Biceps Tendon

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Abbreviations

CSI	Ccorticosteroid injection
ESWT	Extracorporeal shock wave therapy
FABS	Flexed Aabducted Ssupinated
NSAID	Nnon-steroidal anti-inflammatory drug
SLAP	Superior Llabrum Aanterior and Pposterior

Introduction

Tendinopathy of the long head of the biceps is one of the leading causes of shoulder pain [1]. While epidemiologic studies vary, one systematic review reported that the incidence of biceps tendinopathy in the painful shoulder ranges anywhere from 22% to 78% [2]. Proximal tendinopathy is more likely to occur in the elderly or in highly active individuals, especially overhead athletes or those whose occupation requires rigorous manual activity [1, 3]. Distal tendinopathy is rare, representing only 3% of all biceps injuries and occurring in 1.2 of 100,000 people per year [4, 5]. Distal injuries are most commonly complete ruptures and can be seen in bodybuilders, weightlifters, and football players [3]. Males account for 80% of distal ruptures, typically involving the dominant arm [6]. The incidence of distal biceps tendinosis is thought to be even less common than ruptures, but these are likely underdiagnosed [7]. There have been only a few reported cases of proximal short head ruptures [6].

While not linked specifically to the biceps tendon, both intrinsic and extrinsic factors have been implicated in tendinopathy. Intrinsic factors within the tendon can result in degeneration and chronic tendinosis structural changes, including excessive overload from eccentric contraction, age, smoking, and comorbid conditions such as inflammatory arthropathy, obesity, and diabetes mellitus [5]. Medications contributing to tendon degeneration include anabolic and oral steroids, statins, and flouroquinolones [8, 9]. Extrinsic factors include physical forces on the tendon and the surrounding environment. The close proximity of the proximal long head within the rotator interval and other glenohumeral structures inevitably results in biceps tendon lesions being closely connected with other shoulder pathology.

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Anatomy

The long head of the biceps tendon originates within the glenohumeral joint at the supraglenoid tubercle and superior glenoid labrum. It then passes anteriorly and laterally over the humeral head into the rotator interval, which is a triangular space defined superiorly by the anterior border of the supraspinatus, inferiorly by the superior border of the subscapularis, and with the coracoid process acting as the base [10] (See Fig. 4.1). Within this interval, fibers from the coracohumeral ligament and superior glenohumeral ligament form the biceps pulley, which is a sling-like band of tissue that surrounds and stabilizes the long head of the biceps as it enters the bicipital groove [11]. Within this groove, the long head travels between the greater and lesser tuberosities and then exits the joint deep to the transverse humeral ligament. The long head of the biceps tendon is surrounded by a reflection of synovial sheath that is continuous with the glenohumeral joint. The short head of the biceps tendon, which originates medial to the long head at the coracoid process, joins with the coracobrachialis to form the conjoint tendon [5]. The conjoint tendon then merges with the long head of the biceps at the level of the deltoid insertion to form the common muscle belly of the biceps brachii [4].

The distal biceps tendon is a flat extra-synovial structure. The tendon crosses the antecubital fossa, rotating 90° externally, to insert on the posterior ulnar aspect of the radial tuberosity (see Fig. 4.2). This twisting fiber arrangement allows the biceps to act as the most powerful forearm supinator. There is a bifid distal biceps tendon in

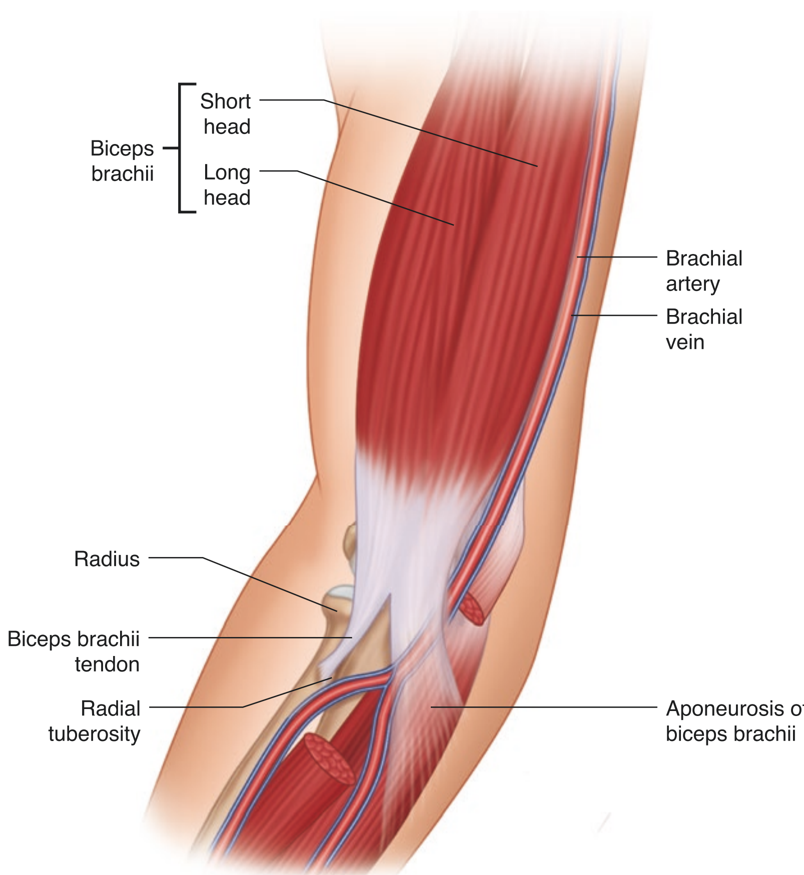

Fig. 4.1 Proximal long head of biceps (short head not shown). Coracoacromial (CAL), coracohumeral (CHL), conoid (CoL), superior glenohumeral (SGHL), transverse humeral (TL), and trapezoid (TrL) ligaments are labeled

