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Short-term functional, imaging, and electrodiagnostic outcomes of arthroscopy-assisted lower trapezius transfer

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Background: The purpose of this study was to evaluate the short-term functional outcomes, structural healing, and neuromuscular activity after arthroscopy-assisted lower trapezius transfer for irreparable posterior superior rotator cuff tears.

Methods: All patients who underwent arthroscopy-assisted lower trapezius tendon transfer for an irreparable posterior superior rotator cuff tear between 2017 and 2021 by 2 surgeons with a minimum of 2-year follow-up were identified. Functional outcome scores (American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form [ASES] score, visual analog scale [VAS] for pain), range of motion, shoulder strength, magnetic resonance imaging (MRI) to assess transfer healing, and needle electromyographic (EMG) examination to assess lower trapezius muscle activity were performed at a minimum of 2 years postoperatively. Contralateral nonoperative lower trapezius muscle activity was assessed by EMG. Grafts were defined as completely healed if anatomic graft healing occurred, partial healing if some graft was healed to the proximal humerus, and unhealed if no graft was attached to the proximal humerus on postoperative MRI.

Results: Twenty-four eligible patients (25 shoulders) were identified through chart review. Mean age and follow-up were 54.9 ± 9.5 and 2.9 ± 1.7 years, respectively. Overall, 72% (18/25) clinical follow-up was obtained. All functional outcomes including ASES (preoperative, 48.8 ± 19.6 ; postoperative, 80.9 ± 15.4 ; $P < .001$), VAS pain (4.9 ± 2.3 ; 1.4 ± 1.5 ; $P < .001$), and active forward flexion ($110^\circ \pm 53.2^\circ$; $141.7^\circ \pm 40.4^\circ$; $P = .024$) statistically significantly improved. Twelve shoulders (48%) presented for EMG follow-up. All 12 patients demonstrated EMG activity of the lower trapezius in forward elevation, external rotation at the side, and external rotation at 90° of abduction, which was symmetric to the contralateral shoulder. Fifteen shoulders (60%) were available for MRI follow-up. Thirteen patients (87%) demonstrated complete or partial healing of the allograft to the greater tuberosity, whereas 2 (13%) demonstrated a complete tear of the graft.

Conclusions: Arthroscopy-assisted lower trapezius transfer demonstrates improved functional outcomes 2 years postoperatively. Complete retear of the transfer is relatively uncommon (13%). The lower trapezius fired in phase in forward flexion, external rotation at the side, and external rotation in 90° of abduction in all patients who underwent EMG testing, which was consistent with the firing pattern of the contralateral normal lower trapezius muscle. These results may support the theory that active function of the muscle transfer itself, as

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opposed to a tenodesis effect, is a potential mechanism by which this procedure improves shoulder function as it consistently fires in phase.

Level of evidence: Level IV; Case Series; Treatment Study

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Keywords: Lower trapezius; tendon transfer; irreparable rotator cuff repair; electromyography (EMG); tendon healing; functional outcomes

Tendon transfers are possible treatment options for massive irreparable posterior-superior rotator cuff tears in patients without arthritis. Transfer of the latissimus dorsi tendon for irreparable rotator cuff tears was originally described by Gerber et al,^{10,11} reporting improvements in range of motion (ROM), strength, and function and showing durable improvements at a minimum of 10-year follow-up. Alternative transfers have been described including transfer of the lower trapezius, which has recently gained popularity because of its in-phase activity and improved line of pull of the transfer with the infraspinatus that may result in an easier muscle to retrain and improved functional results.^{9,17,18} Biomechanical studies have shown the benefits of lower trapezius tendon transfer in improving shoulder external rotation and abduction, with some studies supporting superiority of the lower trapezius transfer compared with a latissimus transfer with respect to restoration of normal kinematics and external rotation.^{12,16} Limitations of open transfers include requirement for larger incisions, possibly leading to increased risk for infection, and requirement for deltoid detachment in the setting of a latissimus dorsi transfer.¹¹

