

What the Radiologist Needs to Know About Biceps Tenodesis: Normal Postprocedure Imaging Appearance and Complications

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After participating in this educational activity, the diagnostic radiologist should be better able to explain the indications and techniques for long head biceps tenodesis and identify normal postprocedure imaging appearance and the potential complications.

Category: General Radiology
Subcategory: Musculoskeletal
Modality: Radiography, MRI

Key Words: Biceps Tenodesis, Imaging of Biceps Tenodesis, Postoperative Complications

Proximal long head biceps tendon (LHBT) pathology is a common and well-recognized cause of anterior shoulder pain.¹⁻⁴ Various surgical procedures have been developed to address LHBT pathology. Postoperative imaging can be confusing if the radiologist is not aware of the various surgical techniques. An astute radiologist may be the first to identify a postoperative complication. An understanding of the LHBT anatomy, surgical indications, surgical procedures, and both

normal and abnormal postoperative imaging appearance will enhance the radiologist's accuracy in imaging interpretation and interactions with referring providers.

LHBT Anatomy

The proximal LHBT extends from the supraglenoid tubercle of the scapula (biceps anchor) to the proximal myotendinous junction and measures 5 to 6 mm in diameter, and 90 mm in length.² Variant tendon origins have been reported including soft-tissue origin at the superior glenoid labrum.^{5,6} Distal to the origin, the LHBT has proximal intra-articular (glenohumeral) and extra-articular (bicipital groove) segments. The intra-articular segment is extrasynovial and courses superolaterally over the humeral head. The LHBT exits the glenohumeral joint at the proximal bicipital groove, an osseous notch between the humeral head greater and lesser tuberosities. Although the osseous bicipital groove serves to provide some stability to the extra-articular LHBT, much of the tendon stabilization is provided by the tendinoligamentous biceps pulley. This soft-tissue stabilizer receives contribution from the superior fibers of the subscapularis tendon, anterior fibers of the supraspinatus tendon, coracohumeral ligament, and superior glenohumeral ligament.^{2,5,6} Features contributing to LHBT injury and synovitis include distracting muscle contraction forces and pulley friction during shoulder motion, as the LHBT glide range at the pulley is up to 18 mm.²

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History of Long Head Biceps Tenodesis

In 1926, Gilcreest EL first described tenodesing a ruptured LHBT to the coracoid process.⁴ In the 1980s, orthopedic

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surgeons made the observation that patients often had shoulder pain relief after proximal LHBT rupture. This led to the development of long head biceps (LHB) tenotomy and tenodesis strategies to address LHBT pathology.⁴

Surgical Indications

LHBT pathologies include tendinitis, rupture, instability, pulley lesions, and superior labral anterior posterior (SLAP) lesions.² Conservative, nonoperative management strategies represent the first-line treatment for LHBT disorders.^{2,4,6}

In patients 60 years and older, symptoms resistant to conservative measures are often addressed with tenotomy, as recovery time is shorter when compared with tenodesis.⁷ Complete proximal LHBT rupture can be managed nonoperatively, as normal flexion power remains intact secondary to an intact short head biceps tendon. For these older patients, repair of LHBT rupture is only indicated to restore partial loss of supination strength or in cases of persistent myospasm.²

Surgical indications are expanded for patients younger than 60 years who fail conservative management. Indications include symptomatic 25% to 50% partial-thickness LHBT tear, instability, chronic atrophic changes, hypertrophy with inflammation, therapy-resistant tenosynovitis, and subpectoral biceps pain.^{4,6} Failed SLAP repair, type IV SLAP tear, and symptomatic type II SLAP tear in a patient older than 50 years are additional relative indications for surgical intervention.⁶

Surgical Techniques

LHBT surgical techniques continue to evolve and discussion of all techniques is

beyond the scope of this article. General surgical categories include tenotomy, suprapectoral tenodesis, and subpectoral tenodesis (Figure 1). Tenotomy and suprapectoral techniques are performed entirely during glenohumeral arthroscopy whereas subpectoral tenodesis requires arthroscopy and distal extra-articular skin incision at the pectoralis insertion. There are also a few historical techniques, not commonly used today, that may be encountered on imaging studies.

Surgical treatment of long head biceps tendon pathology includes tenotomy or tenodesis, suprapectoral or subpectoral.

Tenotomy

Biceps tenotomy is performed arthroscopically, with the LHBT being incised as close as possible to the glenoid labrum. After release, the tendon retracts distally into the bicipital groove. Recovery time is shorter than tenodesis procedures. Patients will usually have a "Popeye muscle deformity" and will lose a portion of supination power.⁶

Tenodesis

There are several tenodesis techniques differentiated by location and type of fixation. All of these techniques begin with an arthroscopic tenotomy, and are generally categorized as arthroscopic suprapectoral, open subpectoral, and soft-tissue tenodesis.

