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Treatment of the painful biceps tendon—Tenotomy or tenodesis?

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Summary
The function of the long head of biceps tendon in the shoulder remains controversial. Pathology of the biceps tendon such as tenosynovitis, subluxation and pre-rupture are intimately associated with rotator cuff disease. Treatment therefore varies widely among surgeons and range from non-operative management to biceps tenotomy or tenodesis. The purpose of this article is to provide an up to date review on the indications and results of biceps tenotomy and tenodesis.

Anatomy

The anatomical origin of the long head of biceps tendon is variable. It arises most commonly from the glenoid labrum (45%), less commonly from the supraglenoid tubercle (30%) and in the remaining it arises from both the glenoid labrum and the supraglenoid tubercle (25%). The tendon travels obliquely within the glenohumeral joint to exit beneath the transverse humeral ligament along the intertubercular sulcus or bicipital groove. In the glenohumeral joint the tendon is encased within a synovial sheath, which ends as a blind pouch at the end of the bicipital groove. As a result, the biceps tendon is intraarticular but extrasynovial.

The average length of the tendon is 102 mm. It is interesting to note that the shape and cross-sectional area of the tendon changes as it runs from proximal to distal. At its proximal attachment near the glenoid, it has an average cross-section of 8.4×3.4 mm. This decreases to 4.5×2.1 mm as the tendon leaves the bicipital groove. Therefore, rupture of the biceps tendon most commonly occurs proximally near the glenoid labrum and distally in the bicipital groove.

Function

The biceps muscle-tendon unit is one of many structures in the human body to cross two joints. In the elbow, it serves primarily as a forearm supinator. Its secondary role is as an elbow flexor. Whilst its function at the elbow is clear, its role in the shoulder joint remains controversial. Cadaveric studies[1–3] suggest that the long head of biceps acts as a humeral head depressor, anterior stabiliser, posterior stabiliser, limiter of external rotation, lifter of the glenoid labrum as well as a humeral head compressor. Warner[4] studied the change in acromiohumeral interval on plain radiographs in patients with isolated loss of the proximal attachment of the long head of biceps. He found that there was 2–6 mm of superior translation of the humeral head in all patients in all positions of shoulder abduction except at zero degrees. He concluded that the long head of biceps acts

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as a stabiliser of the humeral head in the glenoid during shoulder abduction in the scapular plane. The most recent biomechanical data come from Youm et al.[5] who found that loading of the long head of biceps tendon significantly affects the glenohumeral joint range of movement, translations and kinematics. They concluded that the long head of biceps acts as a ligament at the extreme of motion to shift the humeral head to a position more centred on the glenoid.

Electromyographic studies[6–8] have produced conflicting results. There have been seven studies confirming that the long head of biceps acts as a shoulder flexor, three studies supporting its role as a shoulder abductor, two for internal rotator, one for external rotator and one as a shoulder extensor, one as anterior stabiliser of the shoulder and one study showing that it has abductor function only with resistance. A common limiting factor in all these studies is that the electromyographic activity from the motion of the elbow and forearm was not controlled during measurement of shoulder activity. Levy et al.[6] have controlled this variable using a long arm brace, locking the elbow in extension and forearm in a neutral position. They concluded that the long head of biceps is not active in isolated shoulder motion when the elbow and forearm are controlled. They postulated that activity of the biceps tendon in the shoulder is achieved by either passive proprioception of the tendon or by active tension in association with the elbow and forearm activity.

It seems evident therefore that the long head of biceps does not have a primary function in the shoulder but instead has multiple secondary roles. It is hardly surprising, therefore, to know that there is no single reliable clinical test to diagnose biceps pathology, as there is no primary function that can be isolated.

