Improving the Rapid and Reliable Diagnosis of Complete Distal Biceps Tendon Rupture: A Nuanced Approach to the Clinical Examination

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Improving the Rapid and Reliable Diagnosis of Complete Distal Biceps Tendon Rupture

A Nuanced Approach to the Clinical Examination

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Background: Diagnosis of complete distal biceps tendon rupture (DBTR) is frequently missed or delayed on clinical examination. No single clinical test, including MRI, has demonstrated 100% efficacy in assessing the integrity of the distal biceps tendon.

Hypothesis: Combining 3 validated clinical tests for identifying complete rupture can maximize a true-positive diagnosis for complete DBTR without the need for confirmatory soft tissue imaging when performed in concert with other important factors from the history and clinical examination.

Study Design: Cohort study (diagnosis); Level of evidence, 2.

Methods: The hook test, the passive forearm pronation (PFP) test, and the biceps crease interval (BCI) test were applied in sequence in conjunction with a standard patient history and physical examination on 48 patients with suspected distal biceps tendon injuries. If results on all 3 special tests were positive for complete rupture, the patient was referred for surgical repair; diagnosis was confirmed intraoperatively. If results on all 3 special tests were negative, diagnosis was confirmed with soft tissue imaging and patients were managed nonoperatively. If results of the 3 tests were not in agreement, soft tissue imaging was used to clarify the disagreement and to confirm the diagnosis.

Results: Thirty-five patients had unequivocal results based on history, physical examination, and special tests. Thirty-two tested in agreement positive for complete rupture, which were confirmed intraoperatively. Three tested in agreement negative, with subsequent imaging confirming partial rupture. Thirteen patients had equivocal special test results; soft tissue imaging suggested complete rupture in 10 and partial rupture in 3.

Conclusion: Application in sequence of the hook test, the PFP test, and the BCI test results in 100% sensitivity and specificity when the outcomes on all 3 special tests are in agreement.

Keywords: distal biceps; tendon rupture; elbow; avulsion

Before 1995, there were only 53 published articles on injury to the distal biceps tendon. Since 2007, more than 70 new reports on the topic have been published, suggesting an increasing frequency in injury incidence and detection.[26] Distal biceps tendon injuries occur nearly exclusively in middle-aged men and result from a sudden, forced eccentric contraction of the elbow, usually associated with heavy lifting or athletic activities involving arm extension (eg, hockey, rugby). Disruptive injury can result in a partial or complete tear, with the latter being more common.[1,3] The ability to distinguish complete from partial tears is critical because the urgency and nature of treatment options differ significantly. Partial tears have been found to respond positively to nonoperative treatment, whereas complete ruptures require emergent surgical repair to best restore strength in elbow flexion and supination.[4,5,7,10] Frontline clinicians must be able to identify and distinguish these injuries confidently to facilitate rapid surgical referral in cases of complete rupture. Delays in diagnosis of complete rupture greater than 6 weeks can compromise the ability to obtain primary anatomic repair and can increase surgical complication rates.[1,5,15,17]

Despite the benefits associated with prompt identification and surgical management of complete distal biceps tendon ruptures (DBTRs), missed or delayed diagnoses persist.[12,15,19] There are numerous clinical papers reporting on the classic signs and symptoms of these injuries; however, not all patients have these characteristic findings.[2,7,18] Clinicians therefore require a standardized and efficient clinical examination routine that can accurately

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identify cases of complete rupture without the need for delays and expenses associated with confirmatory diagnostic imaging.

Several authors have described specific clinical tests to assess the integrity of the distal biceps tendon without the need for confirmatory imaging.[6,9,15] Each clinical test has been evaluated in isolation for its diagnostic efficacy. However, no previous studies have sought to assess these tests in combination. Incorporating the application of these clinical tests with other potentially important factors from the patient history and clinical examination may provide a clinical examination algorithm that would maximize a true-positive diagnosis of a complete DBTR, facilitating prompt surgical referral of these injuries.

The purpose of this study was to evaluate an efficient and accurate clinical assessment protocol for identifying patients with complete rupture of the distal biceps tendon and to describe the clinical management implications of the diagnostic results.