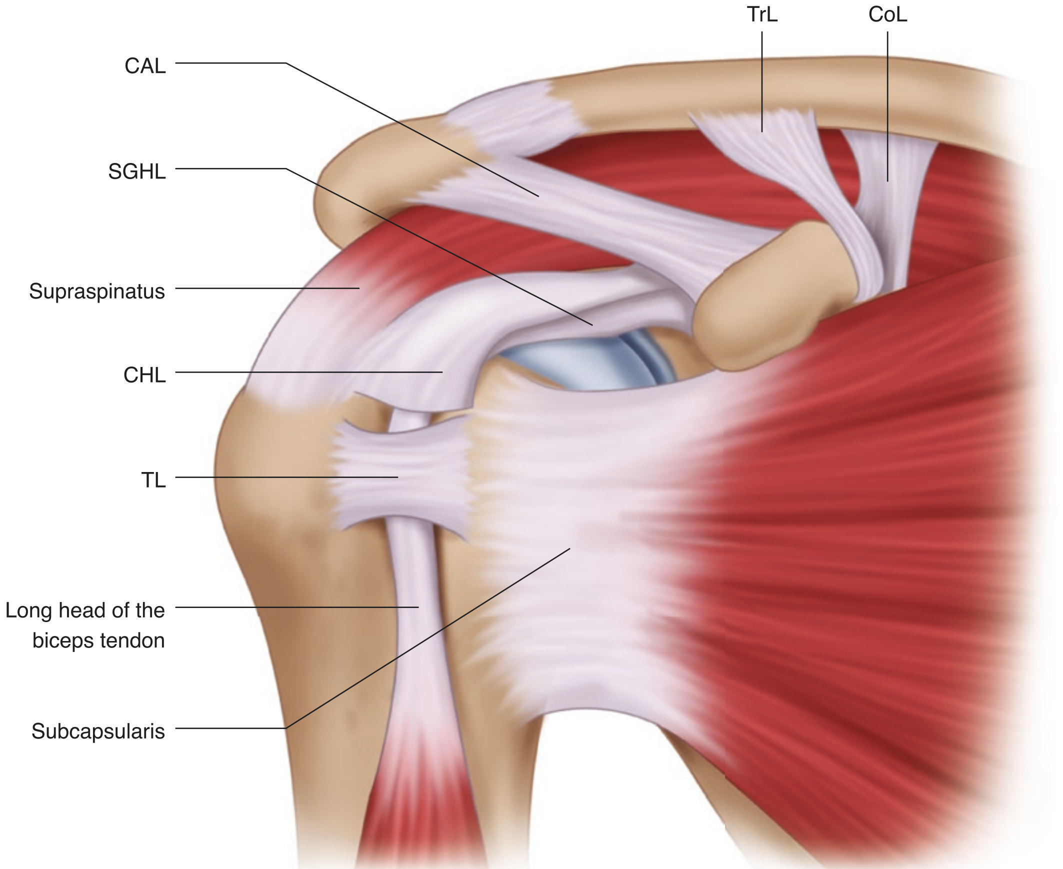

Fig. 4.2 Distal biceps tendon inserting on posterior ulnar aspect of the radial tuberosity with overlying aponeurosis/lacertus fibrosis of the biceps brachii

25–48% of the population. In these individuals, the long head inserts farther from the axis of rotation, and more proximal than the short head, suggesting that it is the dominant supinator, while the short head acts as a more powerful forearm flexor [12]. The bicipital aponeurosis or lacertus fibrosis arises from the medial aspect of the muscle belly and crosses the antecubital fossa medially. It merges with the proximal forearm flexor fascia and inserts on the border of the ulna. This fascia protects the median nerve, brachial artery, and brachial vein, which lie medial to the biceps tendon. If the lacertus fibrosis remains intact, it can help prevent retraction of a ruptured tendon, which is an important factor in the timing and treatment of ruptures [13]. There is a bicipitoradial bursa between the tendon and radial tuberosity that acts to reduce friction during pronation and supination; this is the most common region of distal tendinopathy [5].

The musculocutaneous nerve (C5, 6, 7) innervates the biceps and runs between the biceps brachii and brachialis muscles. It terminates as the lateral antebrachial cutaneous nerve, which supplies sensation to the lateral forearm. The lateral antebrachial cutaneous nerve lies superficially making it vulnerable to injury during operative treatment of distal biceps tears [12]. The ascending branches of the anterior humeral circumflex artery supply the proximal biceps. Distal branches of the brachial artery and the posterior interosseous recurrent artery supply the distal biceps. There is a 2-cm zone of hypo-vascularity just proximal to the distal biceps insertion that may predispose it to degeneration and rupture, although most tendinopathies occur more distally at the insertion on the radial tuberosity as previously mentioned [12].

