Abstract

Introduction: The long head of the biceps (LHB) tendon is considered a common source of anterior shoulder pain. The prevailing belief is that inflammatory pathophysiology is the primary cause. Various treatment approaches, including conservative measures, physical therapy, and surgery, are currently utilized. Among the surgical methods, biceps tenotomy and tenodesis stand out as the most frequently employed options.

Aim of the study: To detect the clinical outcome after arthroscopic suprapectoral bicipital tenodesis using suture anchors.

Subjects and Methods: From June 2019 to December 2021, we conducted a prospective cohort study on 25 patients who presented with anterior shoulder pain due to pathology in the LHB. Participants were recruited for arthroscopic suprapectoral tenodesis and were followed up at six and 12 months. We used the Constant-Murley score to detect clinical and functional outcomes, which encompassed four domains: pain, strength, range of motion, and activities of daily life. We also calculated the frequency of the Popeye sign, which represented LHB rupture.

Results: Patients could have a significant improvement in the Constant-Murley score postoperatively at both six and 12 months compared with the preoperative values, with a postoperative mean of 82.8 (79 - 89) at six months and 85.18 (82 - 93) at 12 months. Also, they achieved significant improvement in each of its components; pain, ADL, stability, and motility at six months compared with the baseline values. Additionally, only four patients developed the Popeye sign.

Conclusions: The supra-pectoral tenodesis was an efficient surgery for treating LHB tendon pain with minor adverse effects. It has the potential to significantly raise the CMS score after six months and one year. Furthermore, only a few patients got the Popeye sign.

Keywords: (LHB; supra-pectoral tenodesis; Constant-Murley score).
1. Introduction

The ventral part of the upper arm has a thick, large muscle called the biceps brachii. The muscle has two heads; The caput longum (long head) and caput breve (short head) of the muscle (1). The short head arises from the tip of the coracoid process, whereas the long head arises from the glenoid/scapula's supraglenoid tubercle (tuberculum supraglenoidale). Both heads run distally and form a muscular belly before tapering over the anterior part of the elbow and inserting onto the forearm fascia and radial tuberosity through the bicipital aponeurosis (2,3). The main function of the biceps brachii muscle is a powerful forearm supinator but a poor elbow flexor (4). According to biomechanics, the shoulder joint's dynamic stability is dependent on the LHB tendon (5). The tendon serves at least a passive stabilizing function in the shoulder (6). Although it is well known that the LHB tendon helps with elbow supination and flexion as well as resistance to superior movement of the humeral head at the shoulder joint, its precise function is still unknown (7). Anterior shoulder pain is frequently connected to the LHB tendon. Repetitive traction, glenohumeral rotation, and friction are examples of mechanical causes (8). Due to its proximity to the glenohumeral joint's synovial lining, the bicipital sheath is itself susceptible to tenosynovial inflammation (9). With neuropeptides like calcitonin gene-related peptide and substance P, the LHB tendon's upper part has a rich sympathetic innervation network (10). These elements are found in the sensory nerves in this area of the tendon (11). This sympathetic network is known to display vasodilatory alterations due to the neurogenic inflammatory process in the LHB tendon (12). These changes may be crucial in the chronic phase of pathophysiology impacting the LHB tendon (13). Several methods have been used to treat the LHB tendon, including non-surgical and surgical management (14). Regarding non-surgical management, non-steroidal anti-inflammatory drugs combined with rest are the first line of treatment (15). Physical therapy programs focused on the underlying cause are another management option (16). Also, the steroid injection with ultrasonography guidance is a different method for the management of the LHB tendon (17). Surgical management is another option for the management of LHB tendons. Tenotomy and tenodesis are two treatment choices for a patient with an injured or painful LHB tendon (18). Although
tenotomy has been found to reduce pain, the arm may develop an undesirable cosmetic deformity due to the procedure (19). Consequently, many tenodesis procedures for transferring the origin of the LHB to the proximal humerus have been established. Open and arthroscopic procedures for treating LHB disease have been reported (20). The usage of biceps tenodesis has lately grown. Tenotomy involved only the release of the LHB tendon from the supraglenoid tubercle (21). At the same time, tenodesis involved the steps of tenotomy beside the reattachment of the LHB tendon distally along its course (22). Biceps tenotomy has the advantages of being quicker, simpler, and less expensive. Tenotomy also eliminates some of the difficulties associated with biceps tenodesis, including technical and hardware issues, chronic shoulder discomfort, humeral fracture, neurovascular damage, delayed failure, complicated regional pain syndrome, and other intrinsic surgical hazards (23). Additionally, tenodesis presents a decreased risk of postoperative biceps cramps or spasms compared to tenotomy (25). Fixation options for biceps tenodesis include soft tissue fixation, all-suture anchors, interference fixation, and suspensory fixation (26). In this study, we report an all-arthroscopic supraperacetal biceps tenodesis with an all-suture anchor and aim to detect the clinical outcomes after arthroscopic supraperacetal bicipital tenodesis using suture anchors.

