Subpectoral Biceps Tenodesis: Interference Screw and Cortical Button Fixation

Nicholas I. Kennedy, M.D., Jonathan A. Godin, M.D., Marcio B. Ferrari, M.D., George Sanchez, B.S., Mark E. Cinque, M.S., Zaamin B. Hussain, B.A., and CAPT Matthew T. Provencher, M.D., M.C., U.S.N.R.

Abstract: Bicep tendon pathology often arises from chronic overuse injuries, acute trauma, or degenerative changes in the glenohumeral joint. These injuries can cause significant shoulder pain, and can greatly limit range of motion and, in turn, activities of daily living. The diagnosis of biceps pathologies can be challenging, because patients often present with nonspecific symptoms. Some bicep tendon pathologies may be treated nonoperatively; however, biceps tendon subluxation and the presence of rotator cuff or SLAP lesions require surgical management. One of the options for the treatment of bicep tendon pathology includes miniopen subpectoral biceps tenodesis. The purpose of this Technical Note is to describe in detail our preferred operative technique for miniopen subpectoral biceps tenodesis with 2 different fixation methods.

Pathology of the long head biceps (LHB) tendon is a common cause of debilitating anterior shoulder pain.[1-3] Biceps tendinopathy can arise for a number of reasons, including chronic tendinitis, acute trauma, overuse, and degenerative changes.[4] Patients commonly present because of pain with overhead movements and pain-limiting range of motion, most notably forward flexion.[1]

Although a traumatic biceps rupture resulting in a "popeye deformity" is fairly evident, the diagnosis of biceps tendinopathy can be more difficult due to the nonspecific presentation and poor sensitivity of existing clinical examinations.[5,6] Imaging studies have also been reported to have low sensitivity and lead to frequently missed diagnoses.[6] Therefore, clinical suspicion according to patient presentation and history is used in combination with a thorough physical examination and imaging studies to guide treatment.

First-line treatment for tendinopathy is often nonoperative.[7] Nonoperative management often consists of a combination of nonsteroidal anti-inflammatory medications, rest, ice, and physical therapy. When pain and inflammation are severe, corticosteroid injections can also be used.[8] However, some cases of tendinopathy require surgical management, including the following: partial-thickness tear of the LHB tendon (>25%-50%), medial LHB subluxation, LHB subluxation associated with lesions of the subscapularis tendon or biceps pulley and/or sling, presence of associated shoulder pathology (rotator cuff and SLAP lesions), and failure of conservative management of LHB tendinopathy.[3,9,10]

The purpose of this Technical Note is to describe in detail our preferred operative technique for miniopen subpectoral biceps tenodesis with 2 different fixation methods. We believe that both fixation techniques presented are viable options for the treatment of biceps tendinopathy recalcitrant to nonoperative treatment modalities.

Surgical Technique

The narrated video provides an overview of the described surgical technique (Video 1).

Patient Positioning and Anesthesia

The patient is placed in the supine position on the operating table and general anesthesia is used for induction. Single shot or catheter infusion regional

From the Steadman Philippon Research Institute (N.I.K., M.B.F., G.S., M.E.C., Z.B.H., M.T.P.) and The Steadman Clinic (J.A.G., M.T.P.), Vail, Colorado, U.S.A.

The authors report the following potential conflicts of interest or sources of funding: M.T.P. is the consultant for Arthrex and JRF Ortho; has patent numbers (issued): 9226743, 20150164498, 20150150594, 20110040339; and receives royalties from Arthrex and SLACK (publishing royalties). Full ICMJE author disclosure forms are available for this article online, as supplementary material.

Received March 31, 2017; accepted May 30, 2017.

Address correspondence to Matthew T. Provencher, M.D., M.C., U.S.N.R., Steadman Philippon Research Institute, 181 West Meadow Drive, Suite 1000, Vail, CO 81657, U.S.A. E-mail: mprovencher@thesteadmanclinic.com

2212-6287/17467/$36.00

http://dx.doi.org/10.1016/j.eats.2017.05.028

anesthesia may be used as well. The patient is then brought into the beach-chair position with care taken to pad all bony prominences. Moreover, the head and neck positioning should be carefully assessed before starting the procedure. We do not use an arm positioner; rather, the operative extremity is draped free with a well-padded Mayo placed under the elbow.