The biceps tendon serves as a powerful flexor and the main supinator of the forearm when the elbow is at least partially flexed. Many studies have supported the role of the long head of the biceps tendon in maintaining glenohumeral joint stability, and analysis has shown that it provides anterior stabilization of the glenohumeral joint by increasing resistance to torsional forces on the humeral head, especially when the shoulder is in an externally rotated and abducted position [14, 15].

Proximal Long Head Tendinopathy

A 44-year-old male construction worker presents with a five-month history of progressive right anterior shoulder pain. There is no specific history of trauma or injury. His discomfort is associated with weakness and a "snapping sensation" that is typically worse with overhead activities and lifting heavy objects. Exam shows weakness and impaired range of motion of his right shoulder. He has focal tenderness on palpation in his right bicipital groove. There is a positive Speed's and Yergason's test, reproducing his presenting anterior shoulder pain.

Clinical Presentation

Tendinopathy of the proximal long head rarely presents as an isolated condition, typically developing as a secondary process from underlying shoulder dysfunction in 90–95% of cases [16]. Rotator cuff tendinopathy, impingement syndrome, glenohumeral osteoarthritis or instability, and biomechanical dysfunction from scapular dyskinesias force the long head to compensate for increasing instability of the shoulder joint. Tenosynovitis develops as the synovial sheath becomes irritated and inflamed from repetitive mechanical overloading and microtrauma. Eventually, this leads to both inflammatory and degenerative processes that work synergistically in the pathogenesis of tendinopathy, thus resulting in a thickened, hypertrophied, and fibrotic tendon [17]. As the hour glassed-shaped tendon moves within the groove, shear forces and traction cause it to become fixed by adhesions and scar tissues [18]. The degenerated, entrapped tendon leads to progressive clinical symptoms. Primary biceps tendinopathy, which can be presumed after co-existing shoulder pathology is excluded, has been attributed to congenital variants in osseous anatomy [19].

The most common presenting complaint is anterior shoulder pain with radiation distally over the biceps muscle belly [20]. Typical rotator cuff tendinopathy symptoms, including generalized shoulder pain with overhead activity and discomfort while lying on the affected side, are common as studies report biceps pathology in 76–85% of rotator cuff tears [8]. In overhead athletes, pain may be especially worse during follow-through motion as the humeral head translates anteriorly, increasing impingement of the biceps tendon [21].

Long-standing tendinosis may result in a weakened tendon, increasing the risk of rupture [18]. Ruptures most commonly result from sudden or forceful eccentric contraction of the long head, such as when a patient catches an object that falls unexpectedly or shovels heavy snow [22]. However, many ruptures are spontaneous because they take place in degenerated tendons [18]. Patients may present with a sudden "pop" accompanied with acute pain, swelling, and ecchymosis. Proximal ruptures often have a classic "Popeye deformity," which can be seen as a focal bulge as the muscle mass moves distally. The most common sites of rupture include the tendon origin and the musculotendinous junction [19]. Proximal long head instability, ranging from subluxation to dislocation, can result in clinical symptoms of anterior shoulder pain, catching, popping, or an audible and palpable "snap" during movement. The long head most frequently subluxes medially and superficially toward the subscapularis insertion on the lesser tuberosity [23]. It is extremely uncommon for instability to occur in the absence of rotator cuff abnormalities, and the subscapularis is the most commonly involved muscle [24]. The biceps pulley, responsible for securing the long head within the groove, must also be disrupted for the tendon to become unstable [25].

Tendinopathy of the biceps can also occur near its origin at the biceps anchor. Snyder et al. described a specific group of lesions, termed SLAP (superior labrum anterior and posterior) lesions, involving the superior aspect of the labrum and origin of the biceps tendon [26]. Eccentric contraction of the long head when the arm is abducted and externally rotated results in excessive stress on the biceps tendon, gradually detaching the superior labrum and biceps origin from the glenoid tissue [27]. Most commonly seen in overhead athletes, symptomology is vague and nonspecific, but the most common complaints include anterior shoulder pain, sensations of instability, and episodic clicking when the arm is in a throwing position [28].

Physical Examination

When examining for proximal biceps tendinopathy, it is imperative to perform a complete shoulder exam due to the high rate of concomitant shoulder pathology. Inspection, palpation, range of motion, manual muscle testing, special testing for rotator cuff pathology, and neurovascular assessment of the entire upper extremity should be performed before focusing on the proximal biceps. A cervical spine examination should also be conducted, as cervical radiculopathy can contribute to shoulder girdle pain/weakness. In the majority of patients with biceps lesions, inspection is unremarkable with the notable exception of biceps tendon ruptures. In this scenario, edema and bruising may be present along with an obvious muscle mass, representing the detached muscle belly [20]. Palpation over the proximal long head within the bicipital groove should elicit point tenderness (see Table 4.1).

The two most commonly performed special tests for biceps tendinopathy are Yergason's and Speed's tests (see Table 4.1 and Figs. 4.3 and 4.4) [29, 30]. The modest sensitivity and specificity of these maneuvers reflect the challenge that clinicians face in distinguishing biceps tendinopathy from other causes of anterior shoulder pain.

