CHAPTER 7

Arthroscopic Treatment of Biceps Tendinopathy

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DEFINITION

- The long head of the biceps tendon has long been recognized as a potential source of pain and cause of shoulder impairment.[1,20,21,35]
- Although biceps tendon pathology can occur in isolation, more frequently, it occurs concomitantly with rotator cuff disease, and its neglect may account for a subset of patients with persistent pain following rotator cuff repair.
- Pathology of the long head of the biceps tendon presents in a spectrum, ranging from subtle tendinopathy detected by diagnostic imaging studies, to frank tearing or subluxation visualized intraoperatively.
- Because the functional significance of the biceps tendon long head has been the subject of considerable debate, treatment has often been tailored more to patient symptoms, activity levels, and expectations, rather than strict operative criteria.
- The ideal indications and optimal operative approach for the treatment of biceps tendinopathy, tears, or instability remain controversial but continue to evolve with advances in arthroscopic technology.

ANATOMY

- The long head of the biceps brachii (LHB) originates from the supraglenoid tubercle and the superior aspect of the glenoid labrum.
- Multiple anatomic variants of the LHB tendon origin have been described, the most common of which involves an equal contribution from the anterior and posterior labrum.[33]
- The tendon travels intra-articularly (but extrasynovially) an average of 35 ± 5 mm toward the intertubercular (bicipital) groove between the greater and lesser tuberosities.[27]
- Mean LHB tendon length is 9.2 cm, with greatest width at its origin (about 8.5 × 7.8 mm).[23]
- At the site of intra-articular exit lies the annular reflection, or biceps pulley, whose fibers are derived from the superior glenohumeral, the coracohumeral ligament, and the superficial or anterior aspect of the subscapularis tendon (**FIG 1**). Externally, this structure's counterpart is the transverse humeral ligament.
- The bicipital groove has been a topic of significant study in the literature for its relevance to arthroplasty, and it has been implicated as a contributing factor to tendinopathy involving the LHB.[5,25]
- The dimensions of the bicipital groove vary along its mean 5-cm length. At its entrance, the width ranges from 9 to 12 mm, and the depth is about 2.2 mm. In its midportion, the groove narrows to a mean width of 6.2 mm, whereas its depth remains comparable at approximately 2.4 mm. This considerable groove narrowing may contribute to entrapment of a hypertrophic intra-articular component, referred to as an *hourglass biceps*.[5,15,25]

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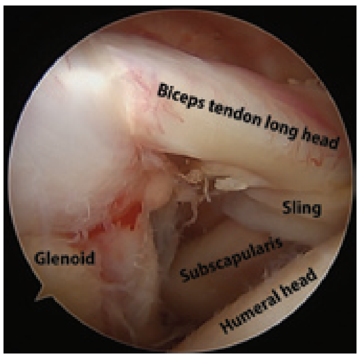

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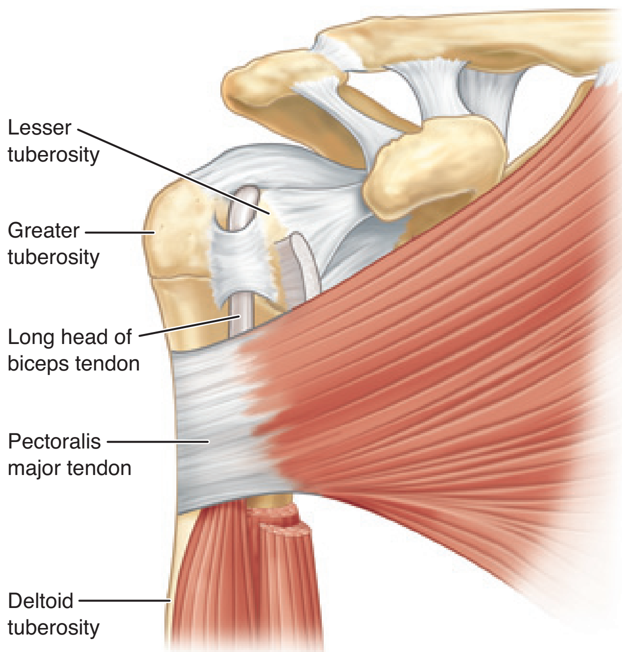

FIG 1 • **A.** Arthroscopic view of biceps tendon long head and proximal aspect of bicipital groove. **B.** Anatomy pertinent to surgery involving the LHB tendon.

- The bicipital groove internally rotates from proximal to distal, with a mean change in rotation of the lateral lip estimated at about 16 degrees.[15]
- The biomechanical significance of the biceps tendon long head is controversial. Some authors have suggested it plays a contributory role in shoulder stability, particularly in overhead athletes.[13,24] Based on electromyographic studies, other authors have concluded that the LHB tendon does not contribute to shoulder stability.[18,37]
- The extent of functional loss of forearm supination and elbow flexion strength following biceps tenotomy has not been clearly established and is a source of controversy in the literature but may be estimated at 10%.[34]

PATHOGENESIS

- LHB tendinopathy encompasses a spectrum of pathology, including intratendinous signal change, synovitis of the sheath, partial tearing, frank tendon rupture, and instability (**FIG 2**).
- The etiology of LHB tendinopathy is thought to be multifactorial.
- Identifiable causes include degenerative changes (usually in association with rotator cuff disease),[20,34,35] degenerative osteophyte spurring and stenosis within the bicipital groove,[5,25] inflammatory disease, traumatic injury, lesions of the biceps pulley complex or subscapularis tendon, and subtle forms of glenohumeral instability or superior labral anterior posterior (SLAP) tears.
- Lesions of the pulley complex or tears of the upper subscapularis tendon or anterior leading edge of the supraspinatus, may permit intra-articular subluxation, LHB instability, and mechanical symptoms.

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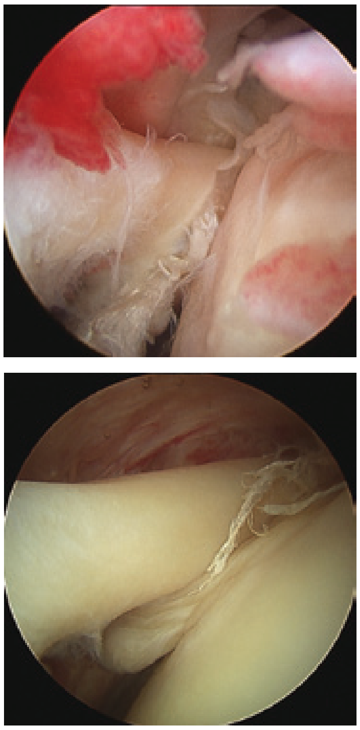


FIG 2 ● **A,B.** Arthroscopic images of tendinopathy and tearing of the LHB tendon.

- "Hidden" cuff tears within the rotator interval, or compromise of the annular reflection pulley may permit LHB subluxation, which can lead to pathologic changes to the LHB tendon.
- Tears of the superior labrum such as type II SLAP tears, and more subtle patterns of instability such as the peel-back mechanism in throwing athletes, can also cause biceps pain and/or bicipital tendinopathy.

