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Lower Trapezius Tendon Transfer for Irreparable Rotator Cuff Injuries: A Scoping Review

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Abstract

Background: Rotator cuff tears are a common source of shoulder pain and dysfunction. An irreparable rotator cuff tear poses a particular treatment challenge. There have been few studies reporting the outcomes of lower trapezius tendon (LTT) transfer for irreparable rotator cuff injuries. Therefore, the purpose of this review is to summarize the postoperative functional outcomes and complications of patients undergoing lower trapezius tendon transfer for massive irreparable rotator cuff injuries.

Methods: A scoping review was performed using the Medline, Embase, Cochrane Central Register of Controlled Trials, and Google Scholar databases with the search terms “trapezius” AND “transfer.” Of 362 studies included for initial screening, 37 full text citations were reviewed with five studies meeting full inclusion/exclusion criteria to be included in the review. Two reviewers extracted data for study design, patient demographics, surgical technique, functional outcomes, range of motion, and complications for each study according to predefined criteria.

Results: Improvements in preoperative to postoperative functional status, using the DASH (50.34 to 18), ASES (48.56 to 80.24), VAS (5.8 to 1.89), SANE (34.22 to 69.86), and SSV (52.24 to 77.66) were evident across all 5 studies. Preoperative to postoperative increases in ROM were seen for flexion (85 to 135), external rotation (18 to 52), and abduction (50 to 98). The overall complication rate was 18%, with seroma formation (8%) as the most common postoperative complication.

Discussion/Conclusion: Our analysis showed that LTT transfer improved postoperative function, ROM, and pain for patients with irreparable rotator cuff tears with an overall complication rate of 18%. Future controlled studies are required to directly compare LTT transfer to other tendon transfers and other surgical techniques for irreparable rotator cuff tears.
Rotator cuff tears are a common cause of shoulder dysfunction and pain. Management for rotator cuff tears includes both non-surgical and surgical options depending on the clinical context, with mixed evidence supporting surgical vs non-surgical management. Massive rotator cuff injuries are described as defects >5cm or tears involving more than 1 tendon. Massive tears are often irreparable; however, some may be managed with advanced arthroscopic techniques and mobilization. Criteria for massive irreparable rotator cuff tears preoperatively on magnetic resonance imaging (MRI) include fatty degeneration index (FDI) >3 of the supraspinatus and FDI >2 of the infraspinatus with >31mm of coronal oblique tear distance (COTD) and >32mm of sagittal oblique tear distance (SOTD). Additional MRI findings suggestive of irreparable rotator cuff tears include increased inferior glenohumeral distance and tendon retraction at or beyond the glenoid. Definitive assessment of irreparability is made intraoperatively after tendon mobilization.

Irreparable rotator cuff tears are often managed non-surgically, especially in patients at high risk for surgical complications and in those with decreased functional demands or mild pain and/or shoulder dysfunction. For patients in whom non-surgical management fails or those who elect for initial surgical management, multiple surgical options are available. These include débridement with partial repair, reverse total shoulder arthroplasty, subacromial spacer insertion, superior capsular reconstruction, and tendon transfers. Latissimus dorsi, pectoralis major, and lower trapezius tendon (LTT) transfer have all been used as tendon transfers for the management of irreparable rotator cuff tears.
The LTT transfer has recently gained popularity to treat irreparable rotator cuff tears\(^1\). The main objective is to decrease pain and improve strength and function to the shoulder joint. Biomechanical studies have shown that LTT transfer maximizes external rotation and recreates more normal glenohumeral kinematics and reactive forces\(^{13,16}\). The procedure may be performed in an open or arthroscopically assisted manner\(^7,8,21,22,24\). There is some variability in techniques, but the LTT is first detached from its insertion at the scapular spine and mobilized away from the middle trapezius\(^7\). The LTT is then augmented, usually with an Achilles allograft. For arthroscopically assisted reattachment, the newly augmented tendon is pulled through the anterolateral port or moved through a subcutaneous tunnel and anchored into the anterosuperior or anterolateral tuberosity. Additional procedures including biceps tenodesis/tenotomy, partial cuff repair, and subacromial decompression may also be concomitantly performed during the LTT transfer.