Suprapectoral Tenodesis

In suprapectoral tenodesis, the entire technique is performed arthroscopically. After the tenotomy, the LHBT stump is trimmed, tension is applied with an arthroscopic grasper, and the proximal tendon fixated to the

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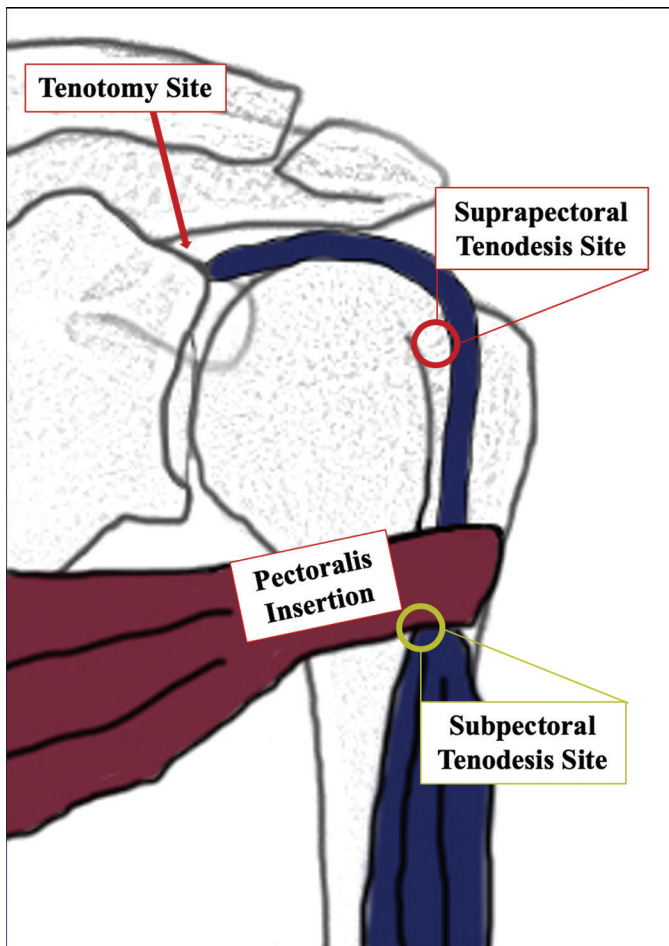


Figure 1. Anatomy overview. Schematic diagram shows the normal proximal long head of biceps tendon (LHBT) anatomy with the proximal surgical tenotomy site. The typical suprapectoral and subpectoral biceps tenodesis anchor sites are shown in respect to the pectoralis major tendon insertion.

superolateral humeral head or proximal bicipital groove with an interference screw or suture anchor.^{3,6} The presence of a normal suprapectoral interference screw can be difficult to identify on a radiograph (Figure 2a), but is more readily apparent on an MRI (Figure 2b). A suprapectoral soft-tissue tenodesis may also be performed with LHBT fixation to the pectoralis major tendon or rotator cuff.^{5,7}

Subpectoral Tenodesis

Although sometimes termed the “open” biceps tenodesis, this technique has both arthroscopic and open components. The procedure is initiated with an arthroscopic tenotomy, which is performed at the biceps anchor.^{3,4,6} A 3-cm longitudinal skin incision is then made 1 cm above to 2 cm below the inferior margin of the pectoralis tendon insertion. The intra-articular LHBT is mobilized, delivered distally through incision (Figure 3), and prepared for attachment with tensioning and length adjustment. The anterior humeral cortex is drilled, and the LHBT stump is attached to the proximal humerus by one of several possible fixation techniques.^{3,4,6} Currently, the most common methods of osseous fixation are cortical button and interference screw. Less prevalent or historical attachment methods are suture anchor, bone tunnel, and keyhole techniques.⁴ A subpectoral soft-tissue tenodesis

