Technical Note

All-Arthroscopic Falciform Portal Biceps Tenodesis

Justin L. Makovicka, M.D., M.B.A., Joseph C. Brinkman, M.D., Nathan Benner, M.D., Aiden J. Tokish, M. Lane Moore, M.B.A., and John M. Tokish, M.D.

Abstract: Biceps tenodesis has been proven to be an effective treatment for biceps tendon and superior labral pathology. Many techniques including both open and arthroscopic approaches have been reported. Open techniques afford management of the entire proximal biceps tendon but are limited by wound healing issues, increased bleeding, and increased surgical time. Arthroscopic tenodesis offers benefits in terms of surgical efficiency, cosmesis, and bleeding risk. However, standard arthroscopic tenodesis only addresses intra-articular biceps pathology. In this report we describe an all-arthroscopic biceps tenodesis technique at the suprapectoral region of the humerus using knotless suture anchor fixation.

Long head of the biceps pathology ranges from degenerative tendinopathy to inflammatory tendonitis.[1] Lesions of the biceps are a common cause of shoulder pain and often co-occur with other conditions, including rotator cuff pathology, impingement, and glenohumeral arthritis.[2,3] Tenodesis and tenotomy both effectively improve shoulder pain associated with biceps pathology, whereas tenodesis shows advantages in terms of cosmesis and spasms.[4,5] Various techniques including both arthroscopic and open approaches have been described for biceps tenodesis.

Open techniques provide adequate exposure and tenodesis but are limited by increased blood loss, potential wound complications, surgical inefficiency, and cosmetic concerns.[6] Arthroscopic techniques address the above concerns and are being performed at an increasing rate compared to open techniques.[7] However, most arthroscopic approaches only address the proximal intra-articular aspect of the biceps tendon, leaving more distal lesions unaddressed.[8,9] Because proximal tenodesis has been suggested to have a higher revision rate, an arthroscopic technique that addresses the extra-articular biceps tendon may afford improved results over standard arthroscopic techniques.[10] In this report we describe an all-arthroscopic biceps tenodesis technique (Video 1) at the suprapectoral region of the humerus using knotless all—soft suture anchor fixation. To allow for perpendicular placement of an anchor at this location, additional portal creation is required and described in this technique. Given its location at the proximal aspect of the pectoralis major tendon, this additional portal is referred to as the "falciform" portal.

Surgical Technique

Step 1: Preoperative Workup

Patients who present to our clinic with shoulder pain undergo a routine history and physical, as well as a standard radiographic imaging series. If the diagnosis is unclear, a diagnostic injection is routinely used to confirm biceps pathology. The patient is then counseled concerning both nonoperative and operative options. As with any surgical decision, the patient is counseled on the risks and benefits and expectations of surgery.

Step 2: Surgical Positioning and Diagnostic Arthroscopy

The patient is brought to the operating room, and, after the induction of general anesthesia, he or she is

From the Mayo Clinic Arizona Department of Orthopedic Surgery (J.L.M, J.C.B., A.J.T., M.L.M., J.M.T.), Phoenix, Arizona, and the Department of Orthopedic Surgery, University of Washington (N.B.), Seattle, Washington.

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Address correspondence to M. Lane Moore, Mayo Clinic Arizona Department of Orthopedic Surgery, 5777 E. Mayo Blvd, Phoenix, AZ 85054, U.S.A. E-mail: moore.michael1@mayo.edu

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examined under anesthesia, which is standard for all arthroscopic shoulder procedures. The patient is positioned in the lateral decubitus position on a beanbag, with the use of a padded arm sleeve (STAR sleeve; Arthrex, Naples, FL), in balanced lateral suspension. A posterior portal is established approximately 1 cm medial and 2 cm distal to the posterolateral acromial border. The arthroscope is introduced, and additional portals are established by an outside-in technique under direct visualization with the use of a switching stick. The anterior portal is established first, approximately 1 cm inferior to the clavicle and lateral to the coracoid through the rotator interval. A standard diagnostic arthroscopy is then performed within the glenohumeral joint, and any intra-articular pathology is treated appropriately. Once diagnostic arthroscopy is performed, the biceps tendon is tenotomized close to its base using curved mayo scissors. The subacromial space is then entered through the posterior portal, and a lateral portal is created approximately 2 cm off of the acromion. If indicated, any subacromial procedures such as decompression, acromioplasty, or rotator cuff work is done at this time (Fig 1).

