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ORIGINAL ARTICLE

Arthroscopic-assisted latissimus dorsi transfer for irreparable posterosuperior cuff tears: Clinical outcome of 15 patients

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Abstract

Objective We analyzed the clinical and functional results of patients with irreparable posterosuperior rotator cuff tears treated with arthroscopic-assisted latissimus dorsi transfer and the clinical relevance of the addition of partial repair of the remaining cuff to the transfer.

Methods This was a prospective cohort study that included patients diagnosed with irreparable massive rotator cuff tears treated by arthroscopic-assisted latissimus dorsi transfer between 2015 and 2018. Demographic characteristics, clinical and functional outcomes (Constant-Murley (CS) score and subjective shoulder value (SSV)), and the incidence of complications were evaluated. Clinical outcomes were compared between patients treated with transfer alone and transfer with partial cuff repair.

Results Fifteen patients were included, with an average follow-up of 37 ± 16 months. The median duration of symptoms before surgery was 66 weeks (24–208). A significant increase in forward elevation of 52° ($p < 0.003$) and abduction of 48° ($p < 0.001$) was obtained. The CS score increased by 48 points ($p < 0.001$), and the SSV changed from 29% preoperatively to 70% postoperatively ($p < 0.001$), with a significant decrease in the visual analog pain score from 7 to 1 ($p < 0.001$).
In 10 patients, partial repair of the rotator cuff was also performed. No statistically significant differences were found in these patients compared with patients treated with transfer alone.
Two patients presented complications, including transient sensitive neuropraxia of the axillary nerve and seroma, which were managed conservatively and did not affect the outcomes.

Conclusion Arthroscopic-assisted latissimus dorsi transfer is a safe technique that significantly improves clinical and functional outcomes in selected patients. Longer follow-up and comparison with other treatment options are needed to confirm these excellent results in this group of difficult-to-treat patients.

Level of evidence IV Nil

Keywords Latissimus dorsi · Tendon transfer · Arthroscopy · Massive rotator cuff tears.

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Introduction

Rotator cuff tears (RCTs) are one of the most frequent pathologies of the shoulder and cause great discomfort in patients. Posterosuperior massive RCT (PSMRCTs) can cause superior humeral head migration [1], producing an eccentric load on the glenoid and eventually glenohumeral arthropathy [2].

The prevalence of irreparable RCTs has been reported to vary between 10 and 40% [3]. These tears are defined as the rupture of two or more tendons associated with advanced fatty infiltration (Goutallier grade ≥ 2) [4], retraction at the level of the glenoid according to the Patte classification [5] and muscular atrophy [6, 7]. PSMRCTs

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lead to eventual external rotation deficits (according to the teres minor status), forward elevation, and shoulder abduction [8, 9], hindering activities of daily life with associated pain.

The reported failure rate of primary repair for these injuries is up to 94%, and failure usually occurs before 6 months after primary repair [10–12]. Treatment remains challenging and controversial [13], and management options include subacromial bursectomy with tenodesis or tenotomy of the biceps [14], partial repair [15], deltoid flaps [16], tendon transfers [8, 17], reverse arthroplasty [18], subacromial spacers [19] and superior capsular reconstruction [20]. Due to the wide variety of treatments available, adequate patient selection is very important.

The goal of transfers is to prevent progression to arthropathy, especially in young patients [8]. To achieve adequate transfer, the following principles must be followed: (1) the transferred muscle must not compromise the function of the donor site; (2) the transferred and recipient tendons must have similar excursion and tension; (3) the vector and direction of contraction of both tendons should be similar; and (4) the transferred muscle must replace the receptor function [21].

L'Episcopo (1934) first described latissimus dorsi (LD) transfer [23] for patients with obstetric paralysis, and the procedure was then modified by Gerber in 1988 [24]. Later, in 2009, Elhassan developed procedures for open and arthroscopic lower trapezius transfer [22].