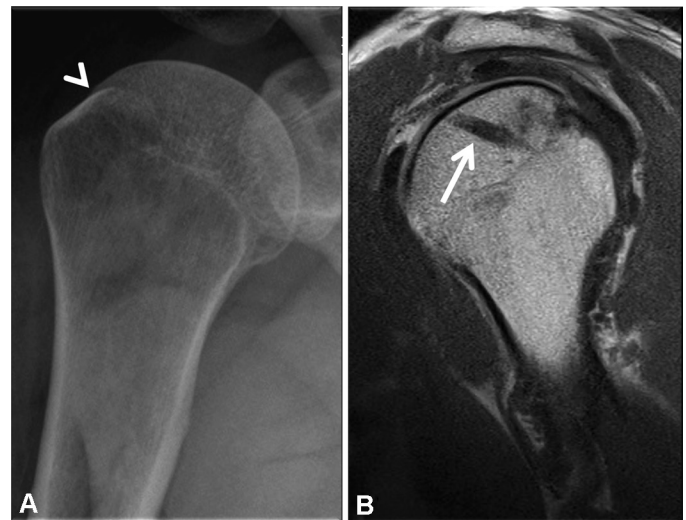


Figure 2. Suprapectoral tenodesis. A: AP shoulder radiograph shows a faint sclerotic track from a radiolucent suprapectoral interference screw insertion (arrowhead). B: Sagittal T1 MR image of the humeral head shows the normal hypointense appearance of the interference screw tract (arrow). In this case, the screw is proximal to the bicipital groove. Suprapectoral anchors also can be placed within the bicipital groove.

may also be performed in the form of a tendon transfer.^{5,7} It is important for the radiologist to be familiar with the varied appearance of these techniques, so as not to mistake a lucent tenodesis anchor site for a humeral bone lesion.

Interference Screw

The interference screw technique is performed with a single anterior humeral cortical hole. A suture attached to the LHBT is loaded through the 8-mm interference screw and drill, and the screw is drilled into the anterior humerus until it is flush with the cortex. The suture ends are then tied at the proximal screw surface.⁴ It is important for the radiologist to realize that these radiolucent interference screws are often not visualized radiographically. Instead, radiographs will show a tubular, radiolucent track extending through the cortex and into the medullary space (Figure 4a). Periosteal reaction may be seen on the surface of the humeral cortex.

Cortical Button

Two variations of this technique may be encountered: unicortical and bicortical button techniques. Unicortical button is more commonly performed today. The LHBT is prepared in the standard open subpectoral tenodesis fashion. An anterior humeral unicortical hole (typically 3.2 mm diameter) is then drilled. The LHBT stump is attached to a proprietary thin button device (often metallic) with suture and passed horizontally through the humeral hole. Once inside the cortex, the button is flipped vertically to lock into place. Imaging will show the metallic button in the intramedullary space (Figure 4b). The sutures are then tightened to achieve appropriate tensioning.⁴

The bicortical button technique is performed less commonly today, as some authors report increased humeral fracture rates and injuries to nerves during posterior cortical drilling.¹ The procedure is the same as the unicortical

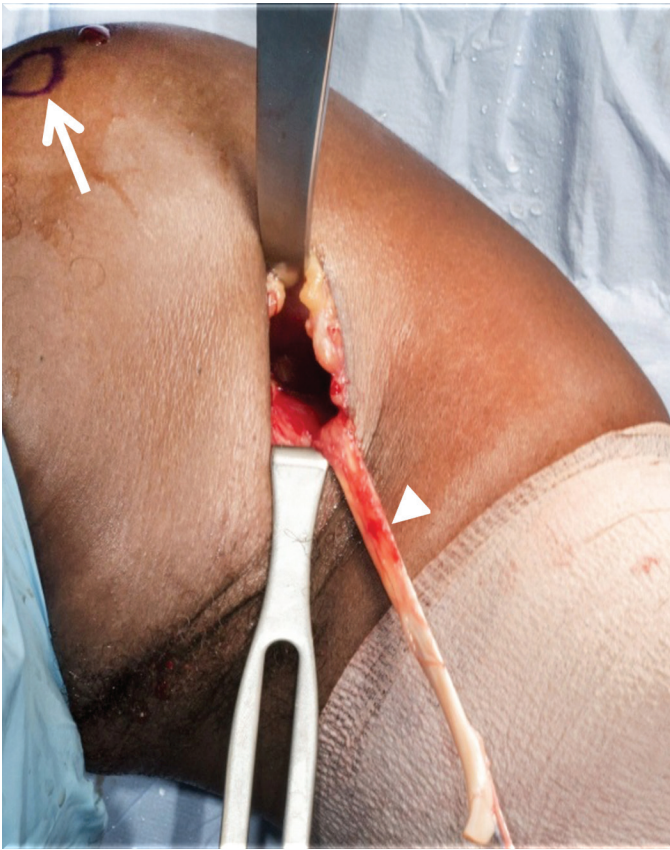


Figure 3. Subpectoral tenodesis. Intraoperative photograph of a subpectoral LHB tenodesis shows a retracted anterior incision in the region of the pectoralis tendon insertion. After arthroscopic LHB tenotomy, the LHB (*arrowhead*) has been pulled distally and delivered through the surgical incision. Also shown are markings for the more proximal shoulder arthroscopy portals (*arrow*).

technique except drilling extends from the anterior humeral cortex through intramedullary space and posterior cortex. The metallic button is passed entirely through the humerus and locks outside the posterior cortex.⁴

