

Arthroscopic-Assisted Latissimus Dorsi Transfer for the Management of Irreparable Rotator Cuff Tears

Short-Term Results

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Background: Irreparable rotator cuff tears associated with shoulder functional impairment represent a challenge, especially in young and active patients. Latissimus dorsi muscle-tendon transfer is performed to replace the irreversibly lost contractile elements in patients with irreparable tears of the posterosuperior aspect of the rotator cuff.

Methods: From 2008 to 2010, we enrolled twenty-seven patients (mean age, sixty years; range, forty-six to sixty-seven years) with irreparable, full-thickness rotator cuff tears involving at least two tendons who underwent arthroscopic-assisted latissimus dorsi muscle-tendon transfer. Outcome measures included the Constant and Murley score, shoulder range of motion in external rotation, and muscle strength in forward elevation. The mean duration of follow-up was twenty-seven months (range, twenty-four to thirty-six months).

Results: There was a significant improvement ($p < 0.05$) in the mean Constant and Murley score, pain score, muscle strength in forward elevation, and range of motion in external rotation at the time of the last follow-up. There was no significant correlation between the mean preoperative range of motion, pain, and strength and the mean postoperative Constant and Murley score. There was no significant osteoarthritis progression and proximal migration of the humeral head after surgery in the time period studied.

Conclusions: Arthroscopic-assisted latissimus dorsi muscle-tendon transfer at short-term follow-up is an effective alternative to open surgery for the management of painful irreparable posterosuperior rotator cuff tears refractory to conservative management.

Level of Evidence: Therapeutic Level IV. See Instructions for Authors for a complete description of levels of evidence.

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Irreparable rotator cuff tears associated with functional impairment of the shoulder represent a challenge, especially in young and active patients^{1,2}. Massive tears are defined as a lesion with a diameter of >5 cm or the involvement of two or more tendons^{3,4}. Irreparable tears can be also defined in terms of retraction, fatty infiltration, and atrophy of the muscle belly⁵. Diagnostic criteria, usually confirmed by magnetic res-

onance imaging (MRI) or computed tomography scan findings, include stage-3 tendon retraction according to Patte⁶, stage-3 or 4 fatty infiltration as described by Goutallier et al.⁷, and stage-3 muscle atrophy according to Thomazeau et al.⁸.

Latissimus dorsi muscle-tendon transfer is performed to replace the irreversibly lost contractile elements in patients with irreparable tears of the posterosuperior aspect of the

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rotator cuff, providing good results in terms of restoration of function and range of motion of the shoulder⁹. Several authors have investigated different techniques to perform the latissimus dorsi muscle-tendon transfer in open surgery, reporting variable results^{5,10-14}. Recently, techniques for arthroscopic-assisted latissimus dorsi muscle-tendon transfer^{15,16} have been described, with minimal clinical data published to date.

We report on a single-center retrospective cohort of patients who had arthroscopic-assisted latissimus dorsi muscle-tendon transfer for the management of irreparable rotator cuff tears. The aim of the study was the assessment of the effectiveness of arthroscopic surgical management of such tears, with the Constant and Murley score, range of motion in external rotation, and muscle strength in forward elevation, at the time of the short-term follow-up.

Materials and Methods

Ethics

The study had the approval of the local ethics committee. Written informed consent was obtained from each patient.

Patient Selection

From March 2008 to December 2010, we enrolled twenty-seven patients with irreparable rotator cuff tears managed with arthroscopic-assisted latissimus dorsi muscle-tendon transfer. We included only patients with a painful chronic rotator cuff lesion consisting of a full-thickness tear with retraction of at least the supraspinatus and infraspinatus tendons⁵. Prior to surgery, all patients were managed with an appropriate conservative regimen based on nonsteroidal anti-inflammatory drugs and rehabilitation programs, including passive exercises to restore glenohumeral motion and strengthening exercises for the rotator cuff, deltoid, and scapulothoracic muscles. Only patients with a rotator cuff tear refractory to appropriate conservative management for at least six months were included. We also included patients who had undergone previous surgery for rotator cuff tears. However, in all patients, no direct tendon repair to the native osseous footprint was possible because of tendon disruption and muscle retraction. At the time of the physical examination, patients showed limited active anterior elevation and abduction of the shoulder, with loss of active overhead elevation and an external rotation lag of $\geq 10^\circ$ (assessed as the difference between maximal active and maximal passive external rotation with the elbow flexed at 90°)⁵.