Pathophysiology

Pathology of the biceps tendon can be broadly divided into three main types: inflammatory, instability and traumatic. Clearly, there is a huge overlap between these categories and in fact biceps pathology is very rarely a single entity (Fig. 1). The pathology most commonly seen is biceps tenosynovitis associated with a rotator cuff tear. This is related to its anatomical arrangement, since the biceps tendon sheath is continuous with the synovium of the glenohumeral joint and therefore any inflammatory process affecting the rotator cuff is likely to affect the long head of biceps as well. Hence, the detection of fluid in the biceps sheath on ultrasound is highly sensitive for rotator cuff disease.

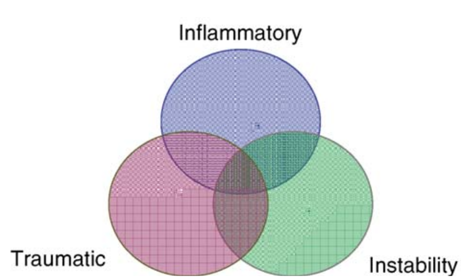

Figure 1 There is often an overlap between different pathologies of the biceps tendon.

Primary versus secondary biceps tendinitis

Primary biceps tendonitis, in which there is isolated pathology affecting the tendon, is rare. One of the few studies that supported the existence of primary biceps tendonitis comes from Berlemann and Bayley[9] who reported the long term results of 14 patients (15 shoulders) following keyhole biceps tenodesis. Fifty-three percent of patients had previously undergone a subacromial decompression but symptoms persisted until the biceps tenodesis was carried out. This would suggest that biceps tendinitis is a primary event. Other researchers, however, believe that biceps tendonitis is secondary to an ongoing subacromial impingement.[10,11] Since the biceps tendon occupies a relatively antero-superior location within the impingement zone, it is prone to mechanical impingement. Neer[10,11] believes that 95% of biceps tendonitis is secondary to impingement. Neviaser[12] has also reported that there is a strong association between rotator cuff tear and biceps tendonitis. In a large series of 210 patients with impingement, Walch[13] found that 70% had concomitant biceps pathology. This is supported by another large series of 200 patients by Murthi et al.;[14] 49% had evidence of biceps pathology and 40% required subsequent tenodesis.

Treatment

The treatment of biceps tendonitis remains controversial. Spontaneous rupture of the long head of biceps is very common but is seldom associated with any significant long term functional deficits. Mariani et al.[15] compared 30 patients with spontaneous rupture of the long head of biceps treated non-operatively with 26 patients who underwent early biceps tenodesis. They found that there was a loss of 21% of supination strength in the group treated non operatively compared to 8% in the tenodesis group. There was no difference in elbow flexion strength but the group treated non-operatively returned to work earlier.

It seems therefore that spontaneous rupture of the long head of biceps tendon can be treated adequately without surgery (Fig. 2). In the context of rotator cuff disease, treatment of the degenerate biceps tendon is more controversial. Surgical options include benign neglect with treatment of concomitant rotator cuff disease only, inspection and synovectomy, repair of partial tear, tenotomy and tenodesis. Proponents for biceps tenotomy advocate that the procedure is simple to do, has limited surgical morbidity, bears no postoperative restriction, avoids implant complications such as hardware loosening, tendon pull-out, bicipital spasm etc.[12,15] Moreover, most patients requiring this procedure are elderly with low functional demand.

One of the largest studies of the results of biceps tenotomy comes from the data in Lyon by Walch et al.[13] Between 1988 and 1999, he carried out 390 biceps tenotomies for full thickness rotator cuff tear. The cuff was not repaired but 35% of patients did have a subacromial decompression. After a mean follow up of 57 months, the mean Constant score improved from 48 preoperatively to 67

