

RESEARCH ARTICLE

Latissimus Dorsi Tendon Transfer and Superior Capsular Reconstruction for Irreparable, Posterosuperior Rotator Cuff Tears

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Abstract

Background: The purpose of this study was to compare latissimus dorsi tendon transfer (LDTT) and arthroscopic superior capsular reconstruction (SCR) to determine if one is superior to the other regarding improvement in range of motion (ROM) or patient-reported outcomes (PROs).

Methods: A multicenter, retrospective cohort study was conducted on 43 patients with an irreparable, posterosuperior rotator cuff tear who underwent either LDTT or SCR. Preoperative and postoperative forward flexion and external rotation, as well as PROs including ASES, VAS, and SSV, were assessed. Student t-test and chi-square statistical analyses were performed.

Results: 16 LDTT, at mean follow-up of 18 months, and 27 SCR, at mean follow-up 15 months, were studied. Mean active forward flexion significantly improved from 85.2° to 137.6° in the SCR cohort ($P=0.001$). SCR patients demonstrated a significantly greater increase in forward flexion as compared to LDTT patients (52.4° vs 14.1°, $P=0.001$). Mean active external rotation amongst the LDTT group significantly improved from 41.7° to 61.5° ($P=0.032$). LDTT demonstrated significantly greater improvement in external rotation as compared to SCR (19.4° vs 0.8°, $P=0.011$). There were no significant differences in reported ASES, VAS, or SSV scores.

Conclusion: This study demonstrates successful clinical and patient-reported outcomes with both LDTT and SCR for irreparable, posterosuperior rotator cuff tears, with greater improvement in forward flexion with SCR and greater improvement in external rotation with LDTT.

Level of evidence: III

Keywords: Latissimus dorsi tendon transfer, Range of motion, Rotator cuff tear, Superior capsular reconstruction

Introduction

Irreparable massive rotator cuff tears are a relatively common problem, and represent a challenging clinical scenario, especially in younger patients. A massive rotator cuff tear is a tear that includes two or more of the rotator cuff tendons or, according to Cofield's definition, is greater than 5 cm in dimension (1). Left untreated, pain and loss of function may occur due to superior migration

of the humeral head and humeral head articulation with the coraco-acromial arch. These changes can subsequently lead to progressive deterioration and arthritis of the glenohumeral joint, termed rotator cuff tear arthropathy. Several options in the literature have been proposed to increase stability and function of the shoulder in attempts to avoid progression to rotator

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cuff tear arthropathy. Two proposed treatments are the latissimus dorsi tendon transfer (LDTT) and superior capsular reconstruction (SCR).

Gerber et al. first introduced the LDTT in 1988 as a technique for posterosuperior cuff insufficiency in an attempt to restore the loss of function of the supraspinatus and infraspinatus (2, 3). Good clinical and functional results were observed for this procedure which were attributed to the conversion of the latissimus into an external rotator and humeral head stabilizer, thus allowing a fulcrum for abduction by the deltoid (2-4). Since its initial conception, long term durable results have been demonstrated (5). On the other hand, SCR is a newer technique recently described by Mihata based on the biomechanical role of the superior capsule (6-11). In a cadaveric model, reconstruction of the superior capsule alone restored biomechanical stability in shoulders with irreparable rotator cuff tears, allowing a functional fulcrum for range of motion. This resulted in decreased superior translation of the humeral head, decreased subacromial contact pressures, and decreased glenohumeral joint forces (11). These basic science observations appeared to correlate with successful clinical outcomes with the earliest study reporting significantly improved functional and radiographic outcomes in patients undergoing arthroscopic SCR with fascia lata autograft (12, 13). In the United States, a dermal allograft is used rather than fascia lata autograft to avoid donor site morbidity and good early results have been shown in the literature (14, 15).

Recently, SCR has grown in popularity as a treatment for patients with massive irreparable rotator cuff tears, possibly related to a minimally invasive approach and a lower complication profile. LDTT on the other hand is a more established technique with longer-term follow up. While many small studies investigating these techniques exist, a comparison between the two has not been previously performed, to our knowledge. The purpose of this study was to compare short-term functional and patient-reported outcomes of LDTT and SCR in patients with irreparable, posterosuperior rotator cuff tears with minimal evidence of arthritis. The hypothesis was that both treatments would have similar outcomes regarding functional restoration and subjective outcomes.