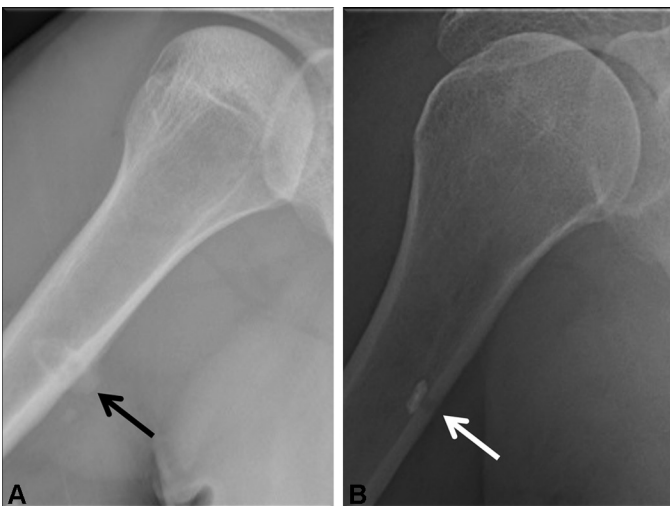


Figure 4. Subpectoral tenodesis. *A:* AP shoulder radiograph shows a faint lucent track from a radiolucent subpectoral interference screw insertion (*arrow*). To the untrained eye, this may be mistaken for a bone lesion with periosteal reaction. *B:* AP shoulder radiograph shows a metallic subpectoral unicortical endobutton anchor (*arrow*). Note the normal position of the endobutton within the intramedullary space next to the anterior cortex.

Other Tenodesis Techniques

Additional subpectoral techniques were performed in the past but are less commonly practiced today. All are alternate methods in LHBST stump attachment to the anterior humeral cortex. The bone tunnel technique involves drilling multiple holes in the anterior cortex with variations in inserting the tendon stump into bone and securing with suture.⁴ The suture anchor technique is similar with multiple drilled holes, but the tendon stump is left outside the humerus and anchored with sutures entering the cortical holes.⁴ In the keyhole technique, a “cortical keyhole” with round hole and distal slit is drilled into the anterior humerus cortex. The LHBST stump is sutured into a ball and passed through the hole and anchors in the cortical slit.⁴

Procedural Complications

Tenotomy, suprapectoral tenodesis, and subpectoral tenodesis are safe and effective procedures, decreasing pain and improving function. Patient satisfaction rates are as high as 95%.⁵ Despite their effectiveness, all these procedures have known complications.

Biceps tenotomy complications include cosmetic deformity (“Popeye deformity”) in 27% to 70%, biceps muscle fatigue discomfort in 38%, and elbow flexion and supination strength deficits.^{2,5,6} These findings are more often reported in young and active populations, and are seldom reported in patients older than 60 years.^{2,5,6}

Tenodesis is the preferred surgical technique in the young and active population. From a physiologic perspective, tenodesis preserves the LHBST length-tension relationship.⁵ There is continued research and debate as to the comparative efficacy of suprapectoral and subpectoral tenodesis techniques, both of which have good outcomes in 98% of cases.⁸ Although all of the LHBST tenodesis techniques are relatively safe, they are not without complication (Table 1).

Given that most tenodesis techniques require humeral cortical drilling, and most require subsequent reaming, there is a risk of unintended bicortical drilling. This may produce a double-ring sign on radiographs with partially overlapping

Table 1. Biceps Tenodesis Complications

Clinical limitation	Inadequate biceps tension
	Surgical site pain
	Complex regional pain syndrome
Structure failure	Humeral anchor dislodgement or failure
	Humerus fracture
	Biceps tendon tear
Iatrogenic injury	Brachial plexus injury
	Suprascapular nerve injury
	Musculocutaneous nerve injury
	Radial nerve injury
	Median nerve injury
	Axillary nerve injury
Pseudotumor	Unintended drilling in the glenohumeral joint
	Heterotopic ossification
	Infection/abscess
	Seroma
	Hematoma

