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Arthroscopic Biceps Tenodesis: Midterm Clinical Results of a New Anchor Suture Technique in Patients with Single-Row Rotator Cuff Repair

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SUMMARY

Objective. This study evaluated the midterm clinical results of doing the arthroscopic proximal long head of the biceps tenodesis with an anchor suture of subscapularis or supraspinatus repair in patients with arthroscopic rotator cuff repair.

Methods. We evaluated the clinical results of long head of biceps tendon tenodesis in patients with single-row rotator cuff repair. They were all treated with our technique in which we did the tenodesis with anchor suture of rotator cuff repair in a manner that provides both bony and soft tissue attachment for the tendon. We evaluated the results of the long head of the biceps (LHB) tenodesis in all patients by looking for Popeye deformity, anterior shoulder tenderness, asking for anterior shoulder pain, and measuring elbow flexion and forearm supination force compared to the normal side as a primary goal, and compared results of LHB tenodesis with subscapularis or supraspinatus tendon suture as a secondary goal too.

Results. A number of 131 patients participated in the final follow-up: 34 patients had LHB tenodesis with subscapularis tendon suture and 95 patients with supraspinatus tendon suture. Mean of follow-up time was four years (24 to 71 months). Two patients had the Popeye deformity (1.5%), five patients had the anterior shoulder tenderness (3.8%), and seven patients suffered from anterior shoulder pain (5.3%). Elbow flexion and forearm supination forces were measured in the affected and non-affected limbs. There was no significant difference between the two limbs. Those who had LHB tenodesis with supraspinatus anchor suture had better results and less complications.

Conclusions. Arthroscopic tenodesis of the LHB tendon incorporated into single-row rotator cuff repair is a cost-efficient method, leading to better results for implant or soft tissue tenodesis too. Fixing to supraspinatus tendon seems to have better results and fewer complications compared to subscapularis tendon.

KEY WORDS

Biceps tenodesis; anchor suture technique; shoulder arthroscopy; rotator cuff repair.

INTRODUCTION

Disorders of the long head of the biceps (LHB) tendon have many pathological conditions, from inflammatory tendinitis to degenerative tendinosis (1, 2). The LHB tendon lesions are frequently associated with partial or complete rotator cuff tears, particularly in older adults (3-10). LHB tendon lesions such as biceps tear of more than 30%, subluxation, dislocation or a degenerative SLAP type II lesion can lead to chronic pain even after rotator cuff surgery (5, 11, 12). Therefore, treating them is recommended during rotator cuff surgery (10, 13-15).

The optimal method for surgical management of LHB tendon's pathology is still in debate (5). Two of the most common procedures are 1) biceps tenotomy and 2) biceps tenodesis. Biceps tenotomy is a recognized, successful procedure (1, 16). Arthroscopic biceps tenotomy is an easy and fast procedure with shorter surgery time and easier postoperative rehabilitation process (17, 18). However, there are always concerns of Popeye deformity or cramping pain and strength loss due to the tendon's distal migration (17). Its Popeye deformity rate is between 3% and 63% (17-21).

On the other hand, the purpose of biceps tenodesis is to keeping the length-tension relationship of the muscle, which may prevent muscle atrophy and help to save the normal contour of the biceps muscle (1). It is believed that biceps tenodesis should be used in younger, active patients (1). We can do tenodesis proximally with maintaining the LHBT in the bicipital groove (22, 23) or distally with removing the tendon from the groove (24, 25). Both proximal and distal tenodesis could be done with different fixation methods, including implant or soft tissue fixations.

In this research we used a cost-effective surgery technique for this procedure using an anchor suture of the rotator cuff repair. The primary goal of the research was to evaluate the overall result of this technique on all patients. The secondary goal was to compare the results of tenodesis by a limb of subscapularis repair suture *versus* supraspinatus repair suture. We believed that our technique could have had advantages for both soft tissue and implant tenodesis without the need for more implants.

