What the radiologist needs to know about biceps tenodesis: Normal post-procedure imaging appearance and complications

Name: David J. Oettel
Position: Musculoskeletal Radiology Fellow, San Antonio Uniformed Services Health Education Consortium
Adjunct Assistant Professor, Department of Radiology, Uniformed Services University of Health Sciences
Telephone: 210-292-5290
Fax: (210) 292-4964
Email: oetdav@gmail.com
Address: 1100 Wilford Hall Loop, BLDG 4554, JBSA Lackland AFB, TX 78236

Name: Nathan D. Cecava
Position: Program Director, Musculoskeletal Radiology Fellowship, San Antonio Uniformed Services Health Education Consortium
Adjunct Assistant Professor, Department of Radiology, Uniformed Services University of Health Sciences
Adjunct Assistant Professor, Department of Radiology, Texas A&M School of Medicine
Telephone: (210) 292-3859
Fax: (210) 292-4964
Email: natececava@gmail.com
Address: 1100 Wilford Hall Loop, BLDG 4554, JBSA Lackland AFB, TX 78236

Corresponding Author
Name: Liem T. Bui-Mansfield
Position: Adjunct Professor, Department of Radiology, Uniformed Services University of Health Sciences
Telephone: (210) 710-2087
Fax: (509) 248-0178
Email: liem.mansfield@gmail.com
Address: 5200 West Nob Hill, APT#145, Yakima, WA 98908

CONFLICT OF INTEREST: The authors declare that they have no conflict of interest.

What the radiologist needs to know about biceps tenodesis: Normal post-procedure imaging appearance and complications

David J. Oettel, Nathan D. Cecava, Liem T. Bui-Mansfield

After participating in this activity, the diagnostic radiologist will comprehend the indications and techniques for long head biceps tenodesis, normal post-procedure imaging appearances, and the potential post-procedural complications.

Introduction

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. Post-operative 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 post-operative complication. An understanding of the LHBT anatomy, surgical indications, surgical procedures, and both normal and abnormal post-operative 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 5-6 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 extra-synovial, 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. While 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 as well as pulley friction during shoulder motion as the LHBT glide range at the pulley is up to 18 mm.[2]

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 surgeons made the observation that patients often had shoulder pain relief following 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, non-operative 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 to tenodesis.[7] Complete proximal LHBT rupture can be managed non-operatively as normal flexion power remains intact secondary to an intact short head biceps. 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 less than 60 years old who fail conservative management. Indications include LHBT symptomatic 25-50% partial-thickness 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 an older patient (>50 years) are additional relative indications for surgical intervention.[6]

Surgical Techniques

LHBT surgical techniques continue to evolve and discussion of all techniques are 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 while subpectoral tenodesis requires arthroscopy and distal extra-articular skin incision at the pectoralis insertion. There are also a few historical techniques, not commonly utilized today, that may be encountered on imaging studies.

Tenotomy

Biceps tenotomy is performed arthroscopically with the LHBT being incised as close as possible to the glenoid labrum. Following 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 different tenodesis techniques which are 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. Following the tenotomy, the LHBT stump is trimmed, tension is applied with an arthroscopic grasper, and the proximal tendon fixated to the superolateral humeral head or proximal bicipital groove (Figure 2) with an interference screw or suture anchor.[3,6] 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 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 (Figure 4b). 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 flips 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 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]

Other Tenodesis Techniques

There are additional subpectoral techniques performed in the past, but less commonly practiced today. All are alternate methods in LHBT stump attachment to the anterior humeral cortex. 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] 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 keyhole technique, a "cortical keyhole" with round hole and distal slit is drilled into the anterior humerus cortex. The LHBT 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 27-70%, 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 over 60 years of age.[2,5,6]

Tenodesis is the preferred surgical technique in the young and active population. From a physiologic perspective, tenodesis preserves the LHBT 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] While all of the LHBT 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 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 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 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 or ultrasound (Figure 7). Metallic cortical endobutton dislodgement (unicortical or bicortical) can be identified radiographically (Figure 8), especially if the radiologist knows the surgical technique and has comparative imaging from the immediate post-operative period. Having a familiarity with the radiographic appearance of the common tenodesis anchors will also aid the radiologist in interpreting post-operative imaging (Figure 9).

