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CLINICAL COMMENTARY

REHABILITATION FOLLOWING DISTAL BICEPS REPAIR

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ABSTRACT

Background and Purpose: Distal biceps rupture is less common than injury to the proximal biceps; however, injury distally has profound functional implications on activities which rely on power during elbow flexion and forearm supination. The majority of distal biceps ruptures can be treated with surgical repair of the distal biceps utilizing either a single or two-incision technique; both of which achieve comparable improved outcomes and reported minimal pain and disability at two years. Safe and effective rehabilitation following distal biceps repair is accomplished through a phased progression, with avoidance of premature stress to the healing soft tissue repair.

The purpose of this clinical commentary is to provide a concise review of distal biceps tendon injury, including relevant anatomy, etiology, diagnosis, and operative intervention as well as post-operative factors influencing the pursuit of a criterion based, progressive rehabilitation program after distal biceps tendon repair. This commentary seeks to provide an update on current treatment strategies used in distal biceps rehabilitation with accompanying scientific rationale.

Level of Evidence: 5

Key words: Distal biceps tendon rupture, distal biceps tendon surgical repair, rehabilitation

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INTRODUCTION

Distal biceps tendon ruptures are rare injuries that may have significant functional sequelae. Debate continues regarding optimal treatment as historical reports comparing operative and conservative treatment outcomes suggest acceptable function following non-operative treatment.[1] As knowledge of native anatomy and fixation methods have progressed, results following operative fixation have improved when compared to non-operative fixation, particularly in the high-demand patient population.[2] Currently, operative fixation is recommended in the majority of cases, and operative management of distal biceps pathology mandates a working knowledge of native anatomy and biomechanical factors for appropriate repair and rehabilitation. The purpose of this clinical commentary is to provide a concise review of distal biceps tendon injury, including relevant anatomy, etiology, diagnosis, and operative intervention as well as post-operative factors influencing the pursuit of a criterion based, progressive rehabilitation program after distal biceps tendon repair. This commentary seeks to provide an update on current treatment strategies used in distal biceps rehabilitation with accompanying scientific rationale.

EPIDEMIOLOGY

Distal biceps tendon ruptures are reported as occurring on the dominant arm of male patients between the third and sixth decades of life.[3] Safran et. al projected an incidence of 1.2 distal biceps tendon ruptures per 100,000 patients per year. They found that the injury occurs in the dominant extremity 86% of the time and smokers have a 7.5 fold greater risk of injury than nonsmokers.[3] Anabolic steroid use and local corticosteroid injection have also been proposed as risk factors for distal tendon rupture.[4,5]

ANATOMY

The biceps brachii muscle and tendon is comprised of two heads. The long head of the biceps tendon originates from the supraglenoid tubercle on the scapula. The long head of the biceps receives its proximal blood supply from the ascending branches of the anterior humeral circumflex artery and from the brachial and deep brachial arteries distally.[6] The short head originates from the coracoid process of the scapula. The two heads merge into a single unit at the level of the deltoid tuberosity and insert distally onto the bicipital tuberosity on the proximal radius with the long head contribution extending over the distal aspect of the tuberosity.[7] The proximal tendon is stabilized by soft tissue constraints collectively known as the biceps pulley, a complex comprised of a portion of the rotator cuff (supraspinatus and subscapularis tendons), coracohumeral ligament, and pectoralis major insertion.[8] Distally, the lacertus fibrosus originates from the distal tendon and expands ulnarly in three distinct layers superficially, forming a distal biceps aponeurosis with the fascia of the forearm, which acts as a stabilizer to the distal tendon.

Several publications have emphasized the anatomic footprint and functional anatomy of the distal biceps insertion, including the predictable orientation of fibers rotated in the coronal plane —clockwise in left elbows and counterclockwise in right.[7,9] Anatomic research on the dimensions of the biceps insertion and the orientation of the radial tuberosity[10-12] have developed the surgeon's understanding of native anatomy and fine-tuned goals of anatomic fixation during repair.