Exclusion criteria included rotator cuff tears that involved less than two tendons and could be anatomically repaired.

Twenty-seven patients met these criteria and were included in the study. Preoperative, intraoperative, and postoperative clinical and imaging data were collected in a prospective fashion. All patients were managed with the same arthroscopic procedure for latissimus dorsi muscle-tendon transfer and postoperative rehabilitation. Follow-up evaluation included a standardized interview, physical examination, and assessment of anteroposterior and lateral radiographs. All patients had a postoperative evaluation at a minimum follow-up of two years.

Clinical Assessment

A standardized physical examination of all patients was performed by a fully trained shoulder surgeon who was not involved in the surgery. Subscapularis function was evaluated with the lift-off test^{17,18}. The range of motion was measured with a goniometer. The range of motion in active internal and external rotation was measured with the elbow flexed at 90° , while the range of motion in active forward elevation and abduction was measured with the elbow extended. Muscle strength in forward elevation was measured with a digital dynamometer (Myometer 500 N; Atlantech Medical Devices, Nottingham, United Kingdom). The mean value of three repeated measurements at 90° of elevation in the scapular plane was recorded¹⁹.

The Constant and Murley scoring system, normalized for patient age and sex, was used to evaluate preoperative and postoperative shoulder func-

tion²⁰. It evaluates both subjective and objective function through four domains, including pain (15 points), activities of daily living (20 points), range of movement (40 points), and power (25 points). The total score ranges from 0, indicating a person with the worst shoulder function, to 100 points, indicating an asymptomatic and healthy person.

Pain was assessed with the pain score according to Constant and Murley, ranging from 0, indicating the severest imaginable pain, to 15 points, indicating no pain.

Imaging Assessment

Imaging assessment was performed in all patients by a musculoskeletal radiologist. Radiographic assessment in a true anteroposterior view was used to evaluate the grade of osteoarthritis in the shoulder. We used a previously described three-stage classification system. Osteoarthritis was mild (stage 1) if a humeral head or glenoid osteophyte measured <3 mm in size, moderate (stage 2) if the size of the osteophyte was between 3 and 5 mm and associated with mild joint-line irregularity and subchondral sclerosis, and severe (stage 3) if greater joint degeneration had occurred^{3,21}.

Proximal migration of the humeral head was assessed on standardized true anteroposterior radiographs in neutral rotation, using a three-stage classification. Stage 1 was assigned if no proximal migration could be detected, stage 2 consisted of mild proximal migration characterized by interruption of the so-called Maloney line of the shoulder, and stage 3 consisted of severe proximal migration characterized by obliteration of the subacromial space and sclerosis of the undersurface of the acromion^{10,11}.

MRI was performed preoperatively to evaluate the rotator cuff tendon tear and muscle quality^{22,23}.

Operative Technique

Surgery was performed by a senior shoulder surgeon (R.C.). The patient was placed in the standard lateral decubitus position. A 6-cm incision was made in the axilla, at the level of the posterior axillary pillar, posterior to the lateral profile of the latissimus dorsi tendon. After incision, the latissimus dorsi muscle and its tendinous insertion on the proximal humeral shaft were identified. The radial nerve cannot be directly visualized because it lies within fat tissue, approximately 2 cm distal to the latissimus humeral attachment, according to the arm position²⁴. With the arm held in internal rotation, the tendon was carefully detached from the humeral shaft (Fig. 1) and then was reinforced by continuous interlocking suture (Orthocord; DePuy Mitek, Raynham, Massachusetts). The undersurface of the muscle was mobilized, and the neurovascular pedicle was identified without mobilizing it. After exposure of the neurovascular bundle,