Imaging can evaluate for other complications such as postoperative seroma, hematoma, abscess, and osteomyelitis bone remodeling. Infection is a rare tenodesis complication with rates reported at 0.28%.[7] When post-surgical 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 to injury given their close proximity to intraoperative retractor placement in open subpectoral tenodesis. The musculocutaneous nerve is most commonly injured by retractors.[1] Brachial plexus, median, and suprascapular (Figure 10) nerve injuries 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 post-operative complications on imaging requires understanding the pre-surgical anatomy and normal post-procedure appearance of the various tenodesis surgical techniques. An astute radiologist can raise concern for tenodesis complications and effectively direct imaging work-up.

References:

1. Dickens JF, Kilcoyne KG, Tintle SM, Giuliani J, Schaefer RA, Rue JP. Subpectoral biceps tenodesis: an anatomic study and evaluation of at-risk structures. Am J Sports Med, 2012; 40:2337–41.

2. Elser F, Braun S, Dewing CB, Giphart JE, Millett PJ. Anatomy, function, injuries, and treatment of the long head of the biceps brachii tendon. Arthroscopy, 2011; 27:581–92.

3. Hodgins JL, Kovacevic D, Purcell S, Jobin CM, Levine WN, Ahmad CS. Arthroscopic suprapectoral and open subpectoral biceps tenodesis: radiographic characteristics. Arthroscopy, 2016; 32:2234–42.

4. Voss A, Cerciello S, Yang J, Beitzel K, Cote MP, Mazzocca AD. Open subpectoral tenodesis of the proximal biceps. Clin Sports Med, 2016; 35:137–52.

5. Hassan S, Patel V. Biceps tenodesis versus biceps tenotomy for biceps tendinitis without rotator cuff tears. J Clin Orthop Trauma, 2019; 10:248–56.

6. Nho SJ, Strauss EJ, Lenart BA, Provencher MT, Mazzocca AD, Verma NN, Romeo AA. Long head of the biceps tendinopathy: diagnosis and management. J Am Acad Orthop Surg, 2010; 18:645–56.

7. Virk MS, Nicholson GP. Complications of proximal biceps tenotomy and tenodesis. Clin Sports Med, 2016; 35:181–8.

8. Abraham VT, Tan BH, Kumar VP. Systematic review of biceps tenodesis: arthroscopic versus open. Arthroscopy, 2016; 32:365–71.

Figure Legend

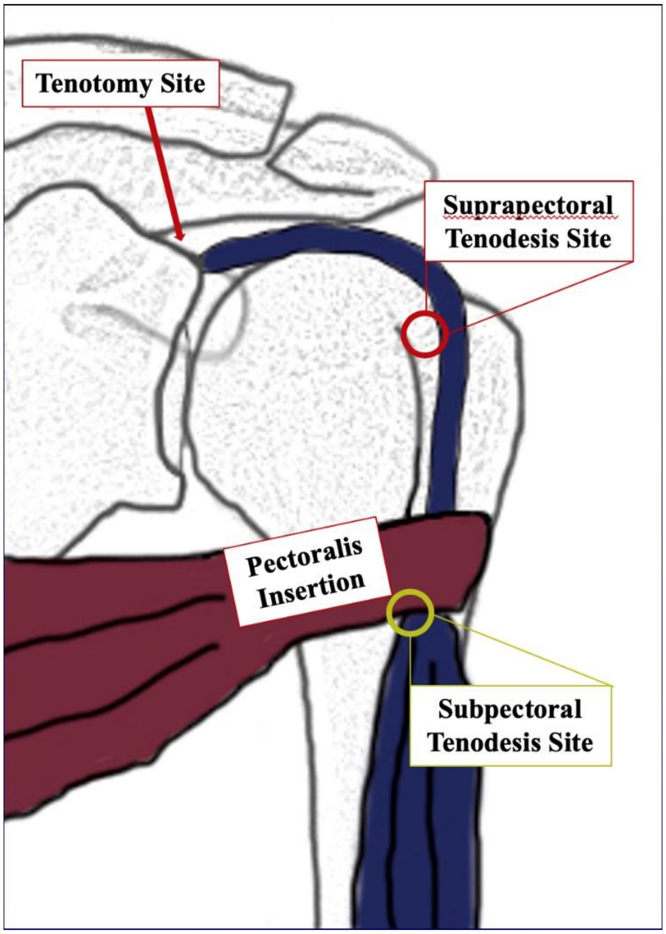

Figure 1. Anatomy overview. Schematic diagram shows the normal proximal long head of biceps tendon (LHBT) anatomy with the proximal surgical tenotomy site. The typical suprapectoral and subpectoral biceps tenodesis anchor sites are shown in respect to the pectoralis major tendon insertion.