METHODS

This cross-sectional study evaluated the clinical results of our different suture anchor technique for LHB tenodesis. The participants were patients who had referred to our center because of rotator cuff tear. All patients signed an informed consent before entering the study. The Ethics Committee of our University approved the study (IR.UMSHA. REC.1396.750 – Date of approval: February 14, 2018).

The inclusion criteria included: 1) being a patient with arthroscopic rotator cuff repair who requires biceps tenodesis because of (a) LHB tendon instability and (b) LHB tendinosis with more than 25% partial tear; 2) being treated with our method instead of any other method for biceps tenodesis.

The exclusion criteria were: 1) incomplete rotator cuff repair; 2) having any disorder in the operated or contralateral upper limb that could affect the pain or force of elbow flexion or supination; 3) revision surgery for rotator cuff tear; 4) not being available for the last follow up.

Surgical technique

Arthroscopy started in beach chair position with the arm in about 30° abduction and 60 forward elevation. Using a 30° scope from the posterior portal, we evaluated the glenohumeral joint for any pathology, including any rotator cuff tears, pulley integrity, and LHB tendon. Afterward, if subscapularis tendon tear needed to be repaired, during preparing subscapularis foot print, we prepared the proximal part of the intertubercular groove with shaver and arthroscopic rasp to make a fresh bony bed for LHB tendon. Then we repaired the subscapularis tendon from the anterolateral portal. However, the sutures were not cut and still left in the anterolateral portal. The suture strands of subscapularis repair passed from the intact LHB tendon. After making a loop around the tendon, the sutures were retrieved from the anterolateral portal again. Then the LHB tendon was cut, and the sutures were tied. If biceps tendon medial subluxation prevents subscapularis repair, first we passed a monofilament suture from LHBT and cut it to pull it out of the subscapularis footprint, then, after subscapularis tendon repair, monofilament suture was replaced by fiber wire of subscapularis repair (**figure 1**).

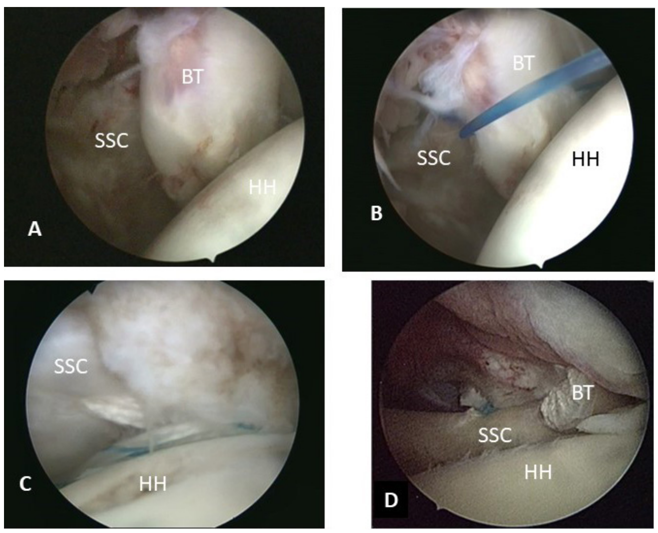

Figure 1. LHB tenodesis using subscapularis tendon suture.

(A) Posterior portal view, subscapularis tendon tear and medial subluxation of LHB tendon; **(B)** Passing a monofilament suture from LHB tendon; **(C)** Passing fiber wire suture of anchor suture from subscapularis tendon; **(D)** Final result of LHB tendon tenodesis after passing fiber wire of subscapularis tendon repair from LHB tendon and knot tying. SSC: subscapularis tendon; HH: Humeral head; BT: Biceps tendon.