NATURAL HISTORY

- Little is known about the natural history of biceps tendinopathy, so prediction of an individual patient's clinical course is difficult.
- Patients with high-grade tendinopathy, either in isolation or in association with cuff tears, seem to be at risk of subsequent rupture.
- Spontaneous LHB tendon rupture often alleviates the chronic pain preceding the event.[34]

PATIENT HISTORY AND PHYSICAL FINDINGS

- Patients with bicipital tendinopathy may complain of anterior shoulder pain exacerbated by resisted elbow flexion and/or supination.
  - Diagnosis of biceps pathology is established by the history and character of shoulder pain, as well as appropriate physical examination and diagnostic imaging.
- Biceps tendon disorders can present either in isolation or in association with other pathology, typically tears of the rotator cuff.
- Pain due to biceps pathology is often referred to the bicipital groove area.
- Physical examination findings are variable but typically include focal tenderness to palpation over the course of the biceps long head within the bicipital groove.
- In addition, physical examination for biceps pathology should include the following:
  - Speed test: Considered positive if pain is elicited on resistance against shoulder flexion with the forearm in a supinated and extended position. However, this test has been found to have low sensitivity and specificity (estimated 32% to 68% and 56% to 75%).[11]
  - Yergason test: Historically perceived to indicate LHB instability, it is performed by having the patient actively supinate his or her forearm with the elbow flexed 90 degrees and in adduction. Pain or subjective reproduction of symptoms suggests biceps tendinopathy, although sensitivity and specificity for this test is also low.
  - Active compression test: Primarily assists in differentiating between symptomatic superior labral pathology and acromioclavicular joint pathology. A positive result may suggest biceps tendinopathy in the appropriate clinical context.
- Despite the fact that clinical tests are well established, few studies have corroborated their sensitivity, reliability, or accuracy.

IMAGING AND OTHER DIAGNOSTIC STUDIES

- Magnetic resonance imaging (MRI) and ultrasound are the primary methods by which biceps tendinopathy is evaluated.
- For the diagnosis of subluxation or dislocation of the LHB, ultrasound has a reported sensitivity of 96% to 100% and specificity of 100%.[2] For the assessment of complete rupture, or

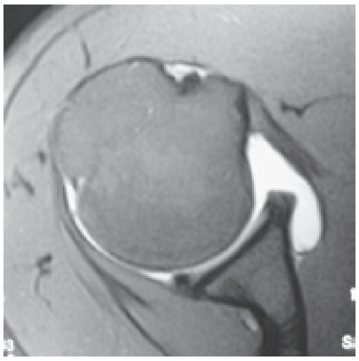


FIG 3 ● Coronal MR image showing a normal-appearing biceps tendon in the bicipital groove adjacent to a normal subscapularis tendon and overlying annular reflection pulley.

confirmation of a normal tendon, ultrasound has a sensitivity of 50% to 75% and specificity of 100%. Ultrasound is most useful to demonstrate pathology in the intertubercular groove and perform a dynamic examination of LHB instability. Notwithstanding its established value, a limiting factor of ultrasound is that it has been shown to be highly operator-dependent.

- MRI can identify intratendinous tendon abnormality, bicipital sheath hypertrophy, concomitant superior labral and rotator cuff pathology, the intra-articular course of the tendon, and the relationship of the biceps to the structures of the annular reflection pulley that stabilize it (**FIG 3**).

DIFFERENTIAL DIAGNOSIS

- LHB tendinopathy or tenosynovitis
- LHB partial tear
- LHB rupture
- LHB instability (subluxation or dislocation)
- SLAP tear
- Acromioclavicular joint pathology
- Anterosuperior rotator cuff tear
- Subcoracoid impingement
- Subscapularis pathology

NONOPERATIVE MANAGEMENT

- Treatment of biceps tendon pathology depends in part on whether it presents in isolation as a primary problem or is associated with other pathology.
- Alternative nonoperative management of suspected biceps pathology includes activity modification, a course of nonsteroidal anti-inflammatory medication, and corticosteroid injections targeted directly into the biceps sheath within the intertubercular groove. Such an injection can be both therapeutic and diagnostic.[4]

FIG 4 ● "Popeye" deformity of the left arm.

- Some clinicians have advocated injection under ultrasound guidance.[14] As portable ultrasound units become increasingly available and integrated into clinical practice, it may become the standard by which biceps tendon sheaths are injected.
- LHB ruptures traditionally have been treated with nonoperative management based on the perception that this problem rarely results in any significant impairment.
  - Patients may object, however, to the "Popeye" deformity (bulge in the volar aspect of the midportion of the brachium) (**FIG 4**) and possible fatigue-related cramping.

SURGICAL MANAGEMENT

- Surgical decision making includes patient factors, biceps tendon structural compromise, and concomitant shoulder pathology.
- Partial-thickness tearing or fraying exceeding 25% to 50% of the LHB tendon's diameter, or tendon subluxation or dislocation from its normal position within the bicipital groove, constitute indications for definitive operative treatment. However, these estimates are somewhat empiric rather than scientifically established.
- Patient factors influencing treatment include the patient's age and activity level, occupation, desired recreational activities, and expectations.
- Because the biceps tendon is a known "pain generator," its evaluation and inclusion in the treatment of cuff disorders is particularly important.
  - Preoperative consideration must be given to anticipate operative strategies if LHB pathology is encountered at the time of surgery.
- Operative alternatives in treating biceps tendon disorders include débridement, tenotomy (release of the biceps tendon long head), and tenodesis, in which the biceps is reattached to either bone or soft tissue of the proximal humerus. Each has advantages and disadvantages (Table 1).

Table 1 Indications for Tenodesis and Tenotomy

Procedure	Advantages	Disadvantages
Tenodesis	Better cosmesis Maintenance of length–tension relationship of biceps Decreased risk of fatigue-related cramping Maintenance of forearm supination and elbow flexion strength	Potential pain at tenodesis site Potential failure of tenodesis to heal Potential persistent tenosynovitis Requires postoperative protection until healed
Tenotomy	Typically minimal discomfort No need for placement of implants into proximal humerus or bone–tendon healing High rate of success for pain relief Minimal risk of persistent tenosynovitis Does not require significant postoperative protection	Potential fatigue-related cramping Significant potential for Popeye sign and undesirable cosmetic result Potential for slight to mild forearm supination and elbow flexion deficit