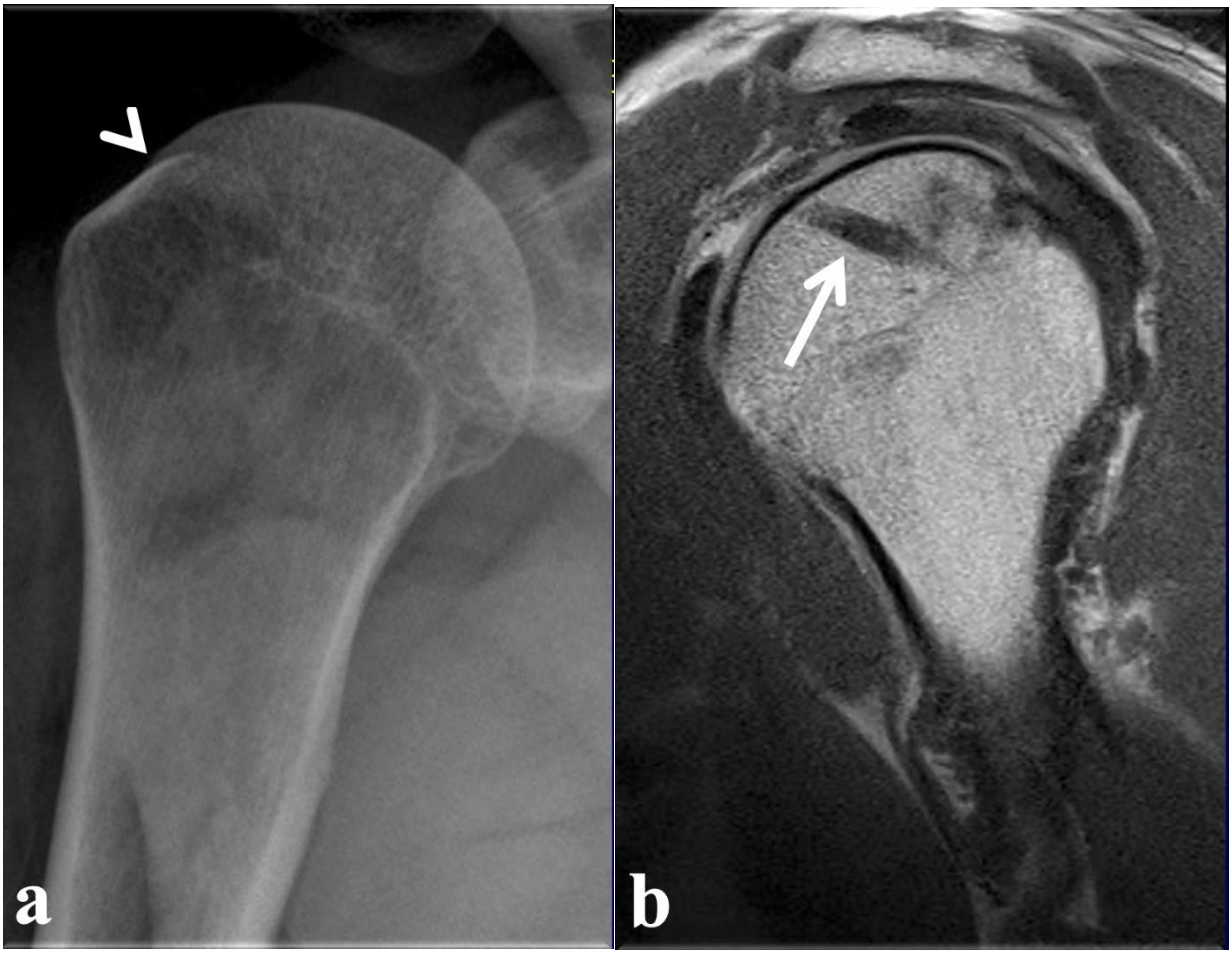

Figure 2. Suprapectoral tenodesis.

(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 can also be placed within the bicipital groove.