Fig 1. This figure demonstrates the important landmoarks and portal placement in the right shoulder of a patient placed in the lateral decubitus position. A triangle is drawn between the lateral midline portal and the anterosuperior portal (black arrows). A cannula is placed in the falciform portal (green arrow), which is established using a spina needle for localization starting at the tip of the drawn triangle (dotted lines). The falciform portal overlies the bicipital groove. The standard posterior viewing portal is established first for diagnostic arthroscopy followed by the lateral subacromial viewing portal for the duration of the biceps tenodesis.

Step 3: Localization of Biceps Tendon

Once completed, all instruments are removed from the subacromial space, and attention is turned to the biceps tenodesis portion of the case. The arthroscope is placed in the previously created lateral subacromial portal, and the viewing field is "reversed" to look distally down the humeral shaft, roughly toward the midpoint between the lateral and anterior portals (off of the anterolateral border of the acromion) to find the biceps tendon in its sheath (Fig 2). A shaver is placed in the previously created anterior portal and can be used to open up a space along the biceps tendon. Once a space is created, 3 "bumps" along the humerus can be palpated with the shaver. Working from lateral to medial, the first "bump" encountered is bone of the humerus. The bump medial to this is the biceps tendon sheath. It is soft, and the shaver is unable to pass beneath it. The far medial bump is also soft, but the shaver is able to pass beneath it and represents the conjoint tendon. Two additional clues to help identify the biceps tendon are to localize the ascending humeral circumflex vessels that run alongside the biceps sheath and also to follow the suspected biceps tendon distally until the pectoralis major tendon is encountered crossing perpendicular to the biceps. Once this space surrounding the tendon is opened and the sheath is identified, an ablator is used to carefully open up the biceps sheath in a proximal-to-distal direction, exposing the biceps tendon (Fig 3).

Step 4: Establish "Falciform" Portal

Next, a "falciform" portal can be established as an outside-in technique. The surgeon's finger is used to

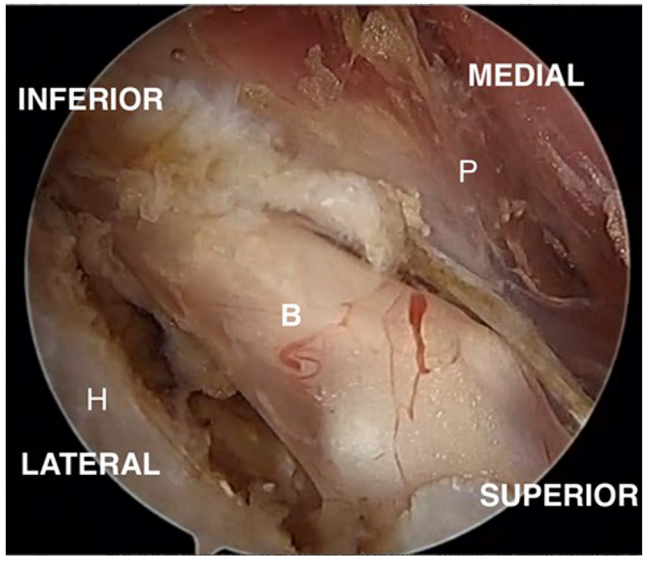

Fig 2. Arthroscopic view of the patient's right shoulder from a lateral subacromial portal looking from superior to inferior down the biceps tendon (B) with the humerus (H) and pectoralis major tendon (P) in view.