- The selected surgical approach should take into consideration patient factors, intraoperative findings, and surgeon preference.
  - Patient factors include age, arm dominance, work, recreational and activity demands, expectations, and perspective on influence of cosmesis.
  - Intraoperative findings influence decision making in a number of ways, including bone quality; soft tissue quality; the presence of injury to the biceps sling, subscapularis, or anterior supraspinatus; and the presence of instability.
  - Surgeon factors include arthroscopic proficiency and experience as well as the performance of concomitant surgical procedures that may influence treatment approach.
- Few studies have compared surgical alternatives within the same population of patients. Most comparative studies have design flaws due to patient and pathology heterogeneity, in addition to variable surgical procedures due to concomitant pathology.
- The ideal indications for débridement versus tenotomy versus tenodesis (soft tissue or bone) remain unclear at this time.
- Arthroscopic débridement may be an initial component of many biceps tendon surgical procedures.
  - In cases of fraying or partial tearing, débridement alone may be adequate to eliminate its contribution as a pain generator.
  - This is particularly true in cases in which the preoperative workup did not suggest the biceps as a significant component of patient symptoms and when concomitant pathology may otherwise explain the patient's presentation.
- The degree of tendon involvement requiring definite surgical management with either tenotomy or tenodesis has not been scientifically established in the literature and varies depending on concomitant pathology.
  - Some authors have advocated consideration of addressing the biceps tendon surgically with débridement alone when less than 50% of the tendon's diameter appears involved (in addition to addressing any concomitant pathology), but assessing the percentage of tendon involvement is an inexact science.
  - When the biceps is thought to be the predominant cause of symptoms or occurs in isolation, débridement alone may fail to adequately address the pathology and relieve the patient's symptoms.
- With regard to tenodesis studies, biomechanical analysis has focused on construct strength.
  - One such study found that interference screw tenodesis had a statistically significantly greater resistance to pullout than a double suture anchor technique.[27]
  - A recent biomechanical study of the interference screw technique highlighted the importance of placing the screw flush with the humeral cortex or just slightly proud. Recessed screw placement resulted in a higher rate of failure under cyclic loading.[28]
  - Some authors have performed recent biomechanical studies investigating the use of a unicortical or bicortical button as an alternative to interference screw or suture anchor fixation.[31]
  - Despite biomechanical testing, the actual amount of fixation strength necessary (and whether there is clear superiority of bone or soft tissue reattachment) remains unknown.
  - One recent study of biceps tenodeses found a statistically significant higher failure rate with proximal techniques compared to more distal techniques, as well as finding greater clinical failure when the biceps sheath (transverse humeral ligament) was not released.[29] On this basis, they advocated a more distal tenodesis site lower in the groove.
    - Another study found a higher rate of persistent pain following tenodesis when the LHB tendon was fixed proximally versus distally within the bicipital groove. On this basis, they advocate a distal arthroscopic technique, with the tenodesis site just proximal to the pectoralis major tendon.[19]
    - Others have recommended a mini-open subpectoral technique in the belief that moving further distal along the groove minimizes the risk of postoperative pain.
      - Recent studies have focused on the risk of complications following mini-open subpectoral biceps tenodesis.[26]
      - One study reported the musculocutaneous and radial nerves, as well as the deep brachial artery, to be within 1 cm of the standard medial retractor for this procedure. They further found that the safety margin from the neurovascular structures was enhanced with external rotation, moving the musculocutaneous nerve an additional 11.3 mm away from the tenodesis site.[9]
    - Further study is needed to clarify the optimal indications for each technique and selection of the tenodesis site.
  - A recent study has advocated biceps tenodesis as a salvage for failed repair of superior labral tears. Some surgeons have begun to recommend consideration of biceps tenodesis for the treatment of superior labral pathology in patients older than the age of 50 years and those with primary SLAP lesions who are heavy-demand or workman compensation patients.

Preoperative Planning

- Clinical evaluation to determine the contribution of the biceps tendon to the patient's symptoms is an important component of decision making and helps when encountering biceps pathology.
- Examinations for cuff pathology, particularly in the rotator interval ("hidden lesions" of the cuff) and for subscapularis integrity (belly press or lift-off test), are necessary components of the preoperative workup.
- Accurate preoperative evaluation should include appropriate radiographs. If indicated, a bicipital groove view may be obtained to better assess the morphology.
  - The bicipital groove view permits assessment of groove depth and the presence of osteophytes but may be unnecessary given the typical quality of routine axial magnetic resonance (MR) images.[8]
- MR images can be viewed to assess for biceps continuity (sagittal and coronal views) and intratendinous signal change (axial views) as well as tendon subluxation (axial and coronal views).
  - Attention must be paid when examining MR films to evaluate the appearance of the adjacent subscapularis, whose upper border is an important restraint against inferior biceps subluxation.

Surgical Positioning

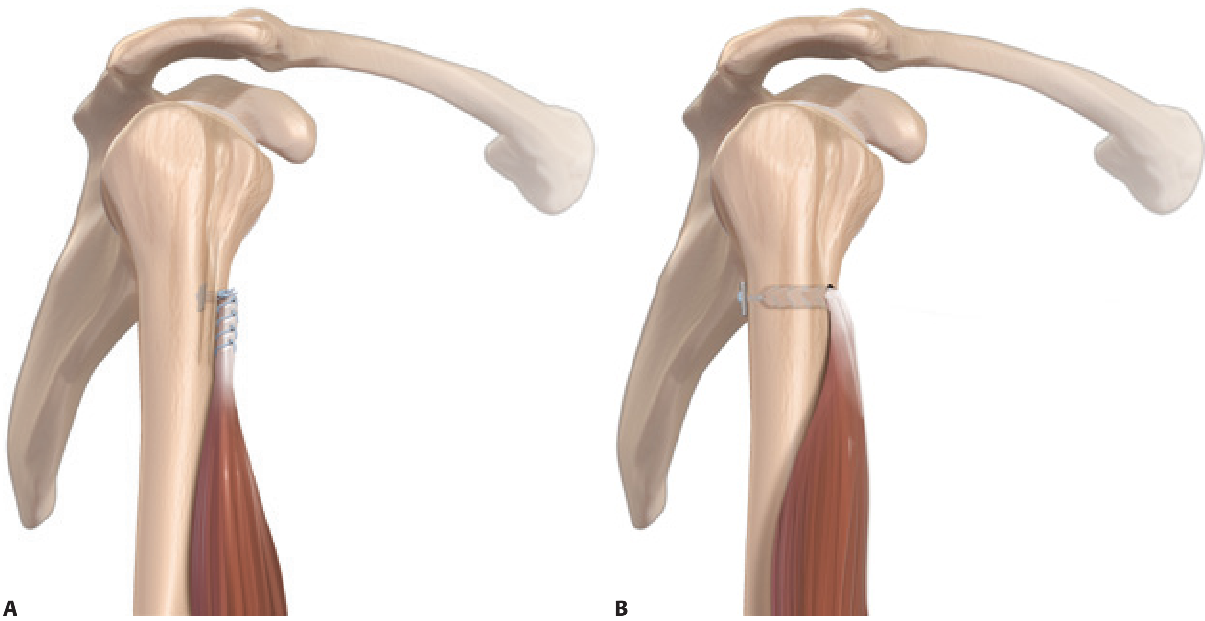
- Positioning is a matter of surgeon preference.
  - When biceps tendon pathology is perceived to be isolated or a significant component of the patient's presentation, we have found that beach-chair positioning affords optimal orientation and access.
  - Biceps tenodesis or tenolysis can also be easily performed in the lateral decubitus position.
- All bony prominences are carefully padded and the neck is maintained in a neutral position, ensuring adequate circumferential exposure to the scapula (posteriorly) and medial to the coracoid (anteriorly).

