Technical Note

Subpectoral Biceps Tenodesis With Interference Screw Fixation

Augustus D. Mazzocca, M.D., Clifford G. Rios, M.D., Anthony A. Romeo, M.D., and Robert A. Arciero, M.D.

Abstract: The proximal portion of the long head of the biceps is a recognized cause of anterior shoulder pain. This article presents a novel technique for tenodesing the proximal biceps tendon. The tendon is evaluated and tenodesed in the same anatomic position beneath the pectoralis tendon, and is removed entirely from the bicipital groove. The proximal portion of the long head of the biceps tendon is marked near its origin and lysed arthroscopically. The skin incision for the subpectoral open biceps tenodesis is made in the axilla exposing the inferior border of the pectoralis major muscle. The tendon is withdrawn from the joint and out of the incision. A Krackow or other type of interrupted tendon whipstitch is placed in the 10 to 15 mm of tendon proximal to the musculotendinous junction. A bone tunnel is created within the bicipital groove. The tendon/tenodesis driver complex is positioned to create a secure fit within the bone tunnel. Our current series includes 22 cases with short-term follow-up of 2 to 10 months. None of the repairs has pulled out and none of the patients reports persistent pain or loss of function. The subpectoral approach with interference screw fixation appears to be a promising, reproducible technique for tenodesing the biceps. **Key Words:** Biceps—Shoulder—Tenodesis—Interference screw—Tendinosis.

The proximal biceps tendon has long been a recognized source of shoulder pain. Gilcreest[1] first described tenodesis of the long head of the biceps to the coracoid process in 1926. Since then, a multitude of techniques have been described for biceps tenodesis. Previous investigations considered instability of the biceps tendon within the bicipital groove as the cause of pain and biceps tendinosis. Therefore, initial techniques were designed to secure the tendon within the groove.[2,3] Froimson and Oh[4] opposed these techniques, arguing that leaving a proximal remnant of the biceps tendon could interfere with joint motion and be a persistent source of shoulder pain. In 1974, they developed the first technique using an interosseous tunnel into which the knotted end of the biceps tendon could be secured. While this keyhole method showed superior clinical efficacy, it was tedious and time consuming. Looking for a simpler and faster technique, Boileau et al.[5] and Edwards and Walch[6] developed an interference screw fixation technique, securing the proximal biceps tendon within the bicipital groove after arthroscopic tenolysis.

From the Department of Orthopaedic Surgery, University of Connecticut School of Medicine (A.D.M., C.G.R., R.A.A.), Farmington, Connecticut; and the Shoulder Section, Department of Orthopaedic Surgery, Rush-Presbyterian-St. Luke's Medical Center (A.A.R.), Chicago, Illinois, U.S.A.

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Address correspondence and reprint requests to Augustus D. Mazzocca, M.D., 10 Talcott Notch Rd, Farmington, CT 06034-4038, U.S.A. E-mail: admazzocca@yahoo.com

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EVALUATION OF THE PROXIMAL BICEPS TENDON

The diagnosis of proximal biceps tendon disease is challenging because of frequently associated pathology and the proximity of the rotator cuff, acromioclavicular joint, superior labrum, and anterior capsule.

Subjectively, the pain is at the anteromedial aspect of the shoulder in the area of the intertubercular groove. This differs from pain resulting from rotator cuff disease or pathology of the subacromial space, which is often localized to the anterolateral or lateral aspect of the shoulder. The shoulder pain of biceps tendinosis is often exacerbated by overhead activities and may "radiate" down the anterior arm into the biceps muscle.

Physical examination most commonly reveals tenderness over the intertubercular groove of the humerus, found by palpating the anterior shoulder approximately 7 cm below the acromion with the arm internally rotated 10°.[7] In proximal biceps tendinosis, tenderness over the intertubercular groove should move laterally with external rotation of the arm as the groove rotates, a technique that helps distinguish it from many other causes of anterior shoulder pain. Provocative tests that help discern causes of anterior shoulder pain include an active compression test of the biceps tendon in the bicipital groove, Speed's test (biceps tension test), O'Brien's test, and Yergason's test.