2. Subjects and methods

2.1. Subjects

According to our inclusion criteria, 25 patients were included in the study. All patients were a candidate for supra-pectoral bicipital tenodesis and followed up at two endpoints; six months and one year.

Preoperative management:

Figure 1: Confirming the disease at the LHB tendon through pulling the extra articular portion of the tendon into the joint for inspection

All patients were examined clinically preoperatively. Also, they were assessed on the CMS. Moreover, they were a candidate for magnetic resonance imaging (MRI) on the affected shoulder to detect the bicipital
pathology and any concomitant shoulder lesion.

**Operative interference:** Patients were recruited for the suprapectoral biceps tenodesis. The operation was done under general anesthesia. Then, we followed the steps of suprapectoral biceps tenodesis published by Lansdown et al. (27). Patients were settled on the beach chair position, and the targeted shoulder was steriley prepped and draped. **Exposure of LHB tendon and arranging for tenodesis** We used a 30° arthroscope of the standard posterior portal to perform the glenohumeral diagnostic arthroscopy. Then, we systematically evaluated the intra-articular structures and ensured the pathology of LHB by inspection of the extra-articular part of the tendon (Fig.1). Next, whenever we decided to do biceps tenodesis, we performed tenotomy by changing the arthroscopic entry to the subacromial space and released biceps from the transverse humeral ligament (Fig.2).

![Figure 2](image2.jpg) **Figure 2:** Releasing the biceps from the transverse humeral ligament.

Placing the anchor and finishing the tenodesis We distally inserted the all-suture anchor through the anterolateral portal (2 cm inferolateral to the anterior stranded portal) to the fibrocartilage end of the groove. We might use a single or double-loaded anchor. Also, we used the bird peak penetrator, passed it from the medial to the lateral end of the tendon, and created a loop medially to the tendon. We passed the bird peak penetrator for the second time with the attached limb through the loop and created a knop to stabilize the tendon. Moreover, we did this procedure again if we selected the double-loaded implant. We tied the knots to protect the biceps while we withdrew the cannula. (Fig.3 and 4)

![Figure 3](image3.jpg) **Figure 3:** An all-suture anchor was inserted immediately distal to the end of the fibrocartilage of the groove.
We remained the tendon without cutting until we finished the tenodesis to get the proper tension. After that, we cut suture limbs and truncated the proximal stump of the LHB tendon using a radiofrequency ablation device (Fig 5). The free proximal stump (approximately 3-4 cm in length) was removed using the posterior portal with the tissue grasper.

**Postoperative management and follow-up:**

We used an abduction arm sling on the patient's arm after surgery and for four weeks. Also, we recommended doing exercises of the pendulum and elbow and wrist range of motion. Additionally, we instructed the patients to stop doing any active biceps exercise for six weeks postoperatively. At the period of six to 12 weeks postoperatively, patients could start gentle strength training could be started. At 12 weeks, patients could do their activities. Using the CMS, we clinically examined the patients six months and one year after surgery.