ETIOLOGY

The etiology of distal biceps ruptures remains an area of active investigation. Current theories posit both anatomic and mechanical causes for rupture. Seiler et el[13] examined these proposed mechanisms in a study involving both radiographic and anatomic components. Twenty-seven cadavers received vascular injections into the blood supply of the distal biceps tendon, revealing a zone of hypovascular tissue measuring approximately 2.14 cm in diameter between the musculotendinous junction and the attachment to the tuberosity. This hypovascular zone corresponded to areas of focal degeneration on light microscopy.[13] The radiographic portion of the same study included computed tomography (CT) comparisons scans of forearm in positions of maximal supination, neutral, and maximal pronation. With the forearm fully pronated, the space for the distal biceps tendon insertion and its course is 48% less than the space available with the forearm in full supination. Accordingly, mechanical impingement on the tendon with the forearm in a pronated position is suggested as another contributing factor of distal biceps tendon rupture.

DIAGNOSIS/IMAGING

Patients often report a sudden "pop" during time of injury following an unexpected extension force to the flexed elbow, often with the forearm pronated. There is subsequent eccentric contraction of the biceps and a sharp tearing pain in the antecubital fossa. After the immediate pain resolves, the patient may complain of continued subtle weakness with elbow flexion and a marked decrease in supination strength, highlighting the biceps role as the forearm's primary supinator.[3] An early and accurate diagnosis is essential, as delayed diagnosis may preclude primary repair and lead to chronic weakness. The biceps squeeze test described by Ruland et al[14] is analogous to the Thompson test for the Achilles tendon,[15] and is performed by squeezing the biceps brachii when the elbow is flexed to 90 degrees to elicit forearm supination if the distal tendon is intact. The hook test developed by O'Driscoll et al[16] is also useful for the diagnosis of complete biceps tendon disruptions. O'Driscoll describes inserting the clinician's finger under the lateral edge of the biceps tendon and hooking the cord-like prominence in the antecubital fossa with the patient's elbow flexed at 90 degrees. This test had 100% sensitivity and specificity in the original cohort of forty-five patients with patients found to have a complete tendon rupture, confirmed during surgical exploration of the tendon and compared to the contralateral, intact upper extremity. It is important to emphasize probing the lateral edge of the biceps tendon, as an intact lacertus fibrosis encountered during a medial approach may be mistaken for an intact tendon. The 100% sensitivity and specificity of the O'Driscoll hook test was higher than the 92% sensitivity and 85% specificity of magnetic resonance imaging (MRI) in the same cohort. Plain radiographs are only occasionally helpful as distal biceps tendon rupture is primarily a soft tissue structure, although occasionally an avulsion fragment may be visible from the radial tuberosity. Suspected incomplete ruptures or chronic tears can be further eludicated with MRI. Giuffre` and Moss describe the flexed abducted supinated (FABS) position for MRI of the distal biceps tendon. This position was described as 90 degrees of elbow flexion, 180 degrees of shoulder abduction, and relative forearm supination.[17]

SURGICAL MANAGEMENT

Surgical repair is ideally performed within a few weeks from injury. A delay in surgical management may necessitate a more extensive surgical approach with reconstruction due to chronic tendon retraction and formation of scar tissue. Surgical approaches for distal biceps tendon repair include single-incision and two-incision techniques. Single-incision approaches are performed at or immediately distal to the transverse elbow crease in the antecubital fossa. Incisions may be transverse, longitudinal, or L-shaped depending on surgeon preference. The incision may be extended proximally if needed to ensure adequate exposure in delayed surgical repair or in revision cases. The single-incision technique is associated with lateral antebrachial cutaneous nerve (LACN) neuropraxia due to a more extensive dissection and longer duration of deep anterior retractor placement.[18] The two-incision approach has a similarly placed, albeit smaller, anterior incision as well as a posterolateral incision to expose the radial tuberosity with subperiosteal elevation of the common extensor muscle mass off the ulna. Although there are several modifications to the two-incision approach, it is reported to be associated with posterior interosseous nerve (PIN) injury and heterotopic ossification which may lead to proximal radioulnar synostosis.[19]

