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Achilles tendon allograft-augmented latissimus dorsi tendon transfer for the treatment of massive irreparable posterosuperior rotator cuff tears

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Abstract

Introduction The purpose of this study was to investigate clinical outcomes following Achilles tendon allograft-augmented latissimus dorsi tendon transfer (LDTT) for the treatment of irreparable posterosuperior rotator cuff tears with a minimum of 2 years post-operative follow-up. We hypothesized that patients would show significant improvement in outcomes scores with a low failure rate.

Materials and methods Patients who were treated with Achilles tendon allograft-augmented LDTT for irreparable posterosuperior rotator cuff tears with a minimum follow-up of 2 years were included. Patient-reported outcomes scores, including ASES, QuickDASH, SANE, SF-12 PCS, and satisfaction, were collected pre- and post-operatively. Pre- and post-operative scores were compared with a Wilcoxon test. Revision to reverse total shoulder arthroplasty (RTSA) was considered as failure.

Results Between March 2006 and November 2014, a total of 16 patients with a mean age of 49 years (range 34–57 years) were included. Minimum 2-year outcomes data were available for 14 of the 16 patients (87.5%) with a mean follow-up of 5.5 years (range 2.1–10.5 years). Two patients (12.5%) advanced to RTSA at a mean of 1.1 years following LDTT. Post-operative median subjective outcomes scores improved, but did not reach statistical significance (SF-12 PCS: 35.4–46.4, $P=0.182$; ASES: 47.5–69.9, $P=0.209$; QuickDASH: 57.9–31.8, $P=0.176$; SANE: 40.0–39.5, $P=0.273$). Median post-operative patient satisfaction was 5 on a 10-point scale (range 1–10).

Conclusion Patients with irreparable rotator cuff tears treated with Achilles tendon allograft-augmented latissimus dorsi tendon transfer did not experience significant post-operative improvement in patient-reported outcomes. Thus, the use of an additional allograft-augmentation remains questionable.

Level of evidence Retrospective case series, level IV.

Keywords Rotator cuff · Latissimus dorsi · Tendon transfer · Irreparable tear

Introduction

Massive rotator cuff tears in patients under the age of 60 years create a significant treatment challenge. When irreparable, multiple factors determine which treatment options to pursue, including the size of the tear, tissue quality and mobility, age, and functional demands of the patient [2, 6, 9]. Specifically, when a functionally impairing, massive, irreparable posterosuperior rotator cuff tear is diagnosed in young patients before the development of glenohumeral osteoarthritis, latissimus dorsi tendon transfers (LDTT) have been considered as a reliable treatment option [5].

Classically, LDTTs typically involve direct transfer of the tendon-muscle unit from the mid-bicipital groove anteriorly to the bony surface of the greater tuberosity postero-superiorly to close the cuff defect and act as an external rotator and humeral head depressor [1, 12]. However, despite extensive soft tissue releases, the natural tendon length can be insufficient to produce an optimal result [12]. Augmenting the muscle–tendon unit with an allograft patch increases the muscle excursion size and length. This augmentation

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reduces the tension on the muscle–tendon unit, thereby theoretically reducing the risk of early post-operative failure [12]. Additionally, closing the cuff defect with a larger structure dissipates repair site forces more effectively and provides a greater surface area for bone–tendon healing [3]. However, this technique has not been widely adopted, and the potential role of graft augmentation in this procedure remains unclear.

Therefore, the purpose of this study was to investigate patient-reported clinical outcomes following Achilles tendon allograft-augmented LDTT for the treatment of irreparable posterosuperior rotator cuff tears with a minimum of 2 years post-operative follow-up. We hypothesized this alternative LDTT procedure would produce significantly improved outcomes compared to preoperative scores and a low rate of postoperative failure.

Methods

Study population

This was an Institutional Review Board-approved level IV retrospective outcomes study (Approval Number: 2002-03) with prospectively collected data. Review of a single surgeon's series (PJM) was performed to identify all patients who underwent augmented LDTT for the treatment of massive irreparable posterosuperior rotator cuff tear and were at least 2 years out from surgery. Patients were excluded if they were non-English speaking and thus unable to complete valid outcomes forms, or underwent a concomitant and potentially confounding reconstructive procedure at the time of index surgery.