The primary indications for using the LTT technique in the setting of irreparable massive posterosuperior rotator cuff tears include persistent pain and shoulder dysfunction with limited forward elevation and external rotation, concomitant subscapularis tears, and previously failed rotator cuff repairs\(^8,22,23\). MRI findings which indicate massive irreparable tears suitable for LTT repair include Goutallier grade ≥ 3 for supraspinatus and ≥2 for infraspinatus, Patte grade ≥ 2, and acromiohumeral interval of <7mm\(^{23}\). Contraindications to performing this procedure include severe glenohumeral arthritis, trapezius dysfunction or paralysis, deltoïd or subscapularis deficiency, and advanced age\(^{23}\). Clinical outcomes of LTT transfers for irreparable rotator cuff tears remain limited, with a systematic review by Clouette et al in 2020 including only two clinical studies on the topic\(^2\). Therefore, the purpose of our scoping review is to characterize the
indications, functional outcomes and complications of patients undergoing LTT transfer for irreparable rotator cuff tears.

 Materials and Methods

 Study Design

 A scoping review was performed to evaluate the literature and identify knowledge gaps for the use of LTT transfer for irreparable rotator cuff injuries. This review combines both qualitative and quantitative properties via a comprehensive search strategy and standardized study selection and evaluation. Due to the heterogeneity between studies and limited sample size, combined with the lack of comparison groups in all but one study, no meta-analyses were performed.

 Selection Criteria

 Studies were included if the following inclusion criteria were met; 1. publication after the year 2000; 2. use of human subjects; 3. age > 18 years; 4. Lower trapezius tendon transfer for irreparable rotator cuff tears. Exclusion criteria included; 1. non-English language; 2. use of cadaveric subjects; 3. publication in the form of an abstract, letter, editorial, or review article; 4. LTT transfer for indications other than irreparable rotator cuff repair (i.e., brachial plexus injury).

 Search Strategy

 MEDLINE, EMBASE, Cochrane Central Register of Controlled Trials, and Google Scholar databases were searched using the terms: “trapezius” AND “transfer.” A search algorithm is outlined in Appendix 1.

 Study selection
The article selection was performed over two rounds, by two reviewers (VD and TS) using the Covidence platform. During the first round, selection was based on the review of titles and abstracts. To be as inclusive as possible, an article was carried forward to the next stage if either reviewer thought that the study was appropriate. In the second round, final study selection was based on full text review using the inclusion and exclusion criteria. Duplicate studies were eliminated at the beginning of the process, using the Covidence software. Consensus was reached for final article inclusion through discussion amongst the investigators. The visual outline of this process can be viewed in Figure 1.

Data Extraction

Two reviewers manually extracted data from the five studies included in the scoping review. Data pertaining to study design, patient demographics, rotator cuff injury details, surgical indications, surgical technique, pre- and postoperative functional outcomes, pre- and postoperative range of motion (ROM), and complications were extracted for each study. Data was confirmed through agreement between all reviewers and included in Tables 1-5.

Results

Article Selection

Using the search strategy outlined above, 362 studies were included for initial screening. After screening through titles and abstracts, 37 full text citations were reviewed according to predefined inclusion/exclusion criteria. Five studies encompassing 111 patients met full inclusion and exclusion criteria and were ultimately included in the scoping review. Study design
and surgical technique for each study is outlined in Table 1. Patient demographics and rotator cuff injury details from all five studies are described in Table 2.

**Surgical Indications**

All five studies exclusively included patients with massive irreparable rotator cuff tears as the indication for lower trapezius tendon transfer surgery (Table 2). Four of the five studies specifically located massive irreparable rotator tears to the posterosuperior cuff involving the supraspinatus and infraspinatus tendons. Multiple study participants also had concomitant subscapularis and teres minor tears or fatty infiltration. No patients had arthritic changes preoperatively.

**Functional Outcomes**

Functional outcomes were assessed using The Disabilities of the Arm, Shoulder, and Hand (DASH), Visual Analogue Scale (VAS), The American Shoulder and Elbow Surgeons Score (ASES), Single Assessment Numeric Evaluation (SANE), and Subjective Shoulder Value (SSV). The DASH (N=74), ASES (N=20), and SANE (N=20) assessments were reported in two studies while the VAS (N=63) and SSV (N=88) assessments were reported in three studies. The mean change from preoperative to postoperative scores for the DASH (50.34 to 18), ASES (48.56 to 80.24), VAS (5.8 to 1.89), SANE (34.22 to 69.86), and SSV (52.24 to 77.66) were noted. Individual and summative results of functional outcomes across all studies are included in Table 3.