Objective Diagnosis

Preoperative evaluation should start with a thorough history and physical examination. Physical examination most commonly yields tenderness over the bicipital groove of the humerus, found by palpating the anterior aspect of the shoulder with the arm internally rotated 10°. In cases of biceps tenodesis, tenderness to palpation should move laterally with external rotation of the arm, which helps distinguish it from other causes of anterior shoulder pain. Provocative tests include an active compression test of the biceps tendon in the bicipital groove, Speed's test, Yergason's test, and O'Brien's test.

Diagnostic imaging should consist of shoulder radiographs to assess for osseous abnormality. Ultrasound is an inexpensive, noninvasive modality that provides dynamic evaluation of the LHB tendon. The bicipital groove is examined both transversely and longitudinally, looking for swelling surrounding the proximal biceps tendon, as well as medial instability with the range of motion. A limitation of shoulder ultrasound is that it is user dependent. Magnetic resonance imaging of the shoulder allows for detailed evaluation of the long head of the biceps tendon, as well as any concomitant loose bodies, labral, chondral, or other soft tissue injuries. Axial T2 sequences are particularly useful to assess the amount of surrounding inflammation within the biceps tendon sheath, medial subluxation or dislocation of the biceps tendon, associated subscapularis tears, and biceps pulley lesions.

Operative Technique

General endotracheal anesthesia may be combined with regional nerve blocks to maximize postoperative pain control. Perioperative antibiotic prophylaxis is administered intravenously before incision. A diagnostic arthroscopy is conducted first to directly visualize the chondral surfaces, glenoid labrum, biceps tendon, and rotator cuff. A standard posterior portal is used for the diagnostic arthroscopy, and an anterior working portal is created within the rotator interval under direct visualization. Using a probe in the anterior portal, the biceps tendon is pulled into the glenohumeral joint to evaluate the tendon's shape, mobility, fraying, and associated synovitis. Because biceps tendon pathology is most often present in the section of tendon located within the bicipital groove, it is critical that this part be drawn into the joint. The coracohumeral ligament, superior glenohumeral ligament, supraspinatus tendon, and subscapularis tendon are evaluated for any pathology. An arthroscopic biter is used to perform a tenotomy near the biceps tendon's insertion on the superior labrum (Fig 1). An arthroscopic shaver is then used to debride the proximal stump to a stable margin. Any concomitant arthroscopic procedures are carried out at this time.

With the arm abducted and internally rotated, the inferior border of the pectoralis major tendon is palpated. On the anteromedial aspect of the proximal arm, an approximately 3-cm incision is made from 1 cm superior to the inferior border of the pectoralis major