Given the high association of biceps tendinopathy with SLAP lesions, maneuvers must be performed to evaluate the pathology at the superior labrum complex. Two common exam maneuvers include O'Brien's active compression test and the biceps load test II (see Table 4.1). No exam maneuver has proven superior over the other in accurately and consistently diagnosing a SLAP lesion, nor has a set of clinical maneuvers proven more efficacious than individual stand-alone testing [31–33].

Diagnostic Workup

Ultrasound

Musculoskeletal ultrasound is an important tool that can be utilized in the assessment and confirmation of proximal long head tendon pathology (see Table 4.2a). Studies have shown that it has superior efficacy in detecting normal tendons, full-thickness and partial-thickness tears, and non-tear abnormalities of the biceps tendon when compared to MRI [34–36].

The exam begins proximally within the groove at the rotator interval, and scanning continues distally in both long and short axes until ending at the myotendinous junction. The normal appearance of the long head will reflect the typical sonographic appearance of most tendons, described as hyperechoic with a linear, fibrillar pattern of echotexture [23]. Because the biceps tendon sheath communicates directly with the glenohumeral joint, any inflammatory or degenerative process of the shoulder can result in fluid accumulation within this sheath (see Fig. 4.5) [37]. Dynamically assessing the proximal tendon with internal and external rotation of the shoulder should be performed as abnormal positioning of the tendon may only

Table 4.1 Descriptions of the most common physical exam maneuvers and corresponding positive findings

Physical exam maneuvers				
Test	Exam maneuver	Positive finding	Sensitivity	Specificity
Palpation of biceps tendon	To identify the tendon, palpate the greater tubercle of the humerus, and move medially into the groove. Flex the patient's elbow to 90° while internally and externally rotating the arm until the long head can be palpated under the examiner's fingers [77]	Pain along the biceps tendon	98%	70%
Speed's test	Patient flexes their supinated and extended arm against the examiner's isometric resistance while the examiner palpates the long head within the bicipital groove (see Fig. 4.4)	Pain along the biceps tendon	63–68%	55%
Yergason's test	Patient's arm should be pronated and elbow flexed to 90° along their torso (see Fig. 4.3). The patient then attempts to supinate their arm against the examiner's isometric resistance while the examiner palpates the long head within the bicipital groove	Pain along the biceps tendon	32–37%	86%
O'Briens test (active compression test)	Patient flexes their extended arm 90°, adducts 10°, and internally rotates the arm until the thumb is pointing downward. The examiner then pushes down on the patient's arm and assesses for pain or a clicking sensation in the shoulder. Next, the patient supinates their forearm and the examiner again pushes downward	If the click or pain is less prominent on with supination, the test is considered positive for a SLAP lesion	28–73%	63–94%
Biceps load test II	Patient is placed in the supine position with the shoulder externally rotated and placed in 120° of abduction, the elbow is flexed to 90°, and the forearm is supinated. The examiner then provides resistance as the patient is asked to flex the elbow	Pain in the shoulder region indicates a positive test for SLAP lesion	90%	97%
Hook test	Patient flexes elbow to 90° and fully supinates the forearm. Examiner uses index finger to "hook" distal biceps tendon from the lateral edge of the antecubital fossa and pulls anteriorly	Unable to "hook" a cord like structure = distal rupture If intact but painful = partial tear or tendinosis	100%	100%
Biceps squeeze test	Similar to Thompson test for Achilles-patient's arm rests in slight pronation with elbow flexed between 60 and 80° and examiner squeezes biceps muscle belly with both hands, observing for forearm supination	Lack of forearm supination = distal rupture	96%	100%
Biceps crease interval	Measure the distance between the antecubital crease and the cusp of the distal biceps descent (where biceps turns most sharply toward the fossa)	>6 cm or ratio of >1.2 from side to side = distal rupture	92–96%	80–100%

occur during these movements. If a subluxation or dislocation is present, a painful click or snap is often seen during dynamic assessment, with medial displacement over the top of the lesser tuberosity.

Additional Imaging

Plain films play little role in diagnosing biceps tendinopathy. However, if underlying impingement or osteoarthritis of the acromioclavicular or glenohumeral joint is suspected, radiographs serve a useful tool in detecting arthritic changes that may be contributing to shoulder pain. Studies have demonstrated that the sensitivity and specificity of MRI and MRA may be insufficient in detecting proximal biceps pathology, especially tendinosis [38, 39]. Advanced imaging should be reserved for cases where labral pathology is suspected or when conservative management has failed and the clinical course is leading toward surgery. MRA is preferred over MRI in diagnosing SLAP tears [40]. Proximal biceps tendon subluxation can be associated with

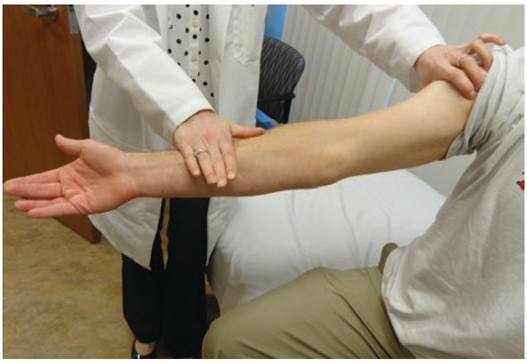

Fig. 4.3 During Speed's test, the patient flexes and supinates their extended arm against the examiner's isometric resistance