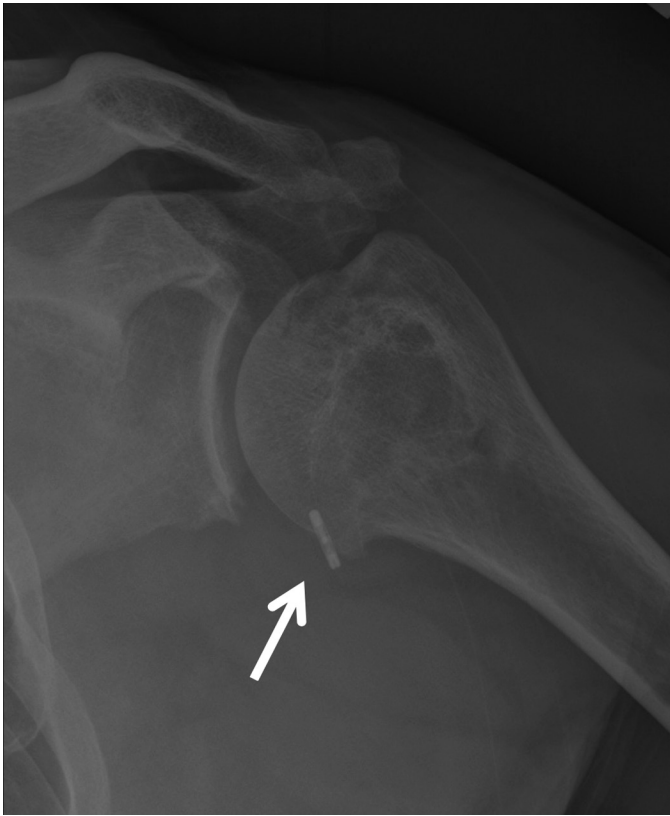


Figure 5. Unintentional intra-articular endobutton anchor placement in a suprapectoral tenodesis with bicortical endobutton technique. This AP shoulder radiograph shows a metallic bicortical tenodesis anchor (*arrow*) misplaced into the articular surface of the humeral head (*arrow*), placing the patient at risk for accelerated arthritis. Note osteophyte formation in the inferior glenoid and inferior aspect of the humeral head.

anterior and posterior cortical holes. The proximal bicipital groove is the intended anchor site for suprapectoral arthroscopic techniques. However, it can be challenging to identify

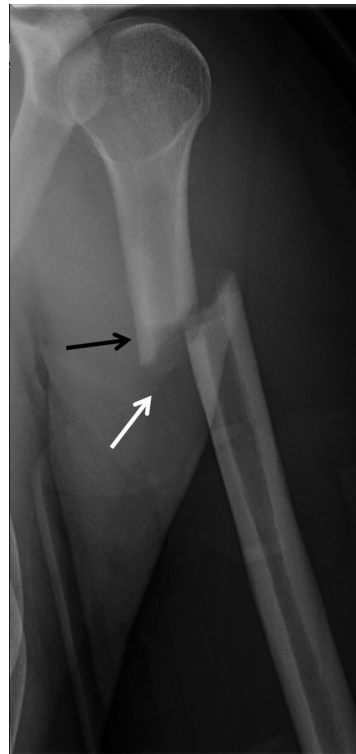


Figure 6. Tenodesis site fracture. AP shoulder radiograph obtained 7 months after subpectoral tenodesis shows a displaced proximal humerus diaphysis fracture (*white arrow*) at the margin of a subpectoral radiolucent interference screw (*black arrow*).

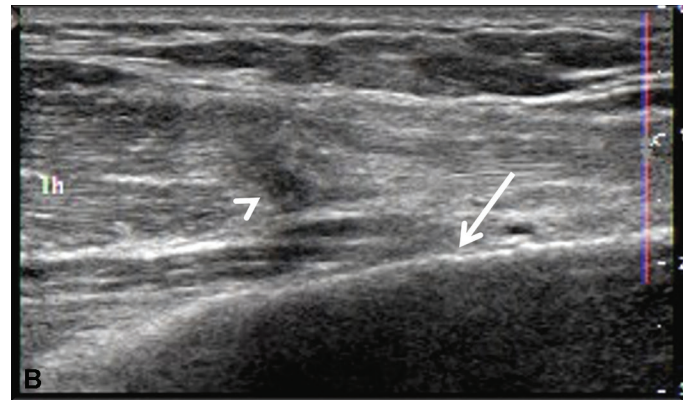
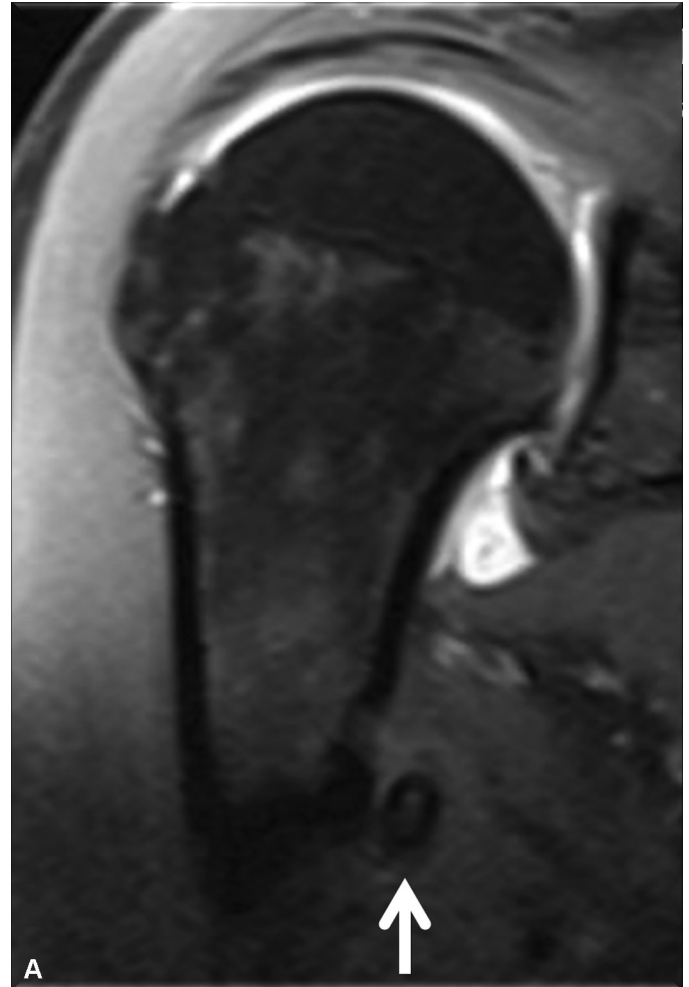


