Outlet Biceps Tenodesis: A New Technique for Treatment of Biceps Long Head Tendon Injury

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Abstract: Degeneration and tearing of the long head of the biceps brachii tendon (LHBT) are common intra-articular findings, and surgical intervention including tenodesis or tenotomy is beneficial. A new arthroscopic shoulder technique may be performed through an anterior portal while one is viewing from a posterior portal: (1) Visualize the intra-articular biceps tendon. (2) Identify the segment of the LHBT to be enlarged. (3) Use a tissue modulation wand to enlarge the tendon. (4) Evaluate the diameter of the enlarged segment. It should be twice the original diameter. (5) Cut the biceps tendon at the proximal end of the enlarged segment. (6) View the tendon within the tunnel. (7) Identify and cut the remaining stump of the biceps tendon. Seventeen cadaveric shoulders were used to compare the pullout force, stiffness, and displacement of outlet tenodesis versus tenotomy. There was a significant increase in pullout force for the outlet tenodesis group when compared with tenotomy. This technique is used to operatively treat LHBT intra-articular pathology in patients who would benefit from tenotomy and traditional biceps tenodesis and may minimize the retraction of the biceps tendon distally.

The long head of the biceps tendon (LHBT) can exhibit intra-articular pathology and be a source of pain in the shoulder. Surgical intervention, including tenodesis and tenotomy, is an accepted method to treat tendonitis or LHBT tear. A Popeye deformity can occur with tenotomy if the tendon slides distally through the bicipital groove, prompting the lateral aspect of the muscle belly to retract distally. This can result in a lateral defect proximally and a prominence of the biceps muscle belly distally. Biceps muscle cramping and loss of strength have also been reported after tenotomy.

To address distal migration of the biceps, Bradbury et al. described a new technique where a part of the labrum was left attached to the tendon before release. They examined pullout force of traditional biceps tenotomy compared with their alternative technique in a cadaveric model and found a higher pullout force with their new technique. However, removing part of the labrum may lead to instability or increased contact pressure on the glenoid. A procedure to treat biceps pathology that is performed with the ease of tenotomy and has increased resistance to distal migration of the LHBT without disrupting surrounding tissue may be useful for many patients.

We have developed a novel surgical technique that is based on the principle of thermal modulation of collagen-rich tissues, which causes morphologic changes by denaturation of collagen fibers, resulting in a shortened tendon with a thicker diameter. It is believed that after tenotomy, the tendon heals in the bicipital groove without distal migration. By heating the tendon, we may improve this outcome by causing it to swell and become wedged in the outlet (outlet tenodesis), increasing the probability that it will remain in the groove and improving the resistance to distal migration, by outlet or aperture healing. This technique, referred to as outlet tenodesis, may minimize the retraction of the biceps tendon distally, thus decreasing the formation of the Popeye deformity and cramping. This has proven to be a reproducible technique that is not more time-consuming or technically difficult than tenotomy.

Technique

Outlet tenodesis is used to operatively treat LHBT pathology in patients who would benefit from traditional...
tenotomy or traditional biceps tenodesis (suture anchor, interference screw, and so on). The senior author (S.L.) performs shoulder arthroscopies with the patient in the lateral decubitus position, but the technique may be performed with the patient in the beach-chair position. Usually, general anesthesia is administered with an interscalene catheter providing analgesia on the operative side, and a warming blanket is applied to prevent hypothermia. Balanced suspension (7.5 lb) is applied with the arm in approximately 30° of abduction and 20° of forward flexion.

Diagnostic glenohumeral arthroscopy is performed through the posterior portal with saline fluid pressure maintained by gravity. During the diagnostic portion of the shoulder arthroscopy, the biceps tendon is evaluated. Physical examination, radiography, magnetic resonance imaging, and arthroscopic evaluation are used to determine the benefit for operative treatment of the LHBT. Outlet tenodesis may be performed through an anterior portal while one is viewing from a posterior portal, or a lateral portal may be used to improve access to the biceps tendon through a large rotator cuff tear.

**Instruments Required**

Thermal modulation devices that have a depth of tissue penetration adequate for the LHBT should be used. The senior author (S.L.) has tried ablation devices (set on the low coagulation setting) and devices specifically designed for collagen denaturation. The senior author has found those devices specifically designed for collagen denaturation to be the most effective; he currently uses the CAPSure 30 radiofrequency wand (ArthroCare, Sunnyvale, CA). An ablation unit (90° Ambient TurboVac ArthroWand; ArthroCare) is used to cut the biceps tendon after collagen denaturation. Real-time feedback of the surgical environment is monitored to ensure that the temperature of the joint stays below 40° to prevent chondrolysis.

**Step-by-Step Technique**

*Step 1: Visualize Biceps Tendon.* The biceps tendon should be visualized from the outlet of the bicipital tunnel to the attachment to the superior labrum and glenoid (Fig 1A, Video 1).