Fig. 4.4 During Yergason's test, the patient flexes their elbow to 90° and attempts to supinate their forearm against resistance while the examiner palpates the tendon of the long head within the bicipital groove

Table 4.2a Findings on ultrasound exam of proximal biceps tendon

Ultrasound examination		
Sonographic finding	Differential	Distinguishing factors
Increased fluid surrounding proximal sheath	Joint effusion, tenosynovitis	Joint effusion: symmetric distention around the sheath, possibly with accumulation of fluid in other joint recesses, such as the subscapular recess or subacromial bursa Tenosynovitis: focal distention of sheath, pain with transducer pressure, hyperemia on Doppler assessment[23]
Absence of proximal long head	Subluxation/dislocation, full-thickness tear/rupture	Subluxation/dislocation: long head commonly found medial and superficial toward the subscapularis insertion on the lesser tuberosity [23] Rupture: long head stump typically found when scanning distally
Increased blood flow on Doppler	Acute inflammatory state (tendinitis, tenosynovitis, infection), tendinosis	Acute inflammation: due to hyperemia Tendinosis: due to neovascularization[a]
Loss of linear, hyperechoic tendon pattern	Partial thickness tear, tendinosis	Partial-thickness tear: well-defined anechoic/hypoechoic abnormality Tendinosis: tendon thickening, heterogeneous hypoechoic enlargement, calcifications, neovascularization [23]
Posterior acoustic shadowing	Partial thickness tear (less likely), complete tear	If seen, it likely signifies the presence of hemorrhage from a complete rupture (or less likely partial tear). The dense hyperechoic fluid causes acoustic shadowing and may obscure the detailed evaluation of deeper structures

When correlated clinically, imaging serves as a valuable tool for the clinician in determining diagnosis and direction of treatment

[a]In a study analyzing patients clinically diagnosed with tendinopathy of the long head of the biceps tendon, 22/28 patients were found to have neovascularization via immunohistochemical staining [78]

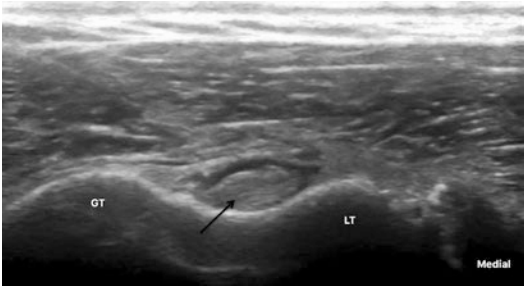

Fig. 4.5 Ultrasound of the proximal biceps brachii long head tendon (*arrow*) in short axis coursing through the bicipital groove. Hypoechoic fluid is seen surrounding the tendon. Greater (GT) and lesser (LT) tuberosities are labeled

full-thickness subscapularis tears and further imaging with ultrasound or MRI may be indicated for confirmation.

Treatment

Conservative

Nonoperative management involves a combination of physical therapy, oral medications, and interventional techniques. Treatment should be focused on both the biceps and any underlying shoulder dysfunction. Initial management should allow for relative rest, activity modification, and pain control.

Non-steroidal Anti-inflammatory Drug (NSAID)

A systematic review of the literature suggests that both oral and topical non-steroidal anti-inflammatory drugs (NSAIDs) are effective in the management of pain associated with tendinopathy in the short term, but no evidence has proven that chronic use of NSAIDs provides any long-term benefit [41, 42]. If there is no contraindication to oral NSAID use, ibuprofen 600–800 mg QID (maximum daily dose of 3200 mg) or naproxen 250–500 mg BID (maximum daily dose of 1000 mg) can be recommended for 7–14 days [43]. If the side effect profile of NSAIDs precludes its use, acetaminophen 1000 mg TID is a reasonable alternative.

Physical Therapy

Physical therapy is similar to that of rotator cuff tendinopathy as previously discussed in Chap. 3. This is because at the time of physical therapy enrollment, diagnosis is typically not etiological and also because concomitant pathologies within rotator cuff tendons are common. The biceps tendon therapy program should focus on the entire kinetic chain of the upper extremity, including the scapular stabilizers. After pain is adequately controlled, the first step involves restoring passive range of motion with progression to active range of motion. Next, gradual strengthening of the scapular stabilizers and individual rotator cuff muscles should follow. Initial training should focus on isometric exercises, which allows for muscle strengthening without adding any stress to the tendon. As the muscle becomes stronger, concentric and eccentric training is implemented, which increases tensile load as the muscle changes in length. Eccentric contraction has been to shown to both normalize tendon structure by increasing collagen synthesis and to halt the degenerative cascade by decreasing neovascularization and tendon swelling [44]. After strengthening, progression to dynamic stability exercises and specific return-to-activity movements are implemented.

Iontophoresis, phonophoresis, and therapeutic ultrasound have been studied in various tendinopathies with modest data showing their efficacy in improving outcomes [45, 46]. Extracorporeal shock wave therapy (ESWT) and diathermy have shown promising results in several large studies involving various tendinopathies, but none have specifically examined the biceps tendon [47].

