Intra-Articular Arthroscopic Biceps Tenodesis With Interference Screw: Clinical And Isokinetic Evaluation

Running Title: Isokinetic testing after biceps tenodesis
Abstract

Background: Biceps tenodesis has been widely used to treat its pathologies, especially in young active patients, in order to maintain or restore biceps muscle strength. However, few studies looked at objective evaluation of elbow strength after this procedure.

Purpose: The purpose of this study is 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.

Study Design: Retrospective case series.

Methods: Patients who had biceps tenodesis were included in the study, if they had minimum follow up of 24 months. Patientes were excluded if they had concomitant irreparable cuff tears or previous or current contralateral shoulder pain or weakness. Postoperative evaluation was based on UCLA score and on measurements of elbow flexion and supination strength, using an isokinetic dynamometer. Tests were conducted in both arms, with velocity set at 60⁰/s with five concentric-concentric repetitions.

Results: Thirty-three patients were included and the most common concomitant diagnosis were rotator cuff tear (69%) and SLAP lesions (28%). Average UCLA score improved from 15.1 pre-operatively to 31.9 in the final follow up (p < 0.001). 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.

Key terms: shoulder, biceps tendon, tenodesis, elbow strength, isokinetic evaluation.
What is known about this subject: Tenodesis is a well established method of treating symptomatic tendinopathy of the LHB. Although there are many techniques available, the use of interference screw seems to be biomechanically superior. However, the exact site of tenodesis is still controversial, some authors suggesting subpectoral tenodesis and others suprapectoral tenodesis. The supra-pectoral tenodesis can be done down at the bicipital groove, or more proximally, close to the humeral articular margin.

What this study adds to existing knowledge: Most of the case series regarding LHB tenodesis rely only on clinical evaluation of the patients. Few studies made isokinetic tests in order to evaluate the effect of tenodesis on elbow strength. We believe isokinetic testing is one of the strengths of our paper. Besides, we found that some of our patients indeed had pain over palpation of the bicipital groove. However, this seems to be clinically irrelevant since only one of them reported spontaneous sporadic pain on the area of the bicipital groove.
Introduction

The long head of the biceps (LHB) tendon may be an important cause of shoulder pain when committed by disease. This commitment may range from a simple inflammatory process (tenosinovitis) to complete tendon rupture, going through several progressive stages of tendinosis. The association between rotator cuff tears and LHB tendinosis has been described, and studies show that larger tears correlate to a higher prevalence of LHB tendon degeneration. Also, LHB instability (luxation and subluxation) may occur, usually associated with lesions of the biceps pulley and/or rotator cuff tears, mainly the subscapular tendon. Superior labrum tears involving the origin of the LHB (SLAP lesions) have also been implicated as causes of shoulder pain.

In general, conservative treatment may be indicated initially, even though supported by little evidence in the literature. Among surgical options, LHB tenotomy and tenodesis are the most common. Both seem equally efficient in the resolution of pain, although tenotomy may cause residual deformity (Popeye sign), and strength impairment. For this reason, tenodesis has been preferred in younger and more active subjects. Epidemiologic studies have shown that the number of such procedures has risen between 2007 and 2011, most performed in individuals between ages 30 and 59. Multiple techniques have been described for LHB tenodesis both on soft tissue and bone, in which tendon fixation may be obtained with transosseous tunnels, "keyholes", cortical buttons, suture anchors and interference screws.

Originally described by Boileau et al., interference screw tenodesis has demonstrated biomechanical superiority to other fixation methods in comparative studies. Lo and Burkhart 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\textsuperscript{53} and
to maintenance of a portion of unhealthy tendon in the intertubercular groove\textsuperscript{22,37}.

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.

