The Biceps Crease Interval for Diagnosing Complete Distal Biceps Tendon Ruptures

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Abstract Complete distal biceps tendon ruptures require prompt surgical management for optimal functional and aesthetic outcome. The need exists for a valid and reliable diagnostic tool to expedite surgical referral. We hypothesized complete distal biceps tendon ruptures result in an objectively measurable anatomic landmark (the distance between the antecubital crease of the elbow and the cusp of distal descent of the biceps muscle, or the biceps crease interval), as a result of proximal retraction of the musculotendinous complex. We established normal biceps crease interval values and biceps crease ratios between dominant and nondominant arms in 80 men with no history of biceps injury (average age, 43 years). The mean ($\pm$ standard deviation) biceps crease interval for dominant and nondominant arms was 4.8 ± 0.6 cm. The mean biceps crease ratio was 1.0 ± 0.1 . We measured the biceps crease interval and biceps crease ratio on 29 consecutive patients presenting with a possible complete distal biceps tendon rupture. Using a diagnostic threshold of a biceps crease

interval greater than 6.0 cm or biceps crease ratio greater than 1.2, the biceps crease interval test had a sensitivity of 96% and a diagnostic accuracy of 93% for identifying complete distal biceps tendon ruptures, making it a valid and reliable tool for clinicians to identify cases requiring urgent surgical referral.

Level of Evidence: Level II, diagnostic study. See the Guidelines for Authors for a complete description of levels of evidence.

Introduction

Rupture of the distal biceps tendon predominantly affects men between 40 and 60 years of age and occurs when a large extension force is applied to the elbow, often from a flexed and supinated position [1–3, 16, 19]. Once believed to be rare, studies during the last several decades have suggested an increase in the number of cases of distal biceps tendon ruptures, and a decrease in the age of those injured [1, 2, 6, 16, 19]. Unlike other tendon ruptures, which can occur intrasubstance or at the musculotendinous junction, a complete distal biceps tendon rupture almost always occurs at the tendon's insertion to the radial tuberosity. The functional superiority of anatomic surgical repair for this injury is now well established and has gained acceptance as the preferred treatment option for restoring strength in supination and flexion [2, 5, 12, 13, 14, 16]. If surgical treatment of a complete distal biceps tendon rupture is delayed, a combination of muscle retraction, adhesion formation, distal tendon shortening, and degeneration can make anatomic reinsertion of the original tendon difficult [14, 16, 22]. Outcome comparisons of acute and chronic repairs suggest a surgical delay greater than 10 days postinjury increases the risk of complications

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Each author certifies that his or her institution has approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

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and the extent of anterior dissection required [9, 20]. Therefore, the earlier patients with suspected complete distal biceps tendon ruptures are referred to a surgeon, the more likely they are to have surgery and experience positive postoperative outcomes.

Although the incidence of distal biceps tendon ruptures is increasing, the first clinician to assess these patients may not see these injuries routinely enough to have confidence in accurately diagnosing complete versus partial ruptures. The current literature does not objectively characterize or quantify alterations in the normal physical findings that might clinically distinguish a complete rupture from other possible injuries, such as a partial rupture or strain. Therefore, clinicians often request corroborative radiographs before initiating an urgent referral for surgical consultation.

Although MRI is considered the gold standard in diagnosis of distal biceps ruptures and has been shown to reliably distinguish complete from partial ruptures, the additional costs and time delays associated with acquiring this imaging, before referral to a qualified surgeon, can compromise positive surgical results [7, 9, 20]. A review of the senior author's (AE) practice revealed greater than half of the patients presenting with possible complete distal biceps tendon ruptures were being referred to our clinic more than 10 days after the initial injury. We believed development of an objective, clinical assessment tool that could reliably identify cases of complete rupture would assist clinicians in providing more rapid surgical referral without the need for prior confirmatory imaging.