**Range of Motion Scores**

All studies included preoperative and postoperative measures of ROM. Five studies (N=108) included preoperative and postoperative measures of shoulder flexion and external rotation. Three studies (N=86) included preoperative and postoperative measures of shoulder abduction.
The mean changes from preoperative to postoperative flexion, external rotation, and abduction were 85 to 135, 18 to 52, and 50 to 98 respectively (Table 4).

Complications

All studies reported on postoperative complications, with only one study reporting the absence of any complications. Overall, there were 20 total complications from 111 total patients resulting in a general complication rate of 18%. Individual complications rates are provided in Table 5 with seroma formation as the most common complication (8%) across all studies.

Discussion

Rotator cuff surgery is a rapidly evolving branch in orthopedics. While arthroscopic repair represents the most widely used approach to treat rotator cuff lesions, other strategies have been described. Musculotendinous transfer, initially presented as an experimental technique in 1982 by Robert Cofield (subscapularis transfer) and in 1988 by Christian Gerber (latissimus dorsi transfer), has since shown increasing promise in select subgroups. These massive irreparable rotator cuff tears may lead to significant patient discomfort and decreased function and range of motion of the affected shoulder joint. The LTT transfer technique was initially used in 2014 for patients with paralytic shoulders and loss of external rotation. It has since been applied in the setting of massive irreparable rotator cuff tears, starting in 2016. Our study showed that the LTT technique improved patients’ shoulder pain and postoperative function and range of motion for irreparable rotator cuff tears with an overall complication rate of 18%. Compared to other surgical options, the LTT may be best suited in young active patients lacking glenohumeral arthritic changes since tendon transfers do not address arthritic changes in the glenohumeral joint. Currently, the decision to perform either the latissimus dorsi tendon (LTD) or the lower
trapezius tendon transfer is based on surgeon preference given the limited data showing
superiority of either procedure\textsuperscript{10}. One biomechanical study showed that patients’ whose main
functional deficit is external rotation may benefit more from an LTT transfer than an LDT
transfer; conversely, a patient whose main deficit is external rotation with the arm at 90° of
abduction would benefit more from an LDT transfer\textsuperscript{13}. Another biomechanical study showed
LTT transfer to be superior to LDT transfer at restoring native glenohumeral kinematics and joint
reaction forces\textsuperscript{16}.

The surgical anatomy of LTT transfers have been determined to offer safe and reliable anatomic
relationships for transfer with no direct neurovascular injury according to a study on 10
cadaveric specimens\textsuperscript{15}. Omid et. al suggest that dissection medial to the tip of the tendinous
portion of the lower trapezius can be performed a minimum of approximately 23 mm and on
average 58 mm without encountering the spinal accessory nerve\textsuperscript{15}. Additionally, Ghoraiashian et
al have suggested that improved techniques such as mini-open and arthroscopic assisted
approaches using a horizontal incision for tendon harvest can avoid damage to the accessory
nerve and problems such as acromial nonunion, thereby limiting complications\textsuperscript{12}.

In all studies we reviewed, participants lacked severe glenohumeral arthritic changes
preoperatively as criterion for LTT transfer consideration. Additionally, concomitant
subscapularis tears are not contraindications for lower trapezius tendon transfers because the
trapezius contracts during external rotation\textsuperscript{8}. This is not reproduced with the latissimus dorsi
tendon transfer (LDT-T) technique and concomitant subscapularis tears had been shown to have
poorer functional outcomes with the LDT-T procedure\textsuperscript{10}. Elhassen et al included 20 patients with
partial subscapularis tears and found no difference in postoperative outcomes between patients
with or without preoperative subscapularis tears undergoing LTT transfer\textsuperscript{7}. However, they
identified negative clinical outcomes in patients having advanced rotator cuff arthropathy changes and shoulder pseudoparalysis.