\textbf{Methods}

\textbf{Materials and Methods}

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: (1) aged greater
than 18 years; (2) minimum follow-up of 24 mouths. Patients were excluded if they
presented: (1) irreparable injuries of rotator cuff muscles in ipsilaterial shoulder, (2)
previous or current contralateral shoulder pain. The main indication for surgery was
symptomatic tendinopathy of LHB, observed through magnetic resonance imaging exam
and confirmed at arthroscopic procedure. Besides that, patients over 40 years old with
superior labrum anterior to posterior (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.
All LHB tenodesis had been performed arthroscopically, in beach chair position, under general anesthesia and interscalene brachial plexus block using nerve stimulator. Thirty degrees scope was routinely used and 70° scope was used only when concomitant repair of large subscapularis tendon tear was needed. After joint inspection, the anatomopathological status of biceps muscle was labeled as exposed in table 1. A braided polyester suture (Ethibond Excel # 2, Ethicon) 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 strong unabsorbable polyester sutures (Fiber Wire # 2, Arthrex) and its diameter was measured in millimeters with a specific measure instrument (Figure 1). The suture limbs were passed through the cannulated driver so that the LHB stump gets in contact with the driver’s extremity. Next, the guide wire was inserted in the proximal region of the intertubercular groove, close to humeral articular cartilage and a hole was made using a cannulated drill with the same tendon diameter (Figure 2). Then the LHB was inserted into the bone socket and the cannulated screw was slipped through the same driver (Figure 3). Lastly, the suture limbs were either cut and removed from the joint or used in the repair of a subscapularis tendon tear.
Table 1: LHB intraoperative anatomopathological classification

<table>
<thead>
<tr>
<th>Type</th>
<th>LHB classification</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Normal</td>
</tr>
<tr>
<td>2</td>
<td>Tendinitis</td>
</tr>
<tr>
<td>3</td>
<td>Fibrillation</td>
</tr>
<tr>
<td>4</td>
<td>Longitudinal tear</td>
</tr>
<tr>
<td>5</td>
<td>Partial tear</td>
</tr>
<tr>
<td>6</td>
<td>SLAP lesion</td>
</tr>
</tbody>
</table>

Figure 1: Right shoulder, superolateral view. (A) Biceps tendon is exposed through the anterior portal and held with a clamp. (B) Krackow suture is made and the tendon diameter is measured.
Figure 2: A bone socket is made using a cannulated drill.

Figure 3: Biceps tendon is placed inside the bone socket and interference screw slides through the driver into the bone socket.

When isolated biceps tenodesis was carried on, without concomitant major procedures, the post-operative program was the following: sling for 3 weeks; active elbow, wrist and hand motion from the first day after surgery; shoulder passive elevation and external rotation started one 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 which 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 to 16 weeks.

The clinical outcomes were evaluated using the UCLA functional scale\(^1\), measured in pre and post-operative 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). The patient was positioned as manufacturer's determinations to measurement of supination and elbow flexion. The flexion test were performed with both neutral and supinated forearm positions. In all tests procedures were conducted in both arms, with velocity set at 60\(^\circ\)/s with five concentric-concentric repetitions. Prior to evaluation familiarization and warmup procedures were conducted. The arm and movements order were randomly assigned. The peak torque done were calculated and normalized by total body weight.

Statistics

The involved and contralateral limbs were compared using separated paired t test for peak torque, as the pre and post-operative UCLA scores. The Cohen’s effect size was used to express the magnitude of difference in assessed comparisons. The Pearson’s 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 values.
All calculations were conducted using SPSS (IBM SPSS Inc., version 19, Chicago, IL, USA) and all graphs were produced with Graphpad Prism (GraphPad Software Inc, Version 5, La Jola, CA, USA). Statistical significance was pre-determined as 5%.

Results

Thirty-three patients took part of the study (age: 50 ± 9.8 years; height: 170.23 ± 7.06 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 others demographic data were displayed in table 2.

Average UCLA score improved from 15.1 pre-operatively to 31.9 in the final follow up (p < 0.001; d = 4.04 – figure 4). A total of nine patients reported palpation pain at intertubercular groove, although only one subject reported occasionally spontaneous pain. Another patient developed post-surgery joint stiffness, and had a good outcome following conservative treatment of 8 months. None of patients showed biceps muscle belly deformity.

