Intra-articular arthroscopic biceps tenodesis with interference screw: clinical and isokinetic evaluation

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Background: Although biceps tenodesis has been widely used to treat its pathologies, few studies looked at the objective evaluation of elbow strength after this procedure. The purpose of this study is to clinically evaluate patients submitted to long head of the biceps (LHB) tenodesis with interference screws through an intra-articular approach and analyze the results of an isokinetic test to measure elbow flexion and forearm supination strengths.

Methods: Patients who had biceps tenodesis were included in the study if they had a minimum follow-up of 24 months. Patients were excluded if they had concomitant irreparable cuff tears or previous or current contralateral shoulder pain or weakness. Postoperative evaluation was based on University of California-Los Angeles (UCLA) shoulder score and on measurements of elbow flexion and supination strength, using an isokinetic dynamometer. Tests were conducted in both arms, with velocity set at 60°/s with 5 concentric-concentric repetitions.

Results: Thirty-three patients were included and the most common concomitant diagnosis was rotator cuff tear (69%) and superior labrum anterior to posterior (SLAP) lesions (28%). The average UCLA score improved from 15.1 preoperatively to 31.9 in the final follow-up (P < .001). Isokinetic tests showed no difference in peak torque between the upper limbs. One patient had residual pain in the biceps groove. None of the patients had Popeye deformity. UCLA score and follow-up length did not demonstrate correlation with peak torque.

Conclusion: Arthroscopic proximal biceps tenodesis with interference screw, close to the articular margin, yielded good clinical results. Isokinetic tests revealed no difference to the contralateral side in peak torque for both supination and elbow flexion.

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Originally described by Boileau et al., interference screw tenodesis has demonstrated biomechanical superiority to other fixation methods in comparative studies. Lo and Burkhardt introduced a modification to the technique, in which interference screw tenodesis was performed on the proximal portion of the intertubercular groove, on the edge of the articular surface of the humerus using an intra-articular view. This location is controversial, however, because residual pain in the intertubercular groove has been reported and attributed to an increase in LHB strain and to maintenance of a portion of unhealthy tendon in the intertubercular groove.

The objectives of this study are, therefore, to clinically evaluate patients submitted to LHB tenodesis with interference screws through an intra-articular approach and analyze the results of an isokinetic test to measure elbow flexion and forearm supination strengths.

**Materials and methods**

**Study design and patient selection**

A retrospective case series was carried out, and patients who had arthroscopic LHB tenodesis with interference screw, performed between 2009 and 2014, were identified from the hospital surgical records. The inclusion criteria were as follows: (1) older than 18 years and (2) minimum follow-up of 24 months. Patients were excluded if they presented (1) irreparable injuries of rotator cuff muscles in ipsilateral shoulder and (2) previous or current contralateral shoulder pain. The main indication for surgery was symptomatic tendinopathy of LHB, observed through magnetic resonance imaging and confirmed with arthroscopic procedure. Besides that, patients older than 40 years with SLAP injuries unresponsive to conservative medical treatment were also an indication for the procedure. The research was approved by the local ethics committee, and all volunteers read and signed an informed consent form, in which the experimental goals and conditions were fully described in accordance with the Helsinki Declaration.

**Surgical technique**

All LHB tenodesis had been performed arthroscopically, in beach chair position, under general anesthesia and interscalene brachial plexus block using nerve stimulator. A 30° scope was routinely used, and when concomitant repair of large subscapularis tendon tear was needed, a 70° scope was used. After joint inspection, the anatomopathologic status of biceps muscle was labeled as shown in Table 1. A braided polyester suture (Ethibond Excel no. 2; Ethicon, Cincinnati, OH, USA) was passed through biceps tendon and a tenotomy was carried on at the superior labrum. When the tendon was brought outside through the anterior portal a Krackow suture was made on the LHB using a speculum (Fig. 2). Then the LHB was inserted into the bone socket, close to the humeral articular cartilage, and a hole was made using a cannulated drill with a diameter same as the tendon’s (Fig. 2). The cannulated screw (Bio-Tenodesis Screw; Arthrex) was slipped through the same driver (Fig. 3). Lastly, the suture limbs were either cut and removed from the joint or used in the repair of a subscapularis tendon tear.