There were significant differences in surgical technique between studies included in the review. Four of the five studies \(^7,8,21,24\) used an Achilles tendon allograft while one study \(^22\) used a semitendinosus autograft for graft augmentation. Due to limited data, no analyses between graft types could be completed. Most studies performed the LTT transfer using an arthroscopic approach \(^7,21,22,24\) while one study \(^8\) used solely an open approach. Suggested benefits of using an arthroscopic assisted approach include the minimally invasive nature of the procedure.

Irrespective of surgical approach, all studies demonstrated increased functional outcomes and ROM postoperatively with the LTT procedure. We identified the following preoperative to postoperative improvements in mean ROM with LTT transfer for flexion (85 to 135), external rotation (18 to 52), and abduction (50 to 98). Improvements in functional outcomes were evident across the DASH, ASES, VAS, SANE, and SSV assessments. Only one study directly compared arthroscopic LTT transfer to the latissimus dorsi tendon transfer (LDT) and found the LTT transfer provided significantly improved functional outcomes two years postoperatively \(^24\).

Across all studies included in this review, no complications were identified as being related to damage to the spinal accessory nerve. The overall complication rate was 18% across all studies with seroma formation being the most common postoperative complication. Of note, two patients (2%) had tendon rupture postoperatively with three patients (3%) developing deep infections.

Although no direct comparison for complications was made between LTT transfer and other surgical techniques, the complication rates outlined above are consistent with those in a systematic review for reverse shoulder arthroplasty treating massive irreparable rotator cuff injuries \(^17\). Specifically, four patients receiving LTT did not show clinical improvement in the
Elhassan et al study. Three of these patients had arthritic changes preoperatively and one had significant pseudoparalysis preoperatively. Of four patients with Hamada grade 2 or greater arthritic changes, only two had functional improvement with the other two patients requiring subsequent reverse shoulder arthroplasty for symptom relief. These findings are consistent with the general knowledge of using the LTT in young patients without glenohumeral arthritis since the LTT technique provides no benefit for treating glenohumeral arthritis.

Limitations

There are several limitations with our review. Due to the novelty of the LTT transfer in treating massive irreparable rotator cuff tears, we only identified 5 studies encompassing 111 patients to assess postoperative outcomes. Studies differed in what scores (DASH, ASES, VAS, SANE, SSV) were used to assess postoperative function limiting the sample size for each individual metric in our review. Four studies in our review were retrospective case studies with one prospective case series which may have introduced inherent bias into our results. The lack of randomized controlled trials limited our ability to compare the LTT transfer to other surgical techniques for the treatment of massive irreparable rotator cuff tears. Another limitation of this study is the heterogeneity of the surgical techniques across each of the five included studies. There were differences in approach (open LTT vs. arthroscopically assisted LTT), graft type (Achilles vs semitendinosus), and materials (suture anchors vs buttons). These differences may have contributed to heterogeneity in the reported mean total values reported across all studies and limited the external validity of this study. Furthermore, conclusions about outcomes and complications from LTT may vary depending on specific surgical techniques. We were not able to analyze differences between surgical techniques with this review. Due to the limited number of studies and small sample size, we were unable to analyze how differences in surgical
technique and preoperative patient functional status impacted postoperative outcomes. Additional sources of heterogeneity which may have affected outcomes include surgeon experience, differences in postoperative rehabilitation therapy protocol, patient baseline demographics, and follow-up duration among others. Due to the limited number of studies and high variation between studies, a meta-analysis was not possible. More research, preferably in the form of randomized controlled trials, is necessary to perform a meta-analysis and have greater confidence in the postoperative functional outcomes and complications than the preliminary data presented here. Additionally, comparing different surgical techniques (arthroscopic vs open), preoperative patient functional status, and allograft types in future studies may further elucidate the optimal practices for using the LTT technique in the setting of irreparable rotator cuff injuries.

**Conclusion**

Our analysis showed that LTT transfer improved postoperative function, ROM, and pain for patients with irreparable rotator cuff tears with an overall complication rate of 18%. Future controlled studies are required to directly compare LTT transfer to other tendon transfers and other surgical techniques for irreparable rotator cuff tears.

