Diagnosis and Treatment of Distal Biceps and Anterior Elbow Pain in Throwing Athletes

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Abstract: Despite the activity of the musculature around the elbow and the high angular velocity and stresses, distal biceps tendon injury is rare in the overhead athlete. The biomechanics of the throwing motion and electromyographic studies of the elbow provide useful clues as to why the biceps stays relatively healthy. Anterior elbow complaints are not uncommon in this population and can easily be mistaken for distal biceps pathology. In the event that a thrower does demonstrate biceps tendon pathology, it should be treated in a similar fashion to all other athletic individuals. It is more important to review the differential diagnosis for anterior elbow pain when an athlete has symptoms that might be attributed to the distal biceps tendon. Once the other possible causes of biceps-related pain have been evaluated, the sports medicine physician can then proceed with appropriate treatment to return that athlete to the playing field as quickly and safely as possible.

Key Words: elbow, distal biceps, overhead athlete, throwing, biomechanics, partial biceps rupture

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Injuries to the distal biceps brachii muscle tendon unit have become an increasingly common topic of interest over the past 2 decades. A current internet PubMed simple search for the phrase "distal biceps" returned 217 publications before 1995 for all publications referenced. The same search returns 388 referenced publications from 1995 to the present. One widely held explanation for this increase in interest in the distal biceps tendon is an increased incidence of injury. While distal biceps tendon ruptures have historically been considered rare injuries,[1] large case series have recently been reported on.[2,3] This increase is seen in both recreational and vocational injuries resulting from higher activity levels in patients in their fifth and sixth decades. Complete traumatic rupture of the distal biceps tendon is almost exclusively a male phenomenon with 1 reported case of a traumatic rupture in a woman in the literature.[4]

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Pathology of the tendon falls into 2 categories: acute traumatic rupture and chronic, overuse tendonitis/tendinopathy. Traumatic ruptures have typically occurred in the dominant extremity of males between the ages of 40 and 60. It is almost universally the result of a sudden eccentric load applied with the elbow flexed. This injury had been treated historically nonoperatively, then with tenodesis to the brachialis and now most commonly with direct, anatomic repair to the tuberosity. Various methods of repair have been used and are described in detail by other authors and reviewed in this issue.

Chronic tendinosis/tendinitis of the biceps does occur with overuse. It generally manifests as chronic pain in the antecubital fossa with use of the elbow. In full pronation, these patients will often display tenderness when the radial tuberosity is palpated through the supinator posterolaterally. The pain is worsened with resisted supination and to a lesser degree, with elbow flexion. Treatment generally consists of a trial of conservative measures geared toward reducing inflammation and improving strength. However, surgical intervention is often necessary because few of these patients will be able to return to full activity with conservative measures alone. Once the decision for surgery has been made, partial ruptures are generally treated with debridement of the tendon itself, its insertion site and the bicipital bursa. Reattachment of the debrided tendon, which may include debridement and detachment of the remaining intact fibers, is critical to the success of this surgical procedure. Recently, some authors have advocated a single posterior approach to treat this condition. Aside from the obvious less invasive nature, this technique may help reduce the complication rates seen with other approaches.[5]

Throwing athletes represent a subset of the general sports medicine population due to the extraordinarily high stresses placed on the elbow and shoulder of the dominant arm. Overhead sporting activities require coordination of a complex series of biomechanical, kinematic, and proprioceptive events to result in the successful execution of the baseball pitch, tennis serve, volleyball spike, etc. These events furthermore incorporate muscle activity that begins in the trunk and lower extremities and concludes with the shoulder, elbow, wrist, and fingers. While medial elbow injury has been extensively documented in this patient/athlete subpopulation, anterior elbow pain is less common in comparison. Furthermore, specific injury to the distal biceps tendon is rare in throwers and has rarely been seen in the senior author's high volume throwing athlete clinical population. However, anterior elbow pain is not uncommon in this patient population and is often confused with distal biceps tendon pathology.