MATERIALS AND METHODS

Patient Population

A prospective cohort study of consecutive patients with suspected distal biceps tendon injuries was conducted in a community teaching hospital between April 2004 and January 2011. All patients were referred by another clinician to our upper extremity orthopaedic clinic. Patients were excluded from the study if they (1) were younger than 18 years, (2) had a penetrating trauma or fracture, (3) demonstrated neurovascular compromise, (4) did not undergo all elements of the standardized physical examination, or (5) did not have the definitive status of the tendon injury confirmed by imaging and/or surgery after clinical evaluation. Research ethics approval was granted without the need for an informed consent form because data were collected as part of the normal standard of care provided during new patient assessments.

Data Collection

A standardized new patient assessment form was used to facilitate data collection during the history and physical examination. The form included clinical variables that were chosen by the authors based on their clinical experience and variables described in the literature associated with distal biceps tendon injuries.[4,8,13,23] Patient history included patient age, sex, occupation, arm dominance, affected arm, the mechanism of injury, timing, and trend (ie, better, worse, or the same). Smoking history and pharmaceutical use, especially steroid use, were also noted. The physical examination included elbow strength and range of motion as dichotomous variables (ie, normal or decreased), notation of any visible biceps muscle deformity, and the outcomes of 3 physical examination maneuvers known to be diagnostic of complete DBTR—the hook test, the passive forearm pronation (PFP) test, and the biceps crease interval (BCI) test.[6,9,15] These 3 "special" tests were selected from the literature because they individually demonstrated high sensitivity (>90%) and could be expeditiously implemented during the physical examination. A demonstration of these maneuvers can be found in the supplementary video to this article.

The clinical assessors were orthopaedic physicians, supervised orthopaedic residents, or physical therapists who had been instructed by the author (A.E.) on a standardized method for collecting the data and performing the physical examination. While recording the results of the patient assessment, assessors were blinded to the final diagnosis, which was subsequently confirmed by either surgery or diagnostic imaging.

An assessment and management algorithm was developed based on the results of the patient history and physical examination, including application of the 3 special tests (Figure 1). If results on all 3 special tests were positive for complete rupture, the patient was offered surgery. Patients consenting to surgery had their diagnosis confirmed at the time of surgical repair. If results on all 3 special tests were negative for complete rupture, the patient was offered nonoperative treatment; diagnosis was subsequently confirmed with high-quality soft tissue imaging (magnetic resonance imaging [MRI] or ultrasound). In cases in which the results of the special tests were equivocal, the assessing physician used soft tissue imaging (MRI or ultrasound) to further evaluate the status of the distal biceps tendon. All imaging was performed by qualified radiologists who were blinded to the data collected during the clinical examination. In the equivocal cases, patients with imaging suggestive of nondisruptive or low-grade partial rupture were offered nonoperative treatment, and those with high-grade partial or complete rupture were offered surgical repair; status of the tendon was intraoperatively confirmed in these cases.

Intraoperatively, a complete tear was defined as complete loss of the normal attachment of the distal end of the biceps tendon to the radial tuberosity. If any tendinous attachment to the radial tuberosity remained (ie, fibers needed to be sharply transected to mobilize the tendon for repair), it was defined as a high-grade partial tear. Intraoperative assessments were performed by the author (A.E.), who was not blinded to the results of the initial clinical examination.

Data Analysis

The primary outcome measure was complete rupture of the distal biceps tendon as confirmed by diagnostic imaging and/or surgery. Therefore, patients who refused confirmatory imaging or surgery were excluded from the calculations for diagnostic efficacy, as a definitive diagnosis to compare against clinical examination results could not be made.

Sensitivity and specificity values were calculated for each physical examination maneuver and for all 3 of the maneuvers combined. The primary objective of the protocol was to develop a clinical examination algorithm that was 100% sensitive for detecting complete rupture, as any false-negative results could result in further diagnostic delays and possibly compromise treatment outcomes.