The arthroscopic modifications for tendon transfers have been described for both latissimus dorsi and lower trapezius allowing for smaller incisions and no deltoid detachment.^{7,19} Arthroscopy-assisted lower trapezius transfer (aLT) has demonstrated good clinical outcomes as well as improvements in external rotation and pain using typical arthroscopic methods limiting the prolonged learning curve of an arthroscopic latissimus transfer.^{1-3,5,8,19} Chopra et al⁵ reported on 19 patients after aLT with 89.5% healing. Baek et al¹⁻³ evaluated repair integrity of patients after aLT using magnetic resonance imaging (MRI) in several studies and reported healing rates ranging from 80.6% to 92.9%, showing superior clinical outcomes with both superior capsule reconstruction and latissimus dorsi tendon transfer. Neuromuscular activity has been previously evaluated by electromyography (EMG) after latissimus dorsi tendon transfer in 14 patients and reported activity of the transfer in forward elevation in only 1 (7%) patient and in external rotation in 6 (43%).¹³ No prior studies have evaluated neuromuscular activity of the lower trapezius after transfer.

The purpose of the current study was to evaluate healing rates, functional outcomes, and neuromuscular activity of the tendon transfer after arthroscopically assisted lower

trapezius tendon transfer at a minimum of 2 years post-operation. We hypothesize that aLT would demonstrate favorable outcomes, a low retear rate, and would fire in phase with active forward elevation and external rotation.

Materials and methods

Patients who underwent arthroscopy-assisted lower trapezius tendon transfer for an irreparable posterior superior rotator cuff tear between 2017 and 2021 were identified through chart review. Patients were indicated for arthroscopy-assisted lower trapezius tendon transfer if the supraspinatus and infraspinatus were considered irreparable preoperatively based on MRI findings (grade 3 or 4 Goutallier grade of the supraspinatus and/or infraspinatus, severe retraction to the level of the glenoid), if the subscapularis was intact or reparable, if radiographs revealed Hamada stage 1 or 2 changes, and the patients were not pseudo-paralytic (<45° of active forward elevation). Surgeries were performed by 2 fellowship-trained orthopedic shoulder and elbow surgeons at an academic medical center. Further demographic variables including gender, smoking status, and worker's compensation were collected. Preoperative patient-reported outcomes including the American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form (ASES) score and visual analog scale (VAS) for pain as well as ROM (forward elevation) were also collected. Preoperative external rotation at the side was collected, but because this study was performed retrospectively, the data are not complete. Preoperative MRIs were assessed for tear width, retraction, and Goutallier grade for fatty degeneration of the supraspinatus, infraspinatus, subscapularis, and teres minor.

Surgical technique

The surgical technique has been previously described by Elhassan et al.⁷ The patients were all operated in the beach chair position. In brief, the lower trapezius is first harvested. A transverse incision is made just inferior to the spine of the scapula from the medial border of the scapula extending laterally approximately 6-7 cm. The lower trapezius tendon is identified extending from about 2-3 cm lateral to the medial border of the scapula attaching to the dorsal aspect of the scapular spine to 5-6 cm lateral to the medial border of the scapula (about a 3-cm footprint).¹⁵ The tendon is sharply detached from the scapula and a No. 5 high-strength suture is placed in the tendon in a Krackow locking pattern.

The subacromial space is then entered arthroscopically using standard portals (posterior, posterolateral, lateral, anterolateral, and anterior) for surgical repair of a large rotator cuff tear. The



Figure 1 Massive irreparable supraspinatus and infraspinatus rotator cuff tear viewed from a lateral portal.

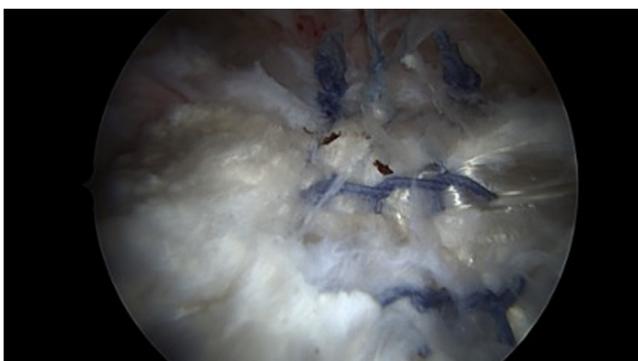


Figure 2 Arthroscopy-assisted lower trapezius transfer repaired to the anterior and posterior aspects of the greater tuberosity viewed from a lateral portal.