We hypothesized proximal retraction of the biceps tendon in a complete rupture would lead to an objectively measurable and reliably diagnostic change in surface anatomy. Ten cases of distal biceps tendon rupture evaluated by MRI with the forearm fully extended and supinated, found that greater than 8 cm of retraction of the distal tendon from the radial tuberosity was associated with a complete rupture [11]. This provided the foundation for the biceps crease interval (BCI) test, which objectively measures and quantifies the BCI, ie, the distance between the antecubital crease of the elbow and the cusp of distal descent of the biceps muscle (Fig. 1). The BCI test was developed by the senior author (AE) to facilitate prompt surgical referral of complete distal biceps ruptures and allow a definitive diagnosis to be made.

The primary objective of our study was to evaluate the diagnostic validity and reliability of the BCI test in an injured population. To establish diagnostic thresholds indicative of a complete distal biceps tendon rupture, it was important to first evaluate the interrater reliability of measuring the BCI and determine the average BCI and its ratio between dominant and nondominant arms in healthy (normal) control subjects. The analysis of normal subjects allowed us to apply the BCI and the BCI ratio between

arms (biceps crease ratio, or BCR) as objective diagnostic components of the BCI test to evaluate specificity, sensitivity, and positive and negative predictive values.

Materials and Methods

After receiving institutional ethics board approval, we recruited a control group of 80 healthy male volunteers between the ages of 26 and 72 years (average [$\pm$ standard deviation] age, 43 ± 11.4 years). Subjects were provided with an initial screening questionnaire documenting age, arm dominance, occupation, and any history of biceps injury or surgery. Arm dominance was defined as the primary arm used to perform functional activities. Seventy-one of the subjects were right-handed and nine were left-handed. Subjects with a history of biceps injury were excluded from the study. An independent researcher (AC) measured the biceps circumference of each arm at its maximal point with the elbow in full extension and the forearm in full supination. With arm dominance controlled as a confounding factor, there was no major difference in biceps circumference measurements between right and left arms (Table 1).

Subjects then were asked to move sequentially among three separate examiners (AE, KT, SC) who measured and documented the normal biceps crease interval (N-BCI) of each subject's right and left arm in centimeters. Examiners were blinded to each other's results, and all marks of surface anatomy made during testing were removed with rubbing alcohol before subjects moved to the next examiner. Each examiner had a different degree of medical training (medical student, physical therapist, or upper extremity orthopaedic surgeon [AE]) and had received a written description and demonstration of the technique of BCI measurement before conducting the study (Fig. 1).

Each examiner recorded right and left arm N-BCI values, resulting in a total of six N-BCI measurements for each control subject. The measured values were divided into right and left arm-dominant groups and independent two-tailed *t* tests were used to identify any variance in the mean N-BCI based on arm dominance. Arm dominance appeared to have no major impact on the measurement of the N-BCI (Table 2). An intraclass correlation coefficient (ICC) was calculated to establish interrater reliability, comparing right arm and left arm N-BCI measures among examiners. Comparison of N-BCI values recorded by the three examiners resulted in ICCs of 0.755 and 0.833, respectively. An ICC greater than 0.70 was deemed indicative of acceptable interrater reliability [4]. Having met this threshold, we averaged all three examiners' N-BCI values from both arms to establish an overall mean N-BCI value. As an internal control against variability in the

Fig. 1 The technique for performing the BCI test is shown. **Table 1.** Effect of arm dominance on biceps circumference in control subjects

Arm dominance	Biceps circumference (cm) (n = 80)*		t test value	p value
	Right arm	Left arm		
Right (n = 71)	27.0 ± 2.2	26.9 ± 2.2	0.49	0.6
Left (n = 9)	27.7 ± 2.1	28.3 ± 2.7	−0.53	0.6

* Values expressed as mean ± standard deviation.