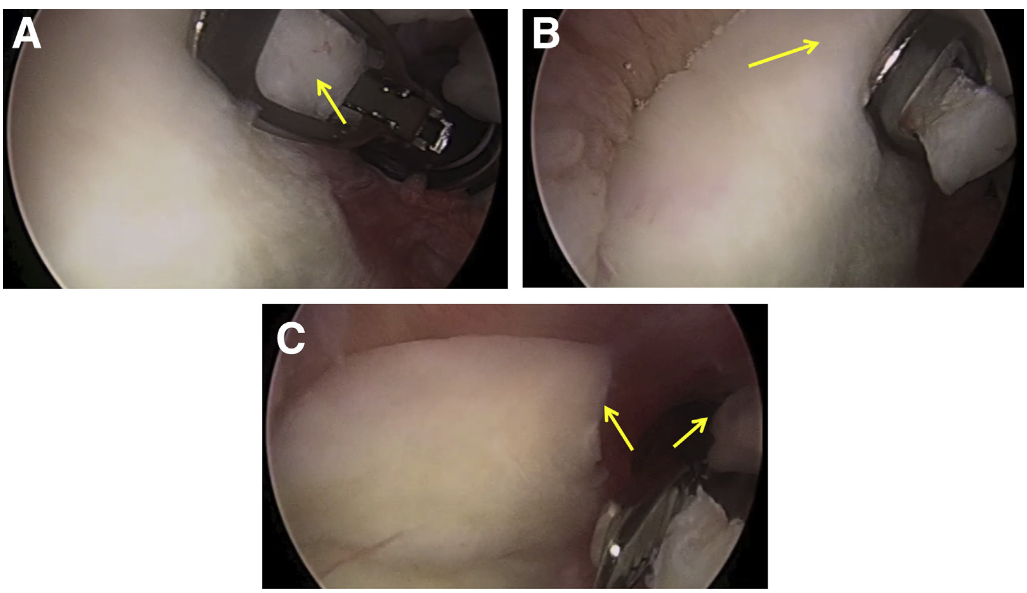

Fig 1. The intra-articular portion of the biceps tendon (yellow arrows) is identified using a 30° arthroscope during the diagnostic arthroscopy in the right shoulder. After this, an arthroscopic bitter (A and B) is used to make a tenotomy (C) near the biceps tendon's insertion on the superior aspect of the labrum.

Fig 2. After the arthroscopic portion of the procedure, attention is turned to the skin incision for the subpectoral biceps tenodesis in the right shoulder. The patient is maintained in the beach-chair position. The pectoralis major tendon is palpated and used as a reference for the position of the skin incision. Then, a 3-cm incision (yellow arrow) is made on the anteromedial aspect of the proximal humerus, from 1 cm superior to the inferior border of the pectoralis major tendon to 2 cm distal to the inferior border.

tendon to 2 cm distal to the inferior border (Fig 2). Electrocautery is then used to control bleeding. The overlaying fatty tissue is dissected with Metzenbaum scissors until the fascia overlaying the pectoralis major, coracobrachialis, and biceps is identified. If these anatomic landmarks are not seen, the dissection is likely too lateral. Once the inferior border of the pectoralis major has been identified, the fascia overlaying the coracobrachialis and biceps is incised in a proximal to distal manner. Blunt finger dissection is carried out under the inferior edge of the pectoralis muscle, palpating up the anterior aspect of the humerus, leading to the long head of the biceps tendon.

Once the biceps tendon is identified, it is delivered from the wound with finger dissection or with the use of a right angle clamp (Fig 3 A and B). A clamp is used to hold the proximal aspect of the biceps tendon. To ensure appropriate tensioning of the biceps tendon, FiberWire (Arthrex, Naples, FL) or FiberTape (Arthrex) is whipstitched from the musculotendinous junction to a point 2 cm proximal (Fig 3C). The remaining proximal portion of the tendon is then sharply excised (Fig 3D). Enough of the tendon is secured to ensure adequate interference fixation within bone and to position the musculotendinous portion of the biceps muscle beneath the inferior border of the pectoralis major tendon. This is critical for the proper tensioning of the muscle-tendon unit, as well as for cosmesis. The anterior cortex of the proximal humerus at the level of the inferior aspect of the bicipital groove is cleared of all soft tissue using a key elevator.

Interference Screw Fixation. A guidewire and an 8-mm reamer (Arthrex) are used to make an anterior unicortical bone tunnel. Note the relation of the arm