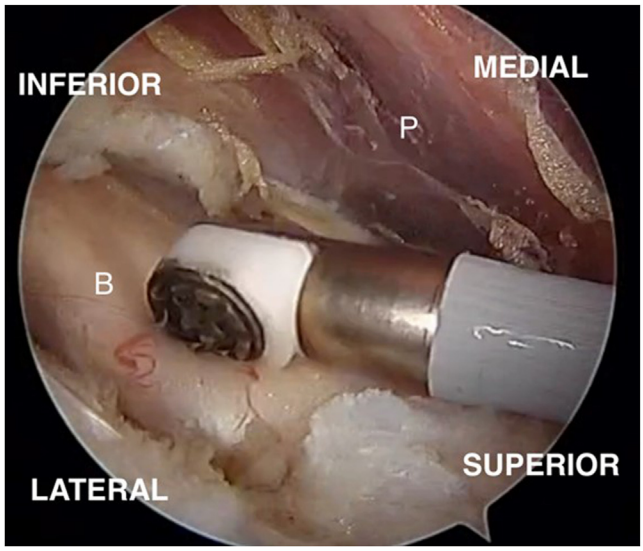

Fig 3. Arthroscopic view of the patient's right shoulder from a lateral subacromial portal looking from superior to inferior demonstrating the biceps sheath being opened up with an ablator looking from superior to inferior down the biceps tendon (B) and pectoralis major tendon (P) in view.

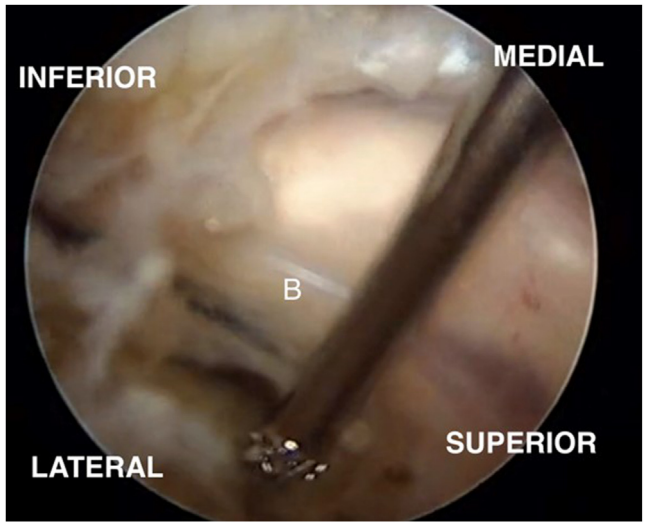

Fig 5. Arthroscopic view of the patient's right shoulder from a lateral subacromial portal looking from superior to inferior demonstrating biologic preparation with a rasp with the biceps tendon (B) in view before suture anchor placement.

probe a spot distal to the anterior portal along the humerus. This spot should be visualized to be perpendicular to the biceps tendon approximately 2 cm above the pectoralis tendon. A spinal needle is then used to confirm the location, and a portal is created (Fig 4). A switching stick followed by a canula is placed in the portal.

Step 5: Anchor Placement

Through the "falciform" portal canula, a rasp is used to biologically prepare the bone laterally to the biceps tendon approximately 2 cm above the pectoralis (Fig 5). Once prepared, a 1.8 knotless suture anchor (Fibertak; Arthrex, Naples FL) is drilled and inserted at this location through the "falciform" portal (Figs 6 and 7).