BIOMECHANICS AND KINEMATICS

To more thoroughly explore the causes and potential treatments for anterior elbow pain in the overhead athlete, a discussion of the throwing motion is warranted. The throwing motion has been extensively studied and its kinematics documented. Electromyographical analysis has also been performed on the shoulder girdle, arm and forearm, and the trunk of throwing athletes.[6–9] When muscle activation patterns are correlated with kinematic data, it is easier to grasp what is occurring at the joints of the upper extremity at each point in the throwing motion. As the baseball throwing/pitching motion has the most complete dataset available, we will generalize that data to other overhead sporting activities.

The throwing motion proceeds through a series of stages (Fig. 1). It begins with wind-up, which is defined as the start of the motion that ends when the hands come apart. This phase of the pitch is the necessary catalyst to begin the kinetic chain but does not result in significant stress or opportunity for injury. Early cocking begins with hands apart and ends when the lead foot lands. During this phase, the elbow remains extended with low electromyographic (EMG) activity in the forearm and elbow musculature. Late cocking starts when the lead foot comes down and ends with maximal external rotation of the shoulder. This is the first opportunity for stress to concentrate during the pitch. Upper extremity pathology here is generally found in the shoulder as external rotation increases from 46 to 170 degrees without a change in abduction angle.[10] Through late cocking, the elbow is flexing to a maximum 120 degrees. The biceps brachii shows EMG activity approximately 25% of maximum manual testing levels (% MMT) during this phase.[6]

The acceleration phase of the pitch demonstrates the highest muscular activities and angular velocities. The shoulder internally rotates approximately 100 degrees in 5 hundredths of a second. The subscapularis, serratus anterior, and lattisimus dorsi all show EMG activity close to or above 200% MMT activity. The elbow rapidly extends to 25 degrees in just over 30 ms with corresponding triceps activity reaching its highest level.[6,10] The average angular velocity at the elbow reaches 5000 degrees/s, with peak elbow angular acceleration at 500,000 degrees/s^2. Therefore, it is during this phase of the throwing motion that the ligaments, tendons, and joints see the highest stresses. In fact, it has been demonstrated in in vitro testing that the stress the ulnar collateral ligament (UCL) sees on each pitch exceeds its load to failure.[11] This fact suggests that the musculature about the elbow acts as a dynamic restraint to resist the forces that are generated. Cadaveric and EMG studies have confirmed the importance of the flexor pronator muscle group in protecting the UCL from the valgus forces generated during pitching.[11]

The biceps muscle shows low-to-moderate electrical activity during late cocking, coinciding with peak elbow flexion. Activity peaks at 26% MMT during this phase and then drops off to 20% in acceleration.[6] The activity noted during acceleration most likely represents an attempt by the biceps to resist the rapid extension of the elbow as it, along with the brachialis, form a force couple with the triceps. In normal elbows, it contracts at 26% MMT during deceleration and follow-through. As the forearm is pronating at ball release, the biceps may also act antagonistically to help control this forearm rotation.

The forearm muscles show very high activities throughout the pitching motion as well (Table 1).[7] Activity in the supinator is fairly constant through late cocking, acceleration, and deceleration with between 52% and 57% MMT. The pronator teres reaches 81% MMT during acceleration and remains high through deceleration at over 50%. These data suggest that the supinator may combine with the biceps in deceleration to limit the rapid and forceful pronation of the forearm.

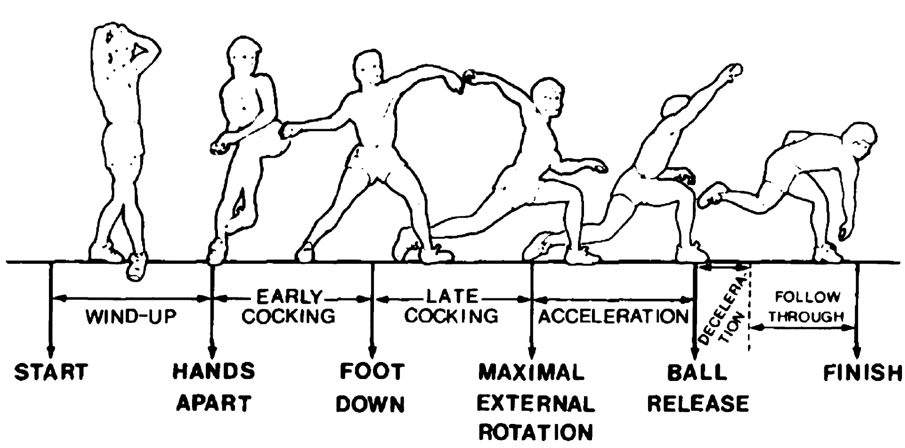

FIGURE 1. The 6 phases of the pitching motion. From *J Shoulder Elbow Surg.* 1996;5:349.

