Combined Latissimus Dorsi and Teres Major Tendon Transfers for External Rotation Deficiency in Reverse Shoulder Arthroplasty

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Abstract

Treatment of rotator cuff deficient shoulders continues to evolve. Reverse total shoulder arthroplasty has proven effective for restoring forward elevation and abduction in patients who suffer from pseudoparalysis secondary to rotator cuff insufficiency. Unfortunately, reverse total shoulder arthroplasty is less effective at restoring lost external rotation function in patients with deficient posterior rotator cuff tissue. Therefore, functional results of reverse arthroplasty in patients who demonstrate preoperative lag signs is inferior to patients with functioning posterior rotator cuff musculature.

Combined latissimus dorsi and teres major tendon transfers have been shown to be effective treatment for patients with isolated loss of external rotation. These transfers have also been shown to improve functional results in patients who undergo reverse arthroplasty and have combined loss of forward elevation and external rotation preoperatively. Previously published studies have evaluated the combined reverse arthroplasty and tendon transfer procedure only in patients with first generation (medial center of rotation) implants. We reviewed our experience with the combined procedure utilizing a third generation (medial center of rotation glenoid and lateral center of rotation humerus) device.

Massive rotator cuff tears may result in significant pain and dysfunction. Historical treatment focused on pain relief, with no reproducible options that allowed for reliable restoration of function. With the advent of the modern reverse total shoulder arthroplasty (rTSA), both pain relief and restoration of function are now predictable outcomes.1-4

Reverse total shoulder arthroplasty restores deltoid function by lengthening the deltoid and reestablishing a stable center of rotation.3 This results in improvement in active forward elevation and abduction but does not restore active external rotation when the posterior portion of the rotator cuff is absent.1 When compared to patients with preoperative active external rotation, those with posterior rotator cuff deficiency (fatty infiltration of the teres minor) have poorer clinical outcomes.5

Patients with isolated loss of external rotation due to isolated irreparable infraspinatus tears often tolerate this condition well and can be managed nonsurgically. However, when these infraspinatus tears are combined with large superior cuff defects and loss of teres minor function, they result in significant dysfunction. These patients with combined loss of active elevation and external rotation (CLEER) often have profound limitations in the ability to perform activities of daily living.6

In 1988, Gerber described a two-incision latissimus dorsi tendon transfer for patients with isolated loss of active external rotation due to irreparable posterior cuff defects (teres minor and infraspinatus).7 This has proven to be a reasonable reproducible procedure for restoration of active external rotation.8-10 In 2007, Gerber described a similar procedure in combination with a rTSA.10 He showed improvement in active forward elevation, abduction, external rotation, and the ability to perform activities of daily living using this procedure. Subsequent studies have reported similar improved outcomes in patients with CLEER defects.6,10-12 Although this procedure increases total operative time, it has not been shown to increase complications when performed in combination with rTSA.

We began using a similar single incision deltopectoral combined latissimus dorsi and teres major tendon transfer (LD-TM) in 2010, in combination with a third generation rTSA (medial center of rotation glenoid and lateral hu-
merus) (Exactech Equinoxe, Gainesville, Florida). While our technique continues to evolve, we have documented an improvement in the ability to perform activities of daily living in patients with CLEER in comparison to patients who undergo rTSA alone.

**Surgical Indications**

Indications for the combined LD-TM transfer include patients with irreparable rotator cuff tears, pseudoparalysis, pain, and loss of active external rotation on clinical exam. While radiographic studies, such as MRI, may be a helpful adjunct, the decision to perform the transfer is best made based upon physical examination. Patients should demonstrate a combined external rotation lag sign and some form of a hornblower’s sign. Specifically, we like to confirm a lag past 0° of external rotation when the arm is released from 20° to 30° of external rotation with the arm at the side. In addition, patients should demonstrate loss of greater than 10° of external rotation when the arm is forwardly elevated or abducted to 90° (hornblower’s sign). Patients who can hold their arm at neutral rotation with the arm at the side or in an elevated position were not considered candidates.

It should also be noted that patients with bilateral disease, who have undergone transfers on the contralateral shoulder are not considered acceptable candidates. The transfer removes two of the remaining internal rotators, and while well tolerated it will contribute to the loss of internal rotation power and possibly motion. Therefore, bilateral transfers may result in loss of the ability to reach behind the back and perform perineal care. Therefore, our preference in patients with bilateral CLEER who are to undergo rTSA is to perform the transfer on only one side.