Good clinical and functional outcomes at the 10-year follow-up after open latissimus dorsi transfer for PSMRCTs [8] have been reported. Recently, arthroscopic-assisted transfer (with minimally invasive harvesting and arthroscopic fixation) was developed and has shown promising clinical results on short-term follow-up [13].

Our aim was to describe the clinical and functional outcomes in patients with irreparable posterosuperior rotator cuff tears treated with arthroscopic-assisted latissimus dorsi transfer. We hypothesized that patients undergoing latissimus dorsi transfer would show improve elevation and external rotation with reduced pain and that patients treated with partial cuff repair in addition to tendon transfer would show better outcomes than those treated with transfer alone.

Methods

Patients

This was a prospective study of 15 patients with irreparable posterosuperior rotator cuff tears treated with arthroscopic-assisted latissimus dorsi transfer between 2015 and 2018 with a minimum follow-up of 1 year (average, 37 ± 16 months). All procedures were performed by the same surgeon (FR) at a level 1 trauma center. It should be noted that all patients included in this study were subject to workers' compensation.

The inclusion criteria were irreparable posterosuperior rotator cuff tears, defined preoperatively by Patte stage 3 medial retraction [5] and fatty infiltration greater than Goutallier stage 2 [4] of the supraspinatus and infraspinatus muscles on MRI. Patients who failed to receive conservative treatment (participate in a specific physiotherapy program) for at least 6 months or who had received prior surgical treatment without obtaining satisfactory results (clinical and imaging findings of healing) were also included.

Patients were excluded if they had subscapularis insufficiency (determined by lift-off test or by Lafosse grade 2 or higher ruptures on imaging), teres minor atrophy with a lag sign on external rotation or a dropping sign, shoulder pseudoparalysis (defined as forward elevation of less than 60° and humeral head anterosuperior escape), rotator cuff arthropathy (Hamada grade 3 or higher) [25], glenohumeral osteoarthritis (Samilson grade > 1) [26] or history of previous glenohumeral joint infections. We also excluded patients with massive rotator cuff tears of type B or E according to the Collin classification [27].

Clinical assessment

Patients were clinically evaluated by a detailed interview and physical examination preoperatively and at 2 weeks, 6 weeks, 3 months, 6 months, and 1 year postoperatively. The range of motion (ROM) was measured with a goniometer on the coronal, sagittal, and axial planes. Functional results were evaluated using the Constant-Murley (CS) score, Subjective Shoulder Assessment (SSV), and visual analog scale (VAS) pain score (0–10).

The presence of complications was also described.

Imaging

All patients were diagnosed preoperatively by magnetic resonance imaging (MRI). All MRIs were performed using a clinical 3-T magnetic resonance scanner. The type of rotator cuff tear was classified according to the Collin classification [27]. The degree of fatty infiltration was evaluated using the Goutallier classification, and tendon retraction was evaluated using the Patte classification.

Surgical technique

All patients were operated on under general anesthesia in a "beach chair" position. A simple interscalene block was performed under ultrasound guidance, and local infiltration around the incision was performed with 15 ml of 0.25% bupivacaine. The arm was left completely free, and the surgical field included the axillary region to the medial edge of the scapula.

A 5-cm incision was made on the posterior axillary line (2 cm above the root of the limb and 3 cm toward the thorax) (Fig. 1A). The latissimus dorsi (LD) and teres major (TM) muscles were identified (Fig. 1B). The white aponeurosis band insertion of the LD was recognized and released at the tendon-bone junction with the help of a blunt retractor on the anterolateral wall of the humerus to obtain the greatest possible length (more than 4 cm in all cases). Then, dissection and release of the LD were performed distally, posteriorly and anteriorly. The neurovascular package is needed to be accurately identified (located in the anterior region between 10 and 14 cm from its humeral insertion) to protect it and prevent its traction at all times. The arm was kept under medial rotation to push out the axillary nerve superiorly and the radial nerve inferiorly.

A critical step was to identify, advance, and release the muscle to obtain the greatest possible excursion by releasing adhesions between the posterior surface and the tip of the scapula.