SUBPECTORAL BICEPS TENDON TEST

Palpation of the biceps tendon under the proximal aspect of the pectoralis major tendon can also implicate the biceps tendon as part of the pathology. In this subpectoral biceps tendon test, the proximal biceps tendon is easily identified underneath the pectoralis tendon while the patient internally rotates against resistance. This maneuver may produce discomfort in a normal shoulder, so it is important to compare the side in question with the unaffected side. Pain greater on the affected side, which is alleviated by intra-articular injection of lidocaine, suggests pathology in the bicipital groove. Pain here can be associated with synovitis which, in our experience, may cause premature failure of the biceps tenodesis within the groove.

IMAGING STUDIES

Radiologic studies that may be used to support the diagnosis of proximal biceps tendinosis are plain radiographs, arthrograms, ultrasound, and magnetic resonance imaging (MRI). The groove view on plain radiograph reveals the depth and width of the bicipital groove.[8] Tendinosis or synovitis is suggested when an arthrogram shows a loss of contour or thickened tendon sheath. However, a negative arthrogram can be expected in more than 30% of all cases of proximal biceps pathology.[9]

Ultrasound is an inexpensive, noninvasive test that provides the advantage of dynamic correlation to clinical examination. Furthermore, an examination of the unaffected side is easily carried out. The bicipital groove is examined transversely first, then longitudinally, looking for effusions or swelling surrounding the proximal biceps tendon.[10-14] A limitation of shoulder ultrasound is that its accuracy is highly dependent on the technician. Thus, its use is recommended as a diagnostic tool only for the radiologist well versed in musculoskeletal sonography.

MRI allows visualization of the biceps tendon, bicipital groove, bony osteophytes, and any fluid collection. Although cost often limits its use, one study has reported MRI to be 98% sensitive and 89.5% specific for superior labral pathology.[15]

NONOPERATIVE MANAGEMENT

Initial nonoperative management relies on principles of treating tendinopathy: Begin with anti-inflammatory modalities such as nonsteroidal anti-inflammatory drugs and ice/cold packs on a consistent basis. Rest and avoidance of aggravating activities are also important. If initial management is unsuccessful, then steroid injections either intra-articularly or in the subacromial space may be used. Techniques such as deep friction massage, iontophoresis, and phonophoresis have been used, although response to these is inconsistent.[16,17]

During nonoperative management, be mindful of the potential underlying causes of biceps tendinosis. Anterior instability, impingement, and chronic rotator cuff tears, for example, require special attention. In such cases, techniques such as cuff strengthening exercises and range-of-motion activities should supplement the aforementioned modalities.

INDICATIONS FOR BICEPS TENODESIS

The decision to surgically treat biceps pathology is predicated on a clinical presentation of bicipital groove pain, provocative tests, and response to injection that implicate the biceps tendon as a significant source of pain and disability. Proximal biceps pathology is frequently associated with rotator cuff disease, and is infrequently an isolated entity.

Furthermore, significant proximal biceps pathology is confirmed by arthroscopic examination. Findings on arthroscopic examination may include biceps tendinosis occurring with or without concurrent rotator cuff problems, biceps tendinosis in association with supe-

rior labral pathology (SLAP), and tendinosis secondary to instability of the biceps tendon. Instability of the biceps tendon can occur with disruption of the lateral aspect of the superior glenohumeral ligament and coracohumeral ligament as observed with anterior supraspinatus tendon tears, or with the disruption of the medial aspect of the coracohumeral ligament often seen with a subscapularis tear.

Recently, it has been recognized that disruption of the coracohumeral ligament without associated rotator cuff tears may also lead to biceps instability. Attempts at stabilizing the biceps tendon have resulted in a secondary rupture of the tendon in at least 25% of the cases in 1 series, and have been associated with stiffness or loss of external rotation due to fixation of the biceps within the bicipital groove.[18] Therefore, instability of the biceps tendon is generally treated with a biceps tenodesis and not an attempt at reconstructing the coracohumeral ligament attachment on the humerus.