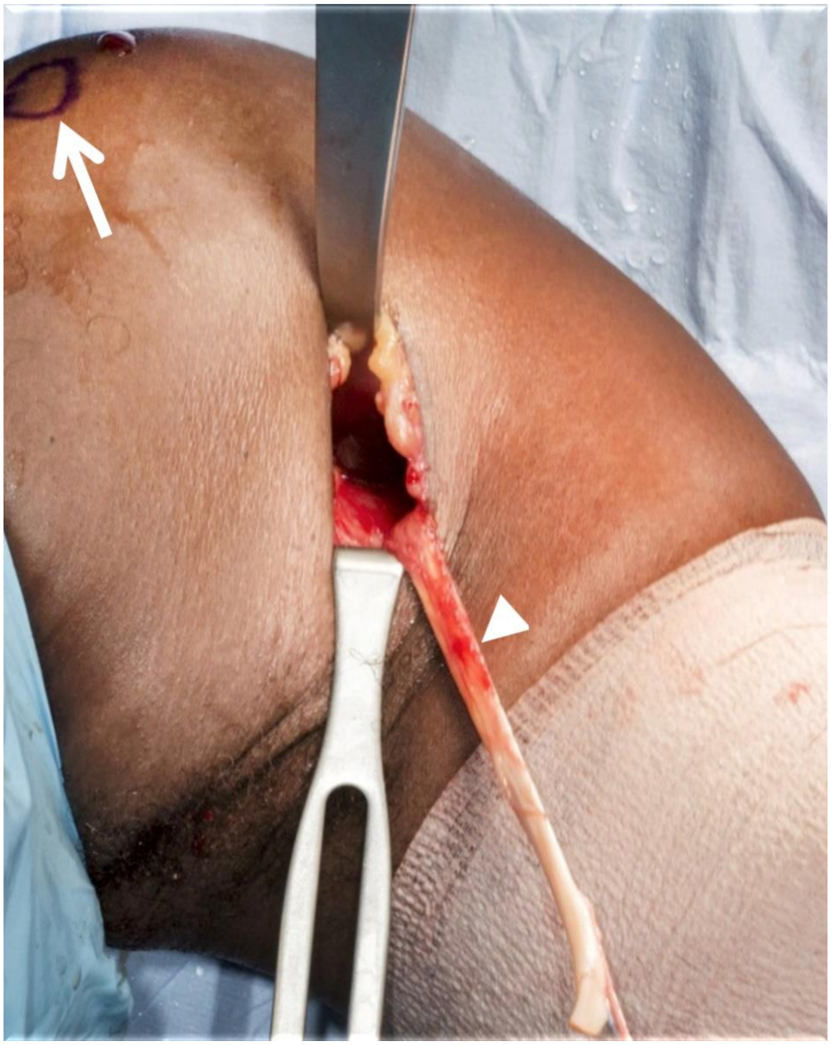

Figure 3. Subpectoral tenodesis. Intraoperative photo of a subpectoral LHB tenodesis showing a retracted anterior incision in the region of the pectoralis tendon insertion. After arthroscopic LHB tenotomy, the LHBT (arrowhead) has been pulled distally and delivered through the surgical incision. Also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