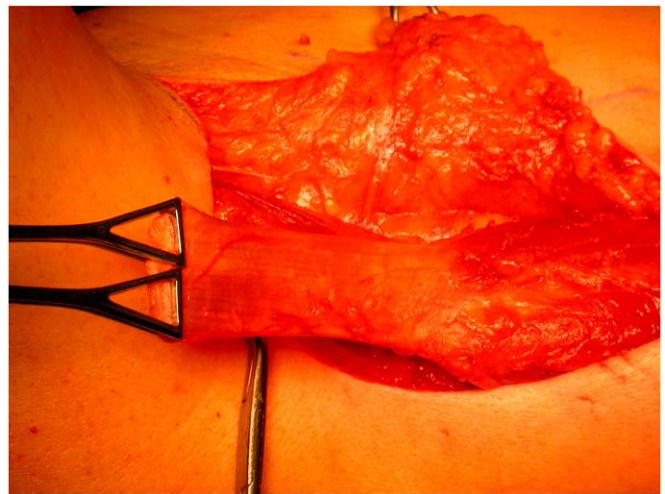


Fig. 1

Intraoperative photograph showing the mobilized latissimus dorsi muscle- and tendon unit detached from its origin on the proximal humeral shaft.

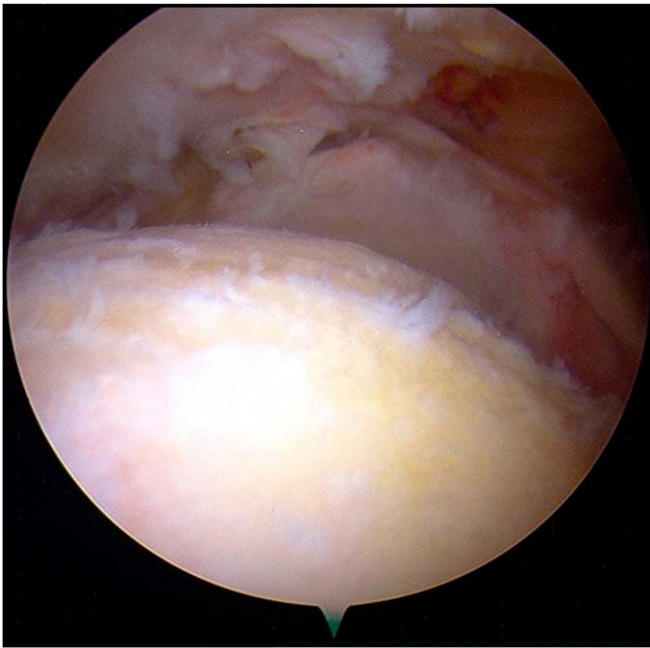


Fig. 2
Intra-articular view showing a massive rupture of the rotator cuff.

the latissimus dorsi tendon was mobilized and pulled over the acromion, until it crossed the acromion posterior edge by >2 cm¹⁵.

Standard shoulder arthroscopy portals were produced, and the arthroscope was inserted in the lateral portal (Fig. 2). Under direct visualization, a Hegar uterine retractor was advanced from the posterior portal to the axilla, passing through the plane between the teres minor and the deltoid muscles superiorly and the triceps and the deltoid inferiorly. As the Hegar retractor was

removed, the proximal end of the latissimus dorsi tendon was shuttled into the subacromial space¹⁵. Before fixation, latissimus dorsi tendon sutures were retrieved out of the anterior portal.

Two Bio-PushLock anchors (4.5 × 24 mm; Arthrex, Naples, Florida) were used to fix the tendon to the bone. The medial anchor was inserted at the anterior aspect of the greater tuberosity, close to the groove of the long head of the biceps. The second anchor was inserted lateral to the first to secure the tendon of the latissimus dorsi to the greater tuberosity (Figs. 3 and 4). When a repairable subscapularis tear was found, an arthroscopic repair was performed. If the long head of the biceps tendon was still present, a tenotomy was performed. An acromioplasty was never performed.

At the end of procedure, two suction drains were positioned at the harvest site.