**Study variables and outcomes** We followed up with patients at two endpoints; six months and one year postoperatively. We used the Constant-Murley score (CMS) as a measure for our clinical and functional outcomes as a primary outcome (28). The original score was developed in 1987. It estimated pain, Activities of daily living (ADL), Range Of Motion (ROM) / mobility, and strength of the affected shoulder. The patients filled out the pain and ADL, while ROM and strength were evaluated and filled out by the surgeon. Also, different modifications were applied to the questionnaire, such as measuring the pain by using the Visual Analog Scale (VAS) (29).
The total score ranged from zero representing the worst score of shoulder function, to 100, representing the best. The score of pain was 15 points, ADL was 20 points, ROM was 40 points (ten for each of the four active motions), and strength was 25 points (30). We also identified the incidence of Popeye among patients postoperatively to represent our secondary outcome. The Popeye sign was assumed to be commonly reported after orthopedic surgery and to be a classic sign of the rupture of the LHB tendon (31).

**Inclusion criteria**

- Bicipital lesions either isolated or with concomitant small or medium sized Rotator cuff tear or subacromial impingement in the form of: Tenosynovitis-Partial or full thickness tears-Subluxation

**Exclusion criteria**

- Patients younger than 18 years
- Bicipital lesions with associated massive rotator cuff tears

2.2. **Study design**

A Prospective Cohort Study

2.3 **Statistical Analysis**

We performed the statistical analysis using Statistical Package for the Social Sciences (SPSS) version 26 (IBM Corp., Armonk, NY, USA). We adjusted the significance of statistical analysis at P≤0.05. Descriptive statistics were performed as follows; qualitative data were presented as median (range), while quantitative data were presented as frequency (percentage). We used the two-way repeated measures ANOVA and the Bonferroni post hoc test to identify significance at different endpoints.

3. **Results**

Demographics of the patients: Our study included 25 patients with an average age of 54 years (between 32 – 69 years). Thirteen patients (52%) included in the study were males, while twelve patients were females (48%). 17 patients were operated on the dominant upper limb, while eight patients were operated on the non-dominant upper limb. Thirteen patients included in the study had an associated rotator cuff tear (RCT). Four patients had associated SLAP lesions. Six patients had associated impingement syndrome, while two patients had isolated bicipital lesions. **Constant-Murley score (CMS)** Patients had an average preoperative CMS score of 51 (46 – 56).
Fortunately, they had significant improvements at both endpoints compared with the preoperative values (P<0.001). At six months, they had an average of 82.8 (79 - 89), while at one year, they had an average of 85.18 (82 - 93). (Table 1)

Table 1) Constant-Murley score

<table>
<thead>
<tr>
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<th>Preoperative</th>
<th>Postoperative</th>
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<tr>
<td></td>
<td>6 months</td>
<td>1 year</td>
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<tr>
<td>Mean (SD)</td>
<td>50 (3.22)</td>
<td>82.3 (3.14)</td>
<td>85.13 (3.31)</td>
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<tr>
<td>Range</td>
<td>45 - 55</td>
<td>78 - 88</td>
<td>80 - 91</td>
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<td>Difference between six and 12 months</td>
<td>P&lt;0.001</td>
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Table 1 shows the postoperative evaluation of the patients. Qualitative data are presented as mean (SD) and range.

SD; Standard Deviation and F; F test (ANOVA) with repeated measures, Significance between periods was done using Post Hoc Test (Bonferroni)

P; P value for comparing different study groups P1: P value for comparing between preoperative and postoperative six months P2: P value for comparing between preoperative and postoperative 1 year

* Statistically significant at p ≤ 0.05

**Pain score:** Patients had an average preoperative pain score of 6.44. It was significantly improved at both endpoints. They had an average pain score of 14.35 at six months and 14.7 at one year.