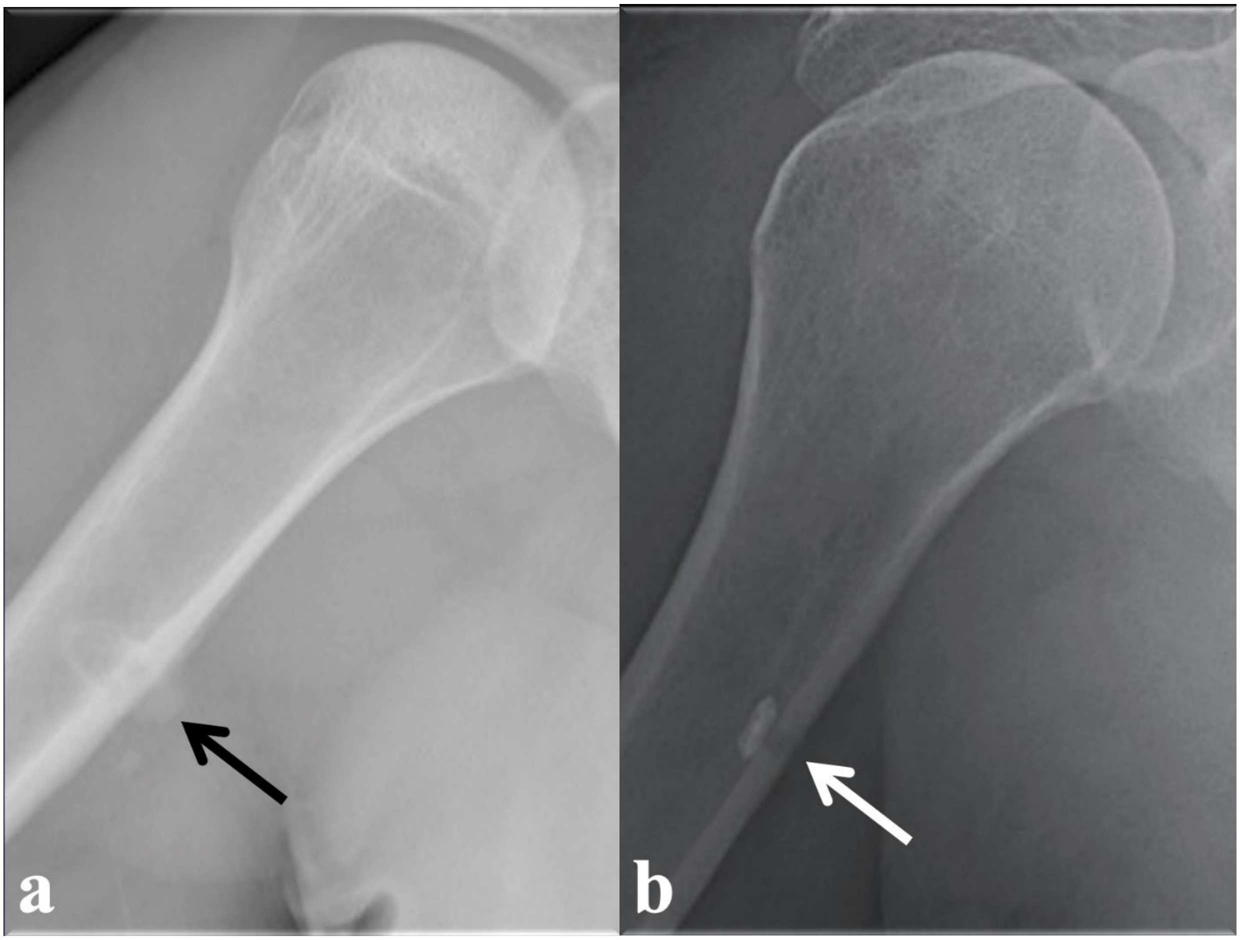

Figure 4. Subpectoral tenodesis.

(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.

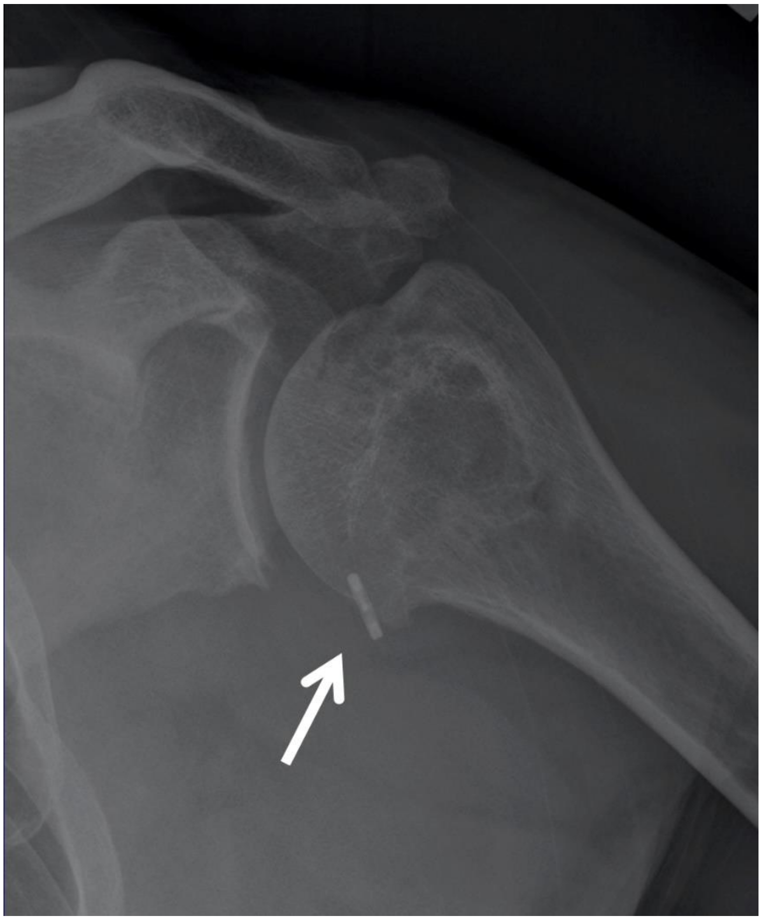

Figure 5. Unintentional intra-articular endobutton anchor placement in a suprapectoral tenodesis with bicortical endobutton technique. AP shoulder radiograph shows a metallic bicortical tenodesis anchor (arrow) misplaced into the articular surface of the humeral head (arrow) placing the patient at risk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

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 inference screw (black arrow).