Postoperative Rehabilitation

Postoperatively, the arm was placed in a brace positioned in 15° of abduction and 15° of external rotation for four weeks. The brace was worn day and night until the fourth postoperative week. Passive forward elevation exercises out of the splint were started on the first postoperative day. After four weeks, the splint was discontinued, and the patients underwent a physiotherapist-assisted rehabilitation program of passive and active mobilization. Isometric strengthening exercises were started after four weeks, and isokinetic exercises were started after eight weeks.

Data Collection and Statistical Analysis

Data were recorded in a computer database and included demographic information, history, physical examination findings, and imaging results. Descriptive statistics were calculated. The significance of improvement of the outcome parameters was assessed using the paired Wilcoxon signed-rank test. A non-parametric statistical test was selected because the values were not normally distributed. A p value of <0.05 was considered significant.

Analysis of the relationship between preoperative range of motion, strength, and pain and the postoperative Constant and Murley score was performed by calculating the Spearman rank-order correlation coefficient.

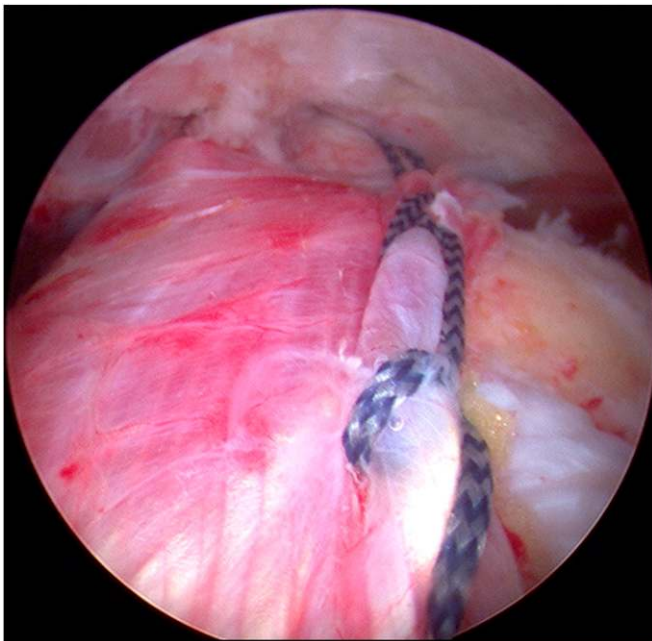


Fig. 3

Fig. 3 Intra-articular view showing the final fixation of the latissimus dorsi muscle-tendon to the greater tuberosity. **Fig. 4** Schematic illustration of the fixation of the latissimus dorsi muscle-tendon to the greater tuberosity.



Fig. 4

TABLE I Clinical Outcomes According to Previous Surgery and Sex

	Previous Surgery*		Sex*	
	No (N = 20)	Yes (N = 7)	Male (N = 16)	Female (N = 11)
Constant and Murley score	76 (62-84)	70 (40-80)	75 (62-84)	73 (40-81)
Forward elevation strength (lb [kg])	4 (2-9) (1.8 [0.90-4.05])	2 (1-5) (0.90 [0.45-2.25])	4 (2-9) (1.8 [0.90-4.05])	4 (1-6) (1.8 [0.45-2.70])
External rotation range of motion (deg)	38 (34-40)	37 (22-40)	38 (34-40)	37 (22-40)

*The values are given as the mean, with the range in parentheses.

For the Constant and Murley score, we calculated the minimal clinically important difference, defined as the smallest difference between the clinical scores perceived as beneficial by the patient. The minimal clinically important difference was estimated by the mean score change for the patients who, at the latest follow-up, reported the result of surgery as satisfactory according to a three-stage self-reported scoring system (with possible answers of very satisfactory, satisfactory, or unsatisfactory). We also estimated the minimal clinically important difference proportion, which was defined as the proportion of the sample with a change in the Constant and Murley score exceeding the minimal clinically important difference.

All statistical analyses were conducted with SPSS (version 16.0; SPSS, Chicago, Illinois).

Source of Funding

There was no source of external funding.