Approach

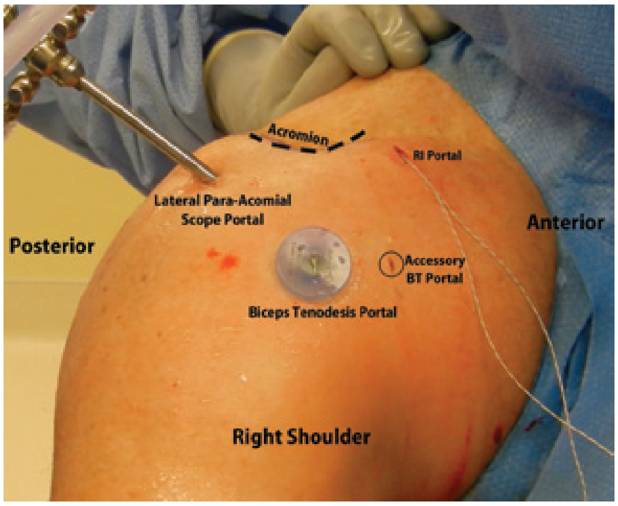
- Standard arthroscopic portals for this procedure include the posterolateral portal for initial viewing, an anterior "operative" rotator interval portal, a direct lateral subacromial portal (operative and viewing), an anterolateral biceps tenodesis portal (BTP), and an accessory portal for tendon manipulation just medial to the biceps tenodesis portal.
- On initial arthroscopic examination, the biceps is carefully inspected along its course from the posterosuperior glenoid labral attachment to its exit within the bicipital sheath.[33]
  - Examination should include both visualization along the course and down the sheath (enhanced by use of a 70-degree lens) and palpation.
- Because only a portion of the biceps tendon long head is visualized within the joint, the biceps tendon must be translated into the joint using a probe, switching stick, or some tissue-safe tool. This enhances the surgeon's ability to visualize tendinopathic changes that may otherwise go unrecognized.
  - Meticulous examination of the proximal annular reflection pulley and subscapularis tendon insertion is obligatory.
- Biceps long head abnormalities can include the following:
  - Hyperemia, seen in patients with adhesive capsulitis or biceps instability
  - Overt subluxation: Most commonly, subluxation is inferior due to injury to its inferior restraints, composed of the upper subscapularis tendon, or bicipital sling.
  - Subtle subluxation: Some authors have described a subtle instability pattern in which biceps tendon excursion within the otherwise normal-appearing sheath is greater than normal and deserves "stabilization." Such diagnostic assessment requires experience and remains somewhat empiric.
  - Biceps "incarceration": Some authors advocate the arthroscopic active compression test to assess for this uncommon entity. This test is performed intraoperatively with the arm positioned in forward elevation, slight adduction, and internal rotation.

Bony Tenodesis

- Bone fixation can be achieved in a variety of ways, most commonly with interference screws, unicortical or bicortical buttons, or suture anchors. Technique is based on surgeon preference and experience.
- Our approach traditionally has been to use interference fixation when performing a tenodesis for isolated biceps pathology, and suture anchors in the face of associated rotator cuff surgery.
- Occasional technical difficulties in performing tenodesis with interference screws (biceps tendon laceration/amputation, tendon malrotation, screw breakage, or implant pain) has led to the development of alternative strategies to achieve fixation.
- The recent emergence of a button and accompanying instrumentation for unicortical or bicortical fixation has been of increasing interest, although data are insufficient to recommend its routine use (**TECH FIG 1A,B**).

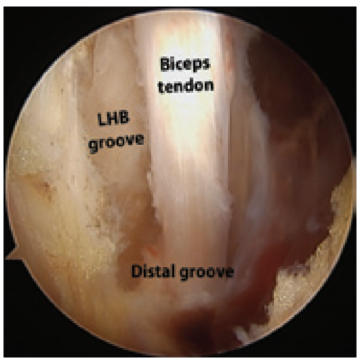


TECH FIG 1 ● **A.** Unicortical biotenodesis button construct. **B.** Bicortical biotenodesis button construct. (Modified with permission from Arthrex, Inc.)

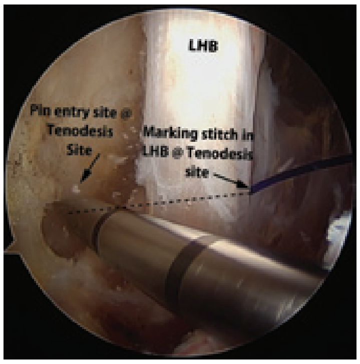


TECH FIG 2 ● Arthroscopic portals used during biceps tenodesis. *RI*, rotator interval portal; *BT*, biceps tenodesis portal.

- Following glenohumeral and subacromial arthroscopy, the 30-degree arthroscope is positioned in the subdeltoid space approximately 2 to 3 cm inferior to the midlateral acromial edge (**TECH FIG 2**).
- A spinal needle is used to establish the biceps tenodesis portal, typically 3 to 4 cm inferior to the anterolateral acromial edge and in line with the biceps muscle's lateral border. A minimal amount of subdeltoid bursal débridement usually permits easy visualization of the biceps sheath with its characteristic shiny decussating fibers directly over the mobile tendon. Use of a probe or switching stick demonstrates the underlying tendon.
- Once established, the appropriate length cannula is positioned directly over the intended site of the biceps tenodesis. A PassPort (Arthrex, Inc., Naples, FL) cannula of appropriate length (usually 30 to 40 mm and measured at the time of placement) is positioned.
- The bicipital sheath is incised with a retractable arthroscopic knife, arthroscopic scissors, or electrocautery device. This release is carried out to expose the distal portion of the bicipital groove just proximal to the upper border of the pectoralis major tendon. Care is taken distally, recognizing the vascularity due to the leash of vessels at the proximal pectoralis border (**TECH FIG 3**).



TECH FIG 3 ● Arthroscopic view of unsheathed long head biceps (*LHB*) tendon within groove.

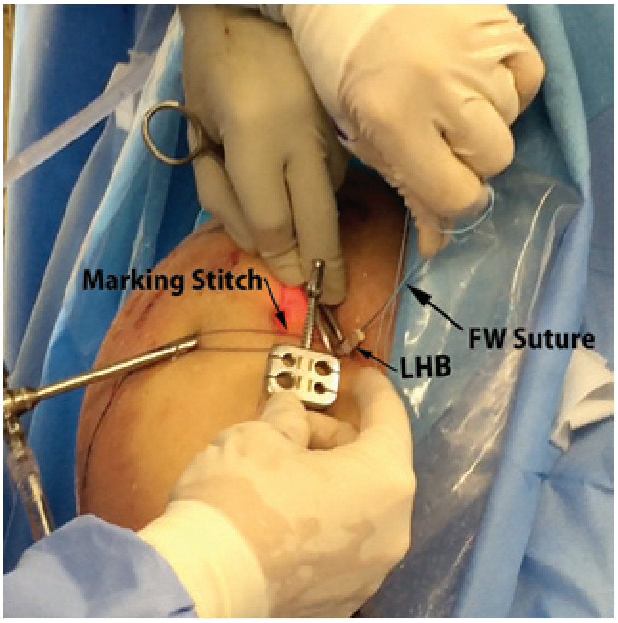


TECH FIG 4 ● A marking suture (no. 1 PDS) has been placed through the long head biceps (LHB) next to intended site of biceps tenodesis.

- To ensure anatomic restoration of normal biceps muscle length tension, the intended site of the tenodesis is marked before releasing the biceps. Using a spinal needle or Spectrum hook via a percutaneous portal 1 to 2 cm medial to the biceps tenodesis portal, a monofilament suture (no. 1 PDS) is shuttled transversely across the tendon. A drill hole in the distal bicipital groove marks the intended site of the bony tenodesis immediately next to the marked tendon (**TECH FIG 4**).
- The biceps tendon long head is released from its superior labral attachment using a basket, scissors, or cautery. In cases of cuff pathology, the scope is left in the tenodesis portal and the release performed through the cuff defect or interval portal. The scope may require repositioning within the glenohumeral joint if the cuff is intact.
- Although we traditionally placed sutures in the biceps tendon within the glenohumeral joint prior to its release, we have found that this step is not necessary; the biceps tendon rarely significantly retracts.
- The tenotomized long head biceps tendon is grasped and exteriorized through the accessory biceps portal just medial to the biceps tenodesis portal.
- Control of the proximal end of the tendon is secured with a nonabsorbable suture. A FiberLoop suture (Arthrex, Inc.) is used to whipstitch the tendon end 15 mm from the PDS marking suture, excess tendon is trimmed, and the tendon diameter is measured (**TECH FIG 5**).