If subscapularis tendon was intact, and supraspinatus tendon was torn so that the lateral restraint to the biceps' tendon stability failed, first a monofilament suture was passed through the biceps tendon with a 18-gauge needle. Then by retracting both sides of the monofilament suture from the supraspinatus tendon defect on humeral head and cutting the LHB tendon, we extracted the tendon from the glenohumeral joint up to the subacromial space. Then we transferred the arthroscopic equipment to the subacromial space and after debridement of subacromial bursa, while preparing supraspinatus footprint, we prepared the proximal part of the inter tubercular groove with shaver and arthroscopic rasp to make a fresh bony bed for LHB tendon. The supraspinatus repair was done in a single row manner, but sutures of the anterolateral anchor were not cut. Finally, we finished tenodesis by passing sutures of supraspinatus repair from biceps tendon in the manner explained for subscapularis sutures. If supraspinatus tear is located anterior and LHB is easily visible from subacromial space, it is not necessary to cut it until fiber wire suture of supraspinatus anchor is passed from LHB (**figure 2**). The important point of this technique is attaching the proximal of the LHB tendon to the bursal side of subscapularis or supraspinatus tendon in a way that it does not disrupt the bone-tendon contact of rotator cuff, and also maintains contact of the LHB tendon to the prepared inter tubercular groove.

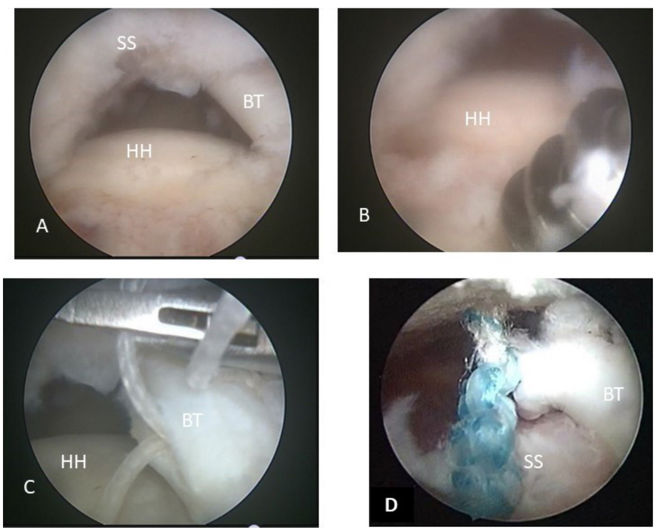

Figure 2. LHB tenodesis using supraspinatus tendon suture.

(A) Lateral portal view of sub acromial space; **(B)** Inserting anchor suture for supraspinatus repair; **(C)** Making a loop into and around LHB tendon using fiber wire suture of supraspinatus anchor suture; **(D)** Final result after knot tying, LHB tendon is attached to bursal side of supraspinatus tendon. SS: supraspinatus tendon; HH: humeral head; BT: biceps tendon.

The first author (HS) did all the surgeries with the same technique and the same suture management of all patients. The post-surgery instructions included four to six weeks of active shoulder motion restriction depending on the extent of rotator cuff tear. The elbow flexion started four weeks after surgery. Strengthening exercises were prohibited until 12 weeks after surgery.

The patients were evaluated by the two other authors who were not aware of the LHB tenodesis type. They recorded the anterior shoulder pain by asking the patients if they have pain at anterior of the operated shoulder, Popeye deformity by comparing two arms during extended and forcefully flexed arms, and anterior shoulder tenderness by palpation of anterior shoulder and bicipital grove while detecting reaction of patient for pain. They also measured the force of elbow flexion and forearm supination (Lafayette dynamometer, USA) and compared it to the normal healthy side. To compare patients who had LHB tenodesis with subscapularis repair sutures and those who had tenodesis with supraspinatus repair as a secondary goal, we divided our patients into two groups: subscapularis and supraspinatus groups. As the purpose of our study was evaluating results of our tenodesis technique in patients with single-row rotator cuff repair, the outcome scores were not evaluated as they can directly be influenced by results of rotator cuff repair.

Statistical analysis

We did all the statistical analyses with the statistical package for social sciences (SPSS) software version 21. Chi-square test and Fisher's exact test were used to compare the frequency of complications between two groups with different techniques.

Due to the normal distribution of data based on test Kolmogorov-Smirnov, Student t-test was used to compare the mean of elbow flexion and forearm supination forces in subscapularis and supraspinatus groups. P-value < 0.05 was considered significant.