Interventional

Corticosteroid injections (CSIs) continue to be a common practice in biceps tendinopathy. Most authors recommend injection if the patient's pain is unrelieved by an initial trial of oral analgesics or if further pain relief is needed to initiate and tolerate a rehab program [48]. Injections may target the concomitant shoulder pathologies by injecting into the subacromial or glenohumeral joint space, or by directly injecting into the tendon sheath of the long head. Multiple studies

Fig. 4.6 Recommended positioning for injection into the sheath of the proximal tendon of the long head of the biceps. Patient is supine with arm in neutral position and palm facing upward. The transducer is placed in an anatomic transverse plane over the bicipital groove

have proven that CSIs improve pain and outcomes in the short term, but this effect is reversed in the intermediate and long term as steroids inhibit collagen synthesis and increase risk of tendon rupture [49, 50]. If indicated, most clinicians recommend a single injection into the sheath of the proximal long head, preferably under ultrasound guidance to minimize risk of intra-tendinous injection [51]. If ultrasound were to be used, the literature indicates that the most technique is to use lateral to medial, in plane approach, with the biceps tendon viewed in short axis (see Figs. 4.6 and 4.7; Video 4.1) [52, 53]. Injectate volumes typically consist of 1 mL of corticosteroid in combination with 0.5–2.0 mL of anesthetic [54]. Utilizing sonographic guidance is recommended as one randomized controlled trial demonstrated significantly greater accuracy when comparing ultrasound-guided versus unguided injections into the proximal

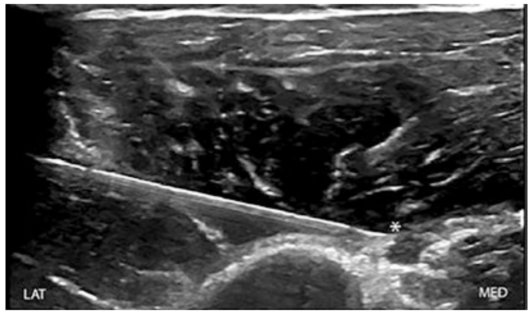

Fig. 4.7 Proximal right biceps tendon sheath viewed in short axis (asterisk). The needle is visualized approaching the target in a lateral to medial, in plane approach

long head tendon sheath [51]. Regenerative injection techniques, including platelet-rich plasma (PRP) and prolotherapy, are increasingly being studied in the treatment of various chronic tendinopathies. Several case reports of biceps tendinopathy successfully treated with PRP have been reported [55]. One study comparing PRP and prolotherapy in patients with biceps tendinopathy found both treatments to be effective, but leukocyte-rich PRP showed a significant better response in long term [56].

Operative

Surgical treatment of the long head of biceps tendon is reserved for patients who have failed nonsurgical management in setting of anterior shoulder pain and positive exam findings consistent with biceps tendinopathy. Surgically treated conditions include, but are not limited to, partial tendon tears, tenosynovitis, tendon instability, select types of SLAP tears (see Fig. 4.8). There are no set guidelines for duration of nonsurgical management. Instead, recommending surgical intervention is individualized for each patient. Biceps tenotomy and tenodesis are two of the most common surgical procedures for treating long head of biceps pathology. In appropriately indicated patients, both options can provide reliable symptomatic relief and patient satisfaction.

Biceps tenotomy has advantages that include decreased surgical time, technical ease of the procedure, no implant cost, and no postopera-

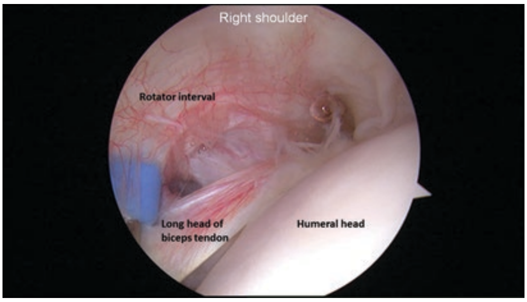

Fig. 4.8 Arthroscopic view of the right shoulder visualized from the posterior portal. The long head of the biceps tendon is inflamed and mildly frayed as it is coursing toward the bicipital groove

tive immobilization. Reported disadvantages include decreased supination strength, biceps fatigue, and cosmetic Popeye deformity (70% of patients) [57, 58].

Biceps tenodesis involves cutting the tendon from its anchor site and reattaching it onto the humerus. It is indicated in younger or active patients, laborers, and overhead athletes, as well as in those who would deem cosmetic deformity to be unacceptable. Tenodesis can be performed arthroscopically or using an open technique. Described complications include infection, musculocutaneous nerve neuropathy, humeral fracture, and hardware failure. In a study of 350 patients treated with open subpectoral biceps tenodesis, the reported rate of complications was 0.7% [59]. Despite much debate and controversy surrounding the optimal location for tenodesis and the fixation method, overall, biceps tenodesis is a successful procedure with low rates of complication [58].