Materials and Methods

A multicenter, retrospective cohort study was conducted on all patients with an irreparable, posterosuperior rotator cuff tear undergoing LDTT and SCR at two separate institutions. IRB approval (PRO16080001) was obtained. Between June 2013 and August 2017, 14 patients (16 shoulders) underwent LDTT, and 27 patients (27 shoulders) underwent SCR. The diagnosis of an irreparable rotator cuff tear was based on the history, physical examination, magnetic resonance imaging (MRI), and intraoperative findings. Eligible patients met the following inclusion criteria: progressive symptoms of pain and severe functional deficit in the shoulder; MRI proven posterosuperior rotator cuff tear with retraction of >3 cm and Goutallier

grade III or IV fatty infiltration, undergone either LDTT or SCR, and 6 month minimum follow-up (16). Patients were confirmed to have irreparable rotator cuff tears intraoperatively by the inability to repair the rotator cuff anatomically to the footprint. All patients had either undergone a previous unsuccessful rotator cuff repair or had a minimum of six months of conservative treatment. The exclusion criteria were: radiographic Hamada classification of grade 3 or higher; a history of fracture around the shoulder; clinical signs of shoulder instability, an irreparable subscapularis tear, active infection, lack of informed consent, inability to comply to postoperative restrictions, and less than 6 months of follow up (17).

Surgical Technique

LDTT was performed with an open approach with the patient in a lateral decubitus position. A posterior incision was made, the latissimus dorsi and teres major tendons were identified, and the latissimus dorsi tendon was released from its insertion on the humerus. After mobilization and taking care to protect its pedicle, the tendon was tunneled under the deltoid to the posterior greater tuberosity and stabilized with suture anchors.

SCR was performed using either a 3mm thick dermal allograft, Arthroflex (Arthrex, Naples, FL) (n=8), or a doubled porcine dermal xenograft, DX Matrix (Arthrex, Naples, FL) (n=19). Patients were placed in the beach chair position and underwent diagnostic arthroscopic evaluation of the shoulder to evaluate for arthritic changes and to confirm an irreparable posterosuperior rotator cuff tear. Subscapularis tendon repair was performed, if necessary, prior to proceeding with LDTT or SCR. After appropriate measurements were obtained to size and prepare the graft, the graft was then affixed to the glenoid medially with two SutureTak™ anchors (Arthrex, Naples, FL) using a double-pulley technique or 2.9mm knotless PushLock™ anchors (Arthrex, Naples, FL). After stabilizing the graft medially, a double row knotless technique using a SpeedBridge™ anchor system (Arthrex, Naples, FL) was utilized to secure the graft laterally onto the greater tuberosity footprint. Finally, the graft was sutured in a side-to-side technique to the teres minor or remaining infraspinatus, and any remaining medial rotator cuff tendon was secured to the glenoid suture anchors.

Outcome measures

Pre- and post-operative clinical, radiographic and functional data were collected retrospectively from the electronic medical record database. All patients underwent standardized clinical and functional outcome measures. Active range of movement was measured with a goniometer. Patient reported outcomes (PROs) were assessed using a subjective shoulder value (SSV), visual analog pain scale (VAS) at rest and during activities of daily living, and American Shoulder and Elbow Society (ASES) score. PROs were obtained either in the clinic or via phone call follow up. Statistical analysis was performed using a Student t-test for ordinal data and Chi-Square analysis for categorical data.

Results

A total of 41 patients with 43 shoulders were identified and eligible for the study (LDTT: 14 patients (9 male and 5 female), 16 shoulders, and SCR: 27 patients (19 male and 8 female), 27 shoulders). Mean age was 60 years in both LDTT and SCR groups. Mean follow-up was 18 months in LDTT group and 15 months in SCR group. No demographic differences were noted between the two cohorts regarding gender, mean age, follow-up, and laterality [Table 1]. There were significantly more patients in the LDTT group that had undergone prior rotator cuff surgery as compared to SCR (9 vs 3, respectively, $P<0.005$). There were significantly more patients in the SCR group that had concurrent subscapularis tendon repairs as compared to the LDTT group (10 vs 0, respectively, $P<0.01$).

Among the SCR group, mean active forward flexion significantly improved from 85° to 138° ($P=0.001$) [Table 2]. Mean preoperative active forward flexion in the LDTT group improved from 123° to 139°, but did not reach statistical significance ($P=0.157$). SCR patients demonstrated a significantly greater increase in forward flexion as compared to LDTT patients (52° vs 14°, $P=0.001$). Mean active external rotation amongst the LDTT group significantly improved from 42° to 62° ($P=0.032$). There was no significant difference in mean active external rotation in the SCR group (43° vs 44°, $P=0.868$). LDTT demonstrated significantly greater improvement in external rotation as compared to SCR (19° vs 1°, $P=0.011$).

At final follow-up, mean ASES score was 66 among LDTT patients as compared to 71 among SCR patients ($P=0.569$). There was also no statistical difference in mean VAS between LDTT patients and SCR patients (1.8 vs 2.3, respectively, $P=0.645$). There was a trend toward higher SSV scores in SCR patients as compared to LDTT, but not statistically significant (73 vs 55, respectively, $P=0.087$).