**Legends**

Table 1: Study Design and Details of Surgical Technique
Table 2: Patient Baseline Demographics
Table 3: Functional Outcomes Across Studies
Table 4: Preoperative and Postoperative ROM
Table 5: Complication Rates Across Included Studies
Figure 1: PRISMA Study Selection Process
Appendix 1: Search Algorithm

References


Lower Trapezius Tendon Transfer: Scoping Review


### Table 1. Study Design and Details of Surgical Technique

<table>
<thead>
<tr>
<th>Study</th>
<th>Study Type</th>
<th>Surgical Technique</th>
<th>Rehabilitation Protocol</th>
<th>Follow-Up (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elhassan et al 2018</td>
<td>Retrospective case review</td>
<td>Exposure of posterior-superior rotator cuff through osteotomy in the middle deltoid. Upper subscapularis and teres minor tears were repaired if present. Tenotomy and tenodesis performed if the biceps was present and diseased. Achilles tendon allograft used to prolong the lower trapezius. A #2 nonabsorbable suture placed in Krakow fashion into tendinous and musculotendinous portions of lower trapezius then passed into Achilles tendon. Multiple nonabsorbable #2 Orthocord sutures reinforced the repair. Endobuttons were occasionally used to reinforce the repair. If impingement of spinal accessory was seen, 1-2cm of the medial spine of the scapula was excised to avoid nerve impingement.</td>
<td>Patients were placed in a custom-made shoulder spica brace in 30 degrees abduction and 50 degrees external rotation for 8 weeks. From weeks 8-12, patients completed active assisted ROM exercises in all directions except internal rotation. After this, patients were allowed full range of motion and gentle strengthening exercises. Patients returned to unrestricted activities after 6 months.</td>
<td>Mean: 47 Range: 24-73</td>
</tr>
<tr>
<td>Valenti et al 2018</td>
<td>Prospective case series</td>
<td>The lower trapezius was harvested using a vertical posterior approach with reinforcement of non-absorbable sutures placed into the tendinous and musculotendinous portions using a Krakow technique. The 20cm semitendinosus autograft was harvested with reinforcement using a braided non-absorbable suture with Krakow technique. Fixation was done using 2 techniques: 1. Semitendinosus graft sutured medially to the tendon of the lower trapezius in a Pulvertaft fashion. A cortical button was then sutured to the lateral free end of the graft and shuttled into the bone tunnel under lateral arthroscopic visualization. The strands of the cortical button were tightened to introduce 2-3cm of the graft into the tunnel. 2. Semitendinosus tendon was fixed by arthroscopy at the level of the infraspinatus footprint with 2 or 3 anchors. The medial stump of the graft was pushed to the subposterior deltoid space following the direction of the infraspinatus to reach the medial tubercle of the scapula. A Krakow suture placed in the trapezius and semitendinosus tendon reinforced the repair. In 4 patients, the lower trapezius transfer was combined to a latissimus dorsi transfer.</td>
<td>Custom-made shoulder brace in 30 degrees of abduction and 30 degrees of external rotation continuously for 6 weeks and only at night following 4 weeks. At 6 weeks, patients started pain-free passive and active assisted ROM exercises in elevation and external rotation. At 3 months, full active ROM exercises were started with strengthening. Full return to unrestricted activities at 6 months.</td>
<td>Mean: 24 Range: 18-36</td>
</tr>
<tr>
<td>Elhassan et al 2020</td>
<td>Retrospective case review</td>