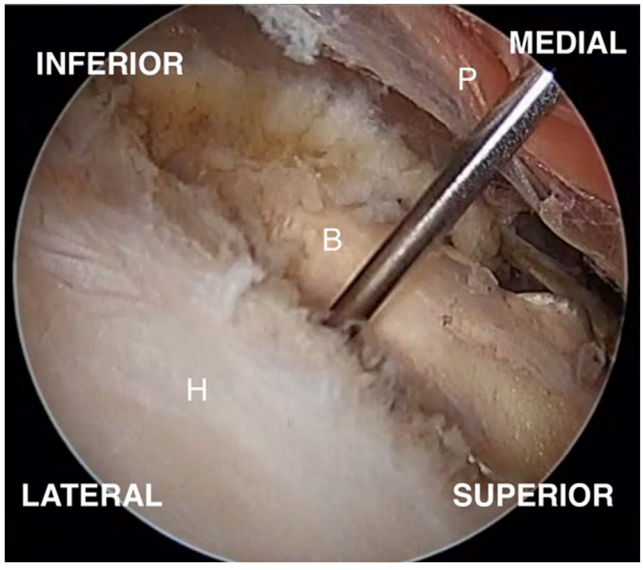

Fig 4. Arthroscopic view of the patient's right shoulder from a lateral subacromial portal looking from superior to inferior demonstrating the spinal needle location and trajectory for falciform portal creation with the biceps tendon (B) with the humerus (H) and pectoralis major tendon (P) in view.

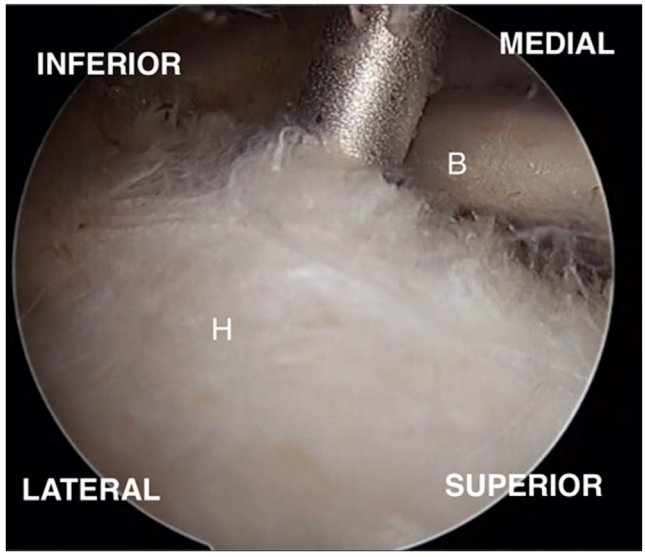

Fig 6. Arthroscopic view of the patient's right shoulder from a lateral subacromial portal looking from superior to inferior of suture anchor placement after biologic preparation with the biceps tendon (B) and humerus (H) in view.

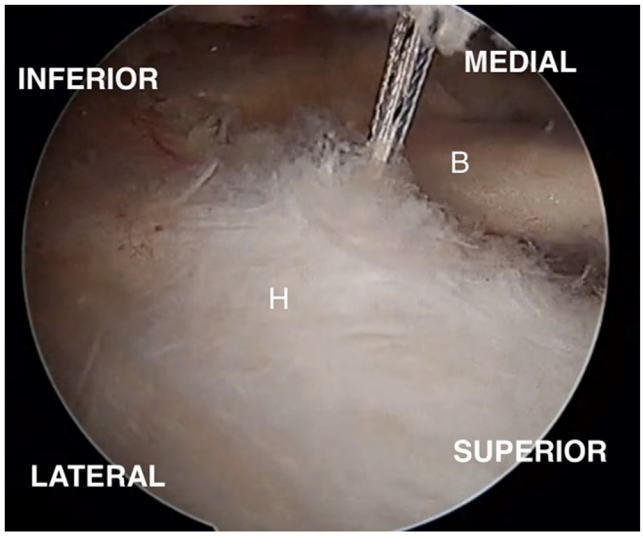

Fig 7. Arthroscopic view of the patient's right shoulder from a lateral subacromial portal looking from superior to inferior after suture anchor placement through the falciform into the humerus (H) portal before passage around the biceps tendon.

Step 6: Biceps Tendon Retrieval

With the use of a switching stick, a canula is established through the anterior portal. Through this portal, a grasper is used to retrieve the white passing sutures of the anchor, leaving the blue working suture out of the "falciform" portal. Next an arthroscopic retriever (King Fisher; Arthrex) is then used through this portal to retrieve the proximal cut end of the biceps tendon into this space. Once the biceps tendon is free from its sheath proximally, the tendon is grasped and pulled proximally to place physiological tension on the tendon during tenodesis.