**Results**

Thirty-three patients took part in the study (age: 50 ± 9.8 years; height: 170.23 ± 706 cm; weight: 83.55 ± 11.72 kg). The dominant upper limb was the involved limb in 69% of cases. The most common associated diagnoses were rotator cuff injury (69%), SLAP lesion (28%), and anterior labrum injury (20%). The mean time of follow-up was 37.9 months. More detailed and other demographic data were displayed in Table II. The average UCLA score improved from 15.1 preoperatively to 31.9 in the final follow-up (P < .001, d = 4.04; Fig. 4). A total of 9 patients reported palpation pain at the intertubercular groove, although only 1 subject reported occasionally spontaneous pain. Another patient developed postsurgery joint stiffness, and had a good outcome following conservative

**Postoperative care**

When isolated biceps tenodesis was carried on, without concomitant major procedures, the postoperative program was as follows: sling for 3 weeks; active elbow, wrist, and hand motion from the first day after surgery; and shoulder passive elevation and external rotation started 1 week after surgery. After sling removal, patients were referred to physiotherapy to regain range of movement. Biceps-strengthening exercises started at 12 weeks after the surgery, although rotator cuff strengthening was allowed earlier, at 8 weeks. When biceps tenodesis was made in conjunction with other major procedure(s), the rehabilitation program was dictated by the one that requires the longest recovery period. For instance, when a biceps tenodesis was made concomitant with the repair of a massive rotator cuff tear, the immobilization period was longer and rotator cuff-strengthening exercises were introduced after 12-16 weeks.

**Clinical and isokinetic evaluation**

The clinical outcomes were evaluated using the University of California–Los Angeles (UCLA) shoulder score, measured in pre- and postoperative moments. The patient’s shoulders were examined by the same physician looking for signs of impairment of LHB, as pain on direct palpation of intertubercular groove and biceps belly deformity. The muscular torque was measured using an isokinetic dynamometer (CSMI; Humac Norm, Stoughton, MA, USA). The patient was positioned as manufacturer’s determinations to measurement of supination and elbow flexion. The flexion tests were performed with both neutral and supinated forearm positions. In all tests, procedures were conducted in both arms, with velocity set at 60º/s with 5 concentric-concentric repetitions. Prior to evaluation, familiarization and warmup procedures were conducted. The arm and movements order were randomly assigned. The peak torque achieved was calculated and normalized by total body weight.

**Statistics**

The involved and contralateral limbs were compared using separate paired t tests for peak torque and peak work, as the pre- and postoperative UCLA scores. Cohen effect size was used to express the magnitude of difference in assessed comparisons. Pearson correlation coefficient was calculated for pre-UCLA vs. post-UCLA, post-UCLA vs. follow-up, and between pre-UCLA, post-UCLA, and follow-up with peak torque and peak work values. All calculations were conducted using SPSS, version 19 (IBM SPSS Inc., Armonk, NY, USA), and all graphs were produced with GraphPad Prism, version 5 (GraphPad Software Inc., La Jolla, CA, USA). Statistical significance was predetermined as 5%.
treatment of 8 months. None of the patients showed biceps muscle belly deformity.

Regarding the isokinetic tests, there was no significant difference between the involved and contralateral limbs (Table III). There were no significant correlations between postoperative UCLA and follow-up length ($r = -0.017, P = .924$) and between pre- and postsurgery UCLA ($r = 0.176, P = .329$). Similarly, UCLA and follow-up did not demonstrate correlation with peak torque (Table IV).

**Discussion**

This study has shown that arthroscopic biceps tenodesis leads to good clinical results and preserves maximum flexion and supination strength of the elbow. All the patients were operated on by the same surgeon and underwent postoperative evaluation by an independent examiner.