RESULTS

Totally, 131 patients participated in the final follow up. **Table I** demonstrates demographic data of the patients. Their mean of age was 60.85 years old (27 to 78 years old). 48.8% of the patients were female and 51.1% male. LHBT tenodesis was performed in 95 patients with supraspinatus tendon suture and in 34 patients with subscapularis tendon suture. Mean age of the patients was not different between two groups, but they were significantly different in sex distribution. The mean of follow up time was four years (24 to 71 months).

First we evaluated clinical results of LHB by evaluating possible complications LHB tenodesis of our suture tech-

Table I. Demographic data of the patients.

	All patients	Supraspinatus group	Subscapularis group	P-value
Number	131	95	34	
Male	67 (51.1%)	45.3%	66.7%	< 0.05
Female	64 (48.8%)	54.7%	33.3%	< 0.05
Mean age	60.85	61.55	58.97	> 0.05

nique in all patients (**figure 2**). Two patients had Popeye deformity (1.5%), anterior shoulder tenderness in five patients (3.8%) and seven patients suffered from anterior shoulder pain (5.3%). There was not significant relationship ($p > 0.05$) between complication rate and sex (**table II**) or age (**table III**) of the patients.
Elbow flexion and forearm supination forces were measured in the affected and normal limbs (Lafayette dynamometer, USA). There was no significant difference ($p > 0.05$) between the two limbs in force of elbow flexion and forearm supination.
Then we compared results of the technique between two groups. **Figure 3** and **table IV** demonstrate comparison of complications between two groups. Two patients who had Popeye deformity, both were in the subscapularis group

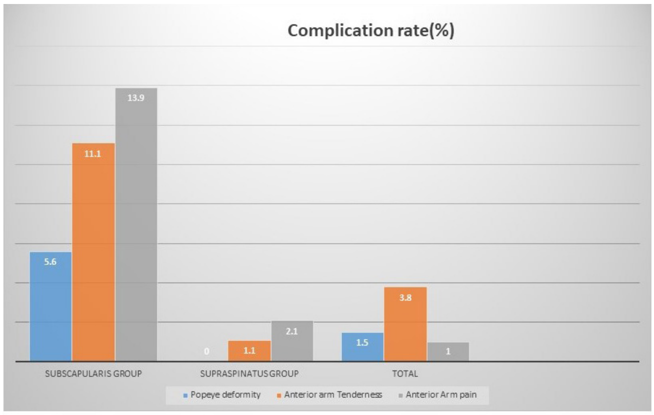

Figure 3. Complication rate (%) in all patients and both groups.

Table II. Dirtribution of complication of LHBT tenodesis by gender of patients.

Complication	Gender		P-value
	Fermale Number (%)	Male Number (%)	
Popeye deformity			
No	64 (100)	65 (97)	
Yes	0 (0)	2 (3)	0.496
Total	64 (100)	67 (100)	
Anterior arm tenderness			
No	63 (98.4)	61 (91)	
Yes	1 (1.6)	6 (9)	0.058
Total	64 (100)	67 (100)	
Anterior arm pain			
No	61 (95.3)	63 (94)	
Yes	3 (4.6)	4 (6)	0.116
Total	64 (100)	67 (100)	

Table III. Distribution of complications of LHBT tenodesis by age in all patients.

Complication	Age (year)		P-value
	No Mean ± SD	Yes Mean ± SD	
Popeye deformity	61.14 ± 8.37	42.00 ± 21.21	0.423
Anterior arm tenderness	61.29 ± 8.21	49.60 ± 16.18	0.182
Anterior arm pain	61.17 ± 8.20	55.14 ± 8.50	0.371

Table IV. Frequency of complications of LHBT tenodesis in each group.

Complication	Tenodesis method		Total	P-value
	SSC group Number (%)	SS group Number (%)		
Popeye deformity				
No	34 (93.4)	95 (100)	129 (98.5)	
Yes	2 (5.6)	0 (0)	2 (1.5)	0.074
Total	36 (100)	95 (100)	131 (100)	
Anterior Arm Tenderness				
No	32 (88.9)	90 (98.9)	126 (96.2)	
Yes	4 (11.1)	1 (1.1)	5 (3.8)	0.020
Total	36 (100)	91 (100)	131 (100)	
Anterior Arm Pain				
No	31 (86.1)	93 (97.9)	124 (94.7)	
Yes	5 (13.9)	2 (2.1)	7 (5.3)	0.017
Total	36 (100)	95 (100)	131 (100)	

Table V. Force (N) of elbow flexion and forearm supination of both limbs in supraspinatus and subscapularis groups.