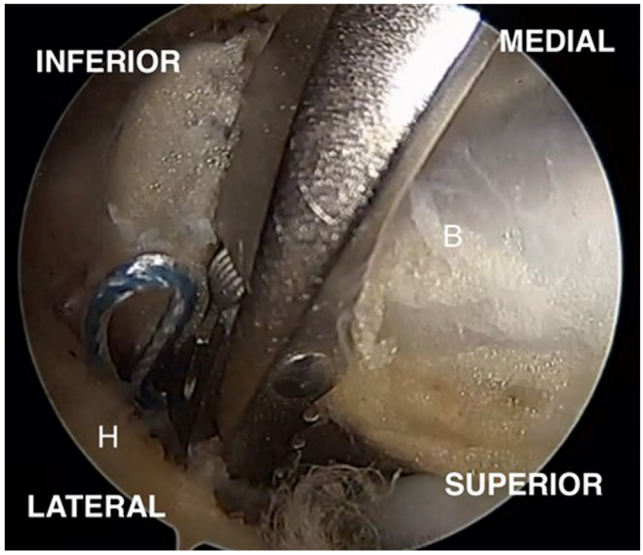

Fig 8. Arthroscopic view of the patient's right shoulder from a lateral subacromial portal looking from superior to inferior of passing the working stitch circumferentially around the biceps tendon with a Scorpion device (Arthrex) with the biceps tendon (B) and humerus (H) in view.

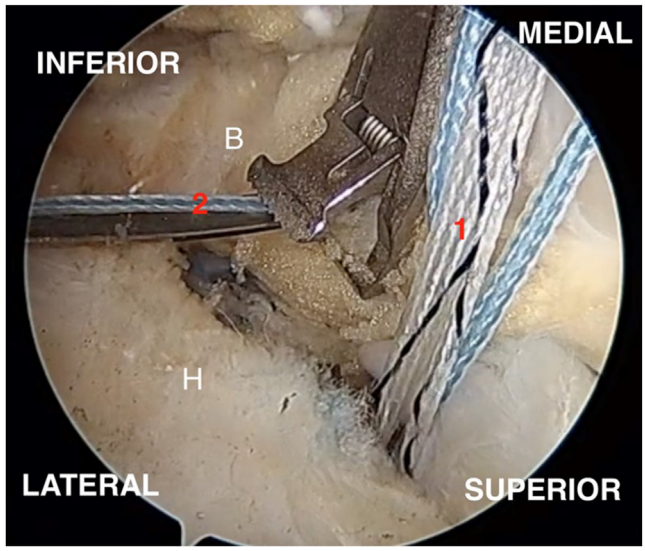

Fig 9. Arthroscopic view of the patient's right shoulder from a lateral subacromial portal looking from superior to inferior of the second pass of the working stitch (2) after passing of the first stitch (1) midway through the biceps tendon with a Scorpion device (Arthrex) with the biceps tendon (B) and humerus (H) in view.

Step 7: Suture Passage

The blue working stitch in the "falciform" portal is placed in a Scorpion device (Arthrex). Through this "falciform" portal, at the level of the previously placed anchor, the Scorpion device is used to pass the working stitch circumferentially around the biceps tendon and to retrieve the stitch through the portal (Figure 8). The same working stitch is then reloaded, and the Scorpion device is used to pass the suture midsubstance through the tendon, establishing a figure-of-eight stitch through the biceps tendon (Fig 9). A knot pusher is then used on the working suture to remove slack from the suture and deliver the biceps tendon down to bone.

Step 8: Knotless Fixation

Using a grasper through the "falciform" portal, the white passing sutures are retrieved from the anterior portal (Fig 10). The blue working suture is then placed through loop of the white passing suture and delivered through the anchor by deploying the knotless mechanism. The working suture is then pulled to tighten the construct and cinch the biceps tendon down to bone (Fig 11). Once tight, the excess suture can then be cut.