There are a variety of techniques to repair the distal biceps to the radial tuberosity. Using the single incision approach, fixation may be performed using suture anchors, an interference screw, a cortical button, or a combination of these methods. If the two-incision method is used, the tendon is generally secured to the biceps tuberosity with high-strength sutures through multiple bone tunnels.[20] The cortical button has been shown to be have the highest load to failure, but is associated with undesired tendon motion at the insertion site with cyclic loading.[21] This may predispose the repair to gap formation at the insertion site, especially with early motion. Sethi et al[22] reported good outcomes on the use of a cortical button in combination with an interference screw; this augmented construct benefits from the strength of the cortical button while the interference screw prevents tendon motion and gap formation at the insertion. Use of this type of dual fixation may allow for a more aggressive post-operative rehabilitation protocol.[23]

In patients with chronic distal biceps injuries and tendon retraction, primary fixation to the radial tuberosity may not be possible. In this situation, the use of autograft or allograft should be considered to lengthen the distal end of the biceps tendon and permit anatomic fixation to the radial tuberosity. Due to harvest site morbidity associated with autografts, allografts (anterior tibialis, achilles or semitendinosus tendon) are more commonly used.

Watson et al,[24] in a systematic review of 22 studies summing 494 patients (498 elbows) who underwent distal biceps repair, reported an overall surgical complication rate of 24.5%. There was no significant difference in complication rates between the single and two-incision techniques. LACN neuropraxia occurred in in 11.6% of patients who underwent repair via the single-incision approach, whereas only 5.8% of the two-incision group experienced LACN neuropraxia. Heterotopic ossification occurred in 7% of patients who had the two-incision approach, and only 3.1% in the single incision group. A lower rate of complications was associated with cortical button fixation (0 of 18) when compared with intraosseous screw fixation and suture anchor fixation. Re-rupture occurred in 1.6% of cases overall, and there was no difference in re-rupture rates between the single and two-incision groups.

Grewal et al[25] reported in a randomized prospective study that patients in her single-incision group had 10% better final isometric flexion strength (104%) compared to the two-incision group (94%), although there were no differences in the rate of strength recovery, ASES, DASH, or PREE scores. Both the single and two-incision groups achieved comparable improved outcomes and reported minimal pain and disability at two years.

REHABILITATION

Progression of Rehabilitation Phases

The post-operative rehabilitation protocol for distal biceps repair utilized at the senior author's (MTP) institution has been provided (Appendix 1). A standard therapy program progresses through sequential phases of rehabilitation, including an acute recovery phase, an intermediate phase featuring motion progression and onset of light isotonics, an advanced strengthening phase, and lastly, a phase focused on return to preferred activity. Each phase must be tailored to the individual patient's needs and restrictions. Temporal phase progressions are provided for guidance; however, the treating therapist should evaluate the patient's readiness to advance at each phase change. Progression of the protocol should be performed under the careful supervision of a rehabilitation team, with strong communication between treating providers. A complaint of persistent or recurrent pain and/or swelling indicate inappropriate phase progression. The overall principles guiding rehabilitation of the distal biceps tendon repair include protection of the tendon from excess load, followed by the safe and step-wise return to activities of daily living and sport.

Bracing and Early Range of Motion

Bracing is implemented post-operatively to protect the soft tissue repair (Appendix 1). Range of motion parameters are established intra-operatively. In the case of a retracted distal biceps tendon, the surgeon may initially limit extension range of motion and progress to full extension based on the amount of tension present in the repaired tendon over four to six weeks. In these cases of restricted extension range of motion, a hinged elbow brace may be implemented to help the patient maintain these parameters.

Phase I: Early Recovery (Weeks 0 to 6)

Early goals include pain and effusion reduction, protection of the surgical repair, and optimization of the tissue healing environment. Cryotherapy should be used and may be incorporated via multiple mediums, including ice massage, ice packs, cold whirlpool, or the Cryo-Cuff, for durations of 5 to 20 minutes with careful attention to avoid skin irritation.[18] Hand and wrist range of motion and gripping exercises should begin immediately, and may include rubber ball squeezing or simple daily tasks such as using a smart phone. Shoulder girdle range of motion is also encouraged to avoid shoulder pain and stiffness and allow hygiene, including glenohumeral and scapulothoracic passive and active motion. Patients may perform computer work/typing; but must refrain from any lifting with their operative extremity. No active elbow flexion or supination is permitted, including tasks such as drinking coffee or feeding. Gravity-assisted flexion and extension may begin at two weeks post-operatively; with restriction in the full arc of motion if an extension limitation has been determined necessary. Contraindication to progression to phase II of the rehabilitation protocol includes persistent or recurrent pain and/or swelling.