*Step 2: Identify Segment to Be Enlarged.* The segment should be as close to the outlet as possible. This will help prevent a large amount of distal retraction of the biceps, minimizing the likelihood of formation of a Popeye deformity (Fig 1B).

*Step 3: Enlarge Tendon.* The tendon to be enlarged should be 1 to 2 cm in length; usually, 1 cm is sufficient. A probe may be used to bring more of the biceps tendon into the glenohumeral joint. The device used for this should be specific for collagen denaturation. This may take up to 10 minutes to complete depending on the tissue, because care is exercised when enlarging the tendon to keep the temperature in the joint low (<45°C). The surgeon should start as close to the outlet of the biceps tendon as possible and proceed in a circumferential manner. Applying energy to the tendon with intervals of examination of progress and flushing the glenohumeral joint helps to keep the temperature low. The surgeon may use a cannula from an accessory portal if available to help gain access to the whole circumferential surface of the tendon. This will result in denaturation of the tendon collagen and enlargement of the tendon diameter. It has been noted in cadaveric studies as well as clinical practice by the senior author that tendons that have more damage have a more dramatic response to the thermal modulation than healthy-looking tendons (Fig 1C).

*Step 4: Evaluate Diameter of Segment.* The LHBT measures 8 × 3 mm on average in its cross section.6 The cross section of the tendon after outlet tenodesis should be approximately double that (16 × 7 mm). If the tendon is larger to begin with, then twice the normal pre-procedure diameter should be the goal (Fig 1D).

*Step 5: Cut Biceps Tendon.* Once the desired diameter is reached, the surgeon should cut the biceps tendon at the proximal end of the enlarged segment. This can be performed with an ablation wand with the ablation (or cutting setting). The biceps tendon will then retract into the biceps tunnel and become lodged or wedged in the outlet. It should be noted that even with subluxation of the LHBT, part of the tunnel is usually competent. This procedure is not indicated in the case of complete dislocation of the LHBT. In this case the tunnel may be completely incompetent, and thus the enlarged tendon has nowhere to become lodged (Fig 1E).

*Step 6: View Tendon Within Tunnel and Verify Status of Tendon.* As shown in Fig 1F, the surgeon should view the tendon within the tunnel and verify the tendon’s status.

*Step 7: Identify and Cut Remaining Stump of Biceps Tendon.* There may be a significant stump of biceps tendon left attached to the superior labrum. This should be cut away and removed from the glenohumeral joint, with care taken to leave the superior labrum intact (Fig 1G).

There are several important points that we have observed while performing this technique (Table 1):

1. More degenerative tendons have a more dramatic response to the thermal enlargement and are more likely to swell to a satisfactory diameter of at least 2 times the original cross section.
2. The tendon should be thermally treated as close to the outlet as possible. Care should be taken to avoid damaging the articular cartilage; this can result in permanent damage to the articular surface.

3. The temperature in the glenohumeral joint should be kept below 45°C (113°F). To achieve this, tissue modulation should be performed in intervals with flushing of the joint and inspection of the enlargement process.

4. Any remaining proximal biceps tendon should be removed from its attachment site at the superior labrum/glenoid.

**Biomechanical Evaluation**

A study was undertaken to compare the biomechanical properties of our new technique, outlet tenodesis, versus the traditional tenotomy. Specifically, we examined the pullout force, stiffness, and displacement for these constructs. This test method was chosen because initial fixation strength provided by the surgical technique during a time of convalescence is thought to be important.5

Seventeen fresh-frozen, human cadaveric shoulders were obtained for this study. The shoulders were thawed for 36 hours at room temperature. After dissection, the

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**Fig 1.** Step-by-step technique with patient in lateral decubitus position. (A) Step 1: visualize the biceps tendon. (B) Step 2: identify the segment to be enlarged. (C) Step 3: enlarge the tendon. (D) Step 4: evaluate the diameter of the segment. (E) Step 5: cut the biceps tendon. (F) Step 6: view tendon within the tunnel. (G) Step 7: identify and cut the remaining stump of the biceps tendon.
shoulders were randomly assigned to one of 2 groups: (1) outlet tenodesis (n = 8) and (2) tenotomy (n = 9).

The mean age of the specimens tested was 71.4 years (range, 62 to 81 years; SD, 4.9 years). Before testing, soft tissue was dissected, leaving the following structures intact: capsule and ligaments of glenohumeral joint, rotator cuff, biceps, biceps sling, 15 cm of proximal humerus, and scapula. The LHBT was exposed, and either a tenotomy was performed at the insertion on the superior labrum or outlet tenodesis was completed.