Table 2. Effect of arm dominance on N-BCI and N-BCR in control subjects

Parameter	Right arm dominant*	Left arm dominant*	t test value	p value
N-BCI (cm) (right arm)	4.8 ± 0.62	4.7 ± 0.66	−0.36	0.72
N-BCI (cm) (left arm)	4.8 ± 0.69	4.7 ± 0.79	−0.47	0.64
N-BCR	1.0 ± 0.07	1.0 ± 0.08	0.19	0.85

* Values expressed as mean ± standard deviation; N-BCI = normal biceps crease interval; N-BCR = normal biceps crease ratio.

N-BCI resulting from age or arm dominance, we also calculated the normal biceps crease ratio (N-BCR) for each subject defined as the dominant arm N-BCI divided by the nondominant arm N-BCI. Pearson's r was used to indicate correlations of the N-BCI and N-BCR to the characteristics of age, biceps circumference, and arm dominance. Data were analyzed using SPSS Version 12.0 (SPSS Inc, Chicago, IL) and Excel[®] Version 5.0 (Microsoft Inc, Redmond, WA). Statistical significance was accepted at $p < 0.05$.

To determine the predictive value of the BCI test, the senior author (AE) applied the BCI test to 32 consecutive patients with a suspected distal biceps tendon rupture between April 2005 and August 2007. All patients already had been seen by a clinician and were referred to our clinic with a suspected distal biceps tendon rupture to determine the extent of the tear (complete versus partial) and/or the need for surgery. All patients were male, with an average age of 47 years (range, 26–63 years). The dominant extremity was injured in 19 of 32 patients (59%). The BCI test was applied as part of the overall clinical examination before application or review of diagnostic imaging.

The senior author (AE) measured the BCI of both arms using the same method applied to the normal population, documenting the distance of the interval in centimeters (Fig. 1). The resulting BCI values were used to calculate the patient's BCR, defined in the injured population as the injured arm BCI divided by the uninjured arm BCI. We established a diagnostic threshold of two standard deviations above the mean N-BCI and N-BCR values found in our normal control population as indicative of a complete distal biceps tendon rupture and evaluated the diagnostic value of each measure (BCI and BCR) as separate components of the BCI test. Patients who tested positive on either component were offered the option of surgical exploration and repair. Patients who tested negative or tested positive but declined surgical repair were offered ultrasound or MRI to definitively determine the integrity of the distal biceps tendon. Three patients were excluded because they refused diagnostic imaging or surgery to confirm the results of the BCI test. For the remaining 29 patients with confirmed BCI test results, we calculated the diagnostic values of sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy for the BCI and BCR components of the BCI test.

Results

In a normal population, with right and left arm values combined, the mean ($\pm$ standard deviation) N-BCI was 4.8 ± 0.6 cm. The mean N-BCR was 1.0 ± 0.1 . There was

a positive ($p < 0.02$) correlation between N-BCI and patient age ($r = 0.271$). However, no correlation was found between patient age and N-BCR. The size of the biceps (biceps circumference) also did not appear to correlate with N-BCI or N-BCR measurements. Interrater reliability of measuring the BCI was 0.794.

Using 6.0 cm as a diagnostic threshold for the BCI component of the BCI test (N-BCI of 4.8 cm + two standard deviations), 22 of 29 injured patients had a positive result for complete rupture (Table 3). A complete rupture subsequently was confirmed by surgery and/or imaging in all 22 patients. This resulted in a PPV of 100%. Seven of the 29 patients tested negative for a complete rupture using the BCI component. Subsequent imaging confirmed the absence of a complete rupture in five cases (ie, high-grade partial tears) and the presence of a complete rupture in two. This resulted in a NPV of 71%. Using the BCI measure as a diagnostic component of the BCI test resulted in a sensitivity of 92% and a specificity of 100%. Overall accuracy of the BCI component of the test is 93% (Table 4).