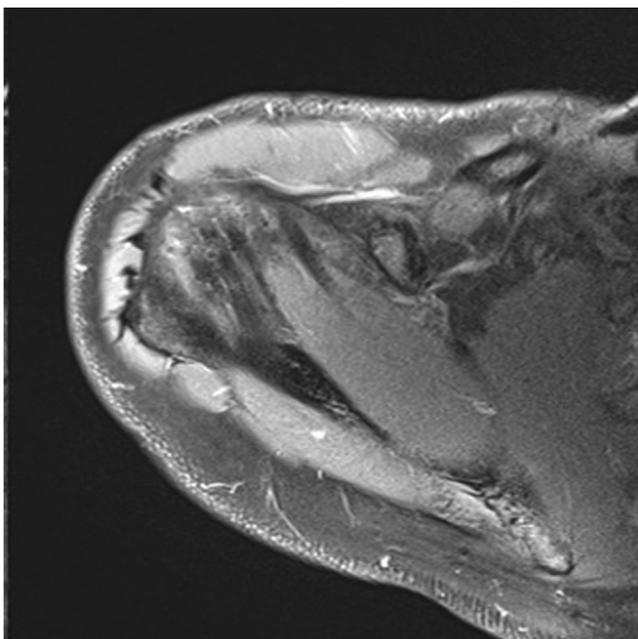


Figure 3 Magnetic resonance imaging axial view after transfer showing anatomic healing of the graft to the anterior aspect of the supraspinatus footprint.

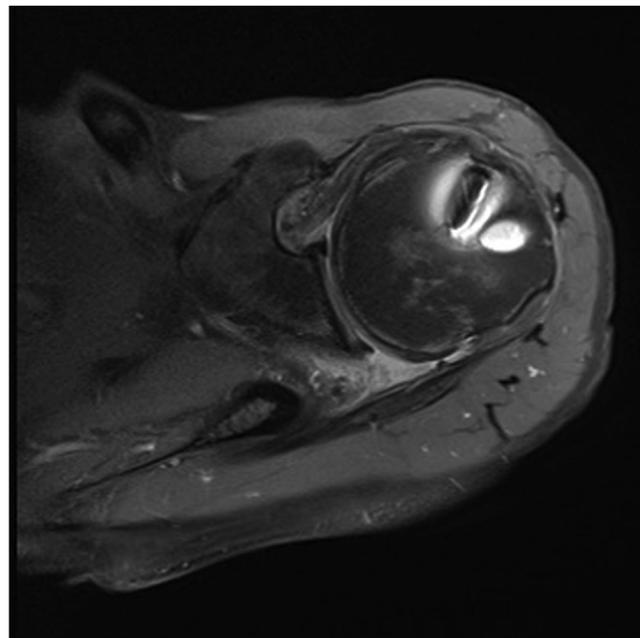


Figure 4 Magnetic resonance imaging axial view after transfer showing partial healing of the posterior aspect of the greater tuberosity at the infraspinatus footprint.

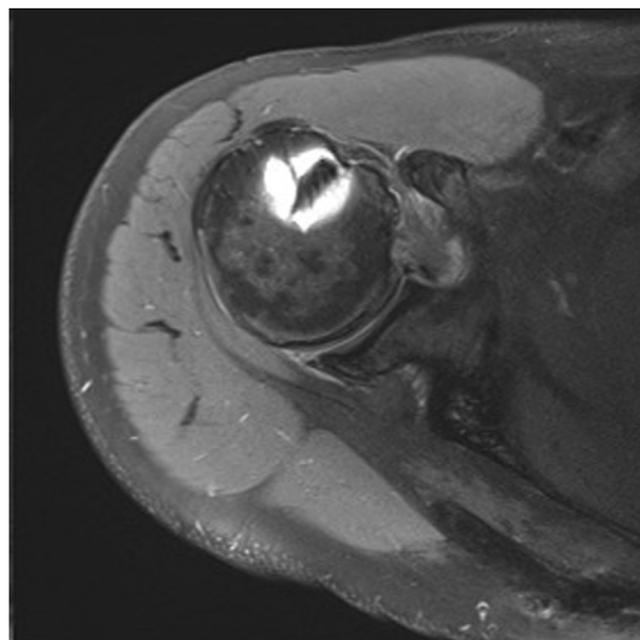


Figure 5 Magnetic resonance imaging axial view after transfer showing failure of healing, with a residual stump of the graft posteriorly not attached to the tuberosity.