No major complications were found in the SCR group.

Table 1. Patient demographics

	LDTT	SCR	<i>p value</i>
Total patients	14	27	
Total shoulders	16	27	
Gender			$P=0.75$
Male	10	19	
Female	6	8	
Mean Age (years)	59.9	60	$P=0.98$
Mean Follow Up (months)	17.9	14.9	$P=0.53$
Laterality			$P=0.25$
Right	12	17	
Left	4	10	
Prior Surgery	9	3	$P<0.005$
Subscapularis Tear	0	10	$P<0.01$

Table 2. Changes in Range of Motion

Motion	LDTT	SCR	<i>P value</i>
Forward Flexion (degrees)			
Preop	123.3°	85.2°	
Postop	139.4°	137.6°	
Mean Improvement	14°	52.4°	$P=0.035$
External Rotation (degrees)			
Preop	41.7°	43.4°	
Postop	61.5°	44.2°	
Mean Improvement	19.4°	0.8°	$P=0.011$

One shoulder in the LDTT group experienced a deep infection requiring surgical debridement without taking the transfer down. 6 weeks of intravenous antibiotics were administered and the infection cleared.

Discussion

The major finding of this study was that both LDTT and SCR produce good, early clinical and patient-reported outcomes for irreparable, posterosuperior rotator cuff tears, but SCR results in better improvements in active forward flexion, and LDTT results in better improvement in active external rotation.

Limited surgical options exist for irreparable rotator cuff tears in young patients. LDTT is a well-established surgical procedure for this condition. This transfer provides a strong, vascularized tendon, which may close the cuff defect, act as a humeral head depressor, or improve function by restoring external rotation. The first reported study by Gerber et al. demonstrated good clinical results with improvement in age-adapted Constant scores in 16 patients with 33-month follow-up. (3) In 2006, similar results were published in 69 patients with an average follow up of 53 weeks (4). Gerber et al. subsequently published their long term follow up of 46 shoulders at 10 years, and reported statistically significant improvements in the SSV (29 preoperatively to 70 at final follow-up, $P<0.0001$), Constant score, pain scores, and functional outcomes including forward flexion (118° to 132°), abduction (112° to 123°), and external rotation (18° to 33°). We found comparable improvements in our cohort in improvements in forward flexion (123° to 139°) and external rotation (42° to 62°), although our cohort started with greater external rotation and thus reached greater final external rotation. Our study had slightly lower final SSV scores (mean 55), but our results are early, and patients may continue to improve subjectively at further follow-up. In addition, Gerber et al. found inferior results in patients with subscapularis insufficiency (5). Our LDTT group did not include any patients with subscapularis insufficiency as LDTT was not offered to patients with subscapularis tears because of this association with worse outcomes.

Recently, newer techniques for LDTT include

arthroscopic assistance, which potentially minimizes the trauma to the overlying deltoid muscle (18-22). Grimberg et al. prospectively followed 55 patients with irreparable massive rotator cuff tears who underwent arthroscopic-assisted LDTT with a mean of 29 months (21). They reported an improvement in the SSV (26 to 71), Constant score, and pain scores, as well as improvement in active forward flexion (134° to 157°), abduction (67° to 93°), and external rotation (29° to 42°). Notably four patients had tendon rupture at 1 year. Kanatli et al. also presented 15 patients who underwent arthroscopic-assisted LDTT with a mean follow up of 26 months (22). They described an open harvest of the tendon through the posterior axillary fold, reinforced with a fascia lata autograft, and fixated arthroscopically with suture anchors. These authors found improvements in University of California – Los Angeles (UCLA) shoulder score, Constant-Murley score, and VAS. Active ROM including forward flexion (58° to 130°), abduction (51° to 130°), and external rotation (13° to 32°) all improved significantly. They also noted a significant improvement in the acromiohumeral distance and no significant complications developed. Studies of both open and arthroscopic-assisted LDTT appear to be consistent with our findings regarding improved clinical and patient-reported outcomes following LDTT in this challenging population, and in particular, improvement in active external rotation.

Possibly as a result of a lower complication profile and a minimally invasive technique, SCR has gained significant popularity over the past several years. Biomechanical testing has demonstrated that loss of the superior capsule results in significant glenohumeral translation in all directions and increased subacromial contact pressures compared to those with an intact capsule (10). Reconstruction of the superior capsule can restore superior translation in cadaveric models, which allows the larger muscles surrounding the capsule and rotator cuff, such as the deltoid, to contribute to greater function from an improved fulcrum (11). Clinically, Mihata and colleagues reported 23 patients who underwent SCR with fascia lata autograft with 2-year follow up (13). They found improvement in the ASES score from 23.5 preoperatively to 92.9 postoperatively, as well as a significant improvement in muscle strength. Additionally, acromiohumeral distance improved by 4.1 mm after surgery with no cases of progression to osteoarthritis or rotator cuff muscle atrophy using sequential postoperative MRIs. More recently, use of human acellular dermal patch for SCR has been described in the literature and avoids donor-site morbidity (23, 24). Despite the popularity of using human acellular dermal patch, new biomechanical data appears to support the use of fascia lata allograft in terms of improved restoration of humeral translation, glenohumeral joint force, and subacromial contact pressure (25).