Arthroscopic Interference Screw Technique

- When using an interference screw, the surgeon must ensure that the length of the suture is sufficient to pass through the cannulated interference screwdriver (**TECH FIG 6**).
  - Attention to suture management by use of cannulas is critical at this point. They ensure optimal visualization, soft tissue and suture management, and minimize iatrogenic trauma to adjacent soft tissues.
- A pilot headed reamer is drilled through the near cortex. Reamer diameter is usually 8 mm.
- The guidewire is removed and a screw is selected for tenodesis. Usually, a 7-mm bioabsorbable implant is chosen, but this varies depending on bone quality, patient size, and other factors.
- The whipstitched biceps tendon is then retrieved out through the biceps tenodesis portal.

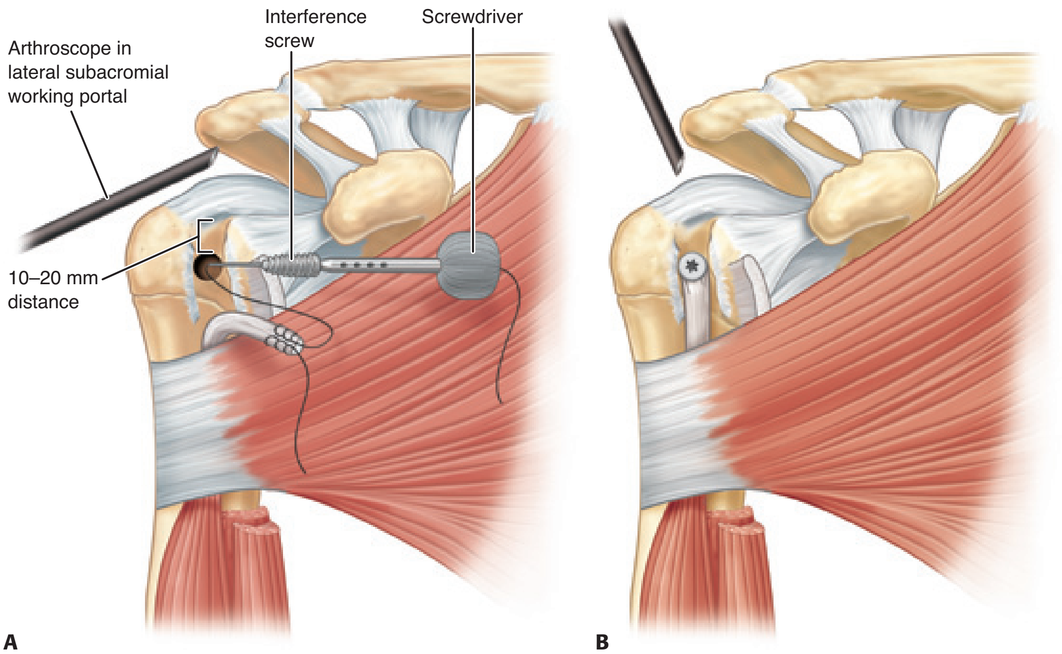


TECH FIG 5 ● The long head biceps (*LHB*) has been retrieved through the accessory portal and whipstitched with FiberWire (*FW*) suture. Note marking suture designating site of tenodesis and measurement paddle.

- One limb of the whipstitch is loaded to the tenodesis screwdriver, and the bioabsorbable screw is loaded (**TECH FIG 6**).
- The suture limb within the screwdriver is secured with a clamp at the top of the driver, thereby fixing the tendon at the tip of the insertion device for delivery to the base of the tunnel.
- The tendon and driver are inserted the full depth of the tunnel, and the interference screw is advanced while maintaining the driver position and suture tension. It should be advanced such that it is flush with the cortical surface of the intertubercular groove or just slightly proud. Gentle traction on the proximal tendon, and or use of a switching stick or probe while advancing the screw, is helpful to avoid the tendon rotating in the tunnel and changing its orientation (and possibly length).
- The two remaining suture limbs (one exiting the cannulated screw, the other trailing between the screw and the bone tunnel) are arthroscopically tied on the top of the interference screw, providing further reinforcement.

Unicortical or Bicortical Button Fixation Technique

- Fixation using an 8.5-mm Proximal Tenodesis Button (Arthrex, Inc.) is achieved by first drilling with a calibrated 3.2-mm Spade Tip drill (Arthrex, Inc.).
- Fixation can be unicortical, penetrating through just the proximal cortex with a drill bit, deploying the button on the endosteum of the proximal cortex, and securing the biceps tendon at the site of pin entry (see **TECH FIG 1A**).
- Alternatively, a button can be used to achieve bicortical fixation, deploying it on the opposite cortex following transhumeral drilling.
- When performing a cortical button fixation, drill only until the tip is felt to penetrate the opposite humeral cortex, usually between 40 and 45 mm in depth. Unpublished anatomic studies suggest that the drill hole is an average of 36.7 mm from the axillary nerve and 48 mm from the radial nerve. However, this was measured in the subpectoral location. Fixation higher in the groove, however, is more proximate to the nerves; thus, care



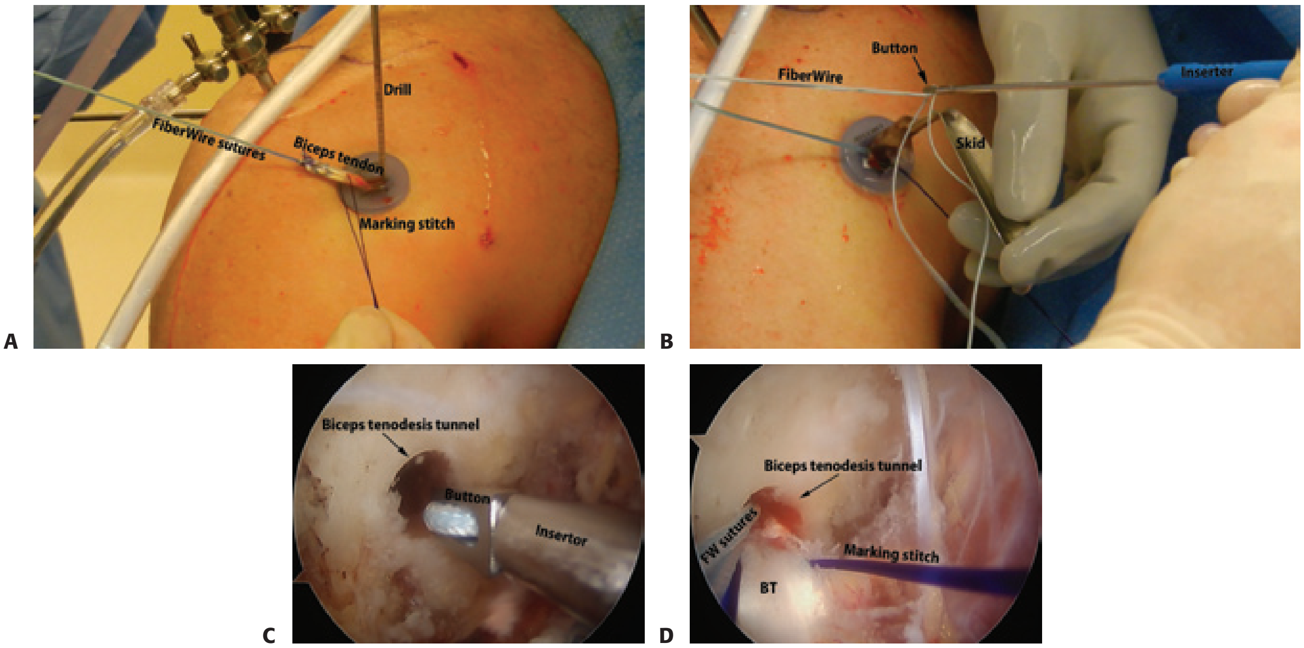
TECH FIG 6 ● Arthroscopic interference screw method of tenodesis of the LHB tendon. The arthroscope is in the lateral subacromial working portal. **A.** The tendon is placed into the recipient hole in the bicipital groove and securely fixed with an interference screw. **B.** Completed tenodesis.

must be taken to ensure the drill is perpendicular to the shaft, aimed posteriorly, and is stopped just after cortical penetration.