Cardiovascular fitness training, such as using a treadmill or elliptical, also be introduced as early as week one post-operatively and is recommended to enable continued overall health; however, the treating therapist must place emphasis on safety and balance in order to avoid a fall onto the operative extremity.

Phase II: Weeks 6 to 12

Isometric triceps exercises (Figure 1) may begin at six weeks post-operative with isotonics beginning at week 8. Strengthening of wrist flexion and extension and the shoulder girdle may also commence at week 8. In addition to traditional isotonics, correction of underlying scapulothoracic dyskinesia to promote proper biomechanics of the shoulder girdle during upper extremity elevation should be incorporated. Postural control exercise (Figure 2) is an essential foundation prior to the strengthening progression included in Phase III.

Phase III: Weeks 12 to 16

At the start of Phase III, biceps isometrics begin, followed by light biceps isotonics at week 16 (Figure 3). Continuation of rotator cuff and periscapular stabilization exercises enable maintenance of overall upper extremity and postural health and promote proper mechanics as the patient advances to more complex exercises and activities. Inclusion of both open and closed kinetic chain exercises is essential, as activity of shoulder girdle musculature demonstrates significant electromyographic (EMG) differences when activated in exercises performed in an open versus closed kinetic chain.[19,20]

Phase IV: Week 16 +

Biceps strengthening is advanced to include side curls (Figure 4). Upon attainment of full upper extremity strength, readiness to return to sport may be assessed on a sport-specific basis. No specific

Figure 1. *Triceps Isometric*
Begin in a seated position with the forearm on an adjacent table with palm down. While keeping the ipsilateral shoulder girdle relaxed, push the entire forearm and palm into the talbe. Hold for 10 seconds and repeat for 10-15 repetitions, 3-5 sets.

Figure 2. *Postural Control*
Begin prone on the ball as pictured. While maintaining a neutral spine and a relaxed cervical spine, abduct and externally rotate the shoulder. Pinch the scapulae together and hold for 3 seconds. Repeat 10-15 repetitions, 3-5 sets.