Results

Demographics

In the period March 2008 to December 2010, we performed a total of 1112 arthroscopic rotator cuff repairs; of those, twenty-seven were unilateral arthroscopic latissimus dorsi muscle-tendon transfers performed in sixteen men and eleven women with a mean age of sixty years (range, forty-six to sixty-seven years) (see Appendix). The dominant side was affected in twenty-one patients (78%). Seven patients had undergone a previous operation for rotator cuff repair. No patient had deltoid muscle tears or axillary nerve lesions. All patients had evidence of a full-thickness tear of at least two tendons on MRI. At arthroscopy, a subscapularis tear was repaired in three patients. A spontaneous rupture of the long head of the biceps tendon was evident in three patients, and a tenotomy was performed in the remaining twenty-four patients.

The mean duration of surgery was seventy minutes (range, forty-five to 120 minutes). The mean duration of physiotherapy was 4.5 months (range, two to ten months). The mean duration of follow-up was twenty-seven months (range, twenty-four to thirty-six months).

Clinical Assessment

The Constant and Murley score improved from a mean value of 36 points (range, 23 to 48 points) preoperatively to 74 points (range, 40 to 84 points) at the time of the latest follow-up ($p < 0.05$). At the latest follow-up, the minimal clinically important

difference was 36 points and the minimal clinically important difference proportion was 72% (twenty-one of twenty-nine patients) for the Constant and Murley score. The mean pain score improved from 1 point (range, 0 to 5 points) preoperatively to 14 points (range, 5 to 15 points) at the time of the latest follow-up ($p < 0.05$).

The mean value of strength increased from 2 lb (0.90 kg) (range, 1 to 6 lb [0.45 to 2.7 kg]) preoperatively to 4 lb (1.8 kg) (range, 1 to 9 lb [0.45 to 4.05 kg]) postoperatively ($p < 0.05$), corresponding to approximately 80% of normal strength for women and approximately 50% of normal strength for men^{5,25}. Five patients did not report any improvement; of those, three had undergone a previous rotator cuff repair.

Before surgery, the forward elevation, according to the Constant and Murley scale, was 31° to 60° in three (11%) of the twenty-seven patients, 61° to 90° in eight patients (30%), and 91° to 120° in sixteen patients (59%). At the time of the latest follow-up, the forward elevation was 91° to 120° in three (11%) of twenty-seven patients, 121° to 150° in nine patients (33%), and 151° to 180° in fifteen patients (56%). Before surgery, the abduction, according to the Constant and Murley scale, was 31° to 60° in two (7%) of twenty-seven patients, 61° to 90° in six patients (22%), and 91° to 120° in nineteen patients (71%). At the time of the latest follow-up, the lateral elevation was 69° to 120° in one (4%) of twenty-seven patients, 121° to 150° in eight patients (29%), and 151° to 180° in eighteen patients (67%). No improvement in active internal rotation was found. Range of motion in active external rotation improved from a mean value of 23° (range, 12° to 30°) preoperatively to 38° (range, 22° to 40°) at the time of the latest follow-up ($p < 0.05$).

Latissimus dorsi muscle-tendon transfer after failure of previous rotator cuff repair was associated with less strength in forward elevation and lower scores on the Constant and Murley scale than was latissimus dorsi muscle-tendon transfer performed as primary surgery (Table I). Conversely, the range of motion in active external rotation was similar between the two subgroups (Table I).

According to the sex of the patient, the results between men and women were found to be similar with respect to the Constant and Murley score, strength in forward elevation, and range of motion in active external rotation (Table I).

No significant correlation was found between the mean postoperative Constant and Murley score and the mean preoperative range of motion ($r = 0.15$, $p = 0.47$), the mean preoperative strength ($r = 0.18$, $p = 0.39$), and the mean preoperative pain score ($r = 0.19$, $p = 0.36$).

Imaging Assessment

Osteoarthritis was stage 1 in fifteen patients and stage 2 in twelve patients preoperatively and was stage 1 in thirteen patients and stage 2 in fourteen patients at the time of the latest follow-up ($p = 0.16$). Proximal migration of the humeral head was stage 1 in twelve patients and stage 2 in fifteen patients preoperatively and was stage 1 in fourteen patients and stage 2 in thirteen patients at the time of the latest follow-up ($p = 0.65$).