**Surgical Technique**

Our surgical technique is similar to the technique described by Boileau. All procedures are performed in a standard beach chair position through a single deltopectoral approach. The pectoralis major tendon is identified and released at its musculotendinous junction. Care is taken to leave a large stump of tendon at its humeral attachment to allow for repair and possible fixation of the transferred LD-TM tendons. The latissimus is located directly below the released pectoralis major tendon (Fig. 1). The teres major tendon lies just deep to the previously identified latissimus dorsi tendon. Standard release of the remaining subscapularis and anterior and posterior cords.

![Figure 1](image1.png)

**Figure 1** Clamp passed under the LD-TM tendons.

![Figure 2](image2.png)

**Figure 2** Location of the nerves in relation to the latissimus.
inferior capsule will further define the superior border of the latissimus tendon.

The combined LD-TM tendons are then released sharply from their humeral attachment. The free ends of the combined tendons are then tagged with two double modified Mason-Allen stitches using heavy high tensile nonabsorbable suture (#2 ORTHOCORD; DePuy Mitek; Warsaw, Indiana). Progressive external rotation and subperiosteal dissection allows for complete release of both tendon attachments.

The free tendon ends are mobilized with blunt dissection in a medial direction. Sharp, blind dissection should be avoided due to the proximity of the radial nerve (Fig. 2). Once the tendon can be freely mobilized 2 cm beyond the lateral border of the humerus, sufficient length has been obtained (Fig. 3). Dissection is then carried out in a subperiosteal fashion around the posterior and medial aspect of the humerus, just superior to the latissimus attachment. Similar subperiosteal dissection is carried out laterally beneath the deltoid until a clamp can be passed to the area of the medial dissection. Care should be taken to make the tunnel wide enough to allow both tendons to pass freely.

The tendons are not passed at this time. Attention is turned towards the humeral preparation. Preparation of the humerus and implantation of humeral component should proceed in standard fashion. Glenoid exposure is then obtained and preparation of the glenoid and insertion of the glenoid component is performed. Humeral component tracking is then completed.

Once the appropriate modular head and humeral components have been determined, the trial components are removed. With the trial humeral components removed, a curved clamp or suture passer is used to pass the tendons around the posteromedial humerus, beneath the deltoid (Figs. 4 and 5). The trial components are then replaced and the shoulder is reduced to allow excursion and tensioning of the tendon to be evaluated.

Previously, our technique was to reattach the tendon to the stump of the pectoralis major as described by Boileau (Fig. 6). However, we were concerned that this may lead to over tensioning the tendon. In addition, more superior placement closer to the greater tuberosity seemed to improve external rotation in an abducted position. Our current technique is to determine the optimal length of the tendon and transfer it to a more superior position on the distal portion of the greater tuberosity. Once the position has been determined, we then place two double loaded suture anchors (ICONIX, Stryker Orthopedics; Mahwah, New Jersey). After seating of the final humeral implant, the tendon is fixed in place with

Figure 3 LD-TM with sutures attached after mobilization.

Figure 4 A, Clamp is passed around the humerus in a lateral to medial direction. B, The sutures are passed around the humerus in a medial to lateral direction.
four modified grasping sutures from the two double loaded anchors. A routine pectoralis major repair and wound closure is performed.

**Postoperative Care**

It should be noted that in our experience, although the transfer will likely result in correction of lag signs, the postoperative management is critical to the development of active external rotation. Patients are immobilized in a neutral rotation sling (Bledsoe Arc 2.0; Bledsoe Brace Systems, Grand Prairie, Texas) in 0° to 10° of external rotation for 5 weeks postoperatively. We use our standard rTSA therapy protocol with some modifications.

As with routine rTSA, outpatient physical therapy is initiated during the first postoperative week. The goal is restoration of full passive range of motion as quickly as can be tolerated by the patient. Internal rotation is limited based on intraoperative findings and is increased 10° per week. Active assisted range of motion is initiated during week 3 to 4 postoperatively. Active range of motion is started during week 5. Gentle resistance exercise is started during week 6 to 7 and includes gentle external rotation isometrics. By week 8 to 10, therapy goals switch to retraining the LD-TM to act as external rotators. The focus during this time is on eccentric external rotation contraction with the arm in an abducted position. This can be facilitated by having the patient focus on a component of humeral extension while performing the eccentric contraction. Full activity is permitted by week 15.

**Results**

The results of rTSA combined with LD-TM transfers were first reported by Gerber in 2007. In 12 patients with the combined procedure, he reported that Constant scores had doubled, and SSV had tripled. The patients demonstrated an improved active elevation and external rotation, with improved ability to perform routine activities of daily living. In 2007, Boileau reported his results on the use of the LD-TM transfer in 15 patients either as an isolated procedure or in combination with a rTSA. This was followed in 2008 with a report of 11 patients with the combined procedure (rTSA and LD-TM transfer). His primary modification was to complete both procedures through a single deltopectoral approach. Gerber has since reported on 40 patients with follow-up greater than 2 years (mean: 53 months).