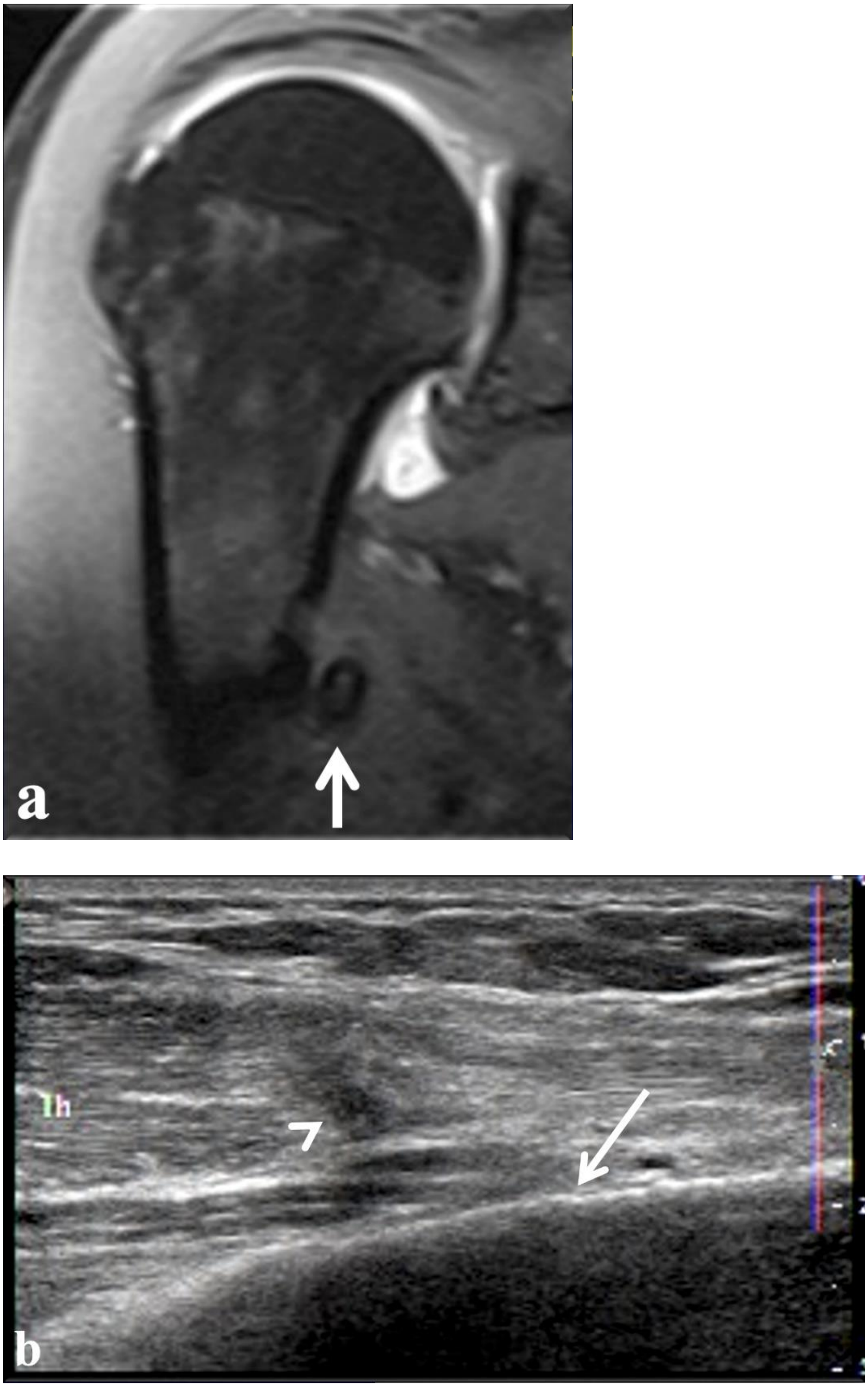

Figure 7. Dislodged interference screw.

(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 arrowhead) with posterior acoustic shadowing in the adjacent soft tissues representing the dislodged interference screw.