Denard et al. reported on 59 patients with a minimum of 1-year follow up who underwent SCR with dermal allograft for irreparable massive rotator cuff tear (15). Similarly, they noted improvement in forward flexion (130° to 158°), improvement in external rotation (36°

to 45°), improvement in SSV (35 to 76), as well as decreased VAS (5.8 to 1.7) and improved ASES (44 to 78) ($P < 0.001$). Postoperative MRI in 20 patients showed only 9 of the 20 demonstrated complete healing. Eleven patients (18.6%) required revision procedures, including 7 reverse total shoulder arthroplasties. Pennington et al. reported on 88 shoulders treated with SCR using a dermal allograft with a minimum of 12 month follow up (14). They reported similar improvements in VAS and ASES scores at one-year, improved acromiohumeral interval, and increased strength and range of motion including forward flexion (120° to 160°) and abduction (103° to 159°). Similar results with SCR were seen in the present study regarding improvements in functional and subjective outcomes, and in particular, improvement in active forward elevation. This study showed comparable good improvement in forward flexion (85° to 137°), but starting from slightly lower preoperative forward flexion. Postoperative ASES score of 71 in the present study was also similar. Improvement in external rotation, as seen in the Denard et al. study, was not observed, but the other published series were also not able to show that improvement in external rotation (15).

While both LDTT and SCR have good support in the literature for the treatment of massive, irreparable posterosuperior rotator cuff tears in patients with minimal arthritis, the present study is, to our knowledge, the first to compare the two treatments. The two treatment groups in this study were similar in terms of gender, laterality, and age, but more patients had undergone prior rotator cuff surgery in the LDTT group, and more patients in the SCR had concomitant subscapularis tendon repairs. SCR resulted in significantly greater improvement in forward flexion as compared to LDTT (52° vs 14°, $P = 0.001$). It is important to recognize that LDTT patients started with a mean forward flexion of 123°, whereas SCR patients had mean 85° forward flexion. Nonetheless, the findings of our paper are consistent with those reported in the literature for both LDTT and SCR. Conversely, external rotation improved to a greater degree in the LDTT cohort, as compared to the SCR cohort (19° vs 1°, $P = 0.011$). This could be expected as LDTT converts the latissimus to an external rotator, and SCR is intended to be a more static stabilizer of the humeral head.

Good postoperative PROs, including ASES, SSV, and VAS, were reported in both treatment cohorts, with no significant difference between groups. Additionally, there was a low complication rate. Only 1 out of 43 shoulders suffered from a major surgical complication; a deep infection after LDTT which required surgical debridement and long-term intravenous antibiotics.

This study has several weaknesses. Preoperative patient-reported outcomes were not collected, limiting the ability to note improvements in these scores over time in the two cohorts. We believe that all patients had similar poor preoperative measures given the inclusion criteria for the study including, failed prior surgery or failure of 6 months of conservative care, massive tear, Goutallier grade III or IV, and poor preoperative range of motion. The good postoperative patient-reported outcomes measures obtained were consistent with the

literature. There were differences between groups with more subscapularis repairs in the SCR group, and more prior rotator cuff repair surgeries in the LDTT as was previously noted. Additionally, LDTT patients had greater preoperative forward flexion, thus statistically limiting their ability to improve as much as the SCR group. As long as the surgeon recognizes these preoperative differences, the results of this study, which show SCR improves forward flexion better and LDTT improves external rotation better, are important to consider when preoperatively counseling patients. Future randomized trials, specifying patients with similar preoperative measures in both cohorts, could more definitively define the treatment differences. Lastly, the follow up was short term with mean follow up of 18 months in the LDTT group and 15 months in the SCR group. This study reported early results and a reasonable time period to achieve substantial improvements. Further studies will be needed to determine long term comparative outcomes.

Although both SCR and LDTT demonstrated successful clinical and patient-reported outcomes for irreparable, posterolateral rotator cuff tears, SCR provided greater improvement in forward flexion and LDTT provided greater improvement in external rotation. These findings can be used to guide treatment based on preoperative range of motion and postoperative goals or expectations. Further studies with larger cohorts in a randomized fashion will be necessary to clarify if one technique is truly superior to the other, or whether one treatment may be more optimal in certain circumstances.

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