residual supraspinatus and infraspinatus are mobilized, releasing the coracohumeral ligament, the capsule between the residual rotator cuff and labrum, and around the base of the spine of the scapula and determined to be irreparable. No supraspinatus or infraspinatus tendons were repaired in this series. All subscapularis tears in this series were repaired using a single anchor

Table I Overall demographic and preoperative radiographic summary (N = 18)

Parameter	Value
Age, yr, mean \pm SD	56.8 \pm 10.2
Follow-up, yr, mean \pm SD	3.5 \pm 1.2
Sex	
Male	18 (100.0)
Smoking status	
Never	12 (66.7)
Former	2 (11.1)
Current	4 (22.2)
Worker's compensation	
No	13 (72.2)
Yes	5 (27.8)
Tear width, mm, mean \pm SD	32.8 \pm 7.7
Tear retraction, mm, mean \pm SD	38.0 \pm 9.4
Supraspinatus atrophy	
Grade 0	0 (0.0)
Grade 1	0 (0.0)
Grade 2	5 (27.8)
Grade 3	9 (50.0)
Grade 4	4 (22.2)
Infraspinatus atrophy	
Grade 0	0 (0.0)
Grade 1	0 (0.0)
Grade 2	2 (11.1)
Grade 3	10 (55.6)
Grade 4	6 (33.3)
Subscapularis atrophy	
Grade 0	0 (0.0)
Grade 1	0 (0.0)
Grade 2	5 (27.8)
Grade 3	9 (50.0)
Grade 4	4 (22.2)
Teres minor atrophy	
Grade 0	0 (0.0)
Grade 1	2 (11.1)
Grade 2	2 (11.1)
Grade 3	8 (44.4)
Grade 4	6 (33.3)

SD, standard deviation.

Unless otherwise noted, values are n (%).

in the lesser tuberosity using 3 simple stitches. The greater tuberosity is lightly decorticated. The scope is placed in the lateral portal (Fig. 1). Through the posterior trapezius harvest wound, the infraspinatus fascia is opened and a large Pean clamp is placed through the fascia into the subacromial space. A passing stitch is grabbed by the Pean and retrieved out of the posterior tendon harvest wound. An Achilles tendon allograft is then prepared by removing the bone block and then placing 2 No. 2 high-strength sutures in Krackow locking pattern in the tendinous end. The graft is then passed subacromially using the passing stitch, which is placed onto the sutures in the graft. At this point, both tails of one stitch is used to repair the graft to the most anteromedial aspect of the supraspinatus footprint using a 5.5-mm SwiveLock anchor (Arthrex, Naples, FL, USA). The second stitch is then used to repair the graft to the most anterolateral aspect of the

supraspinatus footprint using a second SwiveLock anchor. A triple-loaded anchor is placed more posterior on the footprint laterally, approximately 2 cm posterior to the anterior anchors, and 3 simple stitches are passed into the graft more posteriorly and tied. Finally, if there is a residual stump of supraspinatus, 3 more No. 2 high-strength sutures are passed in a simple fashion between the supraspinatus stump and the medial aspect of the graft more posteriorly (Fig. 2).

The arm is then positioned in full external rotation and 45° of abduction. In the posterior wound, the Achilles graft is then attached to the lower trapezius tendon. A slit is made in the Achilles graft and the No. 5 stitch tails from the tendon are then brought through the slit, passed into the Achilles, and tied. Finally, multiple No. 2 high-strength sutures are used to repair the remaining graft to the lower trapezius muscle and tendon using figure-of-8 stitches.

The patient is then placed in an external rotation brace set at neutral rotation and 45° of abduction for 6 weeks and no therapy is performed during this timeframe. At 6 weeks postoperative, the patient is allowed out of the brace and is allowed 5 kg lifting at waist and below and starts passive and active assisted forward elevation and external rotation at the side with no internal rotation. At 12 weeks, the isometric and resistive strengthening is allowed along with internal rotation stretching and lifting to 10 kg at waist and below. At 4.5 months, the patient is allowed full return of activities except lifting >20 kg. At 6 months, the patient is allowed unrestricted use.