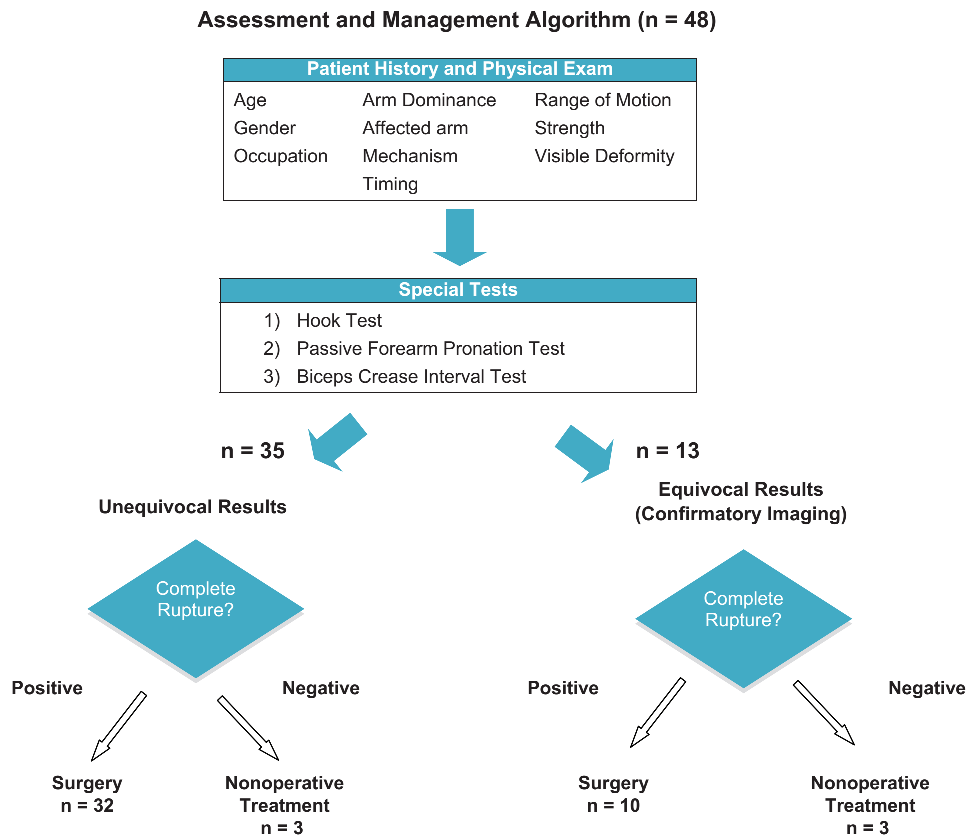

Figure 1. Assessment and management algorithm (N = 48).

RESULTS

Fifty-seven consecutive patients met the inclusion criteria. Nine patients with suspected complete rupture declined to undergo imaging or the offer of surgical repair to confirm their diagnosis, and therefore they were excluded from further analysis. Of the 48 patients remaining in the study, 47 were male and 1 was female. The mean age ± standard deviation was 47 ± 8.9 years (range, 26-69 years). Forty-five patients (94%) were right hand dominant. The dominant arm was injured in 30 cases (63%). The average time between injury and presentation to the clinic was 76 ± 158.8 days (range, 1-913 days).

Forty-two of 48 patients (88%) had a diagnosed complete tendon rupture (confirmed by diagnostic imaging and/or surgery). Six patients had a low-grade partial tear and were offered nonoperative treatment. There was no correlation between complete rupture and pharmaceutical use (eg, steroids). Only 2 patients (4%) acknowledged taking anabolic steroids at the time of their injury. Nine patients (19%) reported a smoking history. All of these smokers received a diagnosis of complete rupture. Additional characteristics of the final study group are listed in Table 1.

Application of the clinical examination algorithm on 48 patients showed that 35 had unequivocal results based on the history, physical examination, and special tests (Figure 1). Thirty-two of these had positive outcomes on all 3 special tests; these were suggestive of complete rupture and were subsequently confirmed intraoperatively. The remaining 3 patients tested negative on all 3 special tests, suggesting that the distal tendon remained intact; low-grade partial rupture was subsequently confirmed by MRI in these 3 cases. Thirteen patients had equivocal results on the special tests and underwent further imaging (Table 2). Imaging results suggested complete rupture in 10 cases and partial tears in 3. The 10 patients with imaging suggestive of complete rupture were offered surgical repair; 8 underwent surgery (all were confirmed to be complete ruptures at surgery), and 2 declined further treatment. The 3 patients with partial tears were treated nonoperatively.

The diagnostic accuracy of the physical examination special tests (hook test, PFP, and BCI test) applied individually and when combined is displayed in Table 3. When the outcomes on all 3 special tests are in agreement, both sensitivity and specificity equal 100% for diagnosis of complete distal tendon rupture.