Subjective evaluations were obtained with the American Shoulder and Elbow Surgeons (ASES), Quick Disabilities of the Arm, Shoulder and Hand (QuickDASH), Single Assessment Numeric Evaluation (SANE), Short-Form 12 Physical Component Summary (SF-12 PCS), and satisfaction scores (10-point scale) pre-operatively and at minimum 2 years post-operatively. The ASES score was the primary outcome measure of interest, and a minimal clinically important difference on this scale is reported to be 12 points [13]. Failures were defined as those patients who progressed to reverse total shoulder arthroplasty (RTSA). The pre-operative cuff arthropathy grade, as classified by Hamada et al. [8] was also determined on preoperative radiographic imaging and magnetic resonance imaging.

Surgical technique

All surgeries were performed by the senior surgeon (PJM), who generally uses allograft augmentation when performing a LDTT. All procedures were performed with the patient under general anesthesia and in the beach chair position, as in the senior author's opinion it is less technically challenging to tension the graft/tendon-complex in the beach chair position compared to the lateral decubitus position. In all cases, a diagnostic arthroscopy with an initial attempt at rotator cuff repair was performed. Following arthroscopic confirmation of an irreparable tear (meaning that the torn tendon could not be re-fixated in full extension at the greater tuberosity—no partial repairs were performed), LDTT was performed. Initially, the arm was abducted, and a curvilinear incision was made posteriorly and laterally following the lateral border of the latissimus dorsi muscle belly. Next, the tendon was harvested at the humeral insertion site once adequate exposure was achieved (Fig. 1). The neurovascular pedicle of the latissimus dorsi muscle belly was identified and protected. The length of the latissimus dorsi tendon was assessed. Augmentation of the latissimus dorsi tendon with an Achilles tendon allograft was performed (Fig. 2) if the tendon's natural length was insufficient to provide an optimal length-tension relationship or if coverage of the cuff defect was inadequate. The allograft was fixed to the distal tendon using multiple whip-stitches of non-absorbable suture. The graft length to achieve ideal length–tension relationship mainly depended on the intra-operatively measured gap between the latissimus dorsi tendon and greater tuberosity which was typically about 10–15 cm. A soft tissue

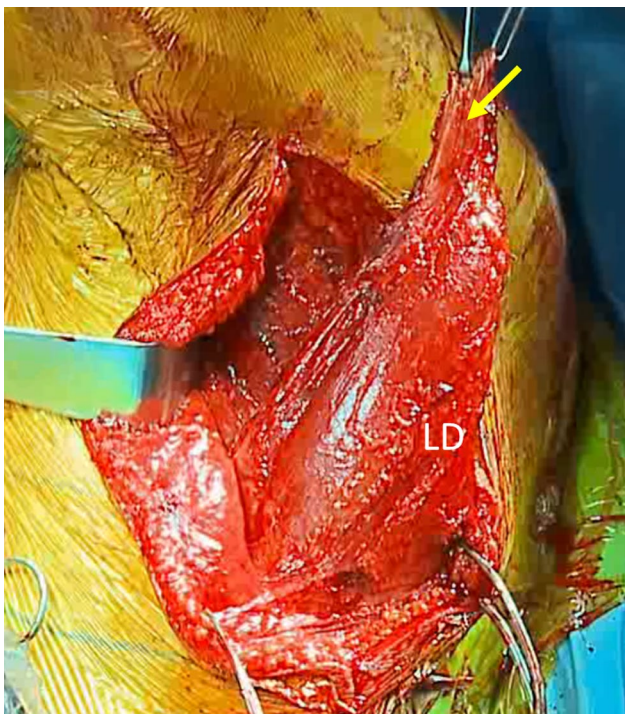

Fig. 1 Operative view of a posterolateral left shoulder. The latissimus dorsi tendon (arrow) has been harvested at the humeral insertion site following adequate exposure. *LD* latissimus dorsi muscle belly