TABLE 1. The % MMT During Fastball for Normal and MCL-deficient Elbows (Mean ± SD)

Muscle	Early Cocking	Late Cocking	Acceleration	Follow-through
FCR				
Injured	16 ± 23	27 ± 33	66 ± 36	39 ± 21
Normal	24 ± 35	47 ± 34	120 ± 66	60 ± 27
Pronator Teres				
Injured	17 ± 17	32 ± 28	69 ± 67	36 ± 8
Normal	18 ± 15	39 ± 28	85 ± 40	34 ± 19
ECRB				
Injured	47 ± 26	128 ± 89	103 ± 80	60 ± 64
Normal	46 ± 26	75 ± 41	55 ± 55	37 ± 22
ECRL				
Injured	39 ± 16	78 ± 28	54 ± 30	31 ± 21
Normal	53 ± 24	72 ± 37	30 ± 20	29 ± 15
Triceps				
Injured	22 ± 23	33 ± 33	65 ± 28	41 ± 14
Normal	17 ± 17	37 ± 32	89 ± 40	42 ± 21
Brachioradialis				
Injured	28 ± 16	44 ± 28	31 ± 20	19 ± 8
Normal	35 ± 20	31 ± 24	16 ± 12	30 ± 21
Supinator				
Injured	30 ± 13	63 ± 40	101 ± 100	101 ± 123
Normal	38 ± 20	54 ± 38	55 ± 31	65 ± 36
Biceps				
Injured	23 ± 29	34 ± 23	25 ± 17	27 ± 18
Normal	22 ± 14	26 ± 20	20 ± 16	26 ± 20

From *Am J Sports Med.* 1992;20(3):313.

ECRB indicates extensor carpi radialis brevis; ECRL, extensor carpi radialis longus; FCR, flexor carpi radialis; MCL, medial collateral ligament; MMT, maximum manual testing.

The medial side forearm musculature has been shown in sectioning studies to play an important role in valgus stability of the elbow[11]. This would imply very high activities in these muscles at points of risk to the UCL. In fact, the flexor carpi radialis and the flexor carpi ulnaris show muscle activity greater than 100% MMT during acceleration and approach 80% during deceleration. Furthermore, the activity in these muscles is accentuated by rapid wrist flexion as the throwing motion approaches ball release.

DIFFERENTIAL DIAGNOSIS OF ANTERIOR ELBOW PAIN

On the basis of the description of the throwing motion and the muscle activity during the pitch, it is evident that the biceps tendon and the anterior elbow is most at risk for injury during acceleration, ball release, and deceleration. At this point, valgus stability is almost exclusively provided by the UCL since the elbow has not extended enough to engage the olecranon in the fossa. However, the pronator teres and the rest of the flexor pronator group of the forearm are at risk. Because biceps activity is at its highest at this point, it is potentially at risk as well.

While isolated biceps pathology is rare in the throwing athlete, anterior elbow pain is not. A discussion of the differential diagnosis and treatment of anterior elbow pain is therefore warranted. The examining physician must be keenly aware of the complex anatomy of the antecubital fossa and the proximal volar forearm and be able to correlate anatomical structures with the disability. Anterior elbow pain can involve tendons, bursae, and nerves. All of these structures must be evaluated and ruled out when a throwing athlete complains of symptoms in the vicinity of the distal biceps tendon.

Distal biceps tendonitis in throwing athletes would present just as it does in other active individuals. Athletes may report progressive pain during throwing that continues after they have stopped the activity. Stiffness in and around the antecubital fossa, tenderness to palpation, and deep soreness are usually present. Throwers may have a flexion contracture and minor edema in the forearm. There may be tenderness to palpation of the biceps tendon. Direct palpation through the supinator on the posterolateral aspect of the forearm in full pronation can also cause pain. Pain with resisted elbow flexion and supination are usually present.