The current account presents a modification to existing tenodesis techniques, in which the tendon of the long head of the biceps is marked arthroscopically and tenotomized at its origin, identified through a subpectoral approach, and tenodesed with bioabsorbable interference screw fixation just distal to the groove, deep to the pectoralis tendon. This technique offers several advantages: First, this is an efficient and reproducible method with no violation of muscle-tendon units and preservation of soft tissue. The relevant anatomy is clearly identified, and the length-tension of proximal biceps tendon can be reproduced. Next, this technique removes the tendon from the confines of the intertubercular groove, a region lined with synovium and a possible source of continued tenosynovitis and pain. Finally, it offers the biomechanical advantages of interference screw and suture anchor construction.

SURGICAL TECHNIQUE

The patient is brought into the operating room and, after the induction of appropriate anesthesia, a complete examination under anesthesia is accomplished to both extremities to evaluate for any loss of motion or abnormal translation. The patient is then given preoperative antibiotic prophylaxis and placed in the beach-chair position.

A standard posterior portal is used for the diagnostic arthroscopy. The biceps tendon is evaluated with no pump pressure ("dry"), as the intra-articular pressure of the fluid can compress many of the vessels causing the inflamed synovium to look "washed out" (Yamaguchi K, Romeo AA, personal communication, September 2001).

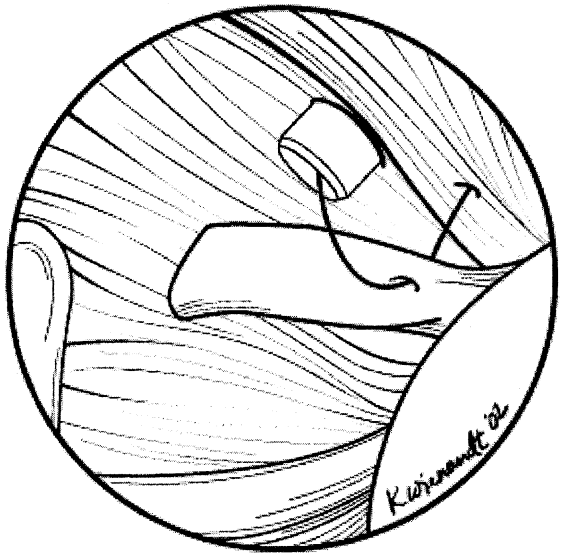

FIGURE 1. The arthroscopic marking of the proximal biceps tendon and excision of tendon.

The rotator interval between the supraspinatus and subscapularis tendons is identified and a standard anterior portal is made from the inside-out or outside-in methods. With a probe in the anterior portal, the biceps tendon is pulled into the glenohumeral joint to evaluate the tendon's mobility and structural lesions. Because biceps tendon pathology is most often in the intertubercular groove portion, it is critical that this part be drawn into the joint.[19-21] The coracohumeral ligament, as well as supraspinatus and subscapularis tendons, is evaluated for any pathology. Fraying of the tendon is a sign of biceps pathology: It is unknown how much biceps fraying is associated with structural change, but some authors have stated that the occurrence rate is 30% to 50%.[22] Using an arthroscopic cutting instrument or thermal ablator through the anterior portal, the biceps tendon is tenotomized at its base. A shaver can be used to debride the proximal portion for a stable base. If desired, the tendon may be marked with a PDS suture through a spinal needle, though this procedure does not require marking the tendon (Fig 1).

With the arm abducted and internally rotated, the inferior border of the pectoralis major tendon is palpated. On the medial aspect of the arm, the incision is made 1 cm superior to the inferior border of the pectoralis tendon and continued to 3 cm below the inferior border (Fig 2). The incision site is injected