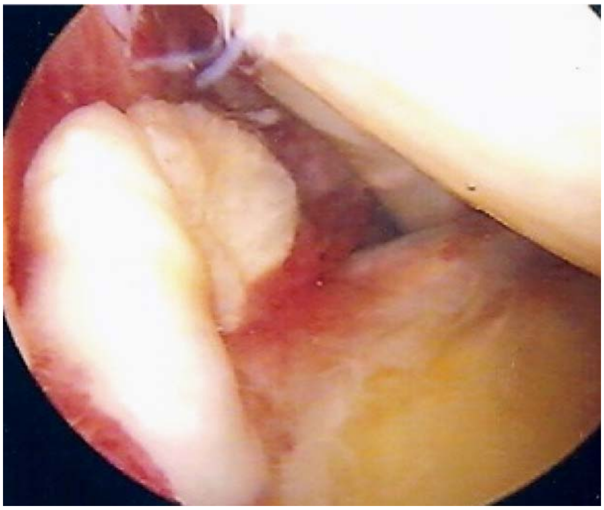

Figure 2 Arthroscopic view of a ruptured long head of biceps tendon.

Figure 3 Popeye sign following proximal rupture of long head of biceps.

postoperatively. The patient satisfaction rate was 87%. Repair of the rotator cuff was required in only 1% of patients and further surgery for cuff tear arthropathy was required in 2%. The authors concluded that in selected patients in whom repair of the rotator cuff is neither possible nor desirable, good objective improvement can be expected with arthroscopic biceps tenotomy. They advocated that the rotator cuff should not be repaired in:

1. Patients aged over 65.
2. Patients with an irreparable rotator cuff tear, indicated by a reduced acromiohumeral interval of less than 7 mm and evidence of extensive fatty infiltration of the rotator cuff musculature on MRI.
3. Patients not willing to undergo post-op rehabilitation for rotator cuff repair.

Gill et al.[16] have also reported favourable results of biceps tenotomy. In 30 patients with biceps tenosynovitis, dislocation or partial rupture treated with a simple arthroscopic tenotomy, they found that there was significant improvement in functional score and reduction in pain. The time taken for return to work averaged 1.9 weeks. There was generally a high patient satisfaction rate although one patient did require revision tenodesis due to cosmetic deformity. The overall complication rate was 13% and included loss of overhead function secondary to impingement, persistent pain and cosmetic deformity.

The incidence of the Popeye sign (Fig. 3) caused by distal migration of the long head of biceps stump following biceps tenotomy is in fact far more common. In 54 patients treated with long head of biceps release carried out as an adjunctive procedure for a variety of conditions including rotator cuff tear, glenohumeral osteoarthritis and instability, the overall incidence of Popeye sign was 70% with 38% complaining of persistent biceps fatigue discomfort after resisted elbow flexion.[17] It is interesting to note that there was a marked difference in the incidence of Popeye deformity between men and women, 83% and 37%, respectively.

The great majority of biceps pathology is encountered with degenerative rotator cuff disease, many of which may not be suitable for repair. In the treatment of a full thickness rotator cuff tear, Maynou et al.[18] advocates biceps tenotomy as he believes that the biceps tendon is often the cause of part or all of the pain. His reasoning is that the long head of biceps occupies an antero-superior position in the shoulder, and as the shoulder forward flexes, the biceps can impinge against the vault of the acromion. In his series of 40 shoulders, he reported satisfactory mid-term results with an average of 34° gain in forward flexion of the shoulder. Although this was described as a simple procedure with limited functional consequences, he recommended this procedure for irreparable rotator cuff tears.

Klinger et al.[19] compared the results of arthroscopic debridement in massive irreparable rotator cuff tears with and without biceps tenotomy. Both groups had significant improvement in Constant scores although the difference between the two groups was not statistically significant. In the group treated with arthroscopic debridement and biceps tenotomy, he found that there was a longer duration of post operative pain relief although the final pain scores were similar. Overall, they found that the additional tenotomy did not significantly improve the outcome.

Biceps tenodesis

Advocates for biceps tenodesis[20] argue that tenodesis is required to:

- Re-establish the resting muscle length and thereby maintain the length-tension relationship.
- Prevent muscle atrophy.
- Avoid cramping pain.
- Maintain elbow flexion and supination strength.
- Avoid cosmetic deformity (Popeye).