Step 9: Biceps Tendon Removal

Next, arthroscopic scissors are placed through the "falciform" portal, and the biceps tendon is cut a few millimeters proximal to the anchor to prevent any slippage of the biceps through the stitch. The previously

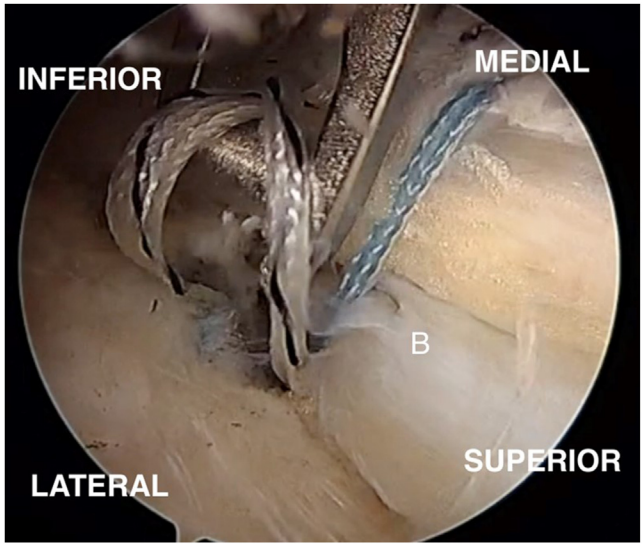

Fig 10. Arthroscopic view of the patient's right shoulder from a lateral subacromial portal looking from superior to inferior of retrieving the white sutures through the anterior portal with the biceps tendon (B) in view.

placed King Fisher is then used to remove the biceps tendon stump out of the anterior portal, along with the canula (Fig 12).

Discussion

The optimal location of biceps tenodesis remains controversial. Despite the benefits of an all-arthroscopic procedure, previous arthroscopic biceps tenodesis techniques are limited by only addressing the proximal segment of the biceps tendon. It has been shown that

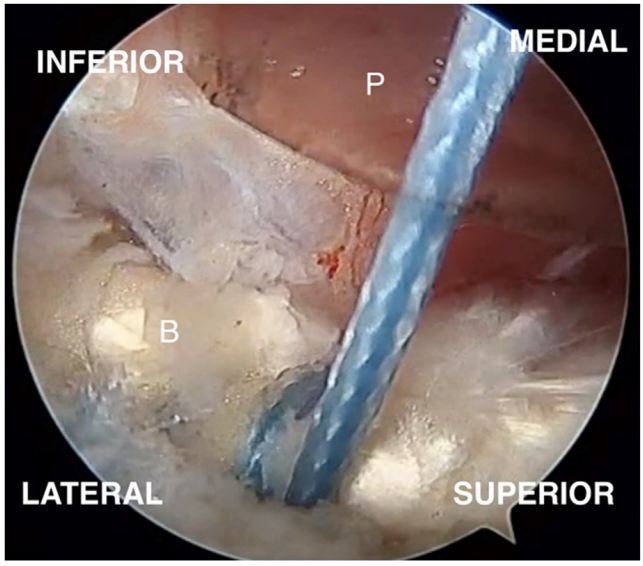

Fig 11. Arthroscopic view of the patient's right shoulder from a lateral subacromial portal looking from superior to inferior of the biceps tendon securely cinched down to bone with the biceps tendon (B) and pectoralis major tendon (P) in view.

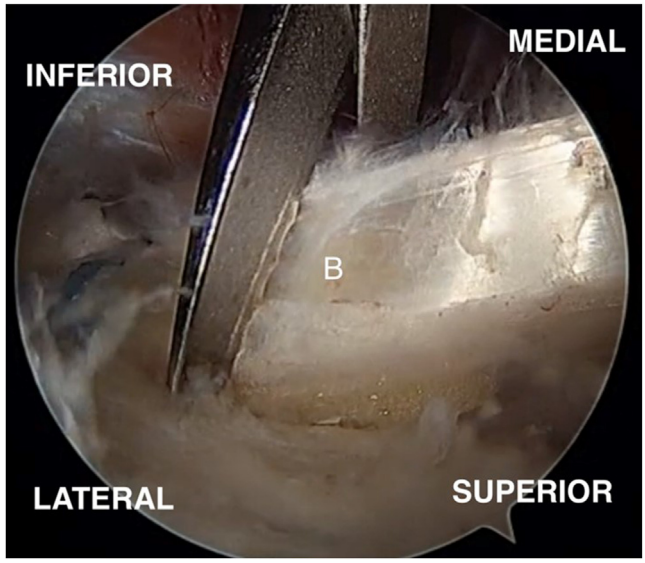

Fig 12. Arthroscopic view of the patient's right shoulder from a lateral subacromial portal looking from superior to inferior of scissors being used to remove the proximal aspect of the biceps tendon (B) by cutting a few millimeters proximal to anchor placement.