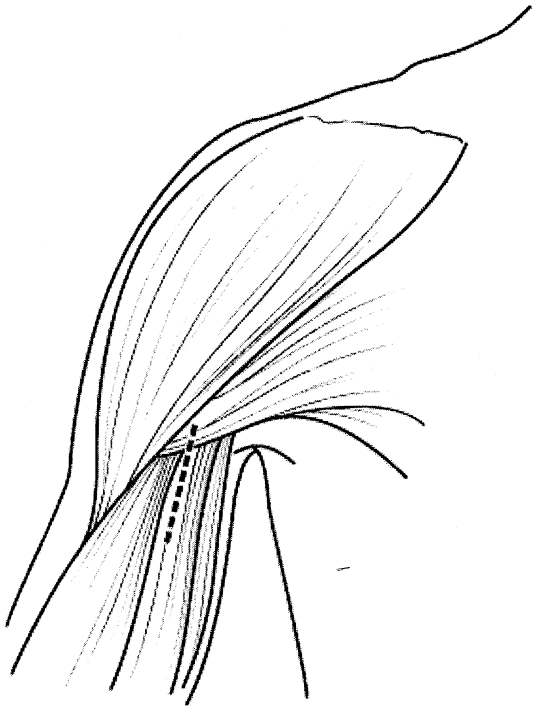

Figure 2. The skin incision for the subpectoral open biceps tenodesis is made in the medial one third of the arm. It extends 1 cm superior to the inferior border of the pectoralis tendon to 3 cm below this border. This tendon can be palpated by resisted internal rotation with the arm abducted and internally rotated 10° to 15°.

with a local anesthetic plus epinephrine for subcutaneous hemostasis and perioperative analgesia. Note that the entire incision may be placed in the axilla for cosmesis if one is familiar with the anatomy. A scalpel is used to cut down through the subcuticular tissue, and electrocautery is used to control bleeding. A Gelpy or Wheatlander self-retaining retractor can be used for visualization. The overlaying fatty tissue is cleared until the fascia overlaying the pectoralis major, coracobrachialis, and biceps is identified. If these anatomic landmarks are not seen, the dissection could be too lateral. If the cephalic vein is seen in the deltopectoral groove, the dissection is too proximal and 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. It is important to see the horizontal fibers of the pectoralis muscle and dissect below this level. Blunt finger dissection under the inferior edge of the pectoralis muscle, palpating up the anteromedial humerus, will identify the longitudinal, fusiform structure of the biceps tendon (Fig 3). A pointed Hohmann retractor is placed into the pectoralis major tendon and on the proximal humerus to retract the muscle proximally and laterally. A blunt Chandler retractor is positioned on the medial aspect of the humerus, and the coracobrachialis and short head of the biceps are gently retracted. Vigorous medial retraction should be avoided to prevent injury to the musculocutaneous nerve.

Once the biceps tendon is identified a right angle clamp is placed deep to it and the tendon is pulled, delivering it into the wound (Fig 4A). One centimeter proximal to the pectoralis major tendon, the periosteum is reflected in a rectangle roughly 2 × 1 cm. To ensure appropriate tensioning of the biceps tendon, the proximal portion of the tendon is resected to leave 20 to 25 mm of tendon proximal to the musculotendinous portion of the biceps. Using a Krackow or whip-stitch, a No. 2 Fiberwire (Arthrex, Naples, FL) nonabsorbable suture is weaved into the proximal 15 mm of tendon (Fig 4B). 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 for cosmesis.

A guidewire and an 8-mm reamer are used to make a 15-mm deep bone tunnel, and all debris is

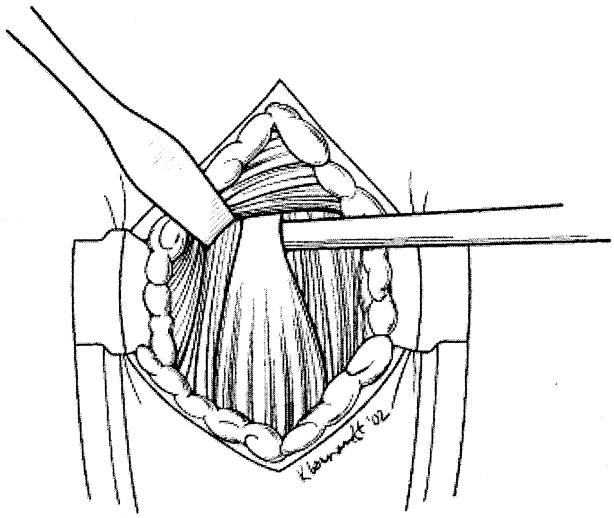

Figure 3. Location of the biceps tendon in the medial third of the arm is generally made by dissecting through the superficial fascia and then using blunt dissection to palpate the tendon. A Hohmann retractor is used to retract the pectoralis deltoid complex superiorly. If needed, a blunt Chandler retractor is placed on the medial side of the humerus to retract the coracobrachialis and short head of the biceps. Vigorous medial retraction may injure the musculocutaneous nerve.