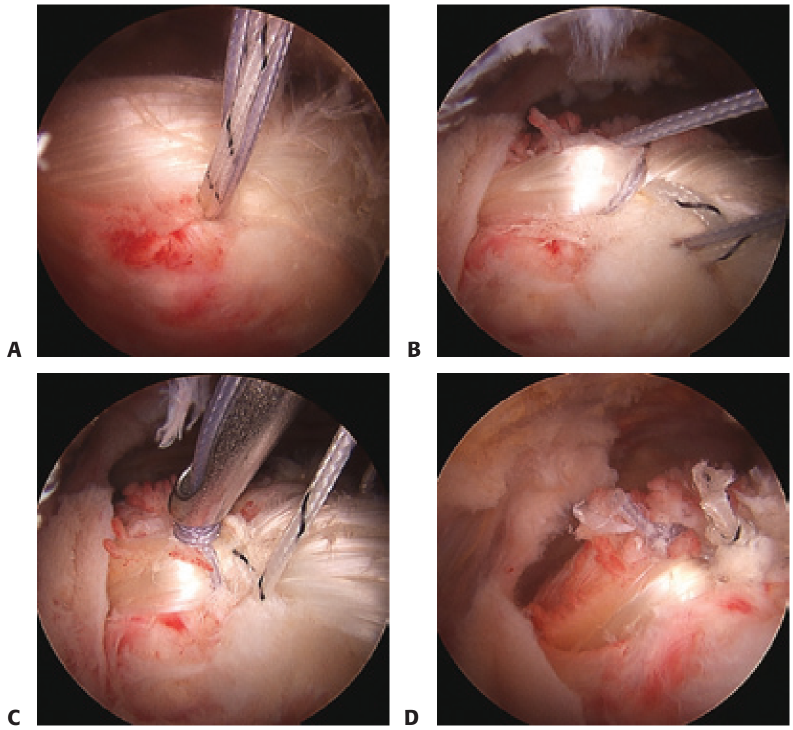
- Until the safety margin of this button placement is established, arthroscopic fixation above the pectoralis tendon cannot be currently recommended.
- The appropriate-sized (usually 5 to 7 mm) cannulated reamer penetrates the proximal humeral cortex. Care is taken to avoid advancing the calibrated drill, which, if left in place, facilitates subsequent targeting during button deployment.
- The whipstitched tendon is retrieved through the arthroscopic biceps tenodesis (ABT) portal (**TECH FIG 7A**) and threaded through the biceps button.
- The button is inserted into the proximal tunnel and, using a skid to maintain the same orientation and angle as the drill bit, is advanced until it is felt to enter the distal cortical drill hole and pass across the opposite cortex (**TECH FIG 7B,C**). The button is deployed by unscrewing the knurled hub, disengaging the threaded inserter.
- A tension-slide technique is used by alternatingly toggling on the two suture limbs until the tendon advances into the canal such that the marked suture site is flush with the tunnel aperture. The sutures are tied with a knot pusher and are cut (**TECH FIG 7C,D**).
- A reinforcement suture may be passed across the biceps tendon at the aperture of the tunnel, using the passing suture to shuttle a limb of the FiberWire (Arthrex, Inc.) suture and tying a knot at this site.

Arthroscopic Suture Anchors

- Before being released at the superior labral attachment, the biceps long head must be controlled. This is best achieved by securing the suture about 1 to 2 cm distal to the attachment.
- This can be achieved either via spinal needle and PDS percutaneously or by suture passage using a variety of available suture-shuttling instruments.
- The biceps tendon attachment is then released at the anterosuperior glenoid using a bipolar cautery, arthroscopic scissors or basket, or retractable knife.
- The tagging 0 PDS or braided suture controlling the proximal aspect of the tendon is pulled through the anterior portal skin incision outside of the cannula, and secured with a Kelly clamp.
- The arthroscope is redirected into the subacromial space, where a bursectomy is performed from a direct lateral portal for adequate visualization within the subdeltoid space. The site of tenodesis is then selected based on surgeon preference.
- The intertubercular groove is identified by incising the annular reflection pulley as described earlier, and an arthroscopic burr is used to abrade the intertubercular groove.
- Two suture anchors are inserted (one proximal and one about 1 to 1.5 cm distal) within the prepared intertubercular groove, and sutures from these anchors are shuttled through the LHB tendon using a spinal needle and 0 PDS suture or a penetrating grasper device to securely fix the biceps into the groove.
- Although simple mattress sutures may be effective at achieving fixation, compromised tissue quality may lend to gradual suture–tissue failure, with slippage and/or pulling out of the tendon.
    - An alternative locking knot configuration can be achieved using multiple percutaneous shuttling sutures retrieved through the anterior interval cannula (**TECH FIG 8**).
- Alternatively, biceps tenodesis may be performed via an intra-articular approach. Advantages include the ability to perform the procedure without requiring repositioning of the scope from the joint to the subacromial space, or subacromial bursectomy.



TECH FIG 7 • **A.** The whipstitched biceps tendon has been retrieved through the PassPort cannula, with the drill in place to maintain orientation of button. **B.** The button has been loaded and preparing to be inserted down the skid. **C.** The button is about to be inserted into the proximal cortex tunnel. **D.** The biceps tendon (*BT*) is being pulled into the tunnel using tension-sliding technique until the marking suture is flush with the tunnel aperture, recreating normal muscle tension length.



TECH FIG 8 ● Arthroscopic images showing intra-articular tenodesis of the LHB tendon at the proximal aspect of the bicipital groove. **A.** Anchor placement. **B.** Suture passage. **C.** Knot tying. **D.** Completed tenodesis.