Regarding the isokinetic tests, there was no significant difference between the involved and contralateral limbs. There were no significant correlations between postoperative UCLA and follow-up length (r = - 0.017; p = 0.924) and between pre and post-surgery UCLA (r = 0.176, p = 0.329). Similarly, UCLA and follow-up did not demonstrate correlation with peak torque (table 4).
Table 2. Demographic data

<table>
<thead>
<tr>
<th>Variable</th>
<th>Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Man</td>
<td>24</td>
</tr>
<tr>
<td>Woman</td>
<td>9</td>
</tr>
<tr>
<td>Age (years) Mean (variation)</td>
<td>48 (27 to 69)</td>
</tr>
<tr>
<td>Laterality: limb dominance</td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>32</td>
</tr>
<tr>
<td>Left</td>
<td>1</td>
</tr>
<tr>
<td>Laterality: involved limb</td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>23</td>
</tr>
<tr>
<td>Left</td>
<td>10</td>
</tr>
<tr>
<td>Rotator cuff tear</td>
<td></td>
</tr>
<tr>
<td>Complete</td>
<td>11</td>
</tr>
<tr>
<td>Partial</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
</tr>
<tr>
<td>Chondropathy</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>7</td>
</tr>
<tr>
<td>No</td>
<td>25</td>
</tr>
<tr>
<td>Labrum repair</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>13</td>
</tr>
<tr>
<td>No</td>
<td>20</td>
</tr>
<tr>
<td>Follow up (months) Mean (variation)</td>
<td>38 (24 to 80)</td>
</tr>
</tbody>
</table>

Figure 4. UCLA scores measured in pre and post-surgery (mean ± SD). Pre = pre-surgery; Post = post-surgery. *Significantly different from pre-surgery score (p < 0.001 – d = 4.04)
Table 3: Peak torque measured in an isokinetic dynamometer at 60°/s (mean ± SD).

<table>
<thead>
<tr>
<th></th>
<th>Peak Torque (Nm.kg^-1)</th>
<th>p-value</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Involved</td>
<td>Contralateral</td>
<td></td>
</tr>
<tr>
<td>FlexN</td>
<td>0.46 ± 0.17</td>
<td>0.45 ± 0.16</td>
<td>0.623</td>
</tr>
<tr>
<td>FlexS</td>
<td>0.48 ± 0.18</td>
<td>0.48 ± 0.18</td>
<td>0.937</td>
</tr>
<tr>
<td>Sup</td>
<td>0.09 ± 0.04</td>
<td>0.10 ± 0.04</td>
<td>0.111</td>
</tr>
</tbody>
</table>

FlexN = elbow flexion with forearm neutral; FlexS = elbow flexion with forearm neutral supination; Sup = forearm supination; d = Cohen’s effect size.

Table 4: Correlation analyzes between UCLA and follow-up with torque measurements of involved limb.

<table>
<thead>
<tr>
<th></th>
<th>pre-UCLA (points)</th>
<th>post-UCLA (points)</th>
<th>Follow-up (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FlexN</td>
<td>r = 0.355* p = 0.042</td>
<td>r = -0.09 p = 0.959</td>
<td>r = 0.194 p = 0.280</td>
</tr>
<tr>
<td>FlexS</td>
<td>r = 0.339 p = 0.054</td>
<td>r = 0.087 p = 0.628</td>
<td>r = 0.143 p = 0.427</td>
</tr>
<tr>
<td>Sup</td>
<td>r = 0.163 p = 0.364</td>
<td>r = 0.126 p = 0.485</td>
<td>r = 0.075 p = 0.680</td>
</tr>
</tbody>
</table>

FlexN = elbow flexion with forearm neutral; FlexS = elbow flexion with forearm neutral supination; Sup = forearm supination; Pre = pre-surgery; Post = post-surgery. *Significantly correlated (p <0.05).