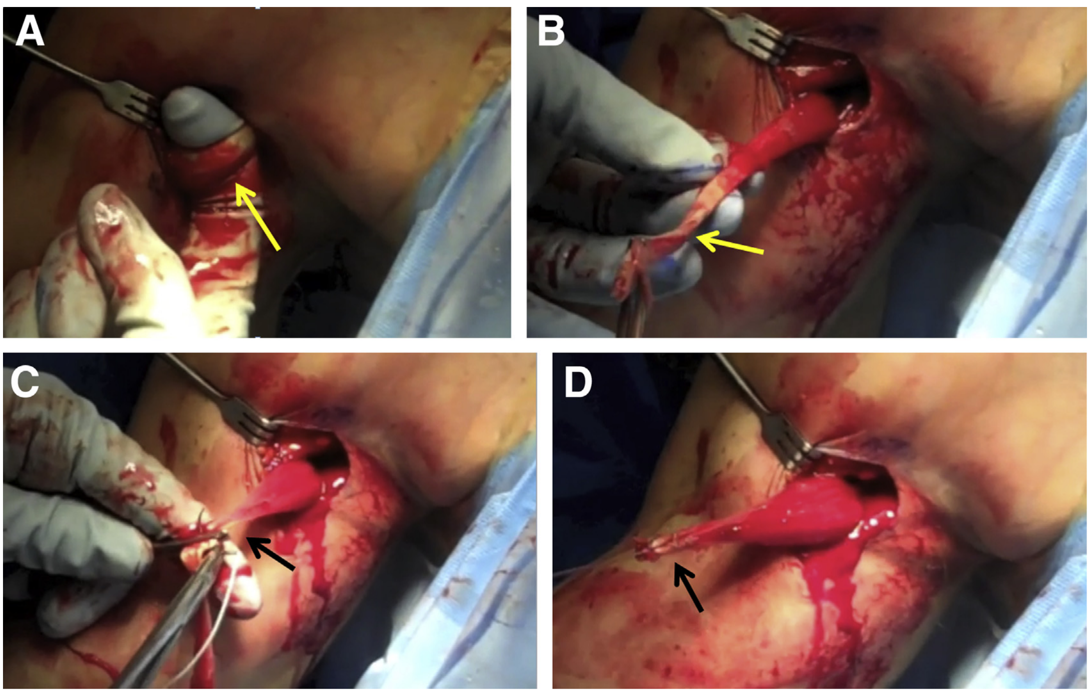

Fig 3. The subcutaneous is carefully dissected to fully expose the biceps tendon in the right shoulder. The long head of the biceps tendon is retrieved from the skin incision (A and B, yellow arrows). The tendon is then prepared and whipstitched using FiberTape (Arthrex) or FiberWire (Arthrex) from the musculotendinous junction to 2 cm proximal (C). Afterward, the excess tendon is removed (D, black arrows).

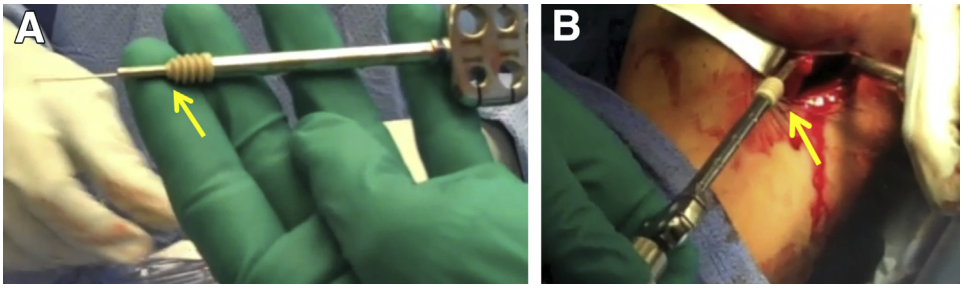

Fig 4. To perform a biceps tenodesis using an interference screw technique performed in the right shoulder, with the patient in a beach-chair position, we use an Arthrex PEEK (polyether ether ketone) tenodesis screw (Arthrex) (yellow arrow). In this case, an 8 × 12 mm screw is used (A and B).

position to the position of the drill and reamer. At this point, the arm is externally rotated approximately 10°, and the drill should be aimed directly anterior to posterior. This helps ensure drilling and reaming in the center of the humerus, rather than eccentrically through the medial or lateral cortex. One limb of the suture is threaded through the Arthrex PEEK (polyether ether ketone) tenodesis screwdriver and screw (8 × 12 mm) (Arthrex) (Fig 4A). The tenodesis screwdriver is placed into the bone tunnel, and the screw is advanced over the tendon until the screw is flushed with the bone tunnel (Fig 4B). The suture is then tied down for back-up fixation. This provides both an interference fit with the screw, and suture anchor stability (tendon-screw construct). The procedure is completed with standard wound closure.