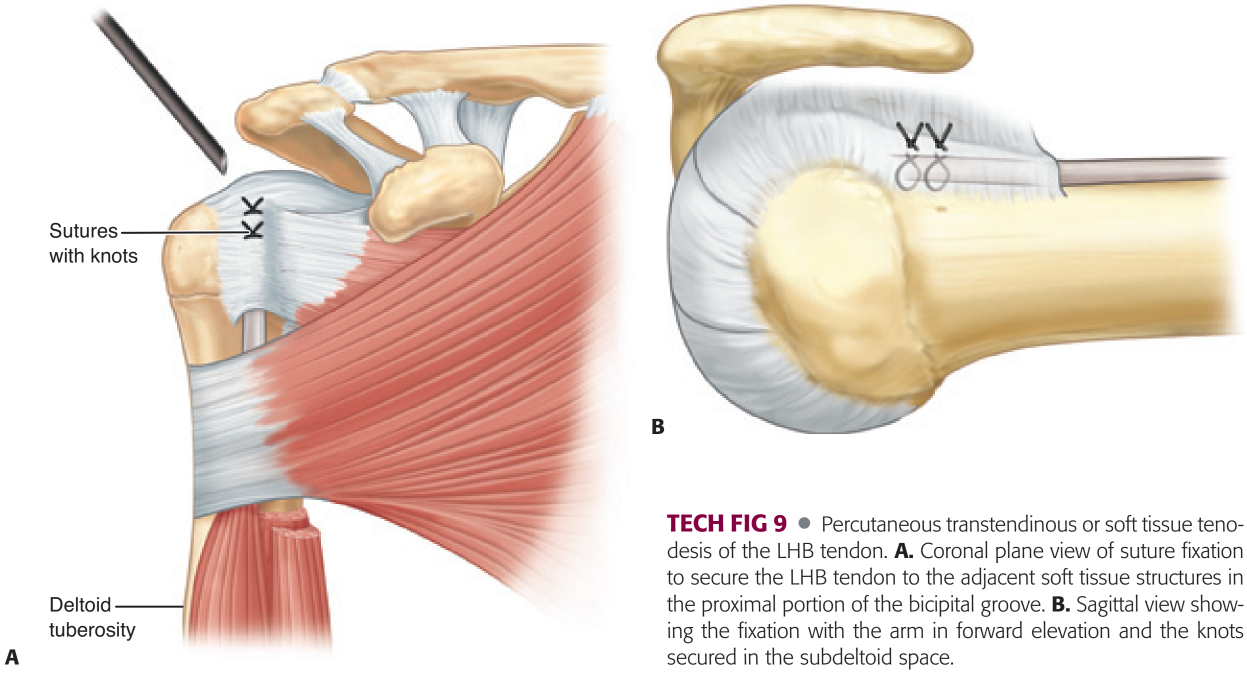
- This latter technique is particularly good in cases with cuff tears, in which the proximal bicipital groove is readily accessible.
- In this procedure, a stay suture is placed at the proximal-most bicipital groove at the anterior margin of the supraspinatus.
- Flexion of the shoulder and use of a 70-degree lens facilitate identification of the most superior aspect of the bicipital groove. This will be the site of tenodesis.
- The biceps tendon is released from its origin, with the stay sutures percutaneous (at the site of spinal needle penetration).
- The anterosuperior portal is used to target the proximal humeral tenodesis site, generating a healing response along the proximal centimeter of the bicipital groove. By rotating and flexing the shoulder, the biceps tendon can be translated to permit good visualization of the tenodesis site and to facilitate subsequent targeting for anchor placement.
- Several alternative fixation techniques exist, the most common of which is anchor insertion, followed by suture passage and knot tying through the proximal tendon stump.
- Alternatively, the surgeon may make multiple passes through the biceps tendon (using a locking stitch of nonabsorbable suture such as FiberWire) and then use a knotless-type anchor (such as the Arthrex PushLock or SwiveLock) to perform a secure tenodesis in a percutaneous fashion over a previously placed small-diameter cannula.

Soft Tissue Tenodesis

Arthroscopic Fixation

- This technique, in which the biceps tendon is secured to the soft tissues in the rotator interval, is based on the percutaneous intra-articular transtendon (PITT) technique described by Sekiya et al[30] and Elkousy et al[10] (**TECH FIG 9**).
- A spinal needle is placed percutaneously through the lateral aspect of the rotator interval proximate to the annular reflection pulley and then through the biceps tendon, about 1 to 2 cm distal to its supraglenoid origin.
- A 0 PDS suture is then shuttled through the tendon; it is retrieved through the anterior interval portal using a grasper.
- This suture is then replaced by shuttling a nonabsorbable suture (such as no. 2 FiberWire or other comparable suture).
- This process is repeated 5 to 6 mm distally along the biceps tendon's course just proximal to the superior aspect of the intertubercular groove shutting a PDS suture across the tendon.
- Next, the limb of the no. 2 nonabsorbable suture exiting the cannula is shuttled with the second PDS back through the biceps and annular reflection pulley. A mattress suture has now been established. It exits the skin through two separate punctures made by the spinal needle passages.

- A tenotomy is performed via the anterior interval portal using an ArthroCare wand, needle-tip Bovie, arthroscopic scissors, or up-biting narrow meniscal basket.
- The intervening residual stump is excised and the arthroscope repositioned within the subacromial space, which is carefully débrided to enhance visualization and retrieval of the two suture sets. Care is taken to avoid inadvertent damage to the passed sutures.
  - Retrieval of the percutaneous sutures is facilitated with an arthroscopic "crochet hook" or suture-manipulating device.
  - An alternative technique for retrieving hard-to-find sutures involves making a small incision directly over the percutaneous suture exit sites and loading the suture limb within a single-loop knot pusher, which is then pushed through the skin and into the cleared anterior subacromial space. The sutures are then easily identified and grasped, unloading from the knot pusher, which is withdrawn without difficulty.
- Upon retrieval, which can be done one at a time, mattress sutures are tied under direct arthroscopic visualization in the anterior subacromial space.
- After thorough irrigation, the joint, subacromial space, and arthroscopic portals are infiltrated with 0.25% Marcaine with epinephrine.



TECH FIG 9 ● Percutaneous transtendinous or soft tissue tenodesis of the LHB tendon. **A.** Coronal plane view of suture fixation to secure the LHB tendon to the adjacent soft tissue structures in the proximal portion of the bicipital groove. **B.** Sagittal view showing the fixation with the arm in forward elevation and the knots secured in the subdeltoid space.

Arthroscopic Biceps Tenotomy

- In the appropriately selected patient, the procedure is carried out by simply releasing the biceps tendon at its attachment site from a rotator interval portal while viewing from posteriorly.
- The intervening segment of diseased biceps tendon (in cases of tendinopathy) can be resected.
- Avoiding distal migration of the tendon has been described by either leaving a residual wider portion of the diseased tendon just proximal to the proximal bicipital groove, or by including a small piece of the anterior superior labrum at the time of tenotomy.
- However, we are concerned that residual diseased biceps tendon can be a source of persistent pain, so this is not typically performed.

PEARLS AND PITFALLS

Indications	▪ Careful assimilation of the preoperative history, physical examination, and imaging data with the findings at surgery is essential to determine which symptomatic lesions require treatment. ▪ A thorough discussion with patients about the goals, expectations, and potential complications of tenotomy and tenodesis is a key principle in obtaining successful patient-based outcomes.
Portal placement	▪ The location of the biceps tenodesis portal will greatly influence the ease with which an arthroscopic tenodesis can be performed. Position the portal 3–4 cm distal to the anterolateral acromial edge, in line with the lateral biceps muscle. ▪ The location of the direct lateral portal along the anterior half of the acromion in the sagittal plane will aid in visualization when working in the subdeltoid space. ▪ Portal placement can be optimized by localization and triangulation using a spinal needle.
Diagnostic arthroscopy	▪ A key component of the arthroscopic examination is using a probe, switching device, or other instrument to displace the intertubercular portion of the tendon into the glenohumeral joint for adequate assessment. In addition, a careful examination of the fibers of the annular reflection pulley and the subscapularis insertion is essential. When viewing from the standard posterior portal, using a 70-degree lens can enhance visualization of the proximal intertubercular groove when performing an intra-articular tenodesis.
Visualization	▪ An adequate bursectomy facilitated by the use of electrocautery for hemostasis will significantly assist in visualization during arthroscopic tenodesis. ▪ Attention to accurate portal placement, fluid management (pump pressure), and procedure duration will help limit soft tissue extravasation.
Arm position	▪ Manipulating the arm in flexion and extension, as well as rotation, can help in visualization as well as anchor or screw targeting.
Suture management	▪ Careful suture management during tenodesis is key to avoid inadvertent soft tissue interposition, leading to inadequate fixation, skin dimpling, or unnecessary soft tissue dissection.