Distal Biceps Tendon Rupture

A 55-year-old man presents with sudden onset of sharp, tearing pain in his anterior elbow after hearing a "pop" while performing heavy bicep curls. He endorses weakness and pain with activities requiring elbow flexion and has had difficulty turning doorknobs [60]. *On inspection, he has swelling and ecchymosis over the antecubital fossa but it is difficult to appreciate any change in muscle contour.*

Clinical Presentation

Distal biceps tendon rupture is almost always caused by a traumatic eccentric overload event with the elbow partially flexed and fully supinated. The tendon typically ruptures at the insertion site on the radial tuberosity. Previously asymptomatic tendinosis may predispose the tendon to rupture [13]. The lacertus fibrosis can rupture with the tendon, allowing for tendon retraction. Occasionally, in patients with a bifid tendon, there is an isolated single tendon rupture of either the long head or short head [5].

Apart from distal biceps tendon rupture, tendinosis can be symptomatic without a tear, which is caused by friction, bony impingement as radius clears ulnar on forearm rotation, and repetitive stress or microtrauma [12, 13, 61]. The distal biceps tendon occupies 85% of the space between the proximal radioulnar joints. There is an additional 50% reduction in the joint space when moving from supination to pronation as the radial tuberosity moves posteriorly. Irregularity of the radial tuberosity may lead to increased impingement of the tendon and thus causing tendinosis or degeneration [12]. As distal biceps tendinopathy can present with lateral elbow pain and mimic common extensor tendinopathy (CET), physicians should elicit history pertaining to CET (see Chap. 5).

Physical Examination

A "reverse Popeye" sign may be challenging to appreciate due to swelling and difficulty contracting the biceps muscle [62]. General ecchymosis and swelling in the antecubital fossa will be seen in biceps tendon tears. In both tendinosis and tears, forearm supination weakness is usually more prominent than weakness in elbow flexion [61]. The most common examination maneuvers to evaluate distal biceps rupture include the hook test, biceps squeeze test, and biceps crease interval (see Table 4.1) [63, 64]. The hook test is the most sensitive test; however, the examiner must be careful to not mistake the biceps tendon for the lacterus fibrosis, which will feel like a flat sheet-like material when palpated from the medial aspect [62]. Pain provocation tests in which the examiner provides resistance during elbow flexion and forearm supination may elicit pain in distal biceps tendinosis or rupture [5, 13]. Distal rupture may also be diagnosed with the passive pronation and supination test in which the biceps muscle belly does not move distally with passive pronation or proximally with supination with the elbow in 90° of flexion [4].

Diagnostic Workup

MRI

The gold standard imaging modality for the diagnosis of tendinosis versus tear of the distal biceps tendon remains the MRI. Optimal positioning is in the "FABS view" in which the patient lays prone with their elbow flexed, shoulder abducted overhead, and forearm supinated so the thumb is pointed upward. This position allows for accurate visualization of the full length of the distal biceps tendon [65]. A complete tear may be demonstrated as fiber discontinuity or absence of the tendon attachment on the radial tuberosity with hyperintense soft tissue edema/hematoma [66]. MRI can be used to evaluate lacertus fibrosis rupture and tendon retraction, which will help with surgical planning. Focal marrow edema in the radial tuberosity may also be seen in complete or partial tendon tears [7]. Signs of a partial tear and tendinosis include alteration of intra-tendinous signal, altered tendon thickness, paralleling fluid, and fluid filled bursa [65, 66].

X-Ray

Plain films are not typically useful except in evaluating avulsion fracture or osseous reaction of the radial tuberosity seen with some complete ruptures. Enlargement or irregularity of the radial tuberosity may be seen, which leaves the tendon susceptible to injury [13].

Ultrasound

As previously discussed, ultrasound examination offers many advantages over other imaging modalities. During evaluation of the distal biceps, ultrasound shows 95% sensitivity and 71% specificity in diagnosing complete versus partial tears [67]. Altered echogenicity with either tendon thickening or thinning and contour irregularities are typically seen with partial tears, while tendon hypertrophy and heterogeneous hypoechoic changes due to edema are seen with tendinosis [66]. A complete tear is visualized as an anechoic or hypoechoic discontinuity of the tendon with or without retraction. There may also be hyperechoic peritendinous fluid, which usually signifies hemorrhage and may be a very sensitive sign of complete tendon rupture. The presence of hyperechoic fluid casts a shadow on ultrasound image, in an artifact called "posterior acoustic shadowing," making it difficult to evaluate deeper structural details (see Table 4.2b) [66]. While shadowing has a poor sensitivity for diagnosing

Table 4.2b Findings on ultrasound exam of distal biceps tendon

Ultrasound examination		
Sonographic finding	Differential	Distinguishing factors
Increased blood flow on Doppler	Acute inflammatory state (tendinitis, tenosynovitis, infection), tendinosis	Acute inflammation: due to hyperemia Tendinosis: due to neovascularization
Loss of linear, hyperechoic tendon pattern	Partial thickness tear, tendinosis	Partial-thickness tear: well-defined anechoic/hypoechoic abnormality Tendinosis: tendon thickening, heterogeneous hypoechoic enlargement, calcifications, neovascularization [23]
Posterior acoustic shadowing	Partial thickness tear, complete tear	If seen, it likely signifies the presence of hemorrhage from a complete rupture (or less likely partial tear). The dense hyperechoic fluid causes acoustic shadowing and may obscure the detailed evaluation of deeper structures

When correlated clinically, imaging serves as a valuable tool for the clinician in determining diagnosis and direction of treatment partial tears, studies suggest that the lack of shadowing can exclude a complete tear [67].