Cortical Button Fixation. All portions of the procedure are identical to those of the interference screw fixation technique to the point of whipstitching the long head of the biceps tendon. We prefer to use No. 2 FiberWire (Arthrex) for interference screw fixation and FiberTape for cortical button fixation. A 3.2-mm drill pin (Arthrex) is inserted through the anterior cortex of the proximal humerus at the level of the inferior bicipital groove (Fig 5). As with the interference screw fixation technique, the surgeon should palpate to ensure that the drill pin is in the center of the humerus. Moreover, the angle between the arm and the drill should be noted. One limb of the FiberTape (Arthrex) is loaded through the Pec Button (Arthrex) with the free end exiting the longer side of the trapezoidal-shaped button (Fig 6). The other free end of the FiberTape (Arthrex) is loaded in a reverse fashion, again with the free end exiting the longer side of the button. This suture-loading configuration helps the button flip and lie flush against the humeral cortex. The button inserter (Arthrex) is then used to insert the loaded Pec Button (Arthrex) while applying traction to one of the free suture ends. After the button is inserted deep to the anterior cortex, the button inserter (Arthrex) is unscrewed and removed. The free suture ends are then toggled to flip the button against the undersurface of the anterior cortex. A tension slide technique is used to complete the tenodesis with the appropriate tension. The FiberTape (Arthrex) ends are then tied down for back-up fixation. The procedure is completed with standard wound closure. The pearls and pitfalls associated with this technique are listed in Table 1.

Fig 5. For the cortical fixation technique, a 3.2-mm drill pin is first used to make a hole in the anterior cortex of the proximal humerus at the level of the inferior bicipital groove in the right shoulder. For this portion of the procedure, it is important that the tunnel is positioned in the center of the intramedullary canal to ensure optimal positioning of unicortical fixation. We recommend performing the tunnel with the arm in abduction and external rotation as shown.

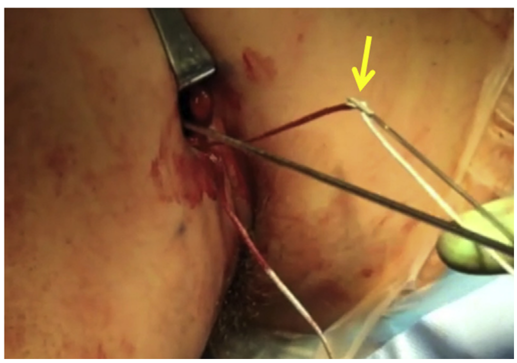

Fig 6. Once the anterior cortex of the humerus is prepared with the tunnel created, 1 limb of the FiberTape (Arthrex) is loaded through the Pec Button (Arthrex) (yellow arrow) with the free end exiting the longer side of the trapezoidal-shaped button. The other free end of the FiberTape (Arthrex) is loaded in a reverse fashion. This allows for optimal fixation through the use of the Pec Button (Arthrex).

Table 1. Pearls and Pitfalls

Pearls	Pitfalls
To ensure adequate interference fixation within bone and proper tensioning of the muscle-tendon unit, enough of the tendon must be secured before fixation	Inadequate interference fixation and improper tensioning of the muscle-tendon unit may result from poor securement of the tendon for fixation
The arm is externally rotated approximately 10°, whereas the drill is aimed directly anterior to posterior to ensure drilling and reaming in the center of the humerus, rather than eccentrically	If the arm is improperly positioned during drilling, eccentric drilling may result and ultimately lead to poor fixation of the biceps tendon
One limb of the FiberTape (Arthrex) is loaded through the Pec Button (Arthrex) with the free end exiting the longer side of the trapezoidal-shaped button (Fig 6). The other free end of the FiberTape (Arthrex) is loaded in a reverse fashion	If the free ends of the FiberTape (Arthrex) are not properly loaded into the Pec Button (Arthrex), then this will lead to poor fixation and greater likelihood of postoperative failure
For both types of fixation, palpation should be done to ensure that the drill pin is in the center of the humerus	Without palpation and ensuring that the drill is in proper place, the fixation of the biceps tendon may not be done correctly