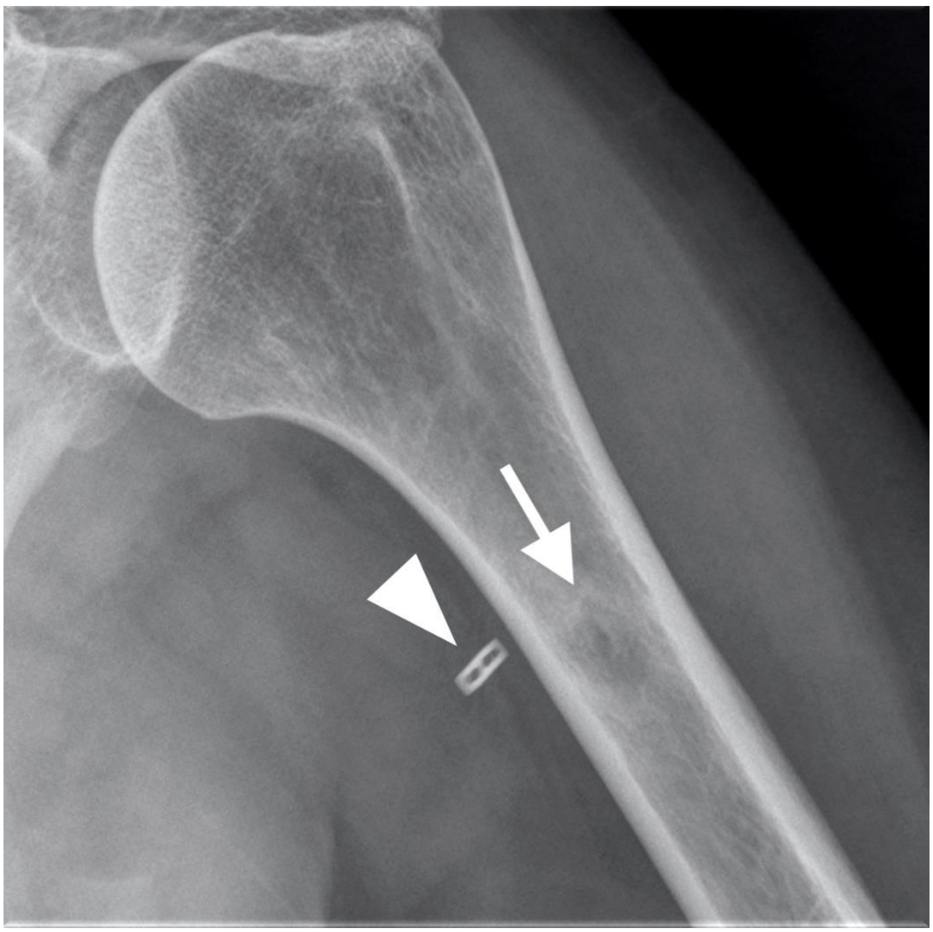

Figure 8. Dislodged endobutton. AP shoulder radiograph obtained after a shoulder injury, 17 months following subpectoral tenodesis (arrow), shows a subpectoral metallic endobutton (arrowhead) originally placed with unicortical technique located outside its expected intramedullary position.