Treatment

Conservative

Non-operative treatment is considered for tendonitis, partial tears, and tendinosis of distal biceps tendon. The general principle is similar to other enthesopathies using a combination of relative rest, activity modification, physical therapy, and both pharmacologic and non-pharmacologic modalities as described in the proximal biceps tendon section. Physical therapy programs typically involve the combination of stretching and strengthening with progression from isometric to concentric to eccentric exercises as suggested for proximal tendinopathy. Use of NSAIDs has been tried in acute phases for the above-stated indications but without a long-term benefit. Nitroglycerin topical patches can be used over the tendon to promote local vasodilation for tendinosis, increasing the blood supply and thus improving tendon repair [68].

Interventional

Corticosteroid injections may be trialed for tendonitis, partial tear, and sometimes for tendinosis, but it may not improve the long-term outcome for distal tendinopathy [68]. Regenerative medications such as platelet-rich plasma (PRP) may be recommended for refractory cases of biceps tendinopathy. There have been reports of positive outcomes after only one to two leukocyte-rich PRP (type 1B per Mishra classification) injections for distal biceps tendinopathy [69]. The safest recommended approach for distal biceps tendon sheath injection is a posterior approach in order to avoid injuries to the brachial artery, which lies just medial to the tendon. For this approach, the patient is positioned in supine with their arm flexed at the elbow and forearm hyperpronated. The transducer is oriented in short axis on the posterior forearm about 3–4 cm distal to the olecranon (see Fig. 4.9). The needle is then advanced in plane to the transducer in a radial to ulnar direction, targeting the superficial surface of the biceps tendon at the distal attachment to the radius [54]. Injectate volumes for CSI are similar to that mentioned for proximal bicep tendon sheath injection and PRP protocols widely vary.

Fig. 4.9 Recommended positioning for peritendinous injection of the distal biceps using a posterior approach. Patient is in supine with elbow flexed and forearm hyperpronated. The transducer is placed in a short axis plane over the posterior forearm, distal to the olecranon. The needle is guided in an in-plane radial to ulnar approach

Radial extracorporeal shock wave therapy (rESWT) may also stimulate cell proliferation, angiogenesis, and collagen synthesis, and many trials have shown improvement in pain and functional limitations over placebo or other alternative therapies [70]. A recent study found that a single session of rESWT using 2000 shock waves with energy flux density of 0.18 mJ/mm was safe and effective in decreasing pain in chronic distal biceps tendinopathy [61].

Operative

There is no definitive data on when to refer to surgery for distal biceps tendinosis and partial tears but most studies recommend trialing conservative treatment for at least 6–12 months [65]. Complete tears can result in up to 40% loss of supination strength, 79% loss of supination endurance, 30% loss of flexion strength, and 30% loss of flexion endurance [71, 72]. To restore strength and function, surgical repair is favored in the young and active population, while non-operative treatment can be considered for older patients who are able to tolerate flexion and supination strength deficits.

When planning for surgical treatment, time from injury is a critical factor, as longer delays result in a retracted tendon that may be adhered to the surrounding tissue. Consequently, more dissection is involved to mobilize the tissue, which can increase the complexity of the case and the complications associated with repair [73].

Surgical repair of distal biceps tendon rupture can be performed through either single or dual incision approach, using various fixation techniques and implants. Regardless of the chosen surgical method, the published studies report good to excellent outcomes with respect to recovery of strength and endurance with low rates of complications. A classic article by Morrey et al. demonstrated recovery of 97% of elbow flexion and 95% supination strength compared to the contralateral extremity, following surgical repair [72]. Most commonly described complications after surgery include injury to the lateral antebrachial cutaneous nerve. Other less common complications include heterotopic ossification, stiffness, re-rupture, and persistent pain [74].

Proximal Short Head

While tendinopathy of the proximal short head of the biceps is rare, it should still be considered in patients presenting with shoulder pain. Much like impingement of the long head tendon, there may be impingement at the coracoid process when the lesser tuberosity infringes on this region during flexion and internal rotation of the arm. Patients will present with anterior shoulder pain that may radiate down the arm; however, typical shoulder impingement exam maneuvers, such as Neer's and Hawkins', will be negative. The tendon origin at the coracoid process may be tender to palpation and worse with passive flexion at the shoulder. Diagnosis may be confirmed with injection of 3–4 mL of local anesthetic between the coracoid process and the humeral head [75]. Following the anesthetic injection with a CSI, typically consisting of 2–3 mL anesthetic and 1 mL of 40 mg/mL DepoMedrol, can result in decreased pain and increased function.

There are very few case reports of isolated proximal short head tendon rupture. The mechanism of injury is described as an abrupt flexion and adduction of the arm with the elbow in extension, which places the short head under the greatest strain. Patients will present with sudden onset of anterior shoulder pain, a "popping" sensation, ecchymosis, swelling, and a mini-"Popeye" sign with a hollow site medial to the biceps brachii long head, where the short head muscle belly normally lies. Shoulder flexion will be weak and there will be tenderness at the coracoid process without a palpable tendon. Histological examinations have revealed degenerative changes in the tendon that were severe enough to cause failure. Surgical repair involves reattachment of the tendon either to the coracobrachialis tendon or partially to the coracoid process and partially to the long head biceps tendon [76].

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