Functional outcomes and physical examination

Patients were evaluated at a minimum of 2 years postoperatively. Patient-reported outcomes collected included ASES and VAS pain. Physical examination included active forward elevation, active external rotation at 90°, and active internal rotation at 90°, which were all measured by study personnel using a goniometer. Active internal rotation at side was graded as in previous studies.⁴ Forward elevation and external rotation strength were measured using a handheld dynamometer (Model 12-0380; Lafayette Instrument Company, Lafayette, IN, USA) with the arm in 90° of scaption and the arm in neutral rotation at the side for assessing strength in forward elevation and external rotation, respectively. All clinical data were collected by a clinical research assistant not part of the surgical team.

EMG was also performed by a fellowship-trained nonoperative sports medicine or physical medicine and rehabilitation physicians, both with more than 5 years of post-training experience. EMG needles were inserted into the lower trapezius on the operative and nonoperative sides separately. The EMG was performed using ultrasonographic guidance to confirm anatomic location of needles into the lower trapezius muscle. A positive finding was considered as activation of motor units in forward elevation, external rotation at side, and external rotation at 90° of abduction.

MRI

Patients were evaluated with MRI to assess healing of the Achilles allograft to the greater tuberosity. MRIs were analyzed by a fellowship-trained musculoskeletal radiologist masked to patient outcomes. Repairs were graded as complete healing, partial

Table II Functional outcome scores

Parameter	Preoperative, mean \pm SD	Postoperative, mean \pm SD	<i>P</i> value
ASES	48.8 \pm 19.6	85.2 \pm 11.9	<.0001
VAS	4.9 \pm 2.3	1.2 \pm 1.0	<.0001
SST	n/a	89.5 \pm 17.7	n/a
SSV	n/a	82.9 \pm 22.2	n/a
Active forward elevation, degrees*	110.2 \pm 53.2	141.7 \pm 40.4	.024
Active external rotation at 90°, degrees*	n/a	70.8 \pm 25.0	n/a
Active internal rotation at 90°, degrees*	n/a	61.3 \pm 24.4	n/a
Active internal rotation*,†	n/a	5.2 \pm 0.7	n/a
Forward elevation strength, kg*	n/a	7.2 \pm 5.1	n/a
External rotation strength, kg*	n/a	6.3 \pm 5.4	n/a

ASES, American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form; VAS, visual analog scale; SST, simple shoulder test; SSV, subjective shoulder value; SD, standard deviation; LS Jxn, lumbosacral junction.

* These values include the 15 patients with physical examination follow-up.

† Internal rotation values are as follows: 1 = lateral thigh, 2 = buttock, 3 = LS Jxn, 4 = waist, 5 = T12, 6 = T7.

Table III Postoperative healing of graft at humeral insertion

Graft status	n (%)
Healed	4 (27)
Partially healed	9 (60)
Torn	2 (13)

healing, or unhealed. Complete healing included if the graft extended across the entire footprint of the greater tuberosity in the anatomic position it was repaired (Fig. 3). Partial healing was considered if any portion of the graft was in continuity with the greater tuberosity (Fig. 4). Unhealed repairs included no allograft in contact with the proximal humerus (Fig. 5).

Statistical analysis

Comparisons between preoperative and postoperative ASES scores, VAS pain, and active forward elevation were performed using Student *t* tests with a significance of .05.

Results

Twenty-eight patients (29 shoulders) who underwent arthroscopy-assisted lower trapezius tendon transfer for an irreparable posterior superior rotator cuff tear between 2017 and 2021 were identified. Four patients were excluded as 2 were revised to a reverse total shoulder arthroplasty (rTSA), 1 had a preexisting brachial plexus injury, and 1 had a preexisting spinal cord injury that limited participation. Those patients converted to rTSA did not have an MRI before conversion and had their conversion before 2 years postoperatively from the transfer; therefore, it was not possible to compare their outcomes with the remaining cohort. Overall, 7% (2/29) of shoulders were converted to RSA in the entire cohort during the study period. This left a

final cohort of 24 patients (25 shoulders), all male, with an average age of 54.9 \pm 9.5 years and a follow-up of 2.9 \pm 1.7 years. Clinical follow-up at >2 years was obtained in 72% (18/25) of patients. The cohort was mostly nonsmokers (64%), and 28% of the patients had worker's compensation. The mean preoperative tear width was 32.9 \pm 7.8 mm and tear retraction was 38.6 \pm 9.1 mm (Table I).