After outlet tenodesis or tenotomy, the scapula was secured in a rectangular aluminum pot with polyester resin material. The pot was mounted to a custom fixture that allowed for angular adjustment in 4 axes. The angle was adjusted so that the humeral head was in 30° of abduction. The proximal portion of the humerus was secured with 4 set screws that were modified to create a point. The fixture was rigidly mounted to the base of a servohydraulic testing machine (Instron 1321; Instron, Canton, MA). The distal portion of the tendon was secured to the actuator of the materials testing machine by sewing the proximal aspect of the distal biceps tendon to Dacron webbing in Krackow fashion and clamping the tendon-webbing complex.

The distal end of the tendon was pulled in line with the bicipital groove from proximal to distal at a rate of 10 mm/s until failure. This testing method is similar to those previously used. Force and displacement data were recorded with software provided by Instron. The mode of failure was manually recorded.

The stiffness was calculated for each specimen after testing by calculating the slope of the line in the linear portion of the force/displacement curve. The peak force was determined for each specimen, and the displacement at that load was recorded. Mean values for each group were determined along with the standard error. Data were compared by a 2-tailed, 2-sample unequal variance Student t test for significance (P < .05).

There was no significant difference between the age of the specimens for either of the groups (P > .05). The mode of failure for the outlet tenodesis and traditional tenotomy was the tendon pulling through the bicipital groove.

The mean pullout force of the outlet tenodesis and traditional tenotomy specimens was 38.8 N (standard error of the mean [SEM], 6.4 N) and 21.4 N (SEM, 4.2 N), respectively (Fig 2). The outlet tenodesis specimens had a significantly higher pullout force compared with the traditional tenotomy specimens (P = .04).

The mean stiffness in outlet tenodesis and traditional tenotomy specimens was 3.5 N/mm (SEM, 1.0 N/mm) and 2.2 N/mm (SEM, 0.6 N/mm), respectively (Fig 3). Although outlet tenodesis specimens had a higher stiffness than traditional tenotomy specimens, this difference was not significant (P = .35). The mean displacement at failure was not significant between the groups.

In this cadaveric, biomechanical study, outlet tenodesis significantly increased the pullout force when compared with tenotomy. It is possible that an increase in pullout force could correlate to a decrease in distal migration of the LHBT, fewer Popeye deformities, and less muscle cramping.

Discussion

Advances in shoulder surgery have often led to improved outcomes and possible decreased surgical time. The use of a thermal device to denature the collagen tissue takes advantage of an already existing technology and can be accomplished with little added surgical complexity compared with other biceps tenodesis techniques. Using this technique to treat proximal biceps tendon pathology may accomplish several improvements over current accepted treatment

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<td>Ensure that the temperature within the shoulder does not increase during thermal modulation</td>
<td>Bicipital groove pain</td>
<td>Complete tendon dislocation from bicipital groove</td>
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<td>Enlarge the segment of the tendon as close to the outlet as possible</td>
<td>≥50% biceps tendon tear</td>
<td>High-demand patients (athletes and so on)</td>
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<td>This technique works best in degenerated tendons</td>
<td>Tendon degeneration</td>
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<td>Remove any remaining biceps tendon from the superior glenoid</td>
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**Table 1. Key Points, Indications, and Contraindications**
methods. It may prevent the Popeye deformity while negating the need to introduce foreign material in the area of the biceps tendon that may lead to persistent bicpital pain. It is less technically difficult than proximal biceps tenodesis with suture anchors or interference screws, and it has similar operative difficulty and time requirements to biceps tenotomy alone. In cases in which traditional tenodesis is less likely to be effective because of damaged or insufficient tendon, outlet tenodesis is an optimal solution because we have observed that the damaged tendon will enlarge more than the undamaged tendon. This technique may result in autotenodesis of the tendon in the bicipital tunnel through the healing response.

A relative contraindication would be a biceps tendon completely dislocated from the groove. An incompetent biceps tunnel would not allow for the wedging of the biceps tendon within the tunnel, and thus the technique would have little added benefit over tenotomy alone. The senior author does not use this technique in high-demand patients (i.e., athletes or patients with jobs that require heavy lifting or manual labor); a tenodesis with suture anchor fixation is more appropriate for these patients. A limitation to this technique is that an ablation unit with environmental feedback is needed to ensure that the temperature of the joint does not approach 45°C because higher temperatures can cause chondrolysis.

Although clinical data have generally shown good results for the biceps tenotomy, it would be beneficial to improve these numbers by introducing a technique that improves the likelihood of autotenodesis within the bicipital grove while maintaining the benefits of tenotomy. In our cadaveric biomechanical study, outlet tenodesis significantly improved the pullout force of the tendon. It is possible that this increase in pullout force could correlate to a decrease in distal migration of the biceps tendon and fewer Popeye deformities.

We present a new technique of treating LHBT injury that may be performed with the simplicity of a biceps tendon tenotomy, with the possible added benefit of preventing a Popeye deformity. Present biomechanical and clinical studies are continuing to evaluate outlet biceps tenodesis compared with current accepted techniques such as tenotomy and suture anchor tenodesis.

**Acknowledgment**

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**References**


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