Most patients included in this study (69%) had associated rotator cuff tears along with the biceps tendinopathy, and frequently, this was the main indication for surgery. In fact, Naudi et al.31 have shown that 90% of patients submitted to rotator cuff repairs have LHB tendon histologic alterations. Also, Jacquot and Boileau16 have found static and dynamic macroscopic alterations on arthroscopic inspection of the LHB tendon in 82% of the 378 patients submitted to rotator cuff repairs in their study. SLAP lesions were found in 28% of cases, also featuring as an important indication for LHB tenodesis. Some authors have demonstrated better results with LHB tenodesis compared with superior labrum repair,4,9,14,54,56 with even worse results for repair in older patients.54 In spite of this, there is no consensus about a minimum age to decide between labrum repair and LHB tenodesis. In our series, the youngest patient was a 27-year-old male bodybuilder who presented with a superior and anterior labrum lesion. A biceps tenodesis was performed considering the patient's high demand and the already present macroscopic tendinopathy alterations.

If, on one hand, there is a trend to perform LHB tenodesis in younger patients, this tendency is also seen in the treatment of older patients. Even though recent epidemiologic studies confirm that most of these procedures are performed in patients 30-60 years old, there was a significant increase in LHB tenodesis performed in patients older than 60 years.52,55 That is also our experience, because a rising number of these patients practice sports regularly and are concerned with aesthetic issues derived from a tenotomy without tenodesis. Although some studies have shown similar functional results with both tenotomy and tenodesis of the
Recently, García-Rell deformity was 3 times more common in the tenotomy patients compared with those with a tenodesis. Moreover, the Popeye strength was significant of functional scores after surgery. However, the supination that both tenotomy and tenodesis patients had similar improvements did not reach that of the contralateral side. Lee et al21 showed the elbow of California scores measured in pre- and postsurgery (mean ± SD). Lee et al21 concluded that tenodesis with a proximal interference screw may increase LHB tension. For this reason, many advocate a more distal tenodesis, suprapectoral or even subpectoral. Nevertheless, we agree with Denard et al,1 who has shown that a better LHB tendon length–tension relation recovery can be obtained with an interference screw adjacent to the articular margin of the humerus in a 25-mm-deep hole. Maybe the persistence of pathologic tendon tissue in the bicipital groove and not the tension increase per se is what precipitates pain on palpation.25,46 It is worth noting that the clinical relevance of this finding is minor, because only 1 of the 33 patients reported spontaneous local pain and 73% demonstrated no pain, not even on palpation. Although subpectoral biceps tenodesis is thought to produce less residual pain because the pathologic part of the biceps is removed, Gombera et al13 and Yi et al11 revealed no difference in outcomes of patients submitted to proximal or subpectoral tenodesis. Moreover, proximal biceps tenodesis have some advantages, including less surgical dissection (all arthroscopic method), easier revision surgery because of tendon preservation, and more accurate restoration of biceps tension. Also, subpectoral tenodesis is not free of complications, including severe ones, such as humerus fracture and nerve injuries.32,36

In this study, our clinical evaluation was based on the UCLA shoulder score1 and on physical examination of the operated shoulder. The mean postoperative score was more than double the preoperative one, showing great functional recovery. Even though only 1 patient reported sporadic localized shoulder pain in the intertubercular groove, precipitated by muscle strain, 9 patients (27%) reported pain when the bicipital groove was palpated on physical examination. This could be attributed to an increase in tension of the LHB tendon on the bicipital groove when intra-articular tenodesis is performed adjacent to the humeral head cartilage. Werner et al17 performed a biomechanical study that concluded that tenodesis with a proximal interference screw may increase LHB tension. For this reason, many advocate a more distal tenodesis, suprapectoral or even subpectoral. Although residual pain in the biceps groove is often reported after proximal biceps tenodesis, its actual incidence is not so clear. The largest series of biceps tenodesis available in the literature is that of Brady et al,2 which was entirely performed with the same technique as that reported in our article. In their article, the endpoint was not pain in the tubercular groove but revision surgery rate due to pain, which was 0.4%. Yi et al11 reported that 5.8% of their patients had tenderness in the bicipital groove at the final follow-up, but the authors did not mention if it was on palpation or spontaneous pain. Sanders et al60 showed that the revision rate was higher for patients who had tendosisis without opening of the transverse ligament. However, the percentage of patients with

![Figure 4](image-url)  
**Figure 4** UCLA scores measured in pre- and postsurgery (mean ± SD). UCLA, University of California—Los Angeles functional scale; Pre, presurgery; Post, postsurgery; SD, standard deviation. *Significantly different from presurgery score (P < .001, d = 4.04).