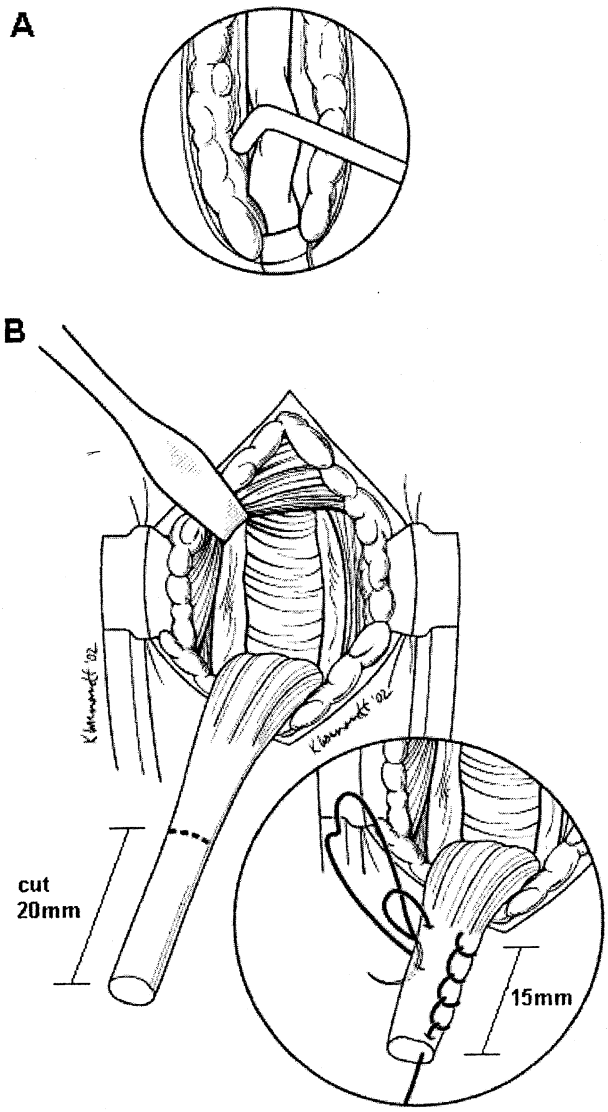

FIGURE 4. (A) A probe is used to withdraw the tendon from the joint and out of the incision. (B) To ensure appropriate tensioning, 20 mm of the diseased portion of the tendon is excised. The musculotendinous border of the biceps muscle is directly under the inferior edge of the pectoralis tendon. A Krackow or other type of interrupted tendon or whipstitch is placed in the 10 to 15 mm of tendon proximal to the musculotendinous junction. This amount of tendon is placed into the bone tunnel, allowing the musculotendinous junction to rest in its exact anatomic location underneath the inferior border of the pectoralis major tendon.

irrigated from the field (Fig 5). One limb of the suture is threaded through the Arthrex Bio-Tenodesis screwdriver and screw (8 × 12 mm) and the end of the suture is snapped. The tenodesis screwdriver is placed into the bone tunnel and the screw is advanced over the tendon (Fig 6). When the screw is flushed with the bone tunnel, the screwdriver is removed. The limb of suture next to the tendon and screw is tied to the limb through the screw. This provides both an interference fit because of the screw, as well as suture anchor stability (tendon-screw construct) (Fig 7). The musculotendinous junction should rest in its exact anatomic location underneath the inferior border of the pectoralis major tendon when finished (Fig 8). The procedure is completed with standard wound closure.

POSTOPERATIVE MANAGEMENT

A sling is worn during sleep for the first 4 weeks and only used while awake if patients are having difficulty keeping the elbow flexed passively or if they are going into public areas. The sling is discontinued completely from weeks 4 to 12.