Figure 7. Dislodged interference screw. *A:* Coronal, T1, fat-suppressed MR arthrogram image obtained 6 months after subpectoral tenodesis shows a hypointense dislodged tenodesis interference screw (*arrow*) outside the anterior humeral cortex. *B:* Grayscale longitudinal ultrasound image shows the humeral diaphysis cortex (*arrow*) and a hypoechoic structure (*white arrow-head*) with posterior acoustic shadowing in the adjacent soft tissues representing the dislodged interference screw.

landmarks arthroscopically, and this may lead to anchoring in an unintended location, such the glenohumeral articular cartilage (Figure 5).³

Humeral fractures are a rare complication of the open subpectoral biceps tenodesis technique (Figure 6). Fractures may occur secondary to eccentric malpositioned drill holes, unintended bicortical drilling or development of a stress riser in techniques with larger cortical tunnels.^{4,7} Lateral eccentric

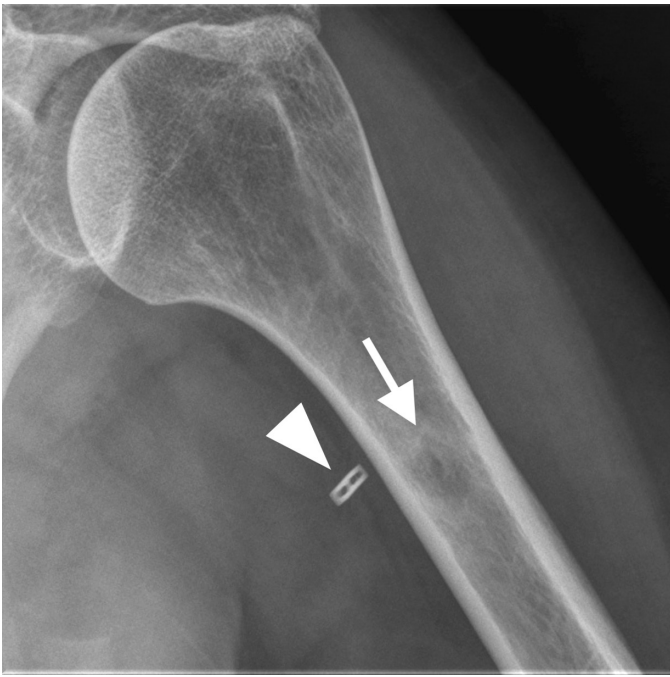


Figure 8. Dislodged endobutton. AP shoulder radiograph obtained after a shoulder injury, 17 months after subpectoral tenodesis (arrow), shows a subpectoral metallic endobutton (arrowhead), originally placed with unicortical technique, located outside its expected intramedullary position.

bone tunnel placement greater than or equal to 30% of the humeral width on an AP radiograph can result in up to 25% humeral strength reduction.³

Possible complications in all techniques include failed fixation, nerve or vascular injuries, complex regional pain syndrome, seroma, hematoma, heterotopic ossification, and infection.⁷ Failed fixation can occur at the implant-bone or implant-tendon interface.⁷ A dislodged radiolucent interference screw would be difficult to see directly on radiographs, but secondary signs such as heterotopic calcification may be visible. Screw dislodgement can be seen directly on MRI (Figure 7a) or ultrasound (Figure 7b). Metallic cortical endobutton dislodgement (unicortical or bicortical) can be identified radiographically (Figure 8), especially if the