Tubulization of the tendon was performed with FiberLoop with Tag and TightRope ABS nonabsorbable sutures plus a TigerLoop suture (Arthrex, Inc., Naples, FL, USA) in a 90°/90° configuration (Fig. 1C).

Diagnostic arthroscopy was performed using the classic portals (posterior, anterior, anterolateral, posterolateral, and lateral), and the reparability of the posterosuperior rotator cuff (Fig. 2A) was evaluated. The cuff remnant was released to perform a partial repair associated with the transfer if possible. Tenotomy or tenodesis of the biceps was performed according to age, clinical/physical status, and patient preference. If a tear of the upper part of the subscapularis tendon was found, repair was performed using a double mattress knot like a pulley with a corkscrew Ti FT2 5.5 anchor (Arthrex, Inc., Naples, FL, USA).

The posterior space between the posterior deltoid muscle and Teres Minor was identified arthroscopically (Fig. 2B). Then, a suture grasper loaded at the tip with a FiberLink suture (Arthrex, Inc., Naples, FL, USA) was advanced posteroinferiorly via the axillary approach, specifically in the interval between the posterior deltoid and the long portion of the triceps muscle. Through this suture, the tubularized LD tendon was rescued and advanced into the bursal space.

The site of the bone tunnel for transfer insertion was identified, usually in the superior part of the greater tuberosity (between the 12 and 11 o'clock positions) (Fig. 2C). Using an "all-inside" ACL reconstruction tibial guide (Arthrex, Inc., Naples, FL, USA) while supporting the distal end of the humerus by percutaneous fixation at the bicipital groove, a 3- to 4-cm-long tunnel was drilled with a FlipCutter Drill Guide (Arthrex, Inc., Naples, FL, USA). The proximal 2 cm of the tunnel was drilled with a diameter of 8.5 mm, and the remaining length of the tunnel, at least 1 cm, was drilled with a diameter of 3.5 mm (Fig. 3A, B). The tubularized LD tendon was rescued and passed from the subacromial space to the upper end of the tunnel, with a minimum of 2 cm of

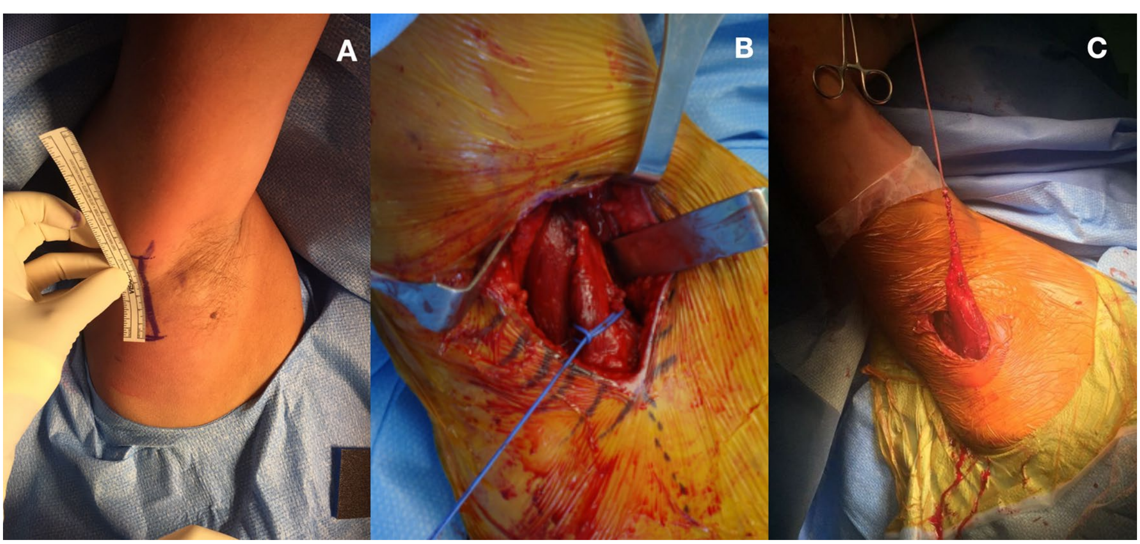


Fig. 1 Open Axillary Mini-Approach. **A** Five-centimeter incision on the posterior axillary line. **B** Latissimus dorsi (LD) muscle identification. **C** Tubulization of the tendon with a nonabsorbable suture