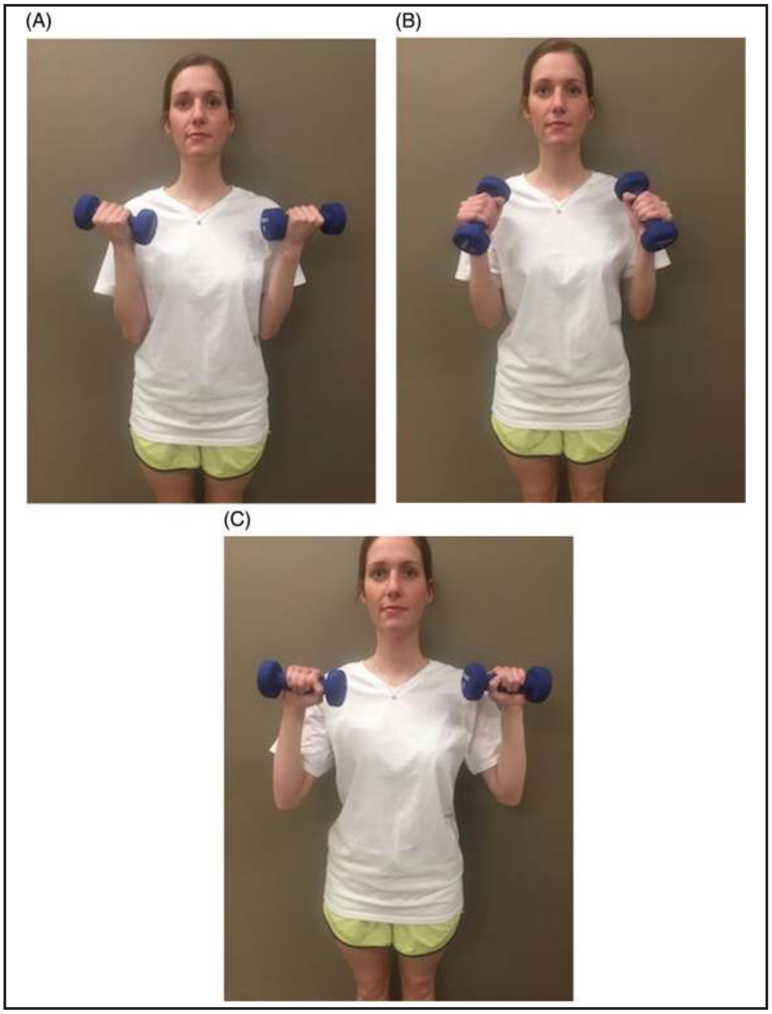

Figure 3. *Traditional Biceps Curls, Hammer Biceps Curls and Reverse Biceps Curls*
3A: Begin in standing with palms facing outward. While keeping the shoulders relaxed, bend the elbows and perform traditional biceps curls. Repeat 10-15 repetitions, 3-5 sets.
3B: Begin in standing with palms facing toward the body. While keeping the shoulders relaxed, bend the elbows and perform hammer biceps curls. Repeat 10-15 repetitions, 3-5 sets.
3C: Begin in standing with palms facing backward. While keeping the shoulders relaxed, bend the elbows and perform reverse biceps curls. Repeat 10-15 repetitions, 3-5 sets.

test for return to sport following distal biceps repair exists; instead therapists must assess the quality and strength of movements specific to the preferred sport. At this stage, therapists are encouraged to employ creativity in designing a gym program focused on functional movement patterns that include the upper body, lower body and trunk prepare the individual for return to their preferred activity. Criteria for return to activity include full and painless range of motion, strength within 10% of the contralateral upper extremity and pain-free participation in activity-specific movement patterns.

SUMMARY

The purpose of this clinical commentary was to present a detailed rehabilitation protocol following distal biceps repair. Distal biceps rupture is a debilitating injury and restoration of function can be successfully achieved with proper surgical technique, followed by a criterion based, progressive rehabilitation. This rehabilitation program progresses through phases with objective criterion requirements being met prior to advancement. The ultimate goal of rehabilitation of a distal biceps repair is to optimize the patient's function and their ability to return to their desired work and recreational activities.