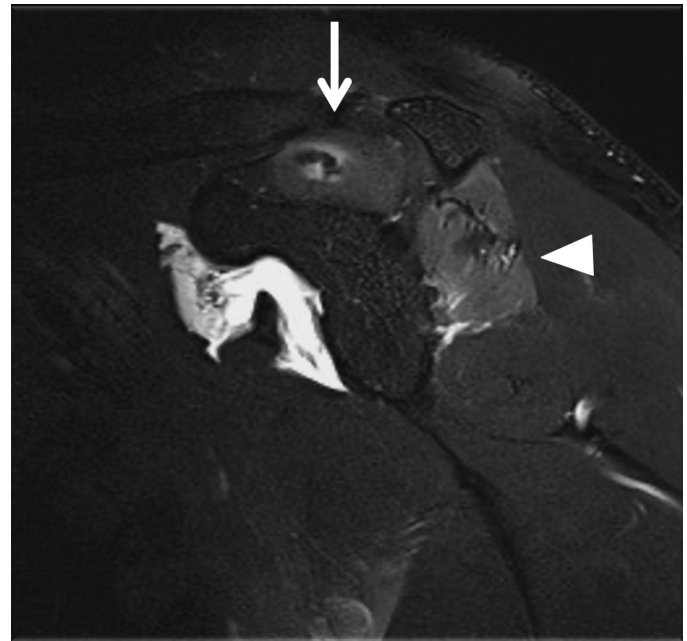


Figure 10. Suprascapular nerve injury. Sagittal, T2, fat-suppressed MR arthrogram obtained 4 weeks after subpectoral LHB tenodesis shows diffuse hyperintense signal within the supraspinatus (arrow) and infraspinatus (arrowhead) muscles, consistent with acute neurogenic myopathy secondary to suprascapular nerve injury. The muscles had normal signal on T1 sequences (not shown). There is no paralabral cyst in the suprascapular notch (not shown).

radiologist knows the surgical technique and has comparative imaging from the immediate postoperative period. Knowing radiographic appearance of the common tenodesis anchors will also aid the radiologist in interpreting postoperative imaging (Figure 9).

The most common complications of biceps tenodesis are structural failure at the tenodesis site, iatrogenic injury of different nerves around the shoulder joint, and pseudotumors.

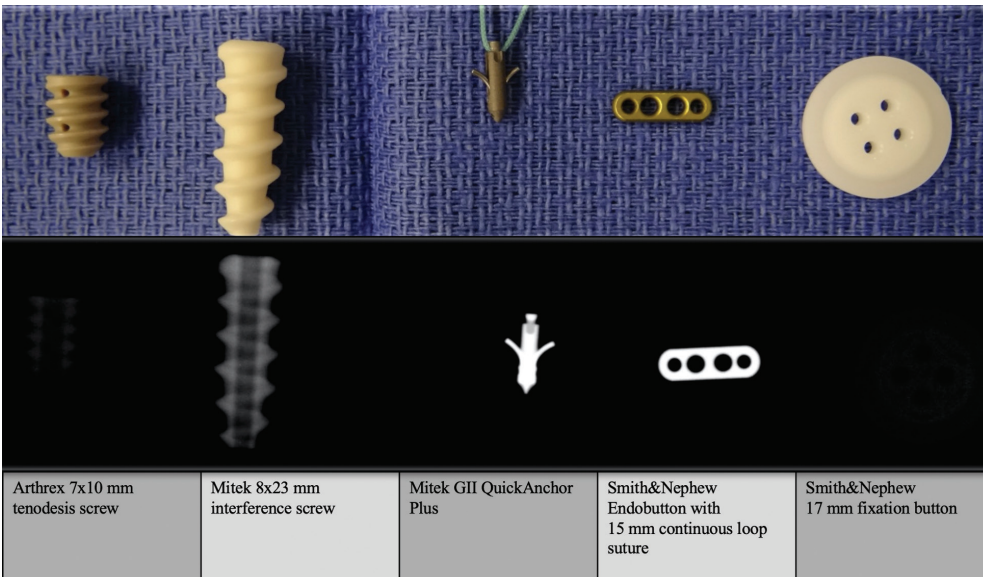


Figure 9. Visual and radiographic appearance of common tenodesis anchors.

Imaging can evaluate for other complications such as postoperative seroma, hematoma, abscess, and osteomyelitis. Infection is a rare tenodesis complication, with rates reported at 0.28%.⁷ When postsurgical masses are encountered, it is important to do an appropriate imaging work-up so pseudotumors are not mistaken for malignancy.

Neurovascular injuries are rare, but are slightly more common in the subpectoral techniques.⁷ The musculocutaneous nerve, radial nerve, and deep brachial artery are at risk for injury given their close proximity to intraoperative retractor placement in open subpectoral tenodesis. The musculocutaneous nerve is most commonly injured by retractors.¹ Injuries to the brachial plexus, most commonly the median and suprascapular (Figure 10) nerves, are also reported complications.⁷ The axillary nerve is adjacent to the posterior humeral cortex and may be injured during suprapectoral bicortical drilling.³

Conclusion

LHBT tenodesis is a commonly performed surgical procedure to address LHBT pain and other pathologies.