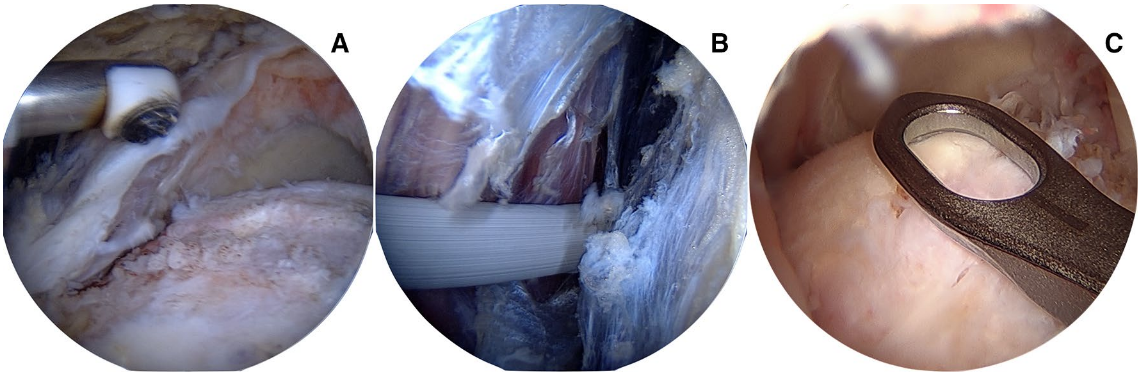


Fig. 2 Arthroscopic Evaluation. **A** Evaluation of rupture and reparability of the posterosuperior rotator cuff. **B** Identification of the posterior space between the posterior deltoid muscle and the remnant posterior cuff. **C** Tibial ACL guide at the site of the bone tunnel for transfer insertion, usually at the top of the greater tuberosity, close to the cartilage margin

intraosseous tendon, and it was fixed distally to the anterior cortex of the humerus using a 14-mm TightRope ABS concave button (Arthrex, Inc., Naples, FL, USA) (Fig. 3C, D).

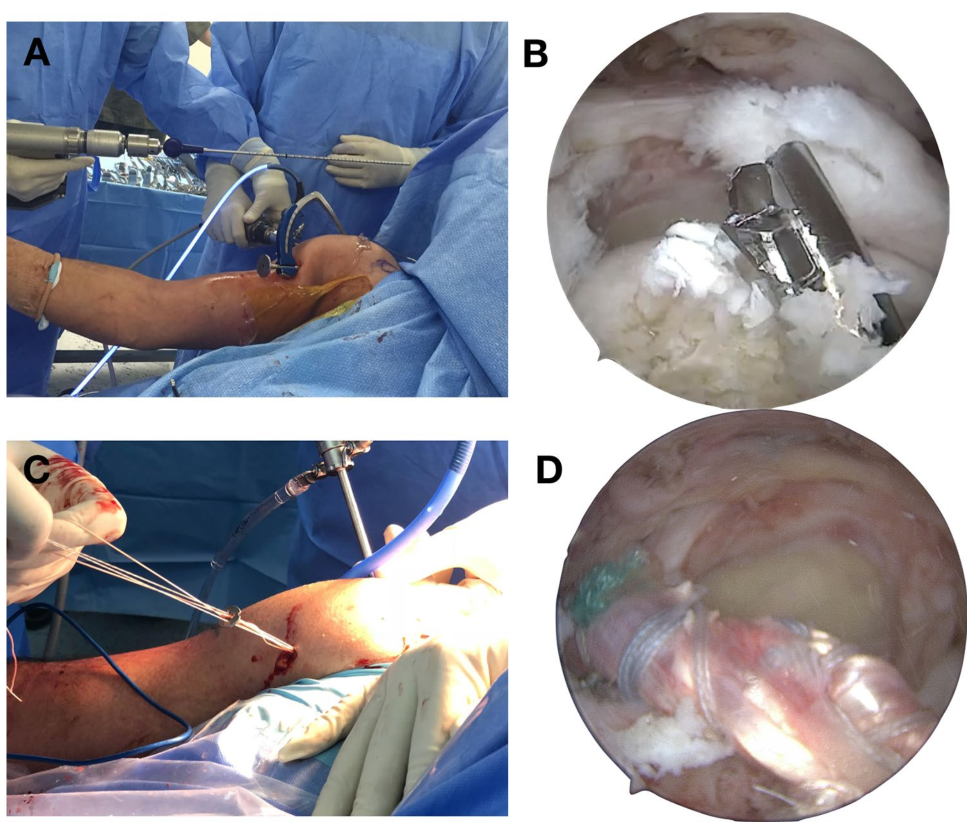
In 10 patients (66%), partial repair of the infraspinatus or supraspinatus tendon was performed through medialized reinsertion of the remnant with a double-loaded metal anchor and massive cuff knot or by a convergence margin technique.