Yamaguchi[21] recommends biceps tenodesis when there is:

- More than 25% partial thickness biceps tear.
- Chronic atrophic changes in the tendon.
- Any subluxation of the biceps tendon from the bicipital groove.
- Altered anatomy of the bicipital groove which would make auto-tenodesis unlikely. For example, four part fracture of the proximal humerus.
- More than 25% reduction or atrophy of normal tendon width.
- Failed decompression in context of rotator cuff tendonitis [relative indication].

The most common indication for biceps tenodesis in Boileau's series was massive, degenerative and irreparable rotator cuff tear, accounting for 79%.[22] Less common is the case of isolated biceps pathology in the presence of an intact cuff (14%). Sometimes, biceps tenodesis is required as part of the arthroscopic cuff repair. For instance in the repair of subscapularis (both open and arthroscopic), Burkhart [23] advocates biceps tenodesis routinely as an adjunctive procedure when there is evidence of biceps instability. He found that attempts at trying to preserve the biceps by stabilising it in the bicipital groove commonly fail due to redislocation of the biceps causing persistent pain and subsequent disruption of the subscapularis repair. The biceps pathologies most commonly encountered include prerupture (35%), luxation (30%), subluxation (26%) and tenosynovitis (9%).

The commonly used methods of biceps tenodesis include:

- Subpectoral bone tunnel technique.
- Interference screw technique.
- Suture anchor technique.
- Keyhole technique.

A detailed description of the surgical technique of biceps tenodesis is beyond the scope of this article and is covered in detail in other sources.[23–25]

There have been several biomechanical studies comparing the fixation strengths of various methods of biceps tenodesis. Using fresh sheep shoulders, Ozalay et al.[26] compared the fixation strength of four methods of biceps tenodesis. They found that the strongest construct was using the interference screw; this was followed by the tunnel technique, then the anchor technique and lastly the keyhole technique.

Using fresh frozen cadavers dissected free of soft tissue, Mazzocca et al.[27] compared the cyclic displacement and ultimate failure strength of four methods of biceps tenodesis: the open subpectoral bony tunnel technique, the arthroscopic suture anchor tenodesis, the open subpectoral interference screw fixation technique and the arthroscopic interference screw technique. Using a Materials Testing System, they found that the subpectoral bony tunnel technique was the weakest and showed significantly greater displacement than the other three methods. The difference between the other three methods was not statistically significant.

Kilicoglu et al.[28] studied two intraosseous techniques (suture sling and tenodesis screw) and one extraosseous technique (2 suture anchors). Using sheep sacrificed at 3, 6 and 9 weeks, the time dependent changes in fixation strengths following biceps tenodesis were evaluated. They found that the load to failure was similar in all three techniques although the interference screw group had a significantly greater increase in fixation strength within the first 3 weeks.

In a similar biomechanical study using fresh frozen cadavers, Richards and Burkhart[29] compared the fixation strengths of the interference screw with the double suture anchor. They found that the group treated with an interference screw had a significantly greater resistance to pullout than the suture anchor group. In view of the greater fixation strength, the authors recommended the use of the interference screw in biceps tenodesis, thereby permitting early active elbow flexion.

Using cadaveric specimens, Jayamoorthy et al.[30] evaluated the initial fixation strength of keyhole tenodesis with two types of interference screw fixation: a cannulated metallic interference screw and a bioresorbable one. They found that the keyhole tenodesis technique was significantly stronger than the cannulated metallic interference screw but it was similar in strength to the bioresorbable interference screw. The mode of failure of both interference screws was by tendon slippage at the screw-tendon-bone interface. On the other hand, the keyhole fixation failed by tendon splitting and slippage out of the restraining key hole.

Tenotomy verus tenodesis

In comparing the results of arthroscopic biceps tenotomy versus tenodesis, Osbahr et al.[31] studied 160 patients with chronic refractive bicipital pain. Half the group was treated with tenotomy and the other half with tenodesis. They found there was no significant difference between the two treatment methods in terms of cosmetic deformity, muscle spasm in biceps and anterior shoulder pain. They concluded that biceps tenotomy may be a reasonable alternative to tenodesis in patients with chronic refractive bicipital pain.

