled data and FW means showed significant improvements in various subjective values, active forward elevation, external rotation, and abduction strength. For RSA with LD TT and RSA alone, complication rates appear comparable, but the rate of neuropraxia may be higher for the combined procedure. Although this review provides valuable information on RSA with LD TT, its lack of a control comparison group and its relatively short follow-up period limited our ability to draw meaningful conclusions about the efficacy of the combined procedure in treating rotator cuff tear arthropathy in the absence of a functional teres minor.

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