Deep drainage and a compressive dressing were applied for 24 h. The limb was positioned on an abductor cushion under 30° of abduction and neutral rotation, which was strictly maintained for 6 weeks.

Rehabilitation

The rehabilitation protocol began after the sixth week postoperatively with assisted passive ROM exercises associated with scapular stabilization exercises. At the twelfth week, patients started progressive active mobility exercises always with scapular stabilization exercises. From the sixteenth

Fig. 3 Arthroscopic Fixation of the LD. Bone tunnel creation using a special drill: **A** External view; **B** arthroscopic view. **C** Fixation of the tendon with a cortical button. **D** Arthroscopic view of the LD tendon inside of the bone tunnel



week, muscle recovery therapy was supplemented with biofeedback techniques, and the patient was authorized to fully return to their activities at the eighth month.

Statistical analysis

The study followed a prospective cohort design, and all variables are presented as the mean and range. For the statistical analysis, the Mann–Whitney U test was applied using Stata version 14 (StataCorp, Texas, USA) with a 95% confidence level; statistical significance was defined by a p-value < 0.05.

Results

During the period of the study, 15 patients were included (7 women and 8 men). The average age was 53.4 years. In 11 cases, the right shoulder was treated, which corresponded to the dominant arm in 66% of the patients. The median time from symptoms to surgery was 66 weeks (24–208). Eleven of the 15 patients had undergone at least one previous surgical intervention (rotator cuff repair).

The mean gain in forward elevation was 52° ($p < 0.003$); abduction, 48° ($p < 0.005$); and external rotation, 10° ($p = 0.13$). Regarding the functional outcomes, a mean increase of 48 points in the adjusted CS score ($p < 0.001$) and an increase in the SSV from 29 to 70% ($p < 0.001$) were observed. The decrease in the VAS pain score from 7 to 1 ($p < 0.001$) was significant Table 1.

Two patients presented complications; one developed transient neuropraxia of the axillary nerve (hypoesthesia and deltoid weakness) lasting for 7 weeks, while the other developed a seroma in the operative wound associated with the harvest of the latissimus dorsi tendon. It was treated with a compressive system for 2 weeks. There were no reported reoperations.

Partial repair of the rotator cuff was performed in 10 patients. No statistically significant differences were found regarding the increase in forward elevation, external rotation, internal rotation, Constant score, or SSV in these patients compared with those treated with transfer alone (Table 2).

Discussion

Currently, multiple options for the treatment of irreparable massive posterosuperior rotator cuff tears have been proposed in the literature [33], and tendon transfer is one of them. While Gerber described open latissimus dorsi transfer in 1988 [24], the technique has been expanded and modified in recent years. Multiple authors prefer the arthroscopic-assisted technique because of the potential benefit in avoiding iatrogenic injury of the deltoid muscle and gaining the opportunity to treat associated tendon or articular injuries [28]. Although no long-term results of arthroscopic-assisted techniques are available, the short- and middle-term outcomes of these techniques are comparable with those of open techniques, with significantly improved shoulder function and reliable pain relief [29].