Sixteen of 18 patients (89%) showed significant improvements postoperatively compared with the preoperative scores (ASES: 80.9 \pm 15.4 vs. 48.8 \pm 19.6, *P* < .001; VAS pain scores: 1.4 \pm 1.5 vs. 4.9 \pm 2.3, *P* < .001; active forward elevation: 141.7 \pm 40.4 vs. 110.2 \pm 53.2, *P* = .024) (Table II). All 16 patients who had improvement in their ASES scores exceeded the minimal clinically important difference for the ASES score as determined after rotator cuff repair.⁶ External rotation at the side was available preoperatively for 14 of 18 patients (average 44°, range 10°-80°). No patients had a preoperative external rotation lag sign at the side with the inability to hold the arm to at least neutral rotation. MRI review revealed complete healing in 3 of 15 patients (20%), partial healing in 10 of 15 patients (67%), and complete retears in 2 of 15 patients (13%) (Table III). Outcomes of healed and non-healed repairs are described in Table III. With low numbers in the retear group, statistical comparisons were not performed on these groups because of such small numbers of patients in the retear cohort (Table III). MRIs were also evaluated for the status of the subscapularis tendon. Fourteen of 18 subscapularis tendons had partial or full thickness rotator cuff tears on preoperative MRIs. Of the 15 shoulders with postoperative MRIs, 13 had subscapularis tears that underwent repair. Ten of those 13 subscapularis tears healed on postoperative MRIs, with 3 of 12 having a full-thickness retear. Again, because of the low numbers in the retear cohort, statistical analyses were not performed. Twelve shoulders (48%) presented for

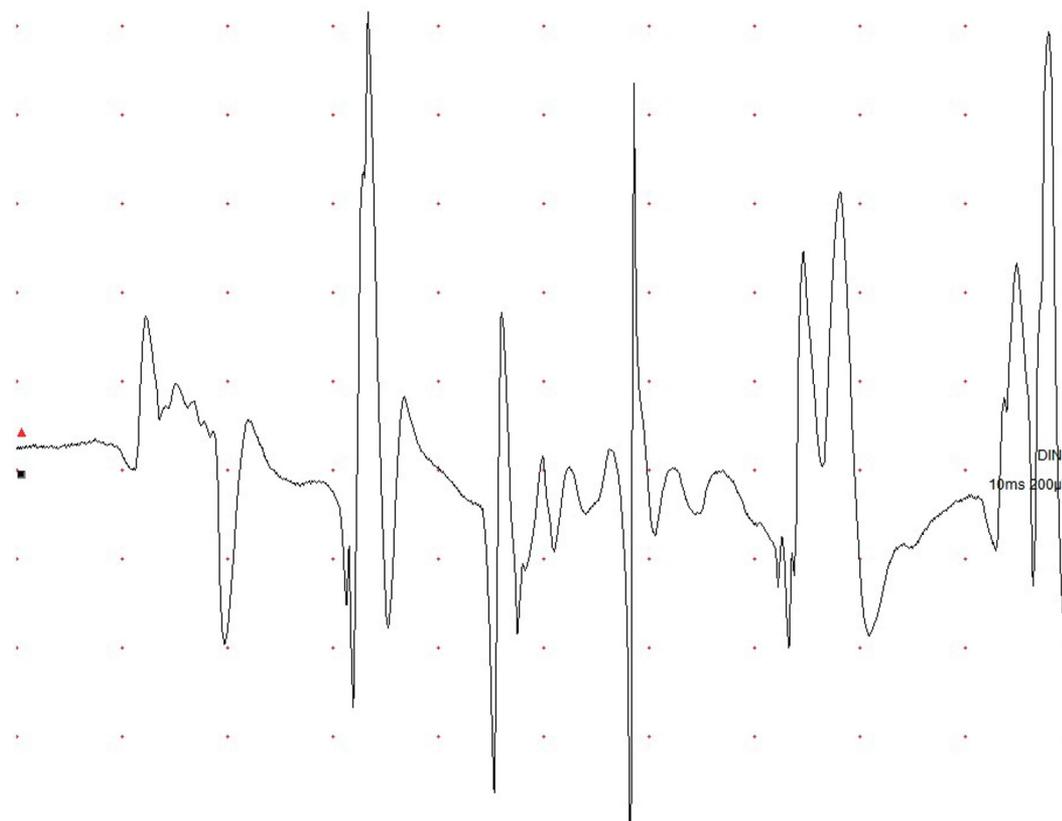


Figure 6 Electromyographic activity of the lower trapezius muscle on the operative side during forward elevation of the shoulder.