Using the ratio of 1.2 as diagnostic for the BCR component of the BCI test (N-BCR of 1.0 + two standard deviations), 24 of 29 injured patients had a positive result for complete rupture. A complete rupture subsequently was confirmed by surgery and/or imaging in 23 of these cases. Magnetic resonance imaging confirmed a high-grade partial tear in one case. This resulted in a PPV of 96%. Five of the 29 patients tested negative for a complete rupture using the BCR component. Subsequent imaging confirmed the absence of complete rupture in four of these cases (ie, partial tears) and the presence of a complete rupture in one. This resulted in a NPV of 80%. Using the BCR as a diagnostic component of the BCI test resulted in a sensitivity of 96% and specificity of 80%. Overall accuracy of the BCR component of the test is 93% (Table 5).

When we combined the results of the two components, ie, testing positive on either the BCI or BCR component was indicative of a complete distal biceps tendon rupture, the diagnostic accuracy of the BCI test was 93% (Table 6).

Discussion

In light of the high frequency of delayed surgical referrals for complete distal biceps tendon ruptures [9, 11, 15], we developed the BCI test to objectively measure and quantify the distance between two relevant, defined anatomic landmarks: the antecubital crease of the elbow and the cusp of distal descent of the biceps muscle (Fig. 1). We hypothesized an increased distance between these landmarks could clearly identify proximal retraction of the distal biceps tendon associated with a complete rupture. Using this valid and reliable measurement in combination with a thorough

Table 3. Demographics and BCI test results in injured patients

Patient number	Age (years)	Dominant arm	Injured arm	Days postinjury	BCI right	BCI left	BCR	BCI component*	BCR component†	BCI test result‡	Reality	Confirmed by
1	45	Left	Left	21	6.5	10.5	1.6	+	+	+	+	Surgery
2	43	Right	Right	6	10.5	4.8	2.2	+	+	+	+	Surgery
3	52	Right	Right	1	10.0	5.5	1.8	+	+	+	+	Surgery
4	62	Right	Left	7	5.0	7.5	1.5	+	+	+	+	Surgery
5	41	Right	Left	49	5.5	8.0	1.5	+	+	+	+	Surgery
6	31	Right	Left	1	3.5	9.2	2.6	+	+	+	+	Surgery
7	49	Right	Right	5	7.6	3.5	2.2	+	+	+	+	Surgery
8	59	Right	Right	14	7.0	5.5	1.3	+	+	+	+	Surgery
9	49	Right	Right	150	9.0	4.5	2.0	+	+	+	+	Surgery
10	43	Right	Left	1	4.5	10.0	2.2	+	+	+	+	Surgery
11	52	Right	Right	440	7.0	4.5	1.6	+	+	+	+	Surgery
12	62	Right	Right	60	5.0	5.0	1.0	—	—	—	+	Surgery
13	54	Right	Right	30	7.0	4.6	1.5	+	+	+	+	Surgery
14	58	Right	Right	5	7.3	5.5	1.3	+	+	+	+	Surgery
15	60	Right	Left	105	6.3	9.3	1.5	+	+	+	+	Ultrasound
16	38	Right	Right	42	7.8	6.0	1.3	+	+	+	+	Surgery
17	36	Right	Left	1	4.5	5.0	1.1	—	—	—	—	MRI
18	53	Right	Left	90	3.5	5.5	1.6	—	+	+	—	MRI
19	26	Right	Right	7	9.5	5.0	1.9	+	+	+	+	Surgery
20	37	Right	Right	18	9.5	4.0	2.4	+	+	+	+	Surgery
21	63	Right	Right	2	4.4	4.7	0.9	—	—	—	—	MRI
22	51	Right	Left	270	7.0	10.5	1.5	+	+	+	+	MRI
23	43	Right	Right	13	4.5	5.5	0.8	—	—	—	—	Ultrasound
24	51	Right	Left	10	5.1	5.4	1.1	—	—	—	—	Ultrasound
25	34	Right	Left	2	3.2	10.0	3.1	+	+	+	+	Surgery
26	37	Right	Left	7	3.5	6.0	1.7	+	+	+	+	Surgery
27	46	Right	Left	6	4.0	7.0	1.8	+	+	+	+	Surgery
28	51	Right	Right	51	5.2	3.0	1.7	—	+	+	+	Surgery
29	48	Right	Right	8	6.5	5.2	1.3	+	+	+	+	Surgery