Table 2 Comparison between patients undergoing isolated transfer or transfer with partial cuff repair

Measured variable	Isolated transfer group	Transfer + partial repair group	p-value
Pain (VAS)	1 ± 0.7	1 ± 0.6	$p > 0.05$
Forward elevation	154° ± 37°	155° ± 29°	$p > 0.05$
Abduction	136° ± 25°	143° ± 21°	$p > 0.05$
External rotation (ER1)	33° ± 17°	40° ± 16°	$p > 0.05$
Constant-Murley adjusted score (points)	83 ± 10	82 ± 16	$p > 0.05$
SSV (%)	69 ± 10	70 ± 20	$p > 0.05$

All variables were presented in mean ± SD, SSV Subjective shoulder value

*Statistical significative difference ($p < 0.05$)

Table 1 Comparison of variables measured pre and post transfer of latissimus dorsi

Measured variable	Pre-op (range)	Post-op (range)	p value
Pain (VAS)	7 (5–10)	1 (0–6)	p 0.001*
Forward elevation	103° (61–153)	155° (110–180)	p 0.003*
Abduction	92° (30–150)	140° (80–180)	p 0.005*
External rotation (ER1)	28° (−10–50)	38° (10–70)	p 0.13
Constant-Murley adjusted score	34 (21–52)	82 (53–100)	p 0.001*
SSV (%)	29 (10–50)	70 (30–90)	p 0.001*

All variables were presented in Mean (Range)

SSV, Subjective shoulder value

*Statistical significative difference ($p < 0.05$)

This study presents the clinical and functional outcomes of a prospective cohort of 15 patients undergoing arthroscopic-assisted latissimus dorsi transfer for PSMRCTs by the same surgeon. All patients showed significant improvements in active forward elevation, abduction, pain, the Constant score, and the SSV.

We found a mean gain in forward elevation of 52°, which is slightly greater than that reported by Valenti et al. in 2019 [13], who described an average increase in 42°, and that reported by Gerber et al. in 2006 [9], who found a mean increase in forward elevation from 104° to 123°. The mean abduction increased from 92° to 140°, which is considerably greater than that reported by Gerber et al. in 2013 [8], who documented an 11° increase in abduction in contrast to the 48° increase observed in our series.

Although the external rotation gain was not statistically significant, the 10° increase in external rotation in position 1 (ER1) coincides with the findings described in the literature. Nove-Josserand et al. [30] described a 7° increase in ER1 in a series of 26 patients undergoing open latissimus dorsi transfer. Valenti, in a series of 25 patients published in 2010 [31], documented an average increase in 12° in ER1.

When analyzing the functional scores, we obtained an average increase in 48 points in the CS score and a mean increase from 29 to 70% in the SSV. These results are similar to those published in 2015 by Grimberg et al. [32] who described an average increase of 28 points in the CS score and 45 points in the SSV in a series of 55 patients. These findings are in line with those described by other research groups [33, 34].

Most likely, the superiority of our functional results compared to those in the literature is related to the strict selection of patients, excluding those with major subscapularis tendon tears, partial static ascension of the humeral head (Hamada 2), and shoulder pseudoparalysis. These conditions have been identified in the same previous articles as risk factors for worse clinical outcomes [8, 9, 13, 32].

In 2018, Valenti et al. [13] conducted a prospective study of 31 patients undergoing latissimus dorsi transfer for the treatment of irreparable posterosuperior rotator cuff tears. The sample was subdivided into 2 groups. In the first group, consisting of 17 patients, isolated transfer was performed, while in the second group, consisting of 14 patients, partial cuff repair was performed along with the transfer. When analyzing their results, they concluded that the patients in the second group, after a mean follow-up of 22 months, presented better functional results. In our series, when comparing the functional results between the patients treated with isolated transfer and those treated with partial cuff repair, we did not find any statistically significant differences, but this result is probably related to the small sample size.