While this diagnosis is rare in throwers, treatment would proceed in the same fashion as it does for other active individuals. Rest, anti-inflammatory medication, ice, compression, and elevation can be combined with local modalities to speed recovery. Pitchers should be shut down for 2 to 6 weeks to allow for resolution of the symptoms, especially at less competitive levels and in younger athletes. If conservative treatment fails, then magnetic resonance imaging can help to demonstrate partial tearing in the tendon. Significant partial tears that have not responded to rest are generally best treated with surgical intervention once the diagnosis is confirmed.[5,12,13] Recently, good success has been reported with surgical repair through a single posterior incision.[5]

A more common cause of anterior elbow pain in a thrower that can be confused with distal biceps pathology is lateral antebrachial cutaneous nerve (LABCN) compression syndrome. The LABCN is a continuation of the musculocutaneous nerve that becomes superficial at the anterolateral aspect of elbow between the biceps and the brachialis muscle. Usually the nerve pierces the brachial fascia about 3 cm proximal to the lateral epicondyle, and provides sensory innervation to lateral aspect of forearm. In throwers, the nerve can be compressed on the lateral edge of the biceps just proximal to the elbow. This condition was first described in throwing athletes in 1982[14] and is sometimes referred to as Bassett's Lesion. Distally, the nerve can be tented by the large vessels in the antecubital fossa. Patients often complain of anterolateral elbow pain and paresthesias in the LABCN distribution. Symptoms are exacerbated with forced pronation and extension, which corresponds to ball release during the throwing motion. Electrodiagnostic studies typically document prolonged distal latency and/or decreased amplitude in the LABCN distribution but are rarely necessary to confirm the clinical diagnosis.[15]

A short course of conservative treatment is warranted and should include rest, ice, nonsteroidal anti-inflammatory medication, and activity modification. Local corticosteroid injection at the lateral edge of the biceps tendon has been attempted as well.[15] However, few patients will have complete resolution of their symptoms with conservative care alone[15,16] and most will require surgical release of the nerve. The technique for release begins by identifying the nerve as it exits the bicipital aponeurosis just proximal to the elbow joint (Fig. 2). Blunt dissection between the brachialis and biceps followed by retraction of the biceps medially will expose the nerve. With the arm in extension and pronation, the site of compression on the edge of the biceps tendon can be identified. A small wedge of tendon can be excised to relieve the tenting of the nerve (Fig. 3). The patient should be splinted for the immediate postoperative period and can usually return to full activities in 2 to 3 weeks.[15,17] Reported results are universally good with complete relief of symptoms.[15–17]

Median nerve compression in the proximal forearm is also a more common cause of anterior elbow pain in an athlete that may present similarly to biceps pathology. Entrapment of the nerve can occur at multiple structures including between the heads of the pronator teres (pronator syndrome), under the lacertus fibrosis (lacertus syndrome), and at the flexor digitorum superficialis (FDS) arch. Regardless of the site of compression, throwers present with an insidious onset of pain in the

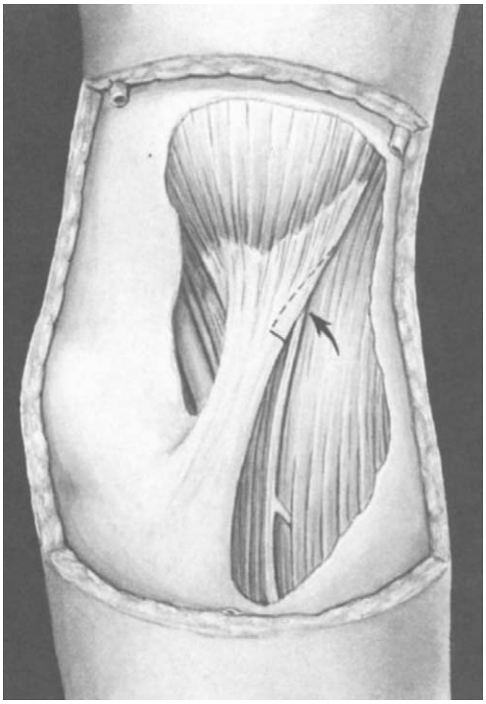

FIGURE 2. Intraoperative findings. Focal compression of lateral antebrachial cutaneous nerve by biceps aponeurosis is present (arrow). Solid transverse line represents location of relaxing incision. Dashed line represents line along which proximal triangular flap was folded. From *J Shoulder Elbow Surg.* 1996;5(4):331.