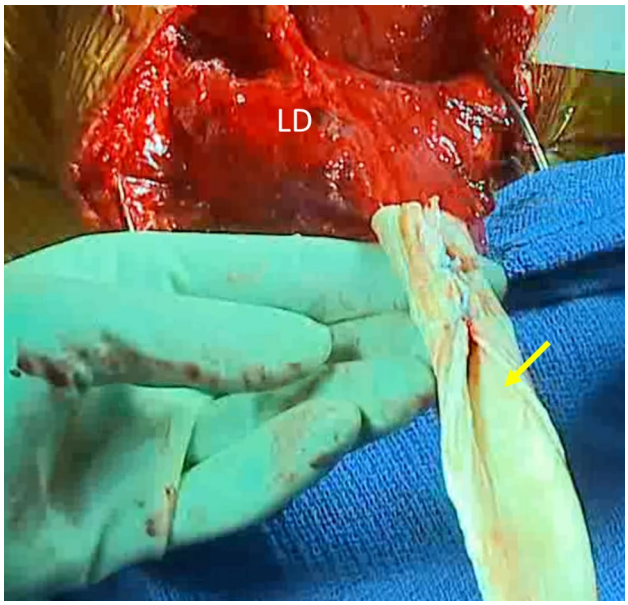

Fig. 2 Operative view of a posterolateral left shoulder. The latissimus dorsi tendon is augmented with Achilles tendon allograft (arrow). The allograft is fixed to the distal tendon using multiple whip-stitches of non-absorbable suture. *LD* latissimus dorsi muscle belly

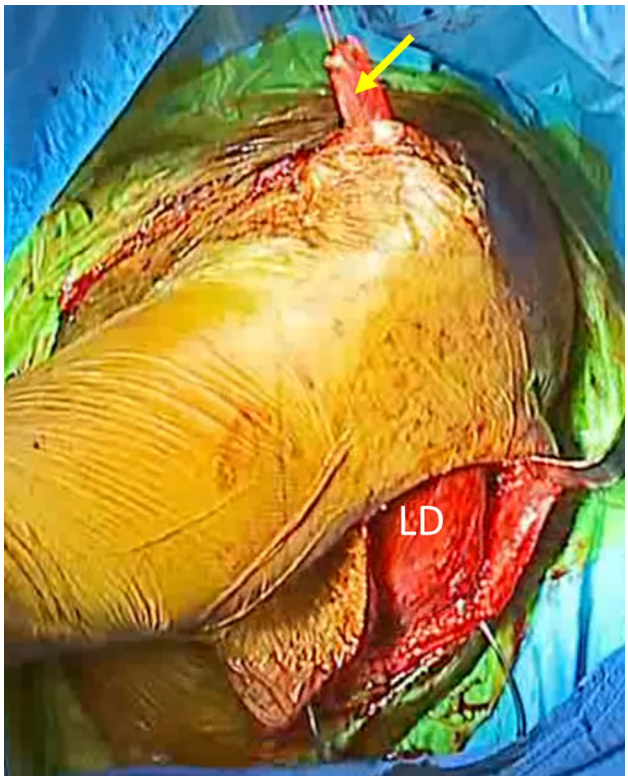

Fig. 3 Operative view of a left shoulder. The Achilles-tendon allograft augmented latissimus dorsi tendon (arrow) is shuttled through the soft tissue tunnel to reach the lateral aspect of the greater tuberosity. *LD* latissimus dorsi muscle belly

tunnel inferior to the deltoid and posterior to the teres minor was created and dilated. The arm was then placed into 30° of abduction, 30° of forward flexion, and 30° of external rotation. The augmented tendon was then shuttled through the tunnel (Fig. 3) and placed on the lateral aspect of the greater tuberosity to create an external rotation moment arm, thereby restoring the function of the posterior rotator cuff. Finally, eight suture anchors were used to fix the allograft in a linked double-row construct.

Immediately following surgery, patients were strictly immobilized in an abduction pillow for 6 weeks. The rehabilitation goals of these first 6 weeks included protecting the surgical repair, minimizing pain and inflammation, and maintaining mobility of accessory joints. After 6 weeks, the patient was cleared by the senior surgeon to begin full passive range of motion as well as active range of motion of the glenohumeral joint. A biofeedback program was initiated, teaching the patient how to activate the latissimus dorsi muscle for forward flexion and external rotation of the shoulder. The muscular strength phase was generally introduced at 10–12 weeks postoperatively. After 3 months, focus turned to building strength and progressing endurance with daily activities as well as work and recreational activities.