### Table II

| Demographic data | Patients |
|------------------|----------|
| **Sex** |          |
| Man | 24        |
| Woman | 9         |
| **Age, yr** |          |
| Mean (variation) | 48 (27–69) |
| **Laterality: limb dominance** |          |
| Right | 32        |
| Left | 1         |
| **Laterality: involved limb** |          |
| Right | 23        |
| Left | 10        |
| **Rotator cuff tear** |          |
| Complete | 11        |
| Partial | 7         |
| **Total** | 18        |
| **Chondropathy** |          |
| Yes | 7         |
| No | 25        |
| **Labrum repair** |          |
| Yes | 13        |
| No | 20        |
| **Follow-up, mo** |          |
| Mean (variation) | 38 (24–80) |

### Table III

| Peak torque measured in an isokinetic dynamometer at 60°/s | Involved | P value | d |
|------------------|-----------|---------|----|
| **Peak torque, Nm/kg, mean ± SD** |          |         |    |
| FlexN | 0.46 ± 0.17 | 0.45 ± 0.16 | .623 | 0.06 |
| FlexS | 0.48 ± 0.18 | 0.48 ± 0.18 | .937 | 0.00 |
| Sup | 0.09 ± 0.04 | 0.10 ± 0.04 | .111 | 0.25 |

*FlexN, elbow flexion with forearm neutral; FlexS, elbow flexion with forearm neutral supination; Sup, forearm supination; SD, standard deviation; d, Cohen effect size.

### Table IV

| Correlation analyses between UCLA and follow-up with torque measurements of involved limb | Presurgery UCLA score | Posturgery UCLA score | Follow-up, mo |
|---------------------------------|----------------------|----------------------|---------------|
| **r** | **P value** | **r** | **P value** | **r** | **P value** |
| FlexN | 0.355 | .042 | –0.09 | .959 | 0.194 | .280 |
| FlexS | 0.339 | .054 | 0.087 | .628 | 0.143 | .427 |
| Sup | 0.163 | .364 | 0.126 | .485 | 0.075 | .680 |

*FlexN, elbow flexion with forearm neutral; FlexS, elbow flexion with forearm neutral supination; Sup, forearm supination; UCLA, University of California—Los Angeles functional scale. *Significantly correlated (P < .05).
residual pain was not mentioned. None of our patients required revision surgery. Besides, only 1 of our patients (0.03%) reported occasional spontaneous pain in the bicipital groove. The other 8 patients denied having pain when asked about it, although they had mild tenderness on palpation of the biceps groove.

Per the clinical results, the isokinetic testing showed satisfactory results. Maximum strength (peak torque) on the operated side was equivalent to that on the contralateral side on both elbow flexion and supination. This finding is in agreement with previous reports, and indicates that no loss of elbow strength should be expected following a biceps tenodesis.

There are many materials and methods for performing an LHB tenodesis, including tenodesis to soft tissues and bony tenodesis without interference screws. Though Levin et al.23 defended soft tissue tenodesis arguing that it better reproduces biceps tension, the Popeye deformity may occur in up to 35% of cases, which did not happen in this series. Complications with tenodesis with anchors and cortical buttons have also been described. Richards and Burkhart35 have shown in a biomechanical study that an interference screw tenodesis has significantly higher pullout strength than one performed with 2 anchors. Ozalay et al.33 performed a biomechanical study comparing 4 arthroscopic techniques of biceps tenodesis and found the interference screw to be almost twice as strong as the fixation with suture anchors. Patzer et al.32 biomechanically compared 4 arthroscopic techniques of biceps tenodesis and also found interference screws to have the higher ultimate load to failure. Although it is difficult to transfer the results of a biomechanical study to the clinical setting, these results should serve as a general guide when choosing a biceps tenodesis technique for our patients, especially those with higher demand in sports or heavy labor. Lee et al.22 performed a retrospective study on technique for our patients, especially those with higher demand in

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Conclusions

Arthroscopic proximal biceps tenodesis with interference screw, close to the articular margin, yielded good clinical results. Isokinetic tests revealed no difference to the contralateral side in peak torque for both supination and elbow flexion.

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