* BCI component is positive (+) for complete rupture if the injured arm BCI is greater than 6.0 cm; †BCR component is positive (+) for complete rupture if the BCR is greater than 1.2; ‡BCI test is positive (+) if either the BCI or BCR component of the test is positive; BCI = biceps crease interval; BCR = biceps crease ratio.

Table 4. BCI test diagnostic results by for the BCI component

Parameter		Reality—complete rupture	
		Positive	Negative
BCI component	Positive	22 (true-positive)	0 (false-positive)
	Negative	2 (false-negative)	5 (true-negative)
Sensitivity	92%	True-positive/(true-positive + false-negative)	
Specificity	100%	True-negative/(false-positive + true-negative)	
Positive predictive value	100%	True-positive/(true-positive + false-positive)	
Negative predictive value	71%	True-negative/(false-negative + true-negative)	
Overall accuracy	93%	(True-positive + true-negative)/(true-positive + false-positive + true-negative + false-negative)	

BCI = biceps crease interval.

Table 5. BCI test diagnostic results by for the BCR component

Parameter		Reality—complete rupture	
		Positive	Negative
BCR component	Positive	23 (true-positive)	1 (false-positive)
	Negative	1 (false-negative)	4 (true-negative)
Sensitivity	96%	True-positive/(true-positive + false-negative)	
Specificity	80%	True-negative/(false-positive + true-negative)	
Positive predictive value	96%	True-positive/(true-positive + false-positive)	
Negative predictive value	80%	True-negative/(false-negative + true-negative)	
Overall accuracy	93%	(True-positive + true-negative)/(true-positive + false-positive + true-negative + false-negative)	

BCI = biceps crease interval; BCR = biceps crease ratio.

Table 6. BCI test diagnostic results (BCI and BCR components combined)

Parameter		Reality—complete rupture	
		Positive	Negative
BCI test	Positive	23 (true-positive)	1 (false-positive)
	Negative	1 (false-negative)	4 (true-negative)
Sensitivity	96%	True-positive/(true-positive + false-negative)	
Specificity	80%	True-negative/(false-positive + true-negative)	
Positive predictive value	96%	True-positive/(true-positive + false-positive)	
Negative predictive value	80%	True-negative/(false-negative + true-negative)	
Overall accuracy	93%	(True-positive + true-negative)/(true-positive + false-positive + true-negative + false-negative)	

BCI = biceps crease interval; BCR = biceps crease ratio.

patient history and clinical examination could increase clinician confidence in making a rapid surgical referral without requiring a delay for confirmatory imaging. The primary objective of our study was to evaluate the diagnostic validity and reliability of the BCI test in a sample of patients presenting with distal biceps tendon ruptures.

Like all physical examination techniques, the BCI test requires a certain degree of practice to identify the landmarks. Although the appearance of the antecubital crease varied somewhat between individuals, we found this landmark remained remarkably consistent between arms of the same individual. If an individual had multiple lines at the antecubital crease, we selected the crease that was most distinctive when the elbow was moved into a flexed position. Identification of the cusp of distal descent of the biceps muscle can be more difficult with obese patients or older patients with diminished muscle mass. Our results showed the size of the arm, measured as biceps circumference, did not affect measurement of the BCI in normal subjects. However, we did not specifically analyze the effect of body mass index or body fat composition on either the interrater reliability of BCI measurements or the diagnostic accuracy of the BCI test. Measurement of the BCI on injured arms that are swollen and edematous did not appear to be problematic. In our experience, the cusp of

distal descent is still apparent on palpation (Fig. 1, Step 3). Eight patients in our study presented fewer than 5 days postinjury (ie, still edematous). Biceps crease interval testing on these patients resulted in six true positives and two true negatives (100% sensitivity and specificity), suggesting reliability in an acutely injured population.