DISCUSSION

When describing the clinical examination for DBTR, numerous authors have documented hallmark clinical signs and symptoms associated with complete rupture, including the patient's experience of a painful "pop," swelling, and ecchymosis over the antecubital region; asymmetry in biceps muscle contour; the absence of a palpable

TABLE 1
Patient Characteristics[a]

Characteristic	Total (N = 48)	Partial Rupture (n = 6)	Complete Rupture (n = 42)
Age, mean ± standard deviation, y	46.8 ± 8.4	45.3 ± 8	47.0 ± 8
Male	47 (98)	6 (100)	41 (98)
Female	1 (2)	0 (0)	1 (2)
Right-arm dominant	45 (94)	5 (83)	40 (95)
Dominant arm injured	30 (63)	5 (83)	25 (60)
Mechanism of injury			
Heavy lifting	26 (54)	4 (66)	22 (52)
Fall	6 (13)	1 (17)	5 (12)
Hockey	4 (8)	0 (0)	4 (10)
Football	3 (6)	1 (17)	2 (5)
Pulling	3 (6)	0 (0)	3 (7)
Wrestling	2 (4)	0 (0)	2 (5)
Blunt impact	2 (4)	0 (0)	2 (5)
Snowboarding	1 (2)	0 (0)	1 (2)
Rugby	1 (2)	0 (0)	1 (2)
Time since injury			
Acute (≤3 weeks)	30 (62)	2 (33)	28 (67)
Chronic (>3 weeks)	18 (38)	4 (67)	14 (33)
Heard or felt "pop"	17 (35)	3 (50)	14 (33)
Visible deformity	18 (37)	2 (33)	16 (38)
Smoking history	9 (19)	0 (0)	9 (21)
Steroid use	2 (4)	0 (0)	2 (5)
Rupture confirmed by			
Surgery	31 (65)	0 (0)	31 (74)
Imaging—ultrasound or magnetic resonance	7 (15)	4 (67)	3 (7)
Combination surgery and imaging	10 (21)	2 (33)	8 (19)

[a]All values are given as number of patients (% of total) except for age.

TABLE 2
Equivocal Results on Special Tests[a]

Patient No.	Age, y	Dom Arm	Inj Arm	Days Since Injury	Hook Test	PFP Test	BCI Test	DBT Tear Status	Bicipital Aponeurosis Intact	Confirmation Method
1	37	R	R	11	+	+	–	Complete	No	Surgery
2	50	R	R	12	–	+	–	Complete	Yes	MRI + surgery
3	35	R	R	14	+	+	–	Complete	Yes	MRI + surgery
4	32	R	R	14	–	–	+	Partial	n/a	MRI
5	47	R	R	35	–	–	+	Partial	n/a	Ultrasound
6	38	R	L	42	–	+	–	Complete	No	MRI + Surgery
7	51	R	L	105	–	+	+	Complete	Yes	MRI + surgery
8	39	R	R	120	–	+	–	Complete	Yes	Ultrasound + surgery
9	64	R	R	180	–	–	+	Complete	Yes	MRI + surgery
10	50	R	R	210	–	–	+	Partial	n/a	MRI
11	56	R	L	240	–	–	+	Complete	n/a	MRI
12	44	R	L	240	–	+	+	Complete	n/a	MRI
13	46	R	L	330	–	+	+	Complete	No	MRI + surgery

[a]BCI, biceps crease interval; DBT, distal biceps tendon; Dom, dominant; Inj, injured; MRI, magnetic resonance imaging; n/a, data not available; PFP, passive forearm pronation.

tendon; and weakness and/or pain primarily in supination.[1,13,17,18,26] However, atypical presentations and partial or chronic injuries may lack some or all of these findings and may create a diagnostic dilemma.[1,7,20] For example, in our patient series, only 17 of 48 patients (35%) described an audible or palpable "pop"; 14 were subsequently confirmed to have complete ruptures and 3 were confirmed to have partial tears (Table 1). Observations of swelling and ecchymosis are most notable only in acute cases, and an intact bicipital aponeurosis has been noted to confine a hematoma and thus prevent ecchymosis formation.[2,4] If swelling, a hematoma, or both are present, they can hide

TABLE 3
Diagnostic Accuracy (in Percentages) of Special Tests[a]