Statistical analysis

All statistical analyses were performed using SPSS version 11.0 (SPSS, Chicago, IL, USA). Because of the limited number of patients included, a formal post hoc power analysis was not appropriate. In this data set, a Kolmogorov–Smirnov test was performed which confirmed that continuous variables were non-normally distributed. The pre- and postoperative outcome scores of the study population were compared with a Wilcoxon signed-rank test. Due to the data's non-parametric distribution, all results were presented as median and range unless otherwise stated. The level of significance was set at $P < 0.05$.

Results

Between March 2006 and November 2014, the senior surgeon (PJM) performed augmented LDTT on 20 patients (Fig. 4). Two patients refused to participate, one was excluded due to being non-English speaking and thus unable to complete the outcomes survey, and one was excluded due to concomitant reconstructive procedure at the time of index surgery (stabilization of a meso-type os acromiale). This left a final study population of 16 patients. Median pre-operative cuff arthropathy grade, as classified by Hamada et al. [8], was grade II (range, grade I–IVa). Further patient demographics are listed in Table 1. Post-operative surveys were

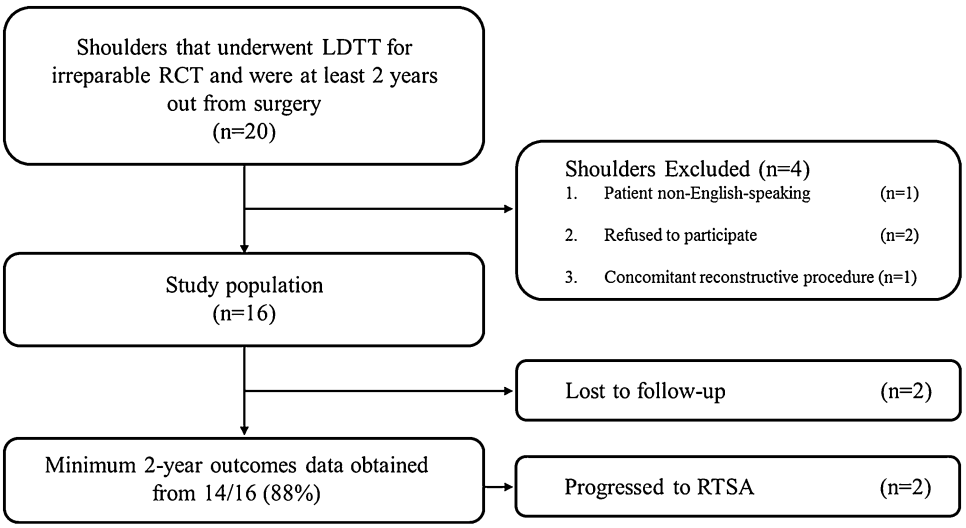

Fig. 4 Flow chart visualizing the patient population for this study after accounting for inclusions, exclusions, clinical failures, and those lost to follow-up. Patients progressing to RTSA were defined as clinical failures. *LDTT* latissimus dorsi tendon transfer, *RCT* rotator cuff tear, *RTSA* reverse total shoulder arthroplasty

Table 1 Study population demographics

Demographics	Study population ($n=16$)
Age at surgery	49 years (range 26–57)
Sex	10 M, 6 F
Workman's compensation	10 (62%)
Prior primary rotator cuff repair	14 (87.5%)
Follow-up	5.5 years (range 2.1–10.5)

Continuous data presented as mean (range)

M male, *F* female

obtained for 14 out of 16 patients (87.5%) with at a mean follow-up of 5.5 years (range 2.1–10.5 years).