One biomechanical study examined the likelihood of distal migration of the biceps stump following simple tenotomy as compared to tenodesis under physiological loading conditions.[32] The cyclical load through which the specimen was tested equates approximately to the force produced during gentle active range of motion without resistance. Wolfe et al. reported that 40% of the tenotomised specimens failed during physiological loading as compared to 0% in the tenodesed group. They therefore concluded that in patients who are concerned about the potential cosmetic deformity and associated dysfunction caused by distal migration of the long head of biceps stump, a tenodesis rather than a tenotomy should be carried out.

However, it is important to remember that not all cases of ruptured long head of biceps lead to the Popeye sign since the biceps tendon does not always retract distally into the upper arm. There are three hypotheses for this observation.[31]

Autotenodesis phenomenon—As mentioned earlier, the biceps tendon has a variable cross-sectional area and is wider proximally near the glenoid than distally as it leaves the bicipital groove. Following an arthroscopic intraarticular biceps tenotomy, the proximal biceps stump becomes entrapped in the bicipital groove and in time, this becomes autotenodesed to the proximal humerus.

Chinese finger trap—Being intraarticular and extrasynovial, the biceps tendon is surrounded by a synovial sheath, which consists of two layers. There is an outer parietal and an inner visceral layer. Distal to the level of the transverse humeral ligament, the synovial sheath reflects back on itself. Following biceps tenotomy, the tendon together with the visceral layer of the synovium slide distally but this sliding is soon stopped by the parietal layer akin to the Chinese finger trap.

Mesotendon—The biceps tendon receives its blood supply from a mesotendon (vincula tendinum) containing the terminal branch of the anterior humeral circumflex artery. This mesotendon is attached to the biceps tendon through the visceral layer of the tendon sheath. The mesotendon is thought to act like a checkrein to prevent excessive distal migration of the tendon.

Summary and conclusion

The functional role of the long head of biceps tendon in the shoulder remains unclear despite numerous cadaveric and electromyographic studies. It is therefore not surprising that the modern management of biceps pathology in the shoulder remains controversial despite major advances in arthroscopic techniques. An algorithm for treatment based on current evidence is proposed and presented in Fig. 4. Until more is known about the functional significance of the long head of biceps tendon in the shoulder, algorithms can only act as a guide to treatment and the final decision must rest with the operating surgeon intraoperatively.

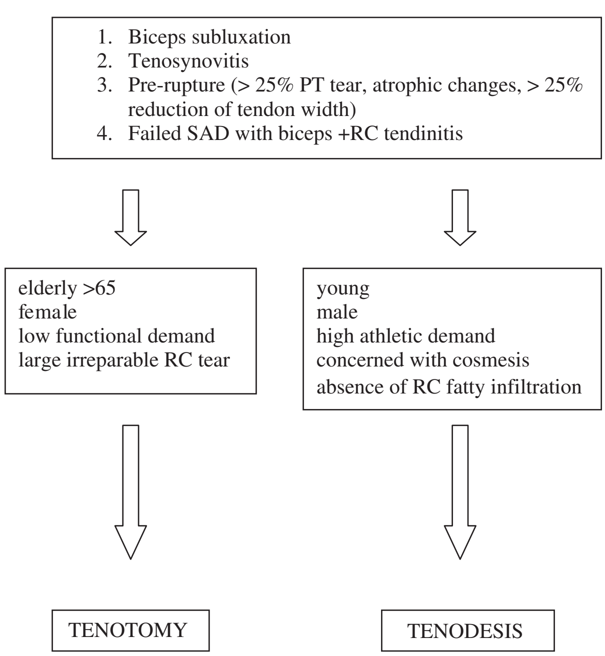

Figure 4 Algorithm for treatment of chronic bicipital pain.

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