Each of these studies has shown complication rates similar to rTSA performed without muscle transfers. Infection and instability rates were nearly identical, while there was a slight increase in transient neurologic deficits. Long-term follow-up did not show significant increase in glenoid

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**Figure 5** LD-TM transferred and repaired to the remaining stump of the pectoralis major tendon.

**Figure 6** Transfer of LD-TM to a more superior position on the distal portion of the greater tuberosity.
loosening. These studies reported increased active elevation in comparison to rTSA performed alone, independent of the preoperative diagnosis.\textsuperscript{1} In patients with combined defects, the transfers have resulted in improved external rotation, independent of teres minor fatty infiltration. This correlates with improved patient scores, satisfaction, and ability to perform activities of daily living.

Our interest in performing the combined procedure began in late 2010. While pleased with the overall results with rTSA, we recognized that patients with severe preoperative rotational pseudoparalysis (lag signs) had more limited functional outcomes. While patients had excellent pain relief and improved elevation, the limitation in external rotation diminished their ability to perform key activities of daily living. In particular, they complained of an inability to get their hand behind their head and perform activities at the mouth (i.e., drinking, brushing teeth).

To date, all studies on transfer in combination with rTSA have been done with Grammont style (medial glenoid center of rotation and medial humerus) designs.\textsuperscript{1,6,11,12} Our goal was to see if similar results could be obtained with a third generation type device in which the glenoid center of rotation remains medial and the humeral component is shifted laterally. We currently do not have data to compare the biomechanical difference of the transferred tendon with this type of device in comparison to the Grammont style design. However, at this time we have performed the combined procedure in 30 patients, which represents less than 10\% of the total rTSA performed. Initially, we performed the procedure as described by Boileau, attaching the transferred tendon to the remaining humeral attachment of the pectoralis major tendon. However, for the past year, we have used the suture anchor reattachment method. This allows for more precise positioning of the transferred tendon. Since the anchor we use is all suture, it does not interfere with the placement of the final humeral stem within the humeral canal. This has also allowed us to place the tendon more superiority and laterally on the lower greater tuberosity, which we believe increases external rotation when the arm is in an abducted position. This is a more critical position for functional activities of daily living.

While not having completed a formal review of our patients, on follow-up our strong impression is that they have a significant improvement in ability to externally rotate with the arm elevated, resulting in less functional deficits. Our results can be divided into three categories: 1. Patients who demonstrate active external rotation greater than 10\° with the arm at the side and in an elevated position. This represents approximately 50\% of the patients; 2. Patients who have a check rein effect, resulting in elimination of their preoperative lag signs but no discernible increase in active external rotation from the transferred muscle. This group represents approximately 30\% of all patients; and 3. The final 20\% continue to demonstrate some component of their preoperative lag sign. Preoperative consultation should take these results into consideration, so that patients have a realistic expectation of potential outcomes. By employing the modified technique, with all suture anchors to optimize the position of the transferred tendon we hope to improve the consistency of these results.

Our overall complication rate has been low. Thus far, there have been no infections, instability, or the need for revision procedures. We have identified four neurologic injuries; two mild transient distal brachial plexopathy issues that fully resolved by 12 weeks; one partial axillary neurapraxia that resolved by 6 weeks; one complete axillary neurapraxia that had significant motor weakness at 12 weeks, but completely resolved by 6 months. None of these became permanent neurologic deficits.

As expected, subjectively, the patients did appear to have more pain during the first 12 weeks following the procedure as well as slower rehabilitation progress in comparison to rTSA performed as an isolated procedure.

Finally, it should be noted that to gain active external rotation we are transferring two of the remaining internal rotators. While, in general, this is well tolerated, we have noticed some loss of internal rotation behind the back, and more notably, some loss of internal rotation power anteriorly at the midline. Both findings have been well tolerated. While we prefer not to repair the subscapularis for our standard rTSA procedures, we may now begin to incorporate subscapularis repair in patients who are undergoing LD-TM transfers. Caution should be carried out in patients who have bilateral CLEER, in that bilateral LD-TM transfers may result in limitations in the patient’s ability to perform perineal care. In our practice, this is a contraindication to bilateral LD-TM transfers.

Longer term follow-up is certainly needed, but the early results of LD-TM tendon transfers in combination with third generation rTSA appear to result in improved function and ability to perform activities of daily living in patients with combined loss of active elevation and external rotation, in comparison to rTSA performed alone.

Disclosure Statement
Sean G. Grey, M.D., is a consultant for Exactech, Inc., Gainesville, Florida, and receives royalties on products related to this article.

References