Recognizing postoperative complications on imaging requires understanding the presurgical anatomy and normal postprocedure appearance of the various tenodesis surgical techniques. An astute radiologist can raise concern for tenodesis complications and effectively direct imaging work-up.

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Erratum

Acute Ischemic Stroke: An Imaging Update

In the article that appeared on page 1 of the July 31, 2019, issue of *Contemporary Diagnostic Radiology*, there was an error in the following statement: “Ischemic perfusion core volume is the volume on a CT perfusion study with a cerebral blood volume less than 30%.”

The corrected statement follows: “Ischemic perfusion core volume is the volume on a CT perfusion study with a cerebral blood flow less than 30%.”

Reference:

Rigsbee C, Vidovish J, Wang DT, Vagal A. Acute ischemic stroke: An imaging update. *Contemporary Diagnostic Radiology.* 2019; 42(16):1-6.

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- Figure 11 is a T1, fat-saturated, gadolinium-enhanced, post-contrast MR image in a 42-year-old man 1 month after an interference screw subpectoral LHB tenodesis. Which one of the following is the *most* likely postoperative complication depicted by the *arrowhead*?
 - Abscess
 - Dislodged tenodesis screw
 - Heterotopic ossification
 - Radial nerve injury
 - Inadequate biceps tension

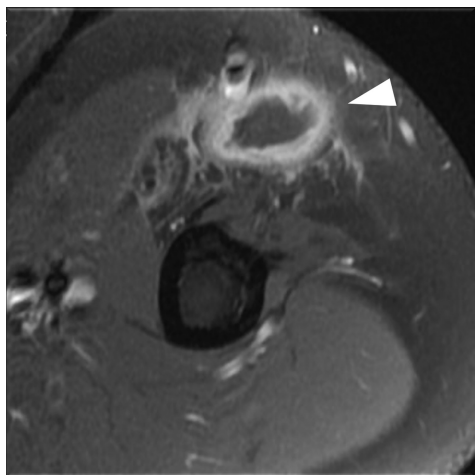


Figure 11.

- The LHB originates from which one of the following osseous structures?
 - Greater tuberosity of the humerus
 - Lesser tuberosity of the humerus
 - Infraglenoid tubercle of the scapula
 - Supraglenoid tubercle of the scapula
 - There is no osseous origin
- All of the following structures are part of the biceps pulley, *except*
 - subscapularis tendon fibers
 - supraspinatus tendon fibers
 - middle glenohumeral ligament
 - coracohumeral ligament
 - superior glenohumeral ligament
- Which one of the following is first-line treatment for proximal LHB pathology?
 - Tenotomy
 - Diagnostic arthroscopy
 - Subpectoral tenodesis
 - Soft-tissue tenodesis
 - Conservative (nonoperative) management
- Which surgical intervention for LHBT pathology would be most common for a 65-year-old patient?
 - Tenotomy
 - Soft-tissue tenodesis
 - Arthroscopic suprapectoral tenodesis
 - Subpectoral tenodesis with interference screws
 - Subpectoral tenodesis with unicortical endobutton
- Which one of the following techniques is performed entirely arthroscopically?
 - Subpectoral tenodesis with interference screw
 - Suprapectoral tenodesis with interference screw
 - Subpectoral tenodesis with unicortical endobutton
 - Subpectoral tenodesis with bicortical endobutton
 - Subpectoral tenodesis with keyhole technique
- All of the following are common tenotomy complications, *except*
 - pronation strength deficit
 - fatigue discomfort
 - elbow flexion strength deficit
 - Popeye deformity
 - supination strength deficit
- Upon reviewing the immediate postoperative radiographs of a 46-year-old woman who underwent a subpectoral interference screw tenodesis, two, equal-sized, partially overlapping holes are visualized within the proximal humeral diaphysis. Which one of the following is the *most* likely explanation?
 - Normal interference screw appearance
 - Acute hardware loosening
 - Osteomyelitis
 - Posterior interference screw migration
 - Unintentional bicortical drilling
- Which one of the following would result in increased risk of postoperative humeral fracture?
 - Tunnel placement within the humeral head
 - Use of bicortical endobutton technique
 - Eccentric tunnel placement
 - Using an undersized interference screw
 - Intra-articular endobutton placement
- All of the following are described as neurovascular complications of suprapectoral or subpectoral LHB tenodesis, *except*
 - musculocutaneous nerve injury
 - deep brachial artery injury
 - radial nerve injury
 - posterior circumflex humeral artery injury
 - axillary nerve injury