<td>Lower trapezius tendon harvested before arthroscopic portion. Tendon prepared using non-absorbable #2 suture in Krakow fashion. Lateral port served for visualization with anterolateral and anterior ports used for working. Subacromial decompression was performed with debridement of irreparable portions of rotator cuff. Achilles allograft prepared with 2 Krakow sutures into the calcaneal end. Allograft anchored into tuberosity with multiple suture anchors in the anterior aspect of the supraspinatus footprint medially and laterally. Multiple cycles of internal and external rotation were used to increase allograft tension. Partial rotator cuff repair, if possible, to the graft was performed in 22 patients and a tenotomy (n=4) or tenodesis (n=13) if biceps tendinitis or tear was present.</td>
<td>0 to 6-8 weeks: Immobilization in custom external rotation brace with shoulder maintained in 40-60 degrees of external rotation 6-8 to 12 weeks: Passive, active-assisted and then active ROM with internal rotation limit to 0 degrees 12 to 16 weeks: Gradual removal of passive and active internal rotation limit; return to most daily activities 16 weeks to 6 months: Gradual strengthening without motion limits 6 months: Return to full unrestricted activities</td>
<td>Mean: 14 Range: 6-19</td>
</tr>
<tr>
<td>Woodmass et al 2020</td>
<td>Retrospective case review</td>
<td>The LTT was harvested through a 6-8cm incision over its insertion on the medial scapular spine. Two non-absorbable running sutures were placed on either side of the Achilles tendon allograft, which was secured to the anterolateral aspect of the greater tuberosity. The allograft and LTT were secured with a pulvertaft weave.</td>
<td>NA</td>
<td>Mean: 22+/-% 10 Range: NA</td>
</tr>
<tr>
<td>Stone et al 2021</td>
<td>Retrospective case review</td>
<td>The open procedure (N=9) involved a medial approach to dissect the LTT. An Achilles allograft was sutured to the lower trapezius using a Pulver-Taft weave with multiple nonabsorbable sutures. The greater tuberosity was prepared with a bur and the graft was stitched with multiple locking stitches from two 5.5mm suture anchors placed medially on the footprint. A double-row construct was created using two 4.75 knotless suture anchors placed laterally. The arthroscopic-assisted procedure (N=6) used a direct approach to the lower trapezius. A diagnostic arthroscopy was performed, and the tuberosity was prepared using burr and two 5.5mm suture anchors placed on the medial aspect. The Achilles tendon allograft was prepared using a series of locking stitches into the tendon. The two suture limbs were tied to another at the medial aspect of the graft which was shuttled into its final position on the greater tuberosity with sutures tied arthroscopically. Two additional suture anchors were placed at the lateral footprint to complete a double-row repair. The graft was tensioned and sutured to the native trapezius in a Pulver-Taft weave with multiple non-absorbable sutures.</td>
<td>The shoulder was placed in a gusligner abduction brace at 30 degrees abduction and 30-60 degrees external rotation for 6 weeks. Supine FE exercises were started 2 weeks after surgery. Physical therapy was initiated 6 weeks postoperatively, starting with ROM and restricting any cross-body adduction until week 12. At 12 weeks, rotator cuff strengthening began with scapular conditioning. Isotonic strengthening at 4 months and return to full unrestricted activities at 6 months.</td>
<td>Mean: 24 Range: 12-39</td>
</tr>
</tbody>
</table>
Table 2. Patient Baseline Demographics. Data provided as Mean ± SD (Range).