Another reconstructive alternative is lower trapezius muscle transfer, initially described by Bertelli [35] for patients with obstetric paralysis but popularized by articles published by Elhassan [17, 21, 22]. In 2018, Valenti [36] reported on the use of an arthroscopic-assisted technique with augmentation with a semitendinosus autograft in a series of 14 patients. He described significant improvement of 24° in external rotation in position 1° and 40° in position 2 with a reduction of 5 points in the VAS score and an improvement of 25 points in the CS score. However, he emphasized that the procedure is an especially effective alternative in patients with an external rotation lag sign or signs of teres minor insufficiency.

The largest series was published by Elhassan in 2020, including 41 patients treated with arthroscopic-assisted lower trapezius transfer with Achilles tendon allografts, with a significant improvement in pain, shoulder motion, and functional outcomes. One of the advantages of this technique is the similar biomechanics of the lower trapezius to the infraspinatus muscle and the ability to use the technique in patients with subscapularis insufficiency and shoulder pseudoparalysis (a risk factor for latissimus dorsi transfer) [37].

Despite the promising results of this recent technique, there have been no comparative studies with a sufficient level of evidence regarding the preferential use of one of these alternatives over the other. There are still differences in the indications for these two tendon transfers. While lower trapezius transfer is mainly reserved for patients with external rotation deficits, the longest clinical follow-up data are available for latissimus dorsi transfer [8].

One of the most recent alternatives is the use of a biodegradable subacromial balloon, which depresses the humeral head in the absence of a rotator cuff to maintain active deltoid function. Lui F et al. [38] performed a meta-analysis of 270 shoulders of 261 patients and found a significant improvement in forward elevation and external rotation at the side, as well as the Oxford shoulder score and American elbow and shoulder score (OSS and ASES, respectively).

Finally, superior capsular reconstruction was initially described by Mihata [20]. The objective of this technique is to generate a fixed fulcrum for glenohumeral rotation, avoiding the dynamic ascension of the humeral head by reconstruction with an autologous graft of fascia lata or acellular dermis allograft and with the capsule between the glenoid and the greater tuberosity of the humerus. Burkhart [39] reported significant improvement in the ASES from 52 to 90 points in a series of 41 patients. This result was maintained at the 2-year follow-up; however, the rate of unsatisfactory results was 19%.

Kovacevic published a systematic review/meta-analysis in 2020 evaluating alternatives for the management of irreparable posterosuperior rotator cuff tears and concluded that according to the available evidence, it was not possible to recommend one technique over another. Clinical experience, patient factors, patient expectations, and rotator cuff tear characteristics should guide clinical decision-making [40]. We recommend the use of arthroscopic-assisted latissimus dorsi transfer for irreparable posterosuperior rotator cuff tears when the patient mainly has deficits of active forward elevation and abduction without unrepairable tears of the subscapular tendon, major external rotation deficits, shoulder pseudoparalysis or cuff tear arthropathy to achieve the best result from this technique.

Our study has numerous limitations. First, it was a prospective cohort study without a control group, which decreases its level of evidence. Second, the number of patients was small, which limits the power of the study. This could explain why we did not find significant differences between patients treated with transfer alone and those treated with transfer combined with partial cuff repair (analyzed power, 30%). We did not evaluate the healing of the transfer, which could be an issue according to the results presented by Kany [41], who described an incidence of retear close to 46%. However, one strength of this study is that all surgeries were performed by the same surgeon, reducing the technical variability of the procedure.

Conclusion

We can conclude that latissimus dorsi transfer with arthroscopic assistance in patients with an irreparable posterosuperior rotator cuff tear is a safe technique and significantly improves pain and clinical and functional outcomes (CS score and SSV). It also improves active forward elevation and abduction, but with no significant improvement in external rotation. We recommend this technique in highly selected patients, i.e., those with no shoulder pseudoparalysis, with a functional subscapularis muscle, and without an external rotation deficit. Longer follow-up is necessary to confirm these excellent early results.

Declarations

Conflict of interest The authors declare that they have no potential conflict of interest.

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