Force	Subscapularis group Mean ± SD	Supraspinatus group Mean ± SD	P-value
Elbow flexion operated side	46.36 ± 18.62	52.14 ± 17.48	0.066
Elbow flexion normal side	48.92 ± 19.85	55.20 ± 19.26	0.100
Forearm supination operated side	36.6 ± 13.39	36.77 ± 14.46	0.726
Forearm supination normal side	38.11 ± 12.16	39.01 ± 13.43	0.538

(5.6%). We found no Popeye deformity in supraspinatus group ($p < 0.05$). Among five patients who had anterior shoulder tenderness, four patients (11.1%) were in the subscapularis group and one (1.1%) in supraspinatus group ($p < 0.05$). Among seven patients who had anterior shoulder pain without tenderness, five patient (13.9%) were in the subscapularis group and two (2.1%) in the supraspinatus group ($p < 0.05$).

Elbow flexion and forearm supination forces of affected and normal limbs, compared between two groups (**table V**). There was no significant difference ($p > 0.05$) between the two limbs in force of elbow flexion and forearm supination between supraspinatus and subscapularis group.

DISCUSSION

Treating LHB tendon lesions such as a biceps tear of more than 25%, degenerative SLAP type II lesion, subluxation or dislocation is recommended during rotator cuff surgery. This is because they can result in chronic pain even after a successful rotator cuff surgery (10-15).

The optimal surgical management of LHB tendon lesions is still controversial (5). The two most common procedures are biceps tenotomy and tenodesis. Although arthroscopic biceps tenotomy is an easy and fast procedure with shorter surgery time and easier postoperative rehabilitation process (17, 18), there are always concerns of Popeye deformity or cramping pain and strength loss due to the tendon's distal migration (1). Biceps tenodesis can maintain the length-tension relationship of the biceps muscle.

LHB tenodesis techniques vary according to the location and method of fixation. We can do biceps tenodesis proximally, in which LHB tendon is maintained within the bicipital groove, or distally so that it is removed from the groove (1). We can do the proximal fixation with an all-arthroscopic technique within the glenohumeral joint or sub deltoid space to the surrounding intact rotator cuff (25) or to the conjoint tendon (26) or just proximal within the bicipital groove. 90% to 100% biceps strength has been reported for different proximal fixation methods compared to the normal side (16, 27).

McCrum *et al.* studied 1,526 shoulders for complications of biceps tenodesis based on location, fixation, and indication (28). They were operated by 84 surgeons in 14 hospitals. This is the most comprehensive study that we have found about complications and results of LHB tenodesis. They defined "persistent" anterior shoulder pain as residual pain that does not resolve with biceps tenodesis, indicating that the procedure fails to alleviate anterior shoulder pain at the last follow-up. "New-onset" anterior shoulder pain was defined as pain that develops in the anterior shoulder after surgery in patients who do not have the anterior shoulder pain before surgery (28). As an indicator of procedure failure, there was Popeye deformity in 4.25% of soft tissue tenodesis and 4.77% of implant tenodesis (28).

In our study, we measured complication rate and force of elbow flexion and forearm supination in order to evaluate clinical results of our new anchor suture technique for LHB tenodesis. We did not measured shoulder function scores because we did LHB in patients who needed rotator cuff repair and shoulder function can be more determined by rotator cuff repair instead of biceps tenodesis. We found Popeye deformity in 1.5% of the patients. An explanation for these good results is probably that this technique has advantages for both soft tissue tenodesis (because of adhesion to the bursal side of the repaired rotator cuff in an early stage) and bony tenodesis (because of preparing the proximal of the bicipital groove for bony adhesion in a later stage after surgery).