<table>
<thead>
<tr>
<th>Study</th>
<th>Patient Demographics</th>
<th>Baseline Function</th>
<th>Type/Degree of Rotator Cuff Tear</th>
<th>Prior Shoulder Surgery</th>
<th>Details of previous surgeries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elhassan et al 2016</td>
<td>N=33</td>
<td>All patients reported preoperative repetitive lifting activities of 10lbs or greater. 13 patients reported heavy lifting activities.</td>
<td>All patients had at least 2 full-thickness rotator cuff tears involving the supraspinatus and infraspinatus with Goutallier grade III-IV and retraction of the torn tendon medial to the level of the glenoid. Patients all had acromiohumeral distance of less than 5mm before surgery with no acetabulation. 10 patients had teres minor tear; 11 patients have evidence of fatty atrophy in the teres minor. 13 patients had tear of the upper part of subscapularis, but none had full-thickness tear or fatty atrophy of the subscapularis. 13 shoulders showed minimal arthritic changes of the glenohumeral joint. Gross arthritic changes were absent in all patients.</td>
<td>N = 22 (67%)</td>
<td>22 patients had attempted full or partial rotator cuff repair through open or arthroscopic technique. 3 patients had 2 prior repairs and 2 patients had 3 prior repairs. 10 patients had prior non-rotator cuff procedures including biceps tenotomy/tenodesis, subacromial decompression, acromioclavicular joint resection, and labral repair.</td>
</tr>
<tr>
<td>Valenti et al 2018</td>
<td>N=14</td>
<td>NA</td>
<td>All patients had a massive irreparable tear of the posterosuperior rotator cuff with atrophy of the teres minor and infraspinatus and fatty infiltration &gt; Grade 2 Goutallier classification. No patients had glenohumeral arthritis, pseudoparalysis, deltoid palsy, or an associated subscapularis tear &gt; grade II Lafosse classification.</td>
<td>N = 9 (64%)</td>
<td>9 patients had prior arthroscopic rotator cuff repair.</td>
</tr>
<tr>
<td>Elhassan et al 2020</td>
<td>N=41</td>
<td>All patients were active with a desire to regain active shoulder use involving shoulder-level or overhead activities.</td>
<td>All patients had full-thickness tears involving the supraspinatus and infraspinatus with Goutallier grade &gt;2 fatty infiltration, tendon length &lt;1cm, tendon retracted to the level medial to the glenoid, or Patte stage 2+. 9 patients had standard Goutallier grade 3 or 4. 20 patients had repairable subscapularis tear on upper ⅓ of tendon. 10 patients had mild glenohumeral arthritis. 29 patients had Hamada Grade 1, 2 patients had Hamada Grade 2, and 2 patients had Hamada Grade 3.</td>
<td>N = 33 (80%)</td>
<td>27 patients with previous rotator cuff repair through open or arthroscopic technique. 9 patients had 2 prior repairs and 3 patients had more than 2 previous repairs. 6 patients had prior shoulder surgery not involving rotator cuff repair.</td>
</tr>
<tr>
<td>Woodmass et al 2020</td>
<td>N=8</td>
<td>NA</td>
<td>All patients had chronic massive posterosuperior rotator cuff tear with Goutallier grade 2, 3, or 4 and Hamada grade of 0, 1, or 2 with inability to reduce the rotator cuff to the rotator footprint despite adequate mobilization. No patients had arthritis and the subscapularis was intact or fully repairable in all cases.</td>
<td>N = 4 (50%)</td>
<td>4 patients had prior rotator cuff repair.</td>
</tr>
<tr>
<td>Stone et al 2021</td>
<td>N=15</td>
<td>13 patients had occupations classified as labor intensive.</td>
<td>All patients had irreparable rotator cuff tears determined by preoperative MRI and confirmed intraoperatively. No patients had severe glenohumeral arthritis or Hamada grades IV and V cuff tear arthropathy.</td>
<td>N = 14 (93%)</td>
<td>14 patients had previous rotator cuff repair with an average of 1.8 +/- 1.3 (range: 0-5) previous surgeries.</td>
</tr>
<tr>
<td>Total</td>
<td>N=111</td>
<td>NA</td>
<td>NA</td>
<td>N = 82 (73.9%)</td>
<td>NA</td>
</tr>
</tbody>
</table>
### Table 3. Functional Outcomes Across Studies