Postoperative activity is typically dictated by the procedures that have been performed in conjunction with the biceps tenodesis. With a rotator cuff repair, passive range of motion of the shoulder is indicated for the first 6 weeks, followed by a gradual progres-

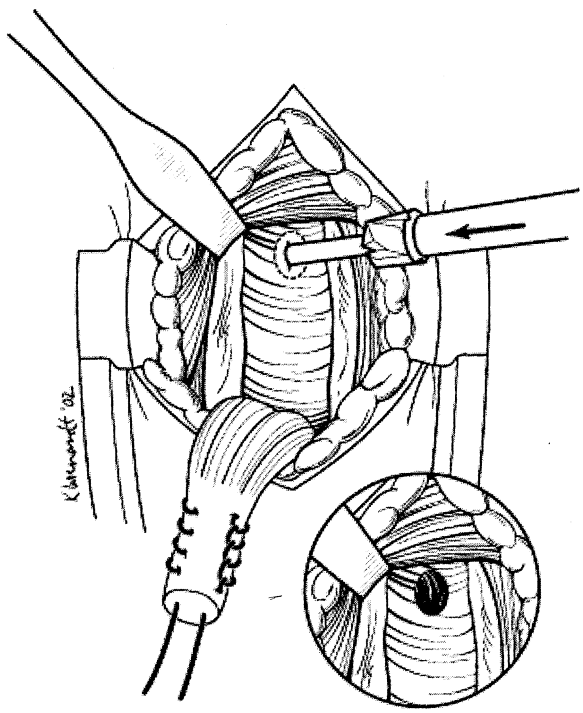

FIGURE 5. A guidewire is placed in the center of the bicipital groove. This is usually at the junction of the middle and distal thirds of the intertubercular groove between the lesser and greater tuberosities. A 7- or 8-mm acorn reamer is then placed over this and reamed to approximately 25 to 30 mm.

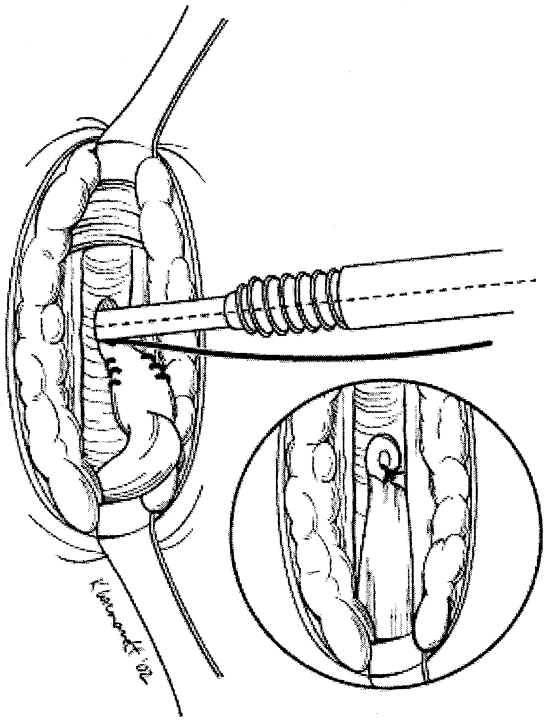

FIGURE 6. Once the bone debris has been removed from this hole, one suture is placed through the Arthrex Bio-Tenodesis driver and one suture is left out. The driver is then placed with the tendon into the hole so there is a secure fit with the driver in the tendon place into the bone tunnel. Generally, the size screw used is the size of the reamer (e.g., an 8-mm reamer equals an 8 × 23 mm Bio-Tenodesis screw).

sion from active-assisted range of motion to active motion. Elbow range of motion and grip strengthening can progress as tolerated without concern for the bicep tenodesis. If the procedure includes only an acromioplasty, then patients begin with passive range of motion but quickly progress to active-assisted and active range of motion without concern of the integrity of the biceps tenodesis. Elbow range of motion and grip strengthening are also included. Strengthening exercises are typically held until 6 weeks after the surgical procedure. If the procedure is only a biceps tenodesis, then the postoperative management is the same as it is for an arthroscopic acromioplasty. Any strengthening activities should be restricted until 6 weeks following the biceps tenodesis.