FIGURE 3. Completed procedure. Compression on LABCN relieved by reflecting triangular flap of aponeurosis and tendon medially and suturing to remaining tendon. Focal hyperemia and narrowing of LABCN was present. From *J Shoulder Elbow Surg.* 1996;5(4):331. LABCN indicates lateral antebrachial cutaneous nerve.

anterior elbow. It may be associated with paresthesias or weakness in the median innervated muscles and distribution. Pain is worsened with repetitive pronation, wrist flexion, and elbow extension. Recall this is the position of the upper extremity at ball release and into follow-through. Continued throwing once the symptoms have started can result in weakness in the hand and usually forces the athlete to stop throwing.

Physical examination reveals tenderness in the proximal anterior forearm. There may be edema or firmness on palpation as well. In cases where patients present with neurologic complaints in the hand and wrist, it is critical to differentiate proximal median nerve compression from carpal tunnel syndrome. The forearm compression test relies on direct compression of the nerve over the proximal portion of the forearm to reproduce symptoms.[18]

To better identify the site of compression, 3 tests are commonly used (Fig. 4). Resisted pronation with elbow flexion and wrist flexion will increase symptoms caused by compression at the pronator muscle itself. Pain in the proximal forearm that is increased with resisted supination and elbow flexion indicates the lacertus fibrosis as the site of the lesion. Finally, resisted flexion of the long finger at the proximal interphalangeal joint will stress the FDS arch and indicates entrapment here.[18,19] Using history and physical examination, the majority of cases are easily diagnosed clinically. Electrodiagnostic testing

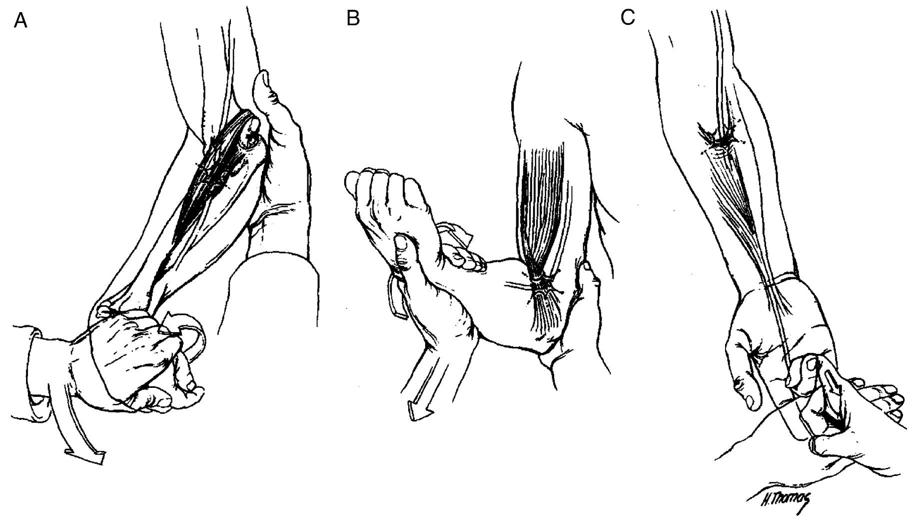

FIGURE 4. Features of the physical examination that help to demonstrate the so-called pronator syndrome. A, Proximal forearm pain is increased by resistance to pronation and elbow flexion as well as to flexion of the wrist. B, Pain in the proximal forearm that is increased by resistance to supination is also suggestive of compression by the lacertus fibrosis. C, Resistance of the long finger flexor produces pain in the proximal forearm when compression of the median nerve occurs at the flexor digitorum superficialis arch. From *The Elbow and Its Disorders*. 3rd ed. Philadelphia: W.B. Saunders; 2000:855.

has historically added little to the diagnosis of proximal median nerve entrapment.[20]

Treatment of pronator syndrome begins with a trial of conservative therapy.[21] This includes activity modification or cessation, immobilization, and anti-inflammatory medication and modalities. Steroid injections are generally not performed and have not been shown to be beneficial.[22] As with most soft tissue injuries, a physical therapy program can begin after the acute symptoms have diminished.