The positive correlation we observed between the normal BCI and patient age is not surprising given published studies of effects of aging in the neuromuscular system. In several studies, sarcopenia (a reduction in the number and size of muscle fibers with specific atrophy of Type II fibers) in those approaching their sixth decade of life was observed [8, 10, 21]. It therefore is possible age-related muscle atrophy can result in a normal, physiologic proximal retraction of the cusp of the biceps muscle belly. The clinical significance of these age-related changes remains to be determined. We suspect it will be minimal, given that in our control group of 80 uninjured men, only two (average age, 50 years) had a BCI value exceeding 6.0 cm (our diagnostic threshold of two standard deviations above the mean N-BCI value of 4.8 cm). Four of the 29 injured men (average age, 49 years) had a BCI greater than 6.0 cm on their unaffected arm. However, when we compared the unaffected arms of all injured patients with those of the control group, there was no difference ($p < 0.05$).

Keeping the correlation between BCI and age in mind, we thought measuring the BCI of both arms was an essential part of the BCI test. Because the N-BCR between arms did not correlate with age in control subjects, we believe the BCR component of the BCI test can allow us to control for normal, symmetric physiologic changes in the biceps muscle that might result in BCI measures on both arms exceeding our diagnostic threshold of 6.0 cm. In the four patients in whom the BCI of injured and uninjured arms exceeded 6.0 cm, the BCR still exceeded the diagnostic value of 1.2. Diagnostic imaging and/or surgery subsequently confirmed a complete distal biceps tendon rupture on the injured side in all four patients. These results suggest utility in retaining the BCR as a secondary indicator of complete rupture when applying the BCI test, particularly in instances when the BCI measure of a patient's unaffected arm is greater than 6.0 cm.

We applied the BCI test to a prospective series of 29 injured patients with an average age of 47 years (range, 26–63 years), which is in keeping with published demographics for distal biceps tendon ruptures [1, 2, 5, 15, 19]. Based on classification of acute distal biceps tendon rupture injuries as less than 10 days [6, 9, 15], our sample represented an adequate mix of acute (19 of 29) and chronic presentations (10 of 29) on which to evaluate the diagnostic efficacy of our test (Table 3). Although we were able to show interrater reliability of BCI measures on a normal population, only the senior author (AE) applied the BCI test on injured patients. Additional research would be beneficial to establish interrater reliability on an injured population and intraobserver reliability on injured and control groups.

When we used control group N-BCI and N-BCR values to establish diagnostic thresholds for the BCI test, our goal was to minimize the number of false-negative results, because a missed diagnosis of complete distal biceps tendon rupture can considerably compromise surgical outcomes. However, given that a positive BCI test would be indicative of the need for surgical repair, we also wanted to limit the number of false-positives. We believed establishing a threshold of two standard deviations above normal values adequately balanced these goals. Our initial results seemed to substantiate this threshold, because application of the BCI test in our injured sample (using combined results of the BCI and BCR as diagnostic indicators of complete rupture) resulted in only one false-negative and one false-positive result, regardless of length of time since injury (Table 6). A subsequent analysis confirmed varying the diagnostic thresholds from our predetermined levels of two standard deviations above normal values did not improve the rate of false-positive and false-negative results. For the purposes of determining the positive and negative predictive values, a relatively small sample size was available ($n = 29$). The small number of confirmed negative results

($n = 5$) limited our ability to provide a reliable specificity value to establish the efficacy of the test in distinguishing partial tears from complete tears.