Please note that this represents a conservative rehabilitation protocol, and it may be modified to allow earlier motion if needed. Many tenodesis patients can resume activity as tolerated at week 2, but they are informed of the risks.

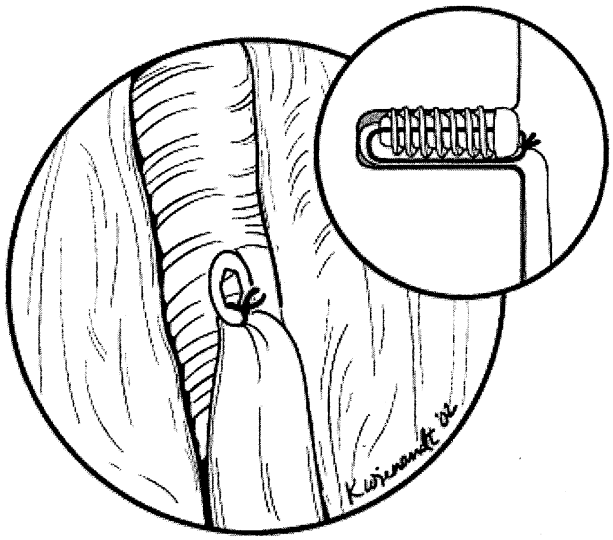

FIGURE 7. After the tenodesis driver has inserted the Bio-Tenodesis screw into the bone tunnel, the suture that is left out of the driver is then tied to the suture that is in or through the cannulated portion of the tenodesis screw. This then allows for both interference and suture anchor fixation.

COMPLICATIONS

No serious complications were observed, but potential complications include failure of tenodesis resulting in a functional tenotomy, hematoma or seroma of the involved area, and infection. Reaction to the biodegradable screw, persistent pain, musculocutaneous or axillary nerve injury, and injury to the brachial artery can also occur. Fracture caused by the stress

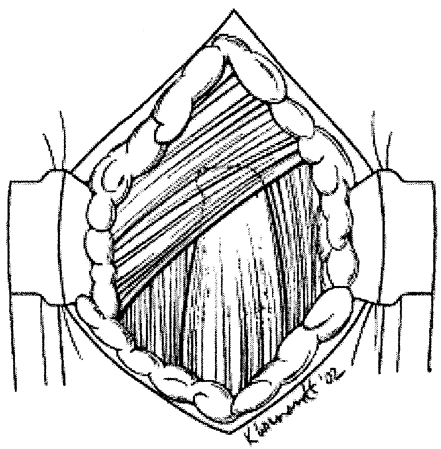

FIGURE 8. The musculotendinous junction should rest in its exact anatomic location underneath the inferior border of the pectoralis major tendon when completed.

riser created by the humeral bone socket is a potential complication that has yet to be reported.

CONCLUSIONS

The value of any surgical procedure can be evaluated in terms of a risk/benefit ratio. Benefits of subpectoral biceps tenodesis include pain relief, the maintenance of functional biceps muscle strength, and cosmesis. The subpectoral method is technically less demanding than the arthroscopic procedure. Moreover, current biomechanical data suggest that it is less likely to fail or displace than the arthroscopic method.[23] The risk of the tenodesis is minimal with disruption or recalcitrant tenosynovitis as the most common complications. Our current series includes 22 patients (ages 30 to 65 years) with short-term follow-up of 2 to 10 months. None of the repairs has pulled out and none of the patients reports persistent pain or loss of function. Moreover, this procedure has not been associated with an increased risk of infection, nerve injury, or wound complications. The subpectoral approach with interference screw fixation appears to be a promising, reproducible technique for tenodesing the biceps.