If conservative therapy fails, then surgical release is indicated. Release proceeds from proximal to distal starting with identification of the nerve just medial to the brachialis (Fig. 5). The lacertus fibrosis is released and the nerve followed to the superficial head of the pronator. The fibrous bands between the heads of the pronator should be released. If visualization of the nerve is limited, the superficial head may need to be detached and tagged for later reattachment. Continuing distally, the FDS arch is incised and any potential compression further distal is evaluated (Fig. 5). Postoperatively, the extremity is immobilized with the wrist slightly flexed, and the elbow in flexion and pronation for 1 week. No resistance exercises are begun until 6 weeks after the operation. Return of complete function can take up to 6 months, especially if there was strength loss preoperatively.

Radial tunnel syndrome and posterior interosseous nerve compression syndrome may also lead to forearm

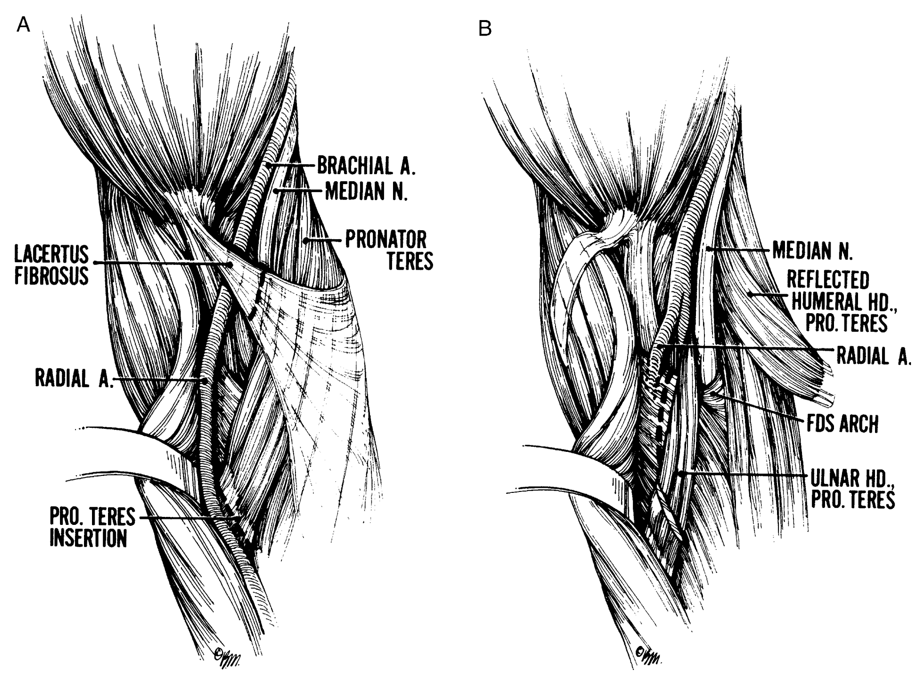

FIGURE 5. A, Distal course of the nerve under the lacertus fibrosis. B, Median nerve coursing deep to the flexor digitorum superficialis arch. From *The Athlete's Elbow*. Philadelphia: Lippincott Williams and Wilkins; 2001:135.

pain in a throwing athlete. These are not easily mistaken for biceps pathology but must be evaluated during the differential diagnosis of anterior elbow pain in an athlete. Brachialis bursitis, or climber's elbow, can be mistaken for distal biceps pathology. This condition causes pain in elbow flexion at the insertion of the brachialis on the coronoid. It is rare in throwers.

CONCLUSIONS

Despite the activity of the musculature around the elbow and the high angular velocity and stresses, distal biceps tendon injury is rare in the overhead athlete. Anterior elbow complaints are not uncommon in this population and can easily be mistaken for distal biceps pathology. Nerve compression syndromes involving the LABCN, the median nerve, and the radial nerve can all present as a cause for pain in the throwing athlete. It is important for the team physician to understand the biomechanics of the throwing motion and how that related to possible pathology about the elbow. This knowledge, combined with physical examination, radiographic imaging, and electrodiagnostic studies will lead the physician and athlete to an accurate diagnosis quickly. Appropriate treatment can then be initiated to return the athlete to the field of play safely and quickly.

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