In a review of the literature, we were able to identify three previously described clinical tests for distal biceps tendon ruptures. The biceps squeeze test was applied to 26 presumptive distal biceps tendon ruptures in 2005 [18]. Failure to elicit forearm supination by firmly squeezing the injured biceps muscle was considered a positive test for complete rupture of the biceps tendon or muscle belly. The sensitivity of the biceps squeeze test was reported as 96%, the same as our combined BCI test result (Table 6). However, in contrast to the anatomic measurements of our BCI test, the biceps squeeze test requires predominantly subjective interpretation of forearm motion. The amount of supination elicited in the biceps squeeze maneuver, even in a normal arm, is small and not objectively quantified. A clinician's perception of the presence of supination in an injured arm may be even more difficult, particularly if the injury is acute and the patient is guarding. The authors of the biceps squeeze test also did not report interrater reliability in their findings [18].

A positive flexion initiation test has been described as the inability to flex a 10-pound weight from a position of full elbow extension and wrist supination, although it does not specifically differentiate between complete tears and high-grade partial tears [17]. We also found this test somewhat impractical, because standardization of the applied force requires the presence of a 10-pound weight in the clinical setting, and patients with acute presentations may find this difficult to perform regardless of the extent of the tear. Data regarding interrater reliability of the flexion initiation test were not reported.

More recently, and since completion of our study, the biceps hook test has been reported to have 100% sensitivity and specificity in the assessment of 45 patients presenting with complete distal biceps tendon ruptures [15]. This test interprets the integrity of the distal biceps tendon with deep invagination of the examiner's finger beneath the lateral edge of the biceps tendon. The procedure requires the examiner to distinguish between normal and potentially present structures, like the lacertus fibrosis and the brachialis tendon, demanding a sophistication of anatomic examination that may be difficult for some clinicians, particularly if there is a large amount of adipose or scar tissue in the antecubital fossa. This test also requires the injured patient to actively maintain 90° flexion and full forearm supination while the examiner vigorously pulls on the biceps tendon after hooking it with a finger. Both of these aspects of the examination may be impractical and difficult in an acutely injured patient. The researchers did not present interrater reliability data for this technique.

The interrater reliability of measuring the BCI (0.79) and the high sensitivity of our test (96%) suggest the BCI test

can reliably identify cases of distal biceps tendon retraction associated with a complete rupture, without requiring any active participation by the patient or aggressive palpation techniques by the clinician. The goal of the BCI test is to identify patients with tendon retraction significant enough to compromise surgical results if they are not quickly referred for surgery. In the single false-negative case in our series, close examination of the MRI revealed the extent of proximal retraction of the avulsed distal tendon was limited despite complete rupture from the tuberosity. At the time of subsequent surgical repair, this was observed to be attributable to an intact lacertus fibrosus. Other authors also have noted an intact lacertus fibrosus can limit proximal retraction of the distal biceps tendon [11, 14]. Although the patient in our case had delayed presentation to our clinic (greater than 60 days postinjury) and a false-negative BCI test, there was no appreciable, detrimental clinical impact on the prognosis of his repair. The cause of the false-negative prediction, namely the absence of significant proximal biceps retraction, meant anatomic surgical repair was still readily achievable without the need for a tendon graft or an extended anterior incision. The true usefulness of the BCI test is in positively identifying cases in which the proximal retraction associated with a complete tendon rupture could compromise surgical results.

Although MRI remains the gold standard for identifying complete ruptures, clinicians who delay surgical referral of patients with these injuries to await confirmatory imaging could compromise postoperative results. The BCI test is a valid and objective assessment tool based on measurable anatomic landmarks, which has acceptable interrater reliability and high diagnostic accuracy as an indicator of a complete rupture. Clinicians can reliably use a positive BCI test result (either a BCI greater than 6.0 cm or a BCR greater than 1.2) to make a rapid and accurate diagnosis of complete distal biceps tendon ruptures, which should lead to an urgent surgical referral.

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