such techniques that fail to expose the tendon more distally have increased revision rates, potentially because of unaddressed pain generators.[10] Accordingly, there is a need for a technique that offers the benefits of an all-arthroscopic technique but still allows for addressing the distal aspects of the tendon. In this report, we describe an all-arthroscopic biceps tenodesis technique at the suprapectoral region of the humerus, below the bicipital groove, using knotless suture anchor fixation. The advantages and disadvantages are listed in Table I.

Several previous reports have investigated biceps tendon pathology in relation to its anatomy. Specifically, it has been well documented that the bicipital groove is a common area of long head of the biceps tendon pathology.[11,12] This correlates with anatomical studies that report a region of hypovascularity that extends from the glenohumeral joint to midway through the intertubercular groove, leaving the tendon

TABLE I. Advantages and Disadvantages of the All-Arthroscopic Falciform Portal Biceps Tenodesis Technique

Advantages
Provides secure fixation
Avoids an open incision
Improved cosmesis
Allows for addressing extra-articular biceps pathology
Performed with standard arthroscopic equipment
Disadvantages
Learning curve
Additional cost of suture anchor
Does not address subpectoral pathology

TABLE II. Pearls and Pitfalls of the All-Arthroscopic Falciform Portal Biceps Tenodesis Technique

Pearls
Create the "falciform" portal at a perpendicular angle to the anchor placement
Look for pectoralis major tendon passing at a right angle to the biceps
Feel for 3 "bumps" on the humerus from lateral to medial: lateral humerus, biceps tendon, and conjoint tendon
Release the biceps sheath for complete visualization
Pull the white sutures out of the anterior portal to avoid tangling with the blue passing stitch
Pitfalls
Inadequate tension on the tendon can cause Popeye deformity
Avoid cutting the tendon too close to the anchor to avoid sliding

susceptible to vascular and mechanical attrition in this region.[13] In 2015, Taylor et al.[14] performed a cadaveric study examining the histology of the biceps tendon in various anatomic regions. These regions included zone 1, which extends from the articular margin to the subscapularis tendon, zone 2, which is defined as the region from the distal subscapularis to the proximal pectoralis major tendon, and zone 3, which is the subpectoral region. The authors found that zones 1 and 2 commonly had synovium whereas zone 3 did not, prompting the authors to recommend techniques that allow decompression of both zones 1 and 2.

An all-arthroscopic technique offers many benefits over an open approach. These include a more efficient surgical workflow, decreased surgical trays, improved cosmesis, and obviating concerns regarding wound healing.[6] However, authors have expressed concern regarding incomplete visualization with an arthroscopic approach. Specifically, Festa et al.[15] noted that only 31% of the tendon can be viewed arthroscopically despite pulling the tendon into the joint. Clinically, Murthi et al.[16] reported that only 49% of pathologic biceps tendons were able to be addressed arthroscopically, whereas Taylor et al.[14] noted that arthroscopic tenodesis did not address extra-articular lesions present in 47% of their series of 277 patients. However, as shown, our technique affords visualization of zones 1 and 2 of the tendon with reversal of the viewing portal and liberation of the sheath with ablation. As a result, this technique may afford improved visualization and thus management of biceps lesions while maintaining the many benefits of an arthroscopic approach.