Complications

No intraoperative complications were recorded. Twenty-one (78%) of the twenty-seven patients did not report any surgery-related complications. There was one wound infection at the harvest site, managed with surgical debridement and antibiotics. Three patients (11%) developed a hematoma at the harvest site, not associated with any impairment, and recovered spontaneously. There were no permanent nerve lesions, but two patients (7%) developed dysesthesia in the posterolateral aspect of the affected arm, which recovered spontaneously over four to six months.

Discussion

Previous studies have assessed the effectiveness and long-term outcomes after latissimus dorsi muscle-tendon transfer for the management of massive rotator cuff tears²⁶. In the present study, we demonstrated that arthroscopic-assisted latissimus dorsi muscle-tendon transfer is technically feasible and provides good short-term outcomes for the treatment of selected patients with irreparable rotator cuff tears.

Our results are comparable with those of traditional latissimus dorsi muscle-tendon transfer performed alone with standard two-incision^{5,10-12} or one-incision^{13,14} techniques. Several authors have reported a significant improvement with regard to the Constant and Murley score, pain, muscle strength, and shoulder range of motion²⁷⁻²⁹. Among studies evaluating the one-incision technique, Habermeyer et al.¹³ and Lehmann et al.¹⁴ reported a significant improvement in the Constant and Murley score. Moreover, Habermeyer et al.¹³ reported increased active flexion, abduction, and external rotation after surgery.

In some studies, progression of osteoarthritis and proximal migration of the humeral head have been evaluated in patients undergoing latissimus dorsi muscle-tendon transfer. Aoki et al.¹¹, Gerber et al.⁵, and Debeer and De Smet³⁰ reported progression of osteoarthritis in 41%, 30%, and 39%, respectively, of the shoulders at a mean follow-up of thirty-five, fifty-three, and forty-three months. Gerber et al.⁵ and Debeer and De Smet³⁰ showed a significant decrease in the acromiohumeral head distance at the time of the latest follow-up. Gerber et al.⁵


also demonstrated a correlation between decreased acromiohumeral distance and progression of osteoarthritis. Conversely, we did not find significant osteoarthritis progression and proximal migration of the humeral head at short-term follow-up. Primary arthroscopic-assisted latissimus dorsi muscle-tendon transfer was associated with the best outcomes in terms of satisfaction, function, and lower percentage of rupture of the transferred tendon^{31,32}. Other authors^{5,33,34} did not find significant differences in the results and outcomes between primary or revision procedures.

We are aware that the retrospective design and the relatively small sample size represent major limitations. However, we included all of the eligible patients who underwent the arthroscopic-assisted latissimus dorsi muscle-tendon transfer procedure. Moreover, we performed a post hoc power analysis on our results obtained in the whole cohort, and the study had a power of 0.80 to detect a significant difference and an alpha error (the probability of yielding a type-I error) equal to 0.05. On the other hand, we acknowledge that we did not perform a statistical comparison of the clinical outcomes reported in subgroups of patients according to previous surgery and sex because there was not sufficient statistical power to perform an appropriate comparison in such small subgroups.

Finally, we did not perform postoperative electromyographic assessment of the latissimus dorsi activity during active function of the shoulder to determine whether the functional improvement was due to synergistically active tendon transfer or tenodesis effect⁵. Habermeyer et al.¹³ demonstrated high activity of transfer for external and internal rotation on electromyographic analysis, while Aoki et al.¹¹ found that the action of the latissimus dorsi is synergistic with that of the supraspinatus in external rotation in abduction. In addition, postoperative imaging was not performed to evaluate the healing and integrity of the transferred tendon.

In conclusion, arthroscopic-assisted latissimus dorsi muscle-tendon transfer with short-term follow-up represents an effective alternative to traditional open surgery for the fixation of the transferred tendon in patients with painful irreparable posterosuperior rotator cuff tears refractory to conservative management³⁵.

Appendix

 A table showing data on the patients is available with the online version of this article as a data supplement at jbjs.org. ■

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