**ADL score:** Patients had an average preoperative ADL score of 10.06. It significantly improved at six months to 18.45. Also, at one year, the mean difference was significantly improved compared with the values of preoperative and six months to be 19.17. **Mobility score:** Patients had an average preoperative mobility score of 23.9. It significantly improved at six months to 37.8. Moreover, at one year, the mean difference was significantly improved compared with the values of preoperative and six months to be 39.4. **Strength score:** Patients had an average preoperative strength score of 13.22. It was significantly improved at six months to 14.89 and at one year to 16.03. However, there was no difference between the values of six months and one year.

**Postoperative Popeye sign:** Four patients (16%) were complicated and showed the Popeye sign, while twenty-one patients (84%) were free.
3. **Discussion** In our study, we enrolled 25 individuals with an average age of 54 years. Suprapectoral tenodesis was necessary for all patients. Thirteen of them were men, and 17 had surgery on their dominant leg. In addition, 13 patients had RCT, four patients had SLAP lesions, and six patients had impingement syndrome. We checked in with the patients after six months and one year. Patients improved significantly in overall CMS score and each of its components at six months compared to baseline values, including pain, ADL, stability, and motility. In addition, only four patients displayed the Popeye sign. **Constant-Murley score** Patients had significant improvements at both endpoints compared with the preoperative values. They had an average of 82.8 (79 - 89) at six months and 85.18 (82 - 93) at one year. We followed prospective research in which patients who underwent arthroscopic tenodesis experienced a substantial increase in the CMS after 14 months of follow-up, with a postoperative mean CMS of 89.1 and P<0.05 (32). Also, RCT that compare the outcomes of suprapectoral tenodesis and arthroscopic tenotomy concluded that suprapectoral tenodesis was superior to arthroscopic tenotomy as the mean CMS for patients in the biceps tenotomy cohort improved from 44 (95% CI, 39-48) to 73 (95% CI, 68- 79), and that for patients in the biceps tenodesis cohort improved from 42 (95% CI, 37-48) to 78 (95% CI, 74-82) (33). Additionally, a network meta-analysis revealed that performing suprapectoral tenodesis instead of arthroscopic tenotomy resulted in a substantially larger mean difference in CMS (MD= 2.46, CI (0.23 to 4.69)) (34). Moreover, a prospective study on patients with isolated biceps lesions allocated for suprapectoral tenodesis showed significant improvements at all intervals compared with the preoperative values (P<0.001). They had mean scores of 79.4 (15.7) at three months, 82.8 (10.2) at six months, 84.6 (9.5) at 12 months, and 84 (7) at 24 months (35). Warner et al. performed a study that evaluated both arthroscopic suprapectoral biceps tenodesis and open subpectoral biceps tenodesis and found that after three years of follow-up, the mean CMS of arthroscopic suprapectoral biceps tenodesis was 90.7 and 91.8 for open subpectoral biceps tenodesis (36). Also, Chiu et al. found the same results as the CMS improved from 23.4 ± 11 preoperatively to 80.7 ± 5.2 postoperatively with p value < 0.001 after 24 months (37). **Pain score:** Both
endpoints revealed a considerable improvement in the patients. At six months, their
average pain score was 14.35; at a year, it was 14.7. We followed a prospective trial
in which patients who underwent arthroscopic tenodesis experienced a significant
VAS improvement after 14 months of follow-up (preoperative pain score was 3.6
(3.5), whereas postoperative pain score was 11.2 (2.2; P=0.000). (32). In 2021,
Cabarcas et al. assessed the outcomes of arthroscopic supraperiosteal onlay biceps
tenodesis and revealed that there was a significant improvement in the pain score
after 6 months of follow-up ( preoperative pain score was 6.1 ± 2.4 and
postoperative pain score was 3.1 ± 2.3) (38). Also, Chiu et al. found the same results
as the pain score improved from 7.3 ± 1.1 preoperatively to 1.8 ± 0.6 postoperatively
with a p-value < 0.001 after 24 months (37). ADL score: Patients significantly
improved at six months, with a mean score of 18.45. Also, the mean difference was
significantly improved at one year compared with the preoperative and six-month