EMG follow-up. All 12 patients demonstrated EMG activity of the lower trapezius on both sides in forward elevation, external rotation at the side, and external rotation at 90° of abduction (Figs. 6 and 7).

Discussion

In this study, we sought to further characterize the healing rates of aLT at the greater tuberosity, evaluate functional outcomes, and assess the neuromuscular firing pattern of the lower trapezius at a minimum of 2 years postoperation. We found that aLT demonstrates improved functional outcomes at 2 years and a low rate of complete retears. Most important, the study supports that the lower trapezius fires in phase in all patients, symmetric to the contralateral lower trapezius, which is different from previously reported results of latissimus dorsi tendon transfers for irreparable posterosuperior rotator cuff tears that showed low rates of in-phase firing.¹³ The current data would support the lower trapezius as an alternative rather than the latissimus dorsi for muscle transfer because of its consistent in-phase firing.

Functional outcomes including ASES scores, VAS pain, and active forward elevation improved significantly from pre- to postoperation. The patients in the current series had improvement in ASES scores by >30 points and drop in

VAS pain scores by >3 points. These findings are almost identical to those of Baek et al,¹ who reported a 26-point improvement in ASES scores and a 3-point improvement in VAS pain scores. The postoperative ROM in the current study was also similar to other reports. Elhassan et al reported 133° forward elevation at a 14-month follow-up compared with our values of 141° forward elevation.⁸ At a 4.9-year follow-up, Baek et al¹ reported forward elevation of 160° and external rotation at 90° of abduction of 69°, which are similar to our reported outcomes of 141° forward elevation and 70° external rotation at 90° of abduction. Additionally, our data support that aLT provides external rotation strength (in addition to active ROM) at 2 years postoperatively, as patients demonstrated a mean of 6.3 ± 5 kg on external rotation strength testing. Normal external rotation strength at the side in a middle-aged man with an intact rotator cuff is 11 kg; therefore, patients after aLT still have only about 60% of normal external rotation strength.¹⁴ Interestingly, despite 78% of patients in the current series having high-grade fatty degeneration of the teres minor (Table I), lower trapezius transfer still provided consistent improvement, which is in contrast to clinical results of latissimus dorsi tendon transfer for posterosuperior rotator cuff tears.⁹ Collectively, these data support that patients obtain good functional outcomes, active ROM, and strength at 2 years postoperatively after aLT.



Figure 7 Electromyographic activity of the lower trapezius muscle on the nonoperative side during forward elevation of the shoulder.

On imaging review, our cohort demonstrated a 13.3% complete retear rate at the greater tuberosity. Baek et al¹⁻³ reported retear rates ranging from 7.1% to 19.4% in patients with minimum 2-year MRI follow-up, which is comparable to our results. Interestingly, the few patients in our cohort who were found to have a full-thickness complete tear of the graft from the greater tuberosity demonstrated excellent functional outcomes, ROM, and strength. This finding is similar to the that of Baek et al,¹ who found no significant differences in forward elevation, internal rotation, or functional outcomes between those with a retear and those whose tears healed. With small numbers in our current study, we are not able to draw conclusions regarding any differences in groups who retear and those who healed although, in general, both groups performed similarly.

An additional finding of the MRI review was that only 20% of cases had anatomic healing of the graft in the position the graft was repaired to the proximal humerus extending all the way across to the greater tuberosity footprint. Overall, 67% of the cases had only partial healing, with only some graft attached to the posterior aspect of the proximal humerus. One explanation of this finding is that the tissue attached superiorly to the tuberosity resorbs

over time and has no significant impact on the functional outcome of the procedure. Another explanation is that posterior healing of the residual rotator cuff soft tissue is more reliable. As a result, fixation of the graft more posteriorly needs to be investigated as it likely will provide a similar clinical result with fewer anchors and greater operative ease.