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.\textsuperscript{28} have shown that 90% of patients submitted to rotator cuff repairs have LHBT histologic alterations. Also, Jacquot & Boileau\textsuperscript{14} have found static and dynamic macroscopic alterations upon arthroscopic inspection of the LHBT 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 when compared to superior labrum repair\textsuperscript{4,8,12,50,52} with even worse results for repair in older patients\textsuperscript{50}. 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 is to perform LHB tenodesis in younger patients, this tendency is also seen in the elderly. Even though recent epidemiologic studies confirm that most of these procedures are performed in patients with 30 to 60 years of age, there was a significant increase in LHB tenodesis performed in patients over 60\textsuperscript{48,51}. That is also our experience, since a rising number of these patients practice sports regularly and are concerned with esthetical issues derived from a tenotomy without tenodesis.

In this study, our clinical evaluation was based on the UCLA functional scale\textsuperscript{1} and on physical examination of the operated shoulder. The mean postoperative score was over double the preoperative one, showing great functional recovery. Even though only one patient reported sporadic localized shoulder pain in the intertubercular groove,
precipitated by muscle strain, nine patients (27%) complained of pain when the bicipital
groove was palpated on physical examination. This could be attributed to an increase in
tension of the LHBT on the bicipital groove when intra-articular tenodesis is performed
adjacent to the humeral head cartilage. Werner et al.\textsuperscript{53} 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\textsuperscript{6,11,16,24,25,27,34,47,52,57}. Nevertheless, we agree with Denard et al.\textsuperscript{7}, who has
shown that a better LHBT length-tension relation recovery can be obtained with an
interference screw adjacent to the articular margin of the humerus in a 25mm deep hole.
Maybe the persistence of pathological tendon tissue in the bicipital groove and not the
tension increase \textit{per se} is what precipitates pain upon palpation\textsuperscript{22,37}. It is worth noting that
the clinical relevance of this finding is minor, because only one of the 33 patients referred
spontaneous local pain, and 73% demonstrated no pain, not even upon palpation. Also,
subpectoral tenodesis, which positions the LHB more distally, is not free of
complications, including severe ones, such as humerus fracture and nerve injurie\textsuperscript{s29,33}.

As 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\textsuperscript{39,41,58} and indicates no loss of elbow strength should be expected
following a biceps tenodesis.

There are many materials and methods for performing a LHB tenodesis, including
tenodesis to soft tissues\textsuperscript{10,13,20}, and bony tenodesis without interference screws. Though
Levin \textit{et al.}\textsuperscript{20} defended soft tissue tenodesis arguing that it better reproduces biceps
tension, the Popeye deformity may occur in up to 35% of cases\textsuperscript{10}, which did not happen
in this series. Complications with tenodesis with anchors and cortical buttons have also
been described\textsuperscript{19,36}. Richards & Burkhart\textsuperscript{32} have shown in a biomechanical study that an interference screw tenodesis has significantly higher pullout strength than one performed with two anchors. Ozalay et al.\textsuperscript{30} performed a biomechanical study comparing four techniques of biceps tenodesis and found the interference screw to be almost twice as strong as the fixation with suture anchors. Patzer et al.\textsuperscript{31} biomechanically compared four 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.\textsuperscript{19} performed a retrospective study on patients undergoing concomitant rotator cuff repair and biceps tenodesis using suture anchors. After a 2-year follow-up period, they noticed a Popeye deformity in 12.9%. This high rate of failure in this clinical study may relate to the inferior performance of the suture anchors in biomechanical studies.

This study has some weakness. First, we have a relatively small sample, as we use other tenodesis techniques, both open and arthroscopic, in our institution. Also, some patients refused to go to the hospital in order to undergo the isokinetic test, as most of them were completely asymptomatic. Nonetheless, the number of patients still allowed for a solid statistic analysis and reliable final results. Secondly, we did not have a control group. Instead, we used the contralateral limb as control. This decision was based in Wittstein et al.’s\textsuperscript{54} study, which showed that the dominant and nondominant upper extremities have similar peak torque and endurance for supination and flexion. The authors concluded that the contralateral upper extremity can be used as a matched control in the evaluation of postoperative biceps isokinetic strength and endurance without adjusting results for handedness.
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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