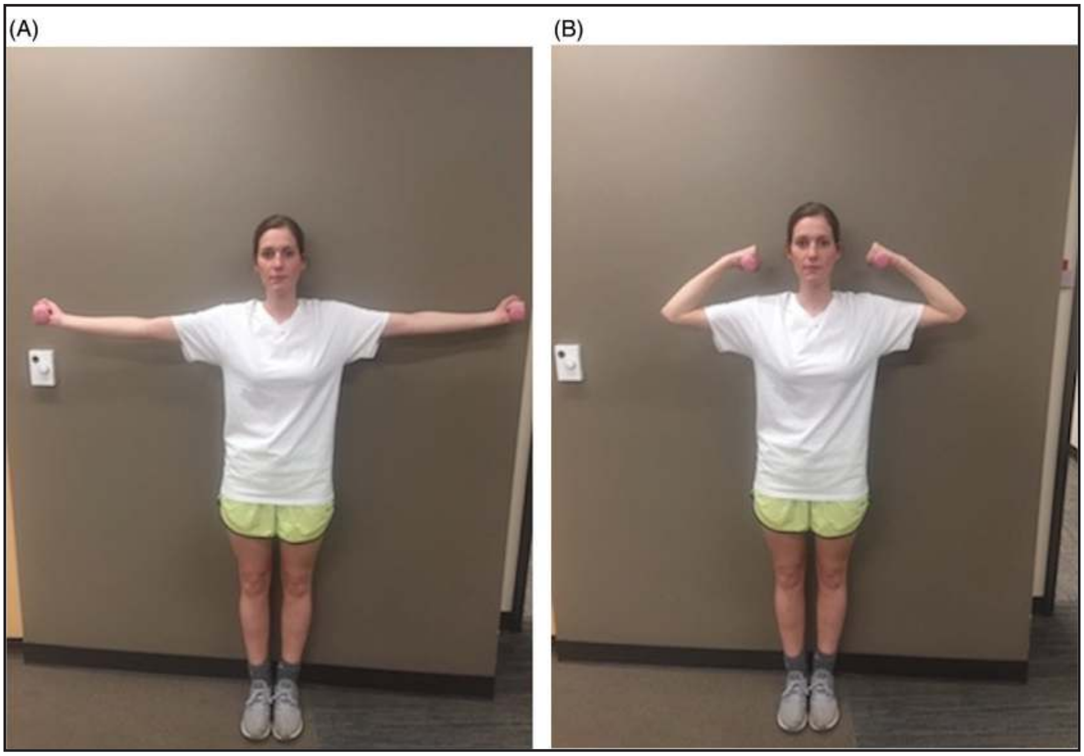

Figure 4. *Figure Biceps Side Curls, position 1 and 2*
4A: Begin in standing, begin with the arms at 90 degrees of flexion and 90 degrees of abduction with palms facing upward.
4B: Maintain a relaxed shoulder girdle and cervical spine while flexing the elbows as shown in 4b. Repeat 10-12 repetitions, 3-5 sets.

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Appendix 1. *Distal Biceps Repair Protocol.*

Phase I

0 to 6 weeks after surgery	
	Precautions: • Range of motion (ROM) parameters established intra-operatively, standardly 0-90 degrees passive is allowable for the first two weeks • Brace for protection until 6 weeks with progressive allowance of ROM • No lifting with operative extremity • No active elbow flexion or supination
	Goals: • Full, pain-free range of motion by week 6
	Therapeutic Exercises: • Elbow range of motion as prescribed • Hand/wrist range of motion and edema control • Scapular retraction/protraction/elevation/depression • Gravity-assisted flexion and extension (begin at week 2) • Cardiovascular fitness (treadmill walking, elliptical without arm use, bike)
Criteria for Progression	Prior to advancing to Phase II of the rehabilitation protocol, contraindication to progression of the protocol includes persistent or recurrent pain and/or swelling.

Phase II

6 to 12 weeks after surgery	
	Precautions: • No lifting with operative extremity • No active elbow flexion or supination
	Goals: • Maintenance of proper scapulothoracic mechanics • Initiation of upper extremity strengthening
	Therapeutic Exercises • Isometric triceps exercises (Figure 1) • Isotonic triceps exercises (begin week 8) • Strengthening of wrist flexors and extensors (begin week 8) • Postural control exercises (Figure 2)
	• Scapular retraction/protraction • Cardiovascular fitness (treadmill walking, elliptical without arm use, bike)
Criteria for Progression	• Full, painless range of motion of the shoulder, elbow, wrist and hand. • Proper scapulothoracic mechanics (no dyskinesia).

Appendix 1. *Distal Biceps Repair Protocol. (continued)*

Phase III

12 to 16 weeks after surgery	
	Precautions: • None
	Goals: • Increase functional strength of upper extremity
	Therapeutic Exercises • Isometric biceps exercises • Light isotonic biceps exercises (begin at week 16) (Figures 3A-C) ○ Hammer ○ Traditional ○ Reverse grip • Rotator cuff and periscapular stabilization exercises ○ Open and Closed Kinetic Chain • Cardiovascular fitness (treadmill walking, elliptical with or without arms, bike)
Criteria for Progression	• Full, painless range of motion of the shoulder, elbow, wrist and hand. • Proper scapulothoracic mechanics (no dyskinesia). • Full biceps strength against gravity (5/5 manual muscle test)

Phase IV

16+	
	Precautions: • None
	Goals: • Continue to increase strength of upper extremities • Return to preferred sport and/or activity
	Therapeutic Exercises • Biceps curls ○ Hammer ○ Traditional ○ Reverse
	○ Side Curls (Figures 4A,B) • Triceps extensions • Rotator cuff and periscapular strengthening exercises • Sport-specific exercises • Cardiovascular fitness (treadmill walking, elliptical with or without arms, bike)
Criteria for Progression	**Functional / Sport Testing for discharge to maintenance program**