The most important finding of the current study is that that all 12 patients who underwent EMG testing at 2 years postoperatively (100%) demonstrated neuromuscular activity of the lower trapezius in forward elevation, external rotation at the side, and external rotation at 90° of abduction. This firing pattern was also symmetric to the opposite intact lower trapezius. These findings are different from those of the function of the latissimus dorsi tendon after transfer. Iannotti et al¹³ found only 1 of 14 firing in phase with forward elevation and 6 of 14 firing in phase with external rotation after latissimus dorsi tendon transfer. These findings have several implications. First, unlike the latissimus dorsi, the lower trapezius most likely acts as a functional unit as opposed to a simply creating a tenodesis effect. Second, no specific therapy was performed in these patients despite a typical rotator cuff repair protocol; consequently, the muscle did not require specialized

“retraining” through biofeedback, which is often the case after latissimus dorsi transfer. Finally, even if only partial healing occurs or in spite of no healing, the lower trapezius still fires in phase. Consequently, fascial attachments of the allograft to the remaining soft tissues attached to the proximal humerus may provide some function without anatomic healing of the graft. In general, the current study supports that the lower trapezius was firing in phase with active motion of the arm, even at 2 years postoperation. These results thus further bolster the muscle transfer itself as the main mechanism by which this procedure improves shoulder function.

Our study is not without limitations. First, this study is retrospective. Second, our results may not be generalizable as this is a single-center study. Third, given our small sample size, results may be prone to type II error, specifically when assessing the outcomes of those with healed vs. retears of the graft at the greater tuberosity. Despite our relatively small sample size and follow-up, our data are comprehensive as we did obtain multiple functional outcome measures, ROM assessment with a goniometer, strength testing, MRI, as well as EMG testing on patients. As a result, these data do support that at 2 years postoperatively, patients do experience significant improvement in functional outcomes, have low rates of complete retears of the transfer, and fire the lower trapezius in phase with active ROM. Fourth, we were only able to recruit 18 patients back for follow-up. Despite these lower numbers, we were able to assess EMGs on 12 patients, which is unique and has not been previously reported. Fifth, the patients who were converted to rTSA within the first 24 months after transfer were excluded, which may be considered a limitation. This was done because we did not have an MRI documenting the status of the transfers prior to rTSA, and therefore the transfer healing status was unclear. Sixth, all patients in the current series were male; therefore, inferring results to female patients may be limited. Because of the concern of the quality and size of the lower trapezius muscle in females, it is the preference of the authors to perform arthroscopic acellular dermal matrix interpositions on female patients with irreparable tears. Seventh, the MRIs did not extend medially enough to reliably evaluate the graft and lower trapezius tendon junction; therefore, the healing status at this location is unclear.

Conclusion

Arthroscopy-assisted lower trapezius transfer demonstrates improved functional outcomes 2 years postoperatively. Complete retear of the transfer is relatively uncommon (13%). The lower trapezius fired in phase in forward flexion, external rotation at the side, and external rotation in 90° of abduction in all patients who underwent EMG testing, which was consistent with the

firing pattern of the contralateral normal lower trapezius muscle. These results may support the theory that active function of the muscle transfer itself, as opposed to a tenodesis effect, is a potential mechanism by which this procedure improves shoulder function as it consistently fires in phase.

Disclaimers:

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Conflicts of interest: Michael A. Moverman is a paid consultant for Enovis. Robert Z. Tashjian is a paid consultant for Zimmer/Biomet, Stryker, Enovis, and DePuy-Mitek; has stock in Conexions and Genesis; receives intellectual property royalties from Stryker, Shoulder Innovations, and Zimmer/Biomet; receives publishing royalties from Springer and the *Journal of Bone and Joint Surgery*; and serves on the editorial board for the *Journal of Bone and Joint Surgery*. Peter N. Chalmers is a paid consultant for Exactech, DePuy-Mitek, DJO, and Smith & Nephew; receives intellectual property royalties from DePuy, Exactech, and Responsive Arthroscopy; is a paid speaker for DePuy; receives research support from Smith & Nephew and DePuy; serves on the editorial board for the *Journal of Shoulder and Elbow Surgery*; and has stock in TitanKM Biomedical. The other authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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