This report describes an all-arthroscopic suprapectoral biceps tenodesis using suture anchor fixation with the location of the tenodesis below the groove. This technique may be a viable option to manage biceps pathology in both zones 1 and 2. By addressing the extra-articular pathology, this technique may afford improved results over previous arthroscopic techniques that only address the proximal tendon. Advantages of this technique include surgical efficiency, ability to address concomitant pathology arthroscopically, using standard arthroscopic equipment and portals, and avoiding the complications associated with open tenodesis. Limitations include a potential learning curve and inability to address biceps lesions distal to the pectoralis major tendon. The pearls and pitfalls of this procedure are listed in Table II.

Conclusions

This report describes an all-arthroscopic suprapectoral biceps tenodesis using suture anchor fixation. This technique allows for improved management of more distal biceps lesions while avoiding the potential complications associated with an open approach.

References

1. Nho SJ, Strauss EJ, Lenart BA, et al. Long head of the biceps tendinopathy: Diagnosis and management. *J Am Acad Orthop Surg* 2010;18:645-656.
2. Wilk KE, Hooks TR. The painful long head of the biceps brachii: Nonoperative treatment approaches. *Clin Sports Med* 2016;35:75-92.
3. Borms D, Ackerman I, Smets P, Van den Berge G, Cools AM. Biceps disorder rehabilitation for the athlete: A continuum of moderate- to high-load exercises. *Am J Sports Med* 2017;45:642-650.
4. Meeks BD, Meeks NM, Froehle AW, Wareing E, Bonner KF. Patient satisfaction after biceps tenotomy. *Orthop J Sports Med* 2017;5:2325967117707737.
5. Pozzetti Daou J, Nagaya DY, Matsunaga FT, Sugawara Tamaoki MJ. Does biceps tenotomy or tenodesis have better results after surgery? A systematic review and meta-analysis. *Clin Orthop* 2021;479:1561-1573.
6. Nho SJ, Reiff SN, Verma NN, Slabaugh MA, Mazzocca AD, Romeo AA. Complications associated with subpectoral biceps tenodesis: Low rates of incidence following surgery. *J Shoulder Elbow Surg* 2010;19:764-768.
7. Werner BC, Brockmeier SF, Gwathmey FW. Trends in long head biceps tenodesis. *Am J Sports Med* 2015;43:570-578.
8. Moon SC, Cho NS, Rhee YG. Analysis of "hidden lesions" of the extra-articular biceps after subpectoral biceps tenodesis: The subpectoral portion as the optimal tenodesis site. *Am J Sports Med* 2015;43:63-68.
9. Provencher MT, LeClere LE, Romeo AA. Subpectoral biceps tenodesis. *Sports Med Arthrosc Rev* 2008;16:170-176.
10. Sanders B, Lavery KP, Pennington S, Warner JJP. Clinical success of biceps tenodesis with and without release of the transverse humeral ligament. *J Shoulder Elbow Surg* 2012;21:66-71.
11. Becker DA, Cofield RH. Tenodesis of the long head of the biceps brachii for chronic bicipital tendinitis. Long-term results. *J Bone Joint Surg Am* 1989;71:376-381.
12. Belk JW, Kraeutler MJ, Houck DA, Chrisman AN, Scillia AJ, McCarty EC. Biceps tenodesis versus tenotomy: A systematic review and meta-analysis of level I randomized controlled trials. *J Shoulder Elbow Surg* 2021;30:951-960.

13. Cheng NM, Pan WR, Vally F, Le Roux CM, Richardson MD. The arterial supply of the long head of biceps tendon: Anatomical study with implications for tendon rupture. *Clin Anat N Y N* 2010;23:683-692.
14. Taylor SA, Fabricant PD, Bansal M, et al. The anatomy and histology of the bicipital tunnel of the shoulder. *J Shoulder Elbow Surg* 2015;24:511-519.
15. Festa A, Allert J, Issa K, Tasto JP, Myer JJ. Visualization of the extra-articular portion of the long head of the biceps tendon during intra-articular shoulder arthroscopy. *Arthroscopy* 2014;30:1413-1417.
16. Murthi AM, Vosburgh CL, Neviaser TJ. The incidence of pathologic changes of the long head of the biceps tendon. *J Shoulder Elbow Surg* 2000;9:382-385.