POSTOPERATIVE CARE

- The postoperative protocols for LHB tendon surgery vary according to the specific technique (débridement, tenotomy, or tenodesis).
  - Often, the protocol will depend on concomitantly performed procedures, such as rotator cuff repair.
- In general, following tenotomy, sling duration varies from 2–4 weeks, as dictated by the surgeon's preference.
  - Forceful, active elbow flexion is prohibited for 6 weeks, by which time it is expected that the biceps tendon will have scarred into the groove or "autotenodesed" sufficiently to begin active motion.[23]
    - This period of protection also serves to minimize the potential for a Popeye deformity and fatigue-related cramping.
  - To further minimize the risk of distal retraction, some surgeons have described the use of a compressive wrap around the arm.
    - We have no experience with this technique, and cannot recommend it.
- After biceps tenodesis, patients are immobilized in a sling for 3 weeks, with the amount of active-assisted elbow flexion and extension dictated by surgeon preference and comfort.
  - Active elbow flexion is prohibited for about 6 to 8 weeks to allow tenodesis healing.
  - Some surgeons favor limiting the last 15 to 20 degrees of terminal extension for 4 to 6 weeks after surgery to minimize stress at the tenodesis site.
  - Active elbow flexion exercises are then slowly incorporated into the rehabilitation program after 6 to 8 weeks, with strengthening delayed until the third postoperative month.

OUTCOMES

- Outcome interpretation is challenging because of the limited number of studies and the lack of homogeneous patient populations. Surgical procedures to the biceps are typically only one component of surgically treated shoulder pathology in most studies. A recent systematic review of 16 studies by Slenker et al[32] reported "comparably favorable results" of both biceps tenodeses and tenotomy, with cosmetic appearance following tenotomy the only appreciable difference in their results.
- Arthroscopic tenodesis
  - Checchia et al[7] reported 93% good and excellent results in 14 of 15 patients who underwent arthroscopic rotator cuff repair and transtendinous soft tissue tenodesis at a mean follow-up of 32 months.
  - Boileau et al[6] published their results of arthroscopic biceps tenodesis with interference screw fixation at a mean follow-up of 17 months, reporting a Constant score improvement from 43 preoperatively to 79 at latest follow-up ($P < .005$).
  - Lee et al[17] reported results of arthroscopic suture anchor tenodesis at the time of cuff repair, with a 13% rate of Popeye deformity and a 7% rate of anterior cramping pain. In this study, American Shoulder and Elbow Surgeons (ASES) and Constant scores increased from 43 and 56 to 85 and 82, respectively.
  - Wittstein et al[36] reported on isokinetic strength, endurance, and subjective outcomes after tenotomy or tenodesis in a cohort study of 35 patients at minimum 2-year follow-up, and found similar subjective outcomes and peak flexion torques for both procedures, but decreased supination peak torque with tenotomy.

- The historical literature regarding biceps tenodesis defines a range of unacceptable or poor results ranging from 6% to 40%.[16]
- The results of arthroscopic biceps tenodesis are summarized in Table 2. Briefly, the results of arthroscopic tenodesis to date indicate that the procedure is an effective treatment for refractory biceps tendinopathy in appropriately indicated patients, and may be more favorable for patients younger than 60 years of age.

- Arthroscopic tenotomy
  - Outcomes of arthroscopic tenotomy suggest that in the appropriately selected patient, this procedure can reliably provide pain relief, with minimal functional limitations or functional improvement.
  - Gill et al[12] in 2001 reported their results of tenotomy in 30 patients at a mean follow-up of 19 months. These patients scored an average of 82 by the ASES grading scale (no preoperative comparison data were available), and showed a significant reduction in pain and improvement in function. They reported 87% satisfactory results and a complication rate of 13%, including 1 patient with a painless cosmetic deformity, 2 patients with loss of overhead function, and 1 patient with persistent pain.
  - Kelly et al[16] reported the results of 54 arthroscopic tenotomies at a mean of 2.7 years of follow-up, with 68% good to excellent results. However, 70% had a Popeye sign, and 38% of patients reported fatigue-related discomfort. They found minimal loss of elbow strength as assessed by biceps curls and 0% loss for individuals older than 60 years of age. Fatigue-related discomfort was not present in patients older than 60 years of age.
  - Walch et al[35] in 1998 reported the results of 307 arthroscopic tenotomies of the LHB in conjunction with cuff tear treatment. They found a statistically significant improvement in the mean Constant score from 48 to 68 points and reported 87% satisfactory results.
  - In summary, the results of arthroscopic tenotomy to date indicate that the procedure is an effective treatment for refractory biceps tendinopathy in appropriately selected patients, and may be more favorable for patients older than 50 to 60 years of age.

COMPLICATIONS

- The primary complications of tenodesis include persistent pain, failure of the tenodesis, and refractory tenosynovitis.
  - Failure of the tenodesis to heal may result in distal tendon retraction. In such cases, analogous to that experienced by patients with spontaneous biceps tendon rupture, symptoms usually resolve with time.
  - One study has suggested that the quality of remaining tendon available for tenodesis can significantly affect the success of the procedure.[6]
  - Nho et al[22] reported a 2% incidence of complications after 353 open subpectoral biceps tenodesis over a 3-year period.
    - Other authors have described complications of this technique to include nerve injury, attritional rupture at the bone–tendon interface, and fracture of the proximal humerus.
  - Recent evidence suggests that oral nonsteroidal anti-inflammatory medication may inhibit healing, so this may be a suboptimal postoperative analgesic option.
- The primary complications of tenotomy are as follows:
  - Cosmetic deformity in the form of a Popeye sign
  - Fatigue-related cramping
  - Potential slight decrease in elbow supination and flexion strength

Table 2 Outcomes of Arthroscopic Treatment of Biceps Tendinopathy

Author	No. of Cases	Technique	Outcome Measure	Outcome
Checchia et al, 2005[7]	15	Arthroscopic transtendon tenodesis	UCLA; mean 32-mo follow-up	93% good and excellent results
Elkousy et al, 2005[10]	12	Arthroscopic transtendon tenodesis	Subjective telephone interview; 6-mo follow-up	100% subjective assessment of benefit from procedure; 0% incidence of cramping or Popeye deformity
Kelly et al, 2005[16]	54	Arthroscopic tenotomy	American Shoulder and Elbow Surgeons (ASES) scale, UCLA, L'Insalata, cramping, Popeye, pain; mean 2.7-y follow-up	68% good to excellent results; 38% complained of fatigue discomfort after resisted elbow flexion; 70% Popeye sign
Walch et al, 2005[34]	307	Arthroscopic tenotomy	Constant score; mean 57-mo follow-up	87% satisfied or very satisfied; mean Constant score improvement from 48 preop to 68 postop
Boileau et al, 2001[6]	43	Arthroscopic interference screw tenodesis	Constant score; mean 17-mo follow-up	Mean Constant score improvement from 43 preop to 79 postop
Gill et al, 2001[12]	30	Arthroscopic tenotomy	ASES; mean 19-mo follow-up	Mean ASES score at follow-up was 82 points; 87% satisfactory results
Berlemann et al, 1995[4]	15	Open keyhole tenodesis	Subjective assessment; mean 7-y follow-up	64% good and excellent results, 29% fair results
Walch et al, 2005[34]	86	Open tenodesis	Subjective assessment	99% satisfied or very satisfied
Becker and Cofield 1989[3]	51	Open tenodesis	Subjective assessment; mean 7-y follow-up	About 48% had moderate to severe pain at mean 7-y follow-up.

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