Considering the anterior shoulder pain after LHB tenodesis, soft-tissue tenodesis can result in a significantly higher rate (11.9%) of new-onset anterior shoulder pain compared to implant tenodesis (2.6%) (28). In our study, we found seven patients with anterior shoulder pain (5.3%). Five of them were in the subscapularis group. Three of the five patients had persistent anterior shoulder pain. In other words, new-onset anterior shoulder pain was only 3% in our patients.

Although it is not possible to determine if anterior shoulder pain is due to LHB tenodesis or repair site of rotator cuff tear, we think that new onset anterior pain is more likely to be related to tenodesis.

McCrum *et al.* did not assess the anterior shoulder tenderness. However, we found five patients have this problem (3.8%), four of whom were in the subscapularis group (11.1%) and one (1.1%) in the supraspinatus group. Although we do not know if this tenderness is related to biceps tenodesis or rotator cuff repair site, its high rate in the subscapularis groove *vs* supraspinatus groove was notable. So, more studies to compare anterior shoulder tenderness in patient with and without LHB tenodesis with this technique is required to determine if high rate of anterior shoulder pain is related to tenodesis or subscapularis repair.

When comparing tenodesis techniques, many studies found out that soft-tissue tenodesis cases had a higher rate of subjective weakness than implant tenodesis cases (28-30). A possible explanation is that bony tenodesis may provide a more secure fixation, which may result in less change in the length-tension relationship over the course of healing, as under-tensioning of the biceps may result in early fatigue (31, 32).

We believe that subjective evaluation of weakness after biceps tenodesis and rotator cuff repair can be influenced by rotator cuff function. So, we measured the force of elbow flexion and supination instead of shoulder functional scores. We found no significant difference between both limbs of the participants. A reason can be that our method is secure enough to keep length tendon relationship over the course of healing.

Veenstra *et al.* evaluated 19 patients with proximal biceps tenodesis incorporated into supraspinatus repair for a mean of two years (33). Their technique incorporated LHB tendon into the articular side of rotator cuff. They did not prepare bicipital groove for bony attachment of biceps tendon. ASES score and visual analog score improved significantly. There was no change in elbow flexion and supination before surgery and at two years follow up. However, four patients had difference in arm contour compared to the non-operated side. We think that ASES and visual analog score could be deeply influenced by rotator cuff repair. Tenderness in the bicipital groove and evaluating Popeye deformity can directly evaluate results of LHB tenodesis.

Meghpara *et al.* evaluated the clinical outcomes of an all-arthroscopic biceps tenodesis using the anterolateral anchor during concomitant double-row rotator cuff repair with two years follow up (34). No patient developed deformity. Interestingly one patient who had LHB tenodesis incorporated into subscapularis tendon repair had persistent anterior shoulder pain. In our study we noticed more anterior shoulder pain, anterior shoulder tenderness and Popeye deformity in the subscapularis group. We did the tenodesis technique incorporated into single row rotator cuff repair and prepared proximal of bicipital groove for bony attachment of the tendon.

Limitation

The number of the participants who attended the final follow-up was limited. We could not determine whether new onset of anterior shoulder pain is related to LHB tendon or rotator cuff repair site, especially in subscapularis group, so more studies to evaluate anterior shoulder pain in patients with and without LHB tenodesis into subscapularis tendon repair is required. Although main goal of the study is evaluating results of the technique in all patients, comparison of two groups had some limitation. There is no homogeneity among the two groups in terms of number and gender due to low incidence rate of subscapularis tear compared to supraspinatus tear.

CONCLUSIONS

Doing arthroscopic tenodesis of LHB tendon using rotator cuff anchor suture is a cost-efficient method, leading to better results of bony or soft tissue tenodesis separately. Considering midterm follow up and number of patients of our study, fixation to supraspinatus tendon has better results and less complications compared with fixation to subscapularis tendon. Although, more studies are necessary to confirm this result.

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DATA AVAILABILITY

Data are available under reasonable request to the corresponding author.

CONTRIBUTIONS

HS: study design, surgeries. AS: follow-up, data collection. AS, HS: writing. BH: discussion, editing. EK: data analysis.

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CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

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