REFERENCES

1. Gilcreest EL. Two cases of spontaneous rupture of the long head of the biceps flexor cubiti. *Surg Clin North Am* 1926;6: 539-554.
2. Lippman RK. Frozen shoulder, periarthritis, bicipital tenosynovitis. *Arch Surg* 1943;47:283-296.
3. Hitchcock HH, Bechtol CO. Painful shoulder. Observations on the role of the tendon of the long head of the biceps brachii in its causation. *J Bone Joint Surg Am* 1948;30:263-273.
4. Froimson AI, Oh I. Kehole tenodesis of biceps origin at the shoulder. *Clin Orthop* 1974;112:245-249.
5. Boileau P, Krishnan SG, Coste JS. Arthroscopic biceps tenodesis: A new technique using bioabsorbable interference screw fixation. *Tech Shoulder Elbow Surg* 2001;2:153-165.
6. Edwards TB, Walch G. Open biceps tenodesis: The interference screw technique. *Tech Shoulder Elbow Surg* 2003;4:195-198.
7. Neer CS II. Impingement lesions. *Clin Orthop* 1983;173:70-77.
8. Cone RO, Danzig L, Resnick D, Goldman AB. The bicipital groove: Radiographic, anatomic, and pathologic study. *AJR Am J Roentgenol* 1983;141:781-788.
9. Ahovuo J. The radiographic anatomy of the intertubercular groove of the humerus. *Eur J Radiol* 1985;2:83.
10. Read JW, Perko M. Shoulder ultrasound: Diagnostic accuracy for impingement syndrome, rotator cuff tear, and biceps tendon pathology. *J Shoulder Elbow Surg* 1998;7:264-271.
11. Teefey SA, Middleton WD, Yamaguchi K. Shoulder sonography. State of the art. *Radiol Clin North Am* 1999;37:767-785.
12. Ahovuo K, Paavollainen P, Slatis P. Diagnostic value of sonography in lesions of the biceps tendon. *Clin Orthop* 1986; 202:184-188.
13. Conrad M, Nelms B. Empty biceps groove due to rupture and retraction of the biceps tendon. *J Ultrasound Med* 1990;9:231-233.
14. Middleton WD, Reinus WR, Totty WG. US of the biceps tendon apparatus. *Radiology* 1985;157:211-215.
15. Connel DA, Potter HG, Wickiewicz TL. Noncontrast magnetic resonance imaging of superior labral lesions. 102 cases confirmed by arthroscopic surgery. *Am J Sports Med* 1999;27:208-213.
16. Cyriax JG. Trauma to soft tissues. In: Cyrizx JG, ed. *Textbook of orthopedic medicine: Diagnosis of soft tissue lesions.* Philadelphia: WB Saunders, 1982.
17. Roberts D. Transdermal drug delivery using iontophoresis and phonophoresis. *Orthop Nurs* 1999;118:50-54.
18. Walch G, Nové-Josserand L, Boileau P, Lévigne C. Subluxations and dislocations of the tendon of the long head of the biceps. *J Shoulder Elbow Surg* 1998;7:100-108.
19. Boileau P, Walch G. So-called "isolated" supraspinatus tears: A plea for systematic opening of the rotator interval. In: Gazielly D, Gleyze P, Thomas T, eds. *The cuff*. Paris: Elsevier, 1997;320-323.
20. Walch G, Nové-Josserand L, Boileau P, Lévigne C. Subluxations and dislocations of the tendon of the long head of the biceps, *J Shoulder Elbow Surg* 1998;7:100-108.
21. Pfahler M, Branner S, Refior HJ. The role of the bicipital groove in tendinopathy of the long biceps tendon. *J Shoulder Elbow Surg* 1999;8:419-424.
22. Ball C, Galatz LM, Yamaguchi K. Tenodesis or tenotomy of the biceps tendon: Why and when to do it. *Tech Shoulder Elbow Surg* 2001;2:140-152.
23. Mazzocca AD, Santangelo SA, Adams DJ, Romeo AA, Arciero RA. Mechanical evaluation of an arthroscopic interference screw, suture anchor, open subpectoral bone tunnel and subpectoral interference screw proximal biceps tenodesis techniques. Presented at the Ninth Inernational Congress for Surgery of the Shoulder (ICSS), Washington, DC, May 2-5, 2004.