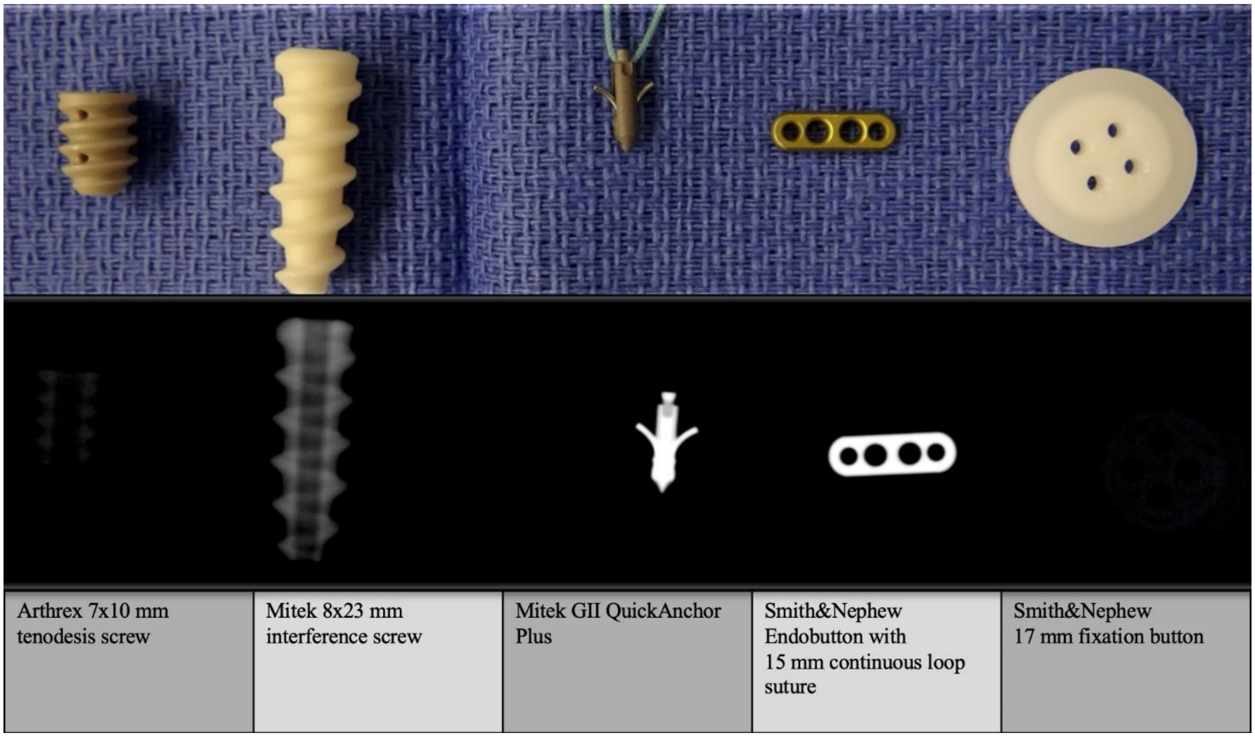

Figure 9. Visual and radiographic appearance of common tenodesis anchors.

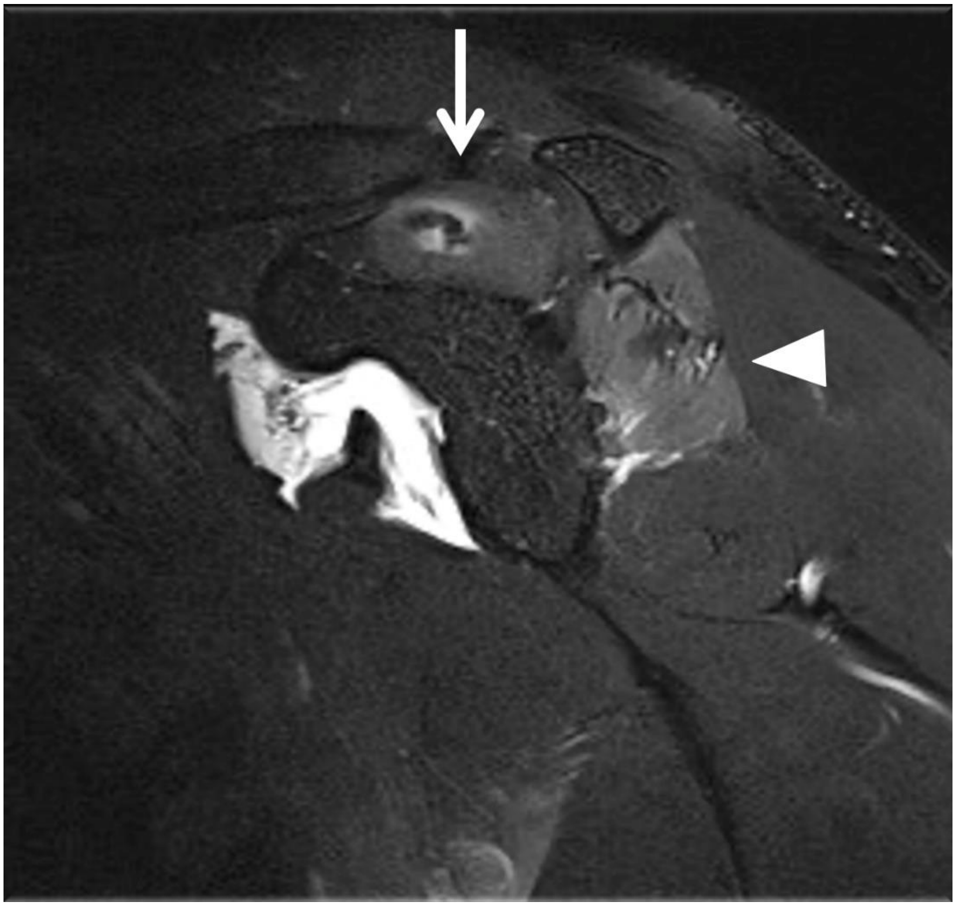

Figure 10. Suprascapular nerve Injury. Sagittal T2 fat-suppressed MR arthrogram image 4 weeks after subpectoral LHB tenodesis shows diffuse hyperintense signal within the supraspinatus (arrow) and infraspinatus (arrowhead) muscles, consistent with acute neurogenic myopathy secondary to suprascapular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

Clinical Limitation	Inadequate biceps tension Surgical site pain Complex region pain syndrome
Structural 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 Drilling into the glenohumeral joint
Pseudotumor	Heterotopic ossification Infection/abscess Seroma Hematoma

Table 1. Biceps tenodesis complications.