<table>
<thead>
<tr>
<th>Study</th>
<th>DASH</th>
<th>ASES</th>
<th>VAS</th>
<th>SANE</th>
<th>SSV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Woodmass et al 2020</td>
<td>Mean: NA</td>
<td>Range: NA</td>
<td>Mean: 56.6</td>
<td>Mean: 84.8</td>
<td>Mean: 2.85</td>
</tr>
<tr>
<td>Stone et al 2021</td>
<td>Mean: NA</td>
<td>Range: NA</td>
<td>Mean: 43.2</td>
<td>Mean: 77.2</td>
<td>Mean: NA</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>N = 74</td>
<td>N = 20</td>
<td>N = 63</td>
<td>N = 63</td>
<td>N = 20</td>
</tr>
</tbody>
</table>

*3 of 15 total study participants excluded from analysis after undergoing
Table 4. Preoperative and Postoperative ROM

<table>
<thead>
<tr>
<th>Study</th>
<th>Flexion Preoperative</th>
<th>Flexion Postoperative</th>
<th>External Rotation Preoperative</th>
<th>External Rotation Postoperative</th>
<th>Abduction Preoperative</th>
<th>Abduction Postoperative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elhassan et al 2016*</td>
<td>Mean: 70</td>
<td>Mean: 120</td>
<td>Mean: 20</td>
<td>Mean: 47</td>
<td>Mean: 40</td>
<td>Mean: 90</td>
</tr>
<tr>
<td>Valenti et al 2018**</td>
<td>Mean: 150</td>
<td>Mean: 160</td>
<td>Mean: -20</td>
<td>Mean: 24</td>
<td>Mean: NA</td>
<td>Mean: NA</td>
</tr>
<tr>
<td>Elhassan et al 2020*</td>
<td>Mean: 67</td>
<td>Mean: 133</td>
<td>Mean: 25</td>
<td>Mean: 70</td>
<td>Mean: 50</td>
<td>Mean: 95</td>
</tr>
<tr>
<td>Woodmass et al 2020**</td>
<td>Mean: NA</td>
<td>Mean: 146</td>
<td>Mean: 33</td>
<td>Mean: 44</td>
<td>Mean: NA</td>
<td>Mean: NA</td>
</tr>
<tr>
<td>Stone et al 2021**</td>
<td>Mean: 98</td>
<td>Mean: 144</td>
<td>Mean: 23</td>
<td>Mean: 43</td>
<td>Mean: 74</td>
<td>Mean: 127</td>
</tr>
<tr>
<td>Total</td>
<td>N = 108</td>
<td>N = 108</td>
<td>N = 108</td>
<td>N = 108</td>
<td>N = 86</td>
<td>N = 86</td>
</tr>
<tr>
<td>(N=108)</td>
<td>Mean: 85</td>
<td>Mean: 135</td>
<td>Mean: 18</td>
<td>Mean: 52</td>
<td>Mean: 50</td>
<td>Mean: 98</td>
</tr>
</tbody>
</table>

*3 of 15 total study participants excluded from analysis after undergoing
<table>
<thead>
<tr>
<th>Study</th>
<th>Total Complications</th>
<th>Seroma Formation</th>
<th>Hematoma Formation</th>
<th>Superficial Infection</th>
<th>Deep Infection</th>
<th>Tendon Rupture</th>
<th>Nerve Disruption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elhassan et al 2016†</td>
<td>N = 5 (15%)</td>
<td>N = 4 (12%)</td>
<td>N = 0 (0%)</td>
<td>N = 0 (0%)</td>
<td>N = 1 (3%)</td>
<td>N = 0 (0%)</td>
<td>N = 0 (0%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All resolved spontaneously</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valenti et al 2018‡</td>
<td>N = 2 (15%)</td>
<td>N = 0 (0%)</td>
<td>N = 2 (14%)</td>
<td>N = 0 (0%)</td>
<td>N = 1</td>
<td>N = 0 (0%)</td>
<td>N = 0 (0%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Both had revision surgery for hematoma at harvest site</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elhassan et al 2020†</td>
<td>N = 10 (23%)</td>
<td>N = 3 (7%)</td>
<td>N = 0 (0%)</td>
<td>N = 1 (2%)</td>
<td>N = 0 (0%)</td>
<td>N = 2 (5%)</td>
<td>N = 4 (9%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All resolved spontaneously over 2-3 weeks</td>
<td></td>
<td>Resolved with oral antibiotic treatment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Woodmass et al 2020†</td>
<td>N = 0 (0%)</td>
<td>N = 0 (0%)</td>
<td>N = 0 (0%)</td>
<td>N = 0 (0%)</td>
<td>N = 0 (0%)</td>
<td>N = 0 (0%)</td>
<td>N = 0 (0%)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stone et al 2021†</td>
<td>N = 3 (20%)</td>
<td>N = 2 (13%)</td>
<td>N = 0 (0%)</td>
<td>N = 1 (7%)</td>
<td>N = 0 (0%)</td>
<td>N = 0 (0%)</td>
<td>N = 0 (0%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Both underwent superficial wound debridment for seroma and posterior wound dehiscence</td>
<td></td>
<td>Patient had cultures positive for Cutibacterium acnes at time of RSA revision surgery</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total (N = 111)</td>
<td>N = 20 (18%)</td>
<td>N = 9 (8%)</td>
<td>N = 2 (2%)</td>
<td>N = 1 (1%)</td>
<td>N = 3 (3%)</td>
<td>N = 2 (2%)</td>
</tr>
</tbody>
</table>
Figure 1. PRISMA Study Selection Process

551 citations imported

362 citations screened

37 citations reviewed

5 citations included in systematic review

189 duplicate citations

325 irrelevant citations

32 citations excluded