Two patients failed and progressed to RTSA at mean 1.1 years following LDTT due to progressive pain and loss of function. Notably, these patients did complete outcome surveys following RTSA, and their data was included in final data analysis. In the total study population, while there was some modest improvement in the median pre- versus post-operative outcomes scores, these differences did not reach statistical significance (Table 2; Fig. 5). However, the

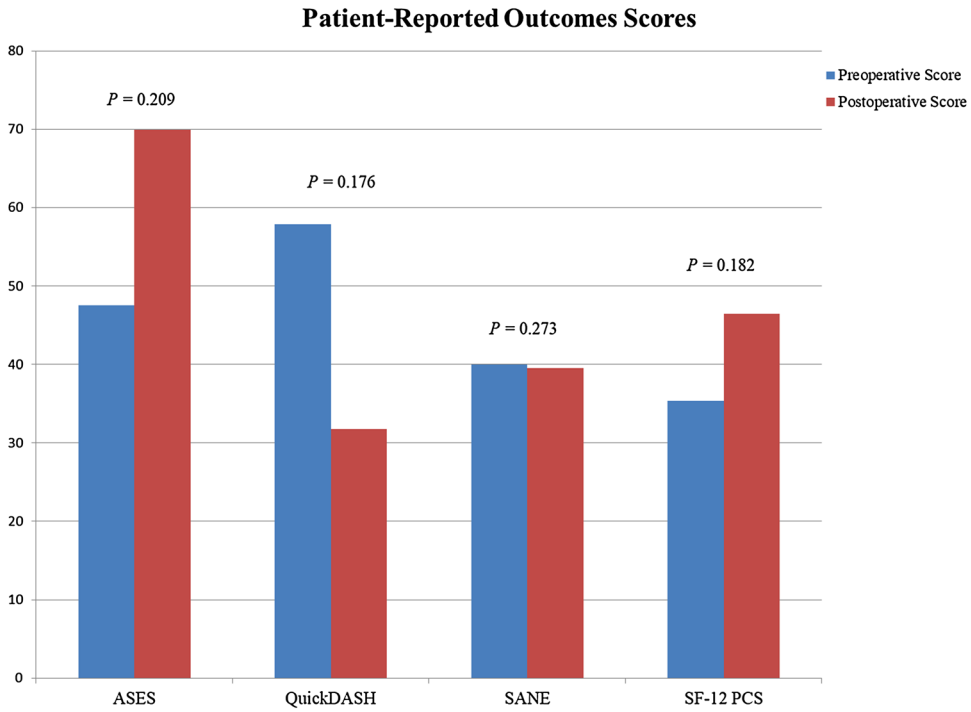

Fig. 5 Chart demonstrating pre- versus post-operative patient-reported outcomes scores

Table 2 Pre- versus post-operative outcomes scores of the study population

Outcomes scores	Pre-operative score	Post-operative score	*P* value
ASES	47.5 (20–75)	69.9 (7–90)	0.209
QuickDASH	57.9 (22.7–81.8)	31.8 (4.5–91)	0.176
SANE	40.0 (15–50)	39.5 (0–98)	0.273
SF-12 PCS	35.4 (27.8–58.7)	46.4 (24.0-60.5)	0.182
Satisfaction	–	5 (1–10)	–

Continuous data presented as median (range)

ASES American Shoulder and Elbow Surgeons Score, *QuickDASH* Quick Disability of the Arm, Shoulder, and Hand, *SANE* Single Assessment Numeric Evaluation, *SF-12 PCS* Short Form 12 Physical Component Summary

median ASES score did improve by 22.4 points, surpassing the minimally clinically significant threshold of 12 points [13].

Discussion

The most important finding of this study is that Achilles tendon allograft-augmented LDTTs for massive, irreparable rotator cuff tears yield improvements in patient-reported outcomes. However, as the median ASES score at final follow up only increased from 47.5 to 69.9 points and did not reach statistical significance, our hypothesis was rejected. Moreover, a total of two (12.5%) patients progressed to RTSA at a mean of 1.1 years.