values to 19.17. Additionally, a prospective study on patients who had isolated
biceps lesions and were recruited for supraperiosteal tenodesis showed significant
improvements at all intervals compared with the preoperative values (P<0.001).
They had mean scores of 15.6 (4.6) at three months, 17.4 (3.9) at six months, 17.2
(3.4) at 12 months, and 18 (2.5) at 24 months (35).Mobility score: Patients
significantly improved at six months, with a mean score of 37.8. Moreover, at one
year, the mean difference was significantly improved compared with the values of
preoperative and six months to be 39.4. Besides, a prospective study on patients who
had isolated biceps lesions and were recruited for supraperiosteal tenodesis showed
significant improvements at all intervals compared with the preoperative values.
They had mean scores of 35.1 (6.2) at three months (P= 0.003), 37.2 (3.7) at six
months (P<0.001), 38.9 (2.5) at 12 months (P<0.001) and 39.2 (2.1) at 24 months
(P<0.001) (35). In addition, a case series study including 50 patients with biceps
lesions revealed substantial improvement of postoperative mobility score compared
with the preoperative values after six months (38).Strength score: Patients
significantly improved at six months with a mean score of 14.89 and at one year
with 16.03. However, there was no difference between the values of six months and
one year. In addition, a case series study including 50 patients with biceps lesions
reported results that were consistent with our findings as they showed substantial improvement \((P = 0.002)\) of postoperative strength score compared with the preoperative values after six months (38). Also, a prospective study on patients with isolated biceps pathology recruited for suprapectoral tenodesis showed no differences between the preoperative and all postoperative values at different intervals; three, six, 12, and 24 months (35). **Postoperative Popeye sign:** Four patients (16%) were complicated and experienced the Popeye sign, while twenty-one patients (84%) were free. We were in line with the results of the network meta-analysis, where the suprapectoral tenodesis showed better significant odds than the arthroscopic tenotomy \((OR = 0.51, CI (0.21 to 1.25))\) (34). RCT that compared the outcomes of suprapectoral tenodesis and arthroscopic tenotomy found that Popeye deformity occurred in 47% of tenotomy patients and 33% of tenodesis patients \((P = .17)\) (33). **Previous studies:** In line with our investigations, a number of complementary studies have also reported significant advancements in patient outcomes following surgical interventions. Notably, Shen et al (32) demonstrated a remarkable enhancement in Constant scores, soaring from an initial 39.4 in the pre-operative phase to an impressive 89.1 post-operatively. These results align closely with our own findings, highlighting the substantial impact of surgical intervention on patient well-being. Furthermore, in a separate study conducted by Werner et al, (36) a cohort undergoing arthroscopic suprapectoral tenodesis exhibited a noteworthy elevation in Constant-Murley scores, reaching an outstanding level of 90.7.

**Strength points and limitations** We could assess the arthroscopic supraoperative tenodesis approach and demonstrate its effectiveness in relieving LHB pain. However, we were constrained due to the nature of observational studies without interventions, the fact that the study was limited to a single arm, and the requirement for a bigger sample size to generalize our findings. Also, we did not consider the effect of many factors on the outcomes of the procedures, such as controlled or uncontrolled diabetes, body mass index, smoking, different daily activity, and other associated conditions.

**Conclusion** The suprapectoral tenodesis was an efficient surgery for treating LHB tendon pain with minor adverse effects. It has the potential to
significantly raise the CMS score after six months and one year. Furthermore, only a few patients got the Popeye sign.

Acknowledgment
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Ethical approval and consent to participate:
From June 2019 to December 2021, we identified individuals who presented with anterior shoulder pain. The Scientific Research Ethics Committee granted ethical permission. In addition, each participant signed an informed consent form.

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Conflicts of Interest:
None

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