Postoperative Rehabilitation

The patient is placed in a sling with the shoulder in neutral or internal rotation. Passive and active range of motion without restrictions is allowed immediately after surgery. Resisted elbow flexion is restricted for 6 weeks after surgery. Progressive resistance training is permitted 6 weeks after surgery. After 3 months, the patient is allowed to return to all activities, provided any concomitant procedures allow.

Discussion

This Technical Note describes our preferred surgical approach, with 2 different fixation methods, for biceps tendinopathy requiring surgery. Although biceps tendinopathy can be treated nonoperatively with relative success, we feel this technique is a viable option for those who have failed nonoperative treatment or have other surgical implications.

In instances where surgery is determined to be the proper treatment, there are a number of options for biceps tendinopathy. In general, there are 2 commonly used procedures—tenodesis and tenotomy. Many studies comparing tenotomy and tenodesis have failed to show any difference between the 2 in terms of subjective or objective outcomes.[11-14] A recent review by Patel et al.[14] concluded that both tenotomy and tenodesis are reliable surgical options with good outcomes; however, further high-powered studies with high levels of evidence need to be conducted. Although both procedures have been shown to produce good outcomes, some studies have reported tenodesis to be superior in terms of cosmesis and ultimate tendon failure strength.[12,15,16] Therefore, tenodesis may show superior biomechanical properties.

Tenodesis is largely performed in young, active patients, particularly those who expose their upper extremities to high loads on a regular basis, such as athletes and those with manual labor jobs. Tenodesis can be performed arthroscopically, via a miniopen and open incisions. Although there are studies reporting on clinical outcomes of the different techniques, there is a paucity of literature comparing the techniques. Werner et al.[17] reported on range of motion, strength, and subjective scores for 32 patients after arthroscopic suprapectoral tenodesis and 50 patients undergoing subpectoral tenodesis, and found no significant differences in any clinical outcomes. These results diverged from previous studies that have reported on the superiority of subpectoral fixation when compared with suprapectoral fixation. In addition, Friedman et al.[7] reported that subpectoral tenodesis had a significantly lower failure rate (2.7% vs 12%) when compared with suprapectoral fixation.

Numerous fixation types have been reported in the literature, including interference screws, suture anchor fixation, soft tissue fixation, and cortical button fixation. Biomechanical studies have been undertaken, with varying results, regarding superiority of fixation techniques, although most seem to be adequate.[18-22] Buchholz et al.[18] evaluated intramedullary cortical button fixation compared with interference screw usage and found similar results in regard to stiffness and ultimate failure loads, suggesting that both can be used for subpectoral fixation.

In conclusion, we recommend an open approach with subpectoral fixation for these instances of biceps tendinopathy requiring surgery. Further comparative studies are needed to elucidate biomechanical and clinical superiority amongst approaches and fixation techniques. Furthermore, more long-term studies need to be undertaken to elucidate the optimal approaches, fixation techniques, and fixation location in regard to prevention of osteoarthritis and restoration of native function.

References

1. Longo UG, Loppini M, Marineo G, Khan WS, Maffulli N, Denaro V. Tendinopathy of the tendon of the long head of the biceps. *Sports Med Arthrosc* 2011;19:321-332.
2. Ahrens PM, Boileau P. The long head of biceps and associated tendinopathy. *J Bone Joint Surg Br* 2007;89:1001-1009.
3. Krupp RJ, Kevern MA, Gaines MD, Kotara S, Singleton SB. Long head of the biceps tendon pain:

differential diagnosis and treatment. *J Orthop Sports Phys Ther* 2009;39:55-70.
4. Longo UG, Franceschi F, Ruzzini L, et al. Characteristics at haematoxylin and eosin staining of ruptures of the long head of the biceps tendon. *Br J Sports Med* 2009;43: 603-607.
5. Carr RM, Shishani Y, Gobezie R. How accurate are we in detecting biceps tendinopathy? *Clin Sports Med* 2016;35: 47-55.
6. Nourissat G, Tribot-Laspiere Q, Aim F, Radier C. Contribution of MRI and CT arthrography to the diagnosis of intra-articular tendinopathy of the long head of the biceps. *Orthop Traumatol Surg Res* 2014;100:S391-S394.
7. Friedman DJ, Dunn JC, Higgins LD, Warner JJ. Proximal biceps tendon: Injuries and management. *Sports Med Arthrosc* 2008;16:162-169.
8. Tallia AF, Cardone DA. Diagnostic and therapeutic injection of the shoulder region. *Am Fam Physician* 2003;67: 1271-1278.
9. 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.
10. Levy DM, Meyer ZI, Campbell KA, Bach BR Jr. Subpectoral biceps tenodesis. *Am J Orthop (Belle Mead NJ)* 2016;45:68-74.
11. Friedman JL, FitzPatrick JL, Rylander LS, Bennett C, Vidal AF, McCarty EC. Biceps tenotomy versus tenodesis in active patients younger than 55 years: Is there a difference in strength and outcomes? *Orthop J Sports Med* 2015;3:2325967115570848.
12. Slenker NR, Lawson K, Ciccotti MG, Dodson CC, Cohen SB. Biceps tenotomy versus tenodesis: Clinical outcomes. *Arthroscopy* 2012;28:576-582.
13. Wittstein JR, Queen R, Abbey A, Toth A, Moorman CT III. Isokinetic strength, endurance, and subjective outcomes after biceps tenotomy versus tenodesis: A postoperative study. *Am J Sports Med* 2011;39:857-865.
14. Patel KV, Bravman J, Vidal A, Chrisman A, McCarty E. Biceps tenotomy versus tenodesis. *Clin Sports Med* 2016;35:93-111.
15. Hsu AR, Ghodadra NS, Provencher MT, Lewis PB, Bach BR. Biceps tenotomy versus tenodesis: A review of clinical outcomes and biomechanical results. *J Shoulder Elbow Surg* 2011;20:326-332.
16. Wolf RS, Zheng N, Weichel D. Long head biceps tenotomy versus tenodesis: A cadaveric biomechanical analysis. *Arthroscopy* 2005;21:182-185.
17. Werner BC, Evans CL, Holzgrefe RE, et al. Arthroscopic suprapectoral and open subpectoral biceps tenodesis: a comparison of minimum 2-year clinical outcomes. *Am J Sports Med* 2014;42:2583-2590.
18. Buchholz A, Martetschlager F, Siebenlist S, et al. Biomechanical comparison of intramedullary cortical button fixation and interference screw technique for subpectoral biceps tenodesis. *Arthroscopy* 2013;29: 845-853.
19. Patzer T, Santo G, Olender GD, Wellmann M, Hurschler C, Schofer MD. Suprapectoral or subpectoral position for biceps tenodesis: biomechanical comparison of four different techniques in both positions. *J Shoulder Elbow Surg* 2012;21:116-125.
20. Baleani M, Francesconi D, Zani L, Giannini S, Snyder SJ. Suprapectoral biceps tenodesis: A biomechanical comparison of a new "soft anchor" tenodesis technique versus interference screw biceps tendon fixation. *Clin Biomech (Bristol, Avon)* 2015;30:188-194.
21. Chiang FL, Hong CK, Chang CH, Lin CL, Jou IM, Su WR. Biomechanical comparison of all-suture anchor fixation and interference screw technique for subpectoral biceps tenodesis. *Arthroscopy* 2016;32:1247-1252.
22. Patzer T, Rundic JM, Bobrowitsch E, Olender GD, Hurschler C, Schofer MD. Biomechanical comparison of arthroscopically performable techniques for suprapectoral biceps tenodesis. *Arthroscopy* 2011;27:1036-1047.