Augmenting the latissimus dorsi tendon can increase the muscle excursion size, and the increased length can hypothetically reduce the tension on the muscle–tendon unit and, therefore, the risk of early post-operative failure. While allograft-augmented LDTT for length-tension optimization could be of value, our study failed to show significant post-operative improvements in patient-reported outcomes. However, the median improvement of 22.4 points in the ASES score surpassed the minimally clinically significant threshold of 12 points, indicating that the majority of patients still felt a postoperative improvement in function and pain. The threshold of statistical significance may not have been reached due to the large variability in outcomes seen in our study. In fact, several factors may have adversely influenced the postoperative outcomes in our patient population. First, nearly all our patients (87.5%) underwent at least one prior rotator cuff surgery, thus making the LDTT a "revision procedure", which is known to adversely impact outcomes [14]. Moreover, 62% of our patients had an on-going workers' compensation claim, which is also known to be a risk factor for lower outcomes and might have adversely influenced our results [7].

In general, our results are similar to the clinical outcomes of LDTTs without augmentation, which have reported a significant reduction in pain and improvement in function. El-Azab et al. [1] recently evaluated the long-term outcomes of 93 shoulders at a mean follow-up of 9.3 years. The authors reported a nearly identical mean post-operative ASES score (70 points) to that in our study. In addition, they showed improvements in relative Constant score (44–71%) and mean visual analog scale (VAS) scores (7.8–2.4). That study also reported a similar clinical failure rate (10%) and progression to shoulder arthroplasty (4%) rates to those noted in our study. Furthermore, a systematic review by Namdari et al. [10] analyzed ten studies between 1992 and 2010 to determine the expected outcomes, predictive factors for success, and complications of LDTTs. The patients in this review showed a significant improvement from pre- (45.9) to post-operative (73.2) frequency-weighted mean adjusted Constant scores ($P < 0.001$). Furthermore, two studies have reported long-term clinical outcomes following LDTT using an open approach. Gerber et al. [4] reported on 46 shoulders with a minimum follow-up of 10 years. There were significant improvements in the relative constant score from 56 to 80%, subjective shoulder value from 29 to 70%, and pain from 7 to 13 (15 point scale with 15 indicating no pain).

Unlike direct LDTT, the literature surrounding the use of a patch-augmented LDTT is limited. Petri et al. [11] described a technique for augmenting the latissimus dorsi tendon with a human acellular dermal allograft patch, passing the tendon underneath the deltoid and posterior to the teres minor, and repairing the native rotator cuff as much as possible. However, no results were reported. Skedros et al. [12] reported one case using a human acellular dermal allograft patch in the context of a short latissimus dorsi tendon. In this report, two 4×7 cm patches were sutured linearly to the tendon, each folded in half to double the thickness. This construct was then attached directly to the footprint of the supraspinatus, upper infraspinatus and upper subscapularis. The patient-reported shoulder function improved at 2-year follow-up with the ASES score rising from 26.6 points pre-operatively to 68.3 points with a high level of satisfaction post-operatively. Although these patients started at a lower pre-operative level than those in our cohort (median ASES value of 47.5 points), the post-operative outcome is very similar to our reported median value of 69.9 points. Despite the dearth of literature on allograft-augmented LDTT, the limited outcomes results are similar and suggest that augmentation is a viable option in cases where the native tendon is too short. Further study is clearly warranted to elucidate this clinical question, including a direct comparative study between allograft-augmented and standard LDTT, and investigation into a "minimum length" below which augmentation would be superior.

Limitations

As this is a retrospective study and these patients were selected for augmentation at the time of surgery based on their limited tendon lengths, it remains difficult to suggest whether these patients would have experienced increased or decreased outcomes with a standard LDTT. Moreover, the limited study size made our statistical analysis less robust for false-negative results (type II, or beta error). However, we are reporting a unique surgical technique that has not been widely investigated, and we believe that our results are valuable for other surgeons. Additionally, as the senior author only performed a non-augmented LDTT in an additional three patients, we do not have a suitable patient population to utilize as a comparison group for this data. Finally, we also did not collect postoperative MRI, which could have provided explanations for the low outcome scores found in this study.

Conclusion

Patients with irreparable rotator cuff tears treated with Achilles tendon allograft-augmented latissimus dorsi tendon transfer did not experience significant post-operative improvement in patient-reported outcomes. Thus, the use of an additional allograft-augmentation remains questionable.

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Compliance with ethical standards

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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