Special Test	Sensitivity	Specificity	Comments
Hook test (N = 48)	81	100	8 false-negative
PFP test (N = 48)	9	100	2 false-negative
BCI test (N = 48)	88	50	5 false-negative
Hook + PFP + BCI tests unequivocal (n = 35)	100	100	3 false-positive

[a]BCI, biceps crease interval; PFP, passive forearm pronation.

the asymmetry in biceps muscle contour associated with proximal tendon retraction.[17] In our sample, only 18 of 48 patients (37%) demonstrated visible deformity of the biceps muscle on the affected arm (Table 1). Festa et al[7] used surgical findings to confirm complete versus partial distal biceps tendon tears and noted that only 75% of complete tears actually showed some degree of tendon retraction, whereas partial tears had subtle proximal migration of the musculotendinous junction. Discerning the absence of a palpable tendon can also be difficult. In the presence of a complete tear, an intact bicipital aponeurosis may thicken and become more prominent in response to injury or subsequent increased load, thereby being mistaken for an intact distal biceps tendon.[1] The underlying brachialis tendon can also be mistaken for the distal biceps tendon, especially if the hook test is performed with active elbow flexion (versus the correct isolated isometric supination contraction).[1,15] Last, weaknesses in flexion and supination are not always reliable signs in the acute setting secondary to pain.[13,17,18] In subacute and chronic cases, flexion strength can often be recovered with a functioning brachialis, although supination strength usually remains impaired if the tendon is completely ruptured.[8,17] The variability in clinical signs and symptoms associated with distal biceps tendon injury likely contributes to the delays in diagnosis and increased reliance on MRI to achieve the correct diagnosis for complete rupture.[3,7,8] This appeared to be the case in our sample, where 18 of 48 patients (38%) were seen more than 3 weeks after injury (average, 187 ± 221 days). This phenomenon of delayed presentation without appropriate treatment has been reported by other authors.[15,19]

All of the special tests applied as part of our clinical assessment algorithm were originally intended to independently and accurately identify cases of complete rupture, which require emergent surgical management, from cases of partial rupture or tendinosis, which can be treated nonoperatively. Each of the tests can be quickly and easily performed. Despite this, our clinical experience has shown that no individual test is diagnostically perfect. However, the combination of all 3 tests together results in both 100% sensitivity and specificity when they are in agreement.

Furthermore, because the mechanistic rationale of each test differs, subtle interpretation of the results can give a more nuanced appreciation of the structural pathologic lesion. We therefore apply the tests in the following order: (1) the hook test, to identify the presence or absence of a palpable distal tendon; (2) the passive forearm pronation test, to determine whether the tendon is functionally attached to the radial tuberosity; and (3) the biceps crease interval test, to assess the extent of tendon retraction, which can affect the urgency of surgical repair.

When performing the hook test, the examiner attempts to detect a tendon spanning the antecubital fossa in front of the brachialis.[15] The authors of this test underscore the importance of hooking the lateral edge of the biceps tendon, not the medial edge, to avoid mistaking the bicipital aponeurosis for an intact biceps tendon. Similarly, it is important that the patient isometrically supinate the forearm but not actively flex the elbow to avoid mistaking the underlying brachialis as an intact biceps tendon. After applying this technique on 45 patients, O'Driscoll et al[15] demonstrated 100% sensitivity and specificity for identifying DBTRs. In our study of 48 patients, the hook test resulted in a sensitivity of 81% (8 false negatives) and a specificity of 100% (Tables 2 and 3). In our experience, interpretation of the test may be subject to a potential pitfall where an intact bicipital aponeurosis could provide enough tension to pull the biceps tendon distally and sufficiently enough for the examiner to palpably "hook," even laterally. Alternatively, large amounts of scar tissue or the presence of a pseudo-tendon, often seen in chronic presentations, can also provide a "hookable" cord and be mistaken for an intact tendon. It is interesting to note that all 8 false negatives on the hook test were chronic cases, with an average time from injury to examination of 159 ± 109 days.

Application of the PFP test allows assessment of the functional continuity of the muscle-tendon-bone complex at the biceps tendon's distal insertion on the radial tuberosity and appears to be reliable in both acute and chronic cases of DBTR.[9] Harding,[9] the author of the test, notes that complete avulsion of the distal tendon from the radius will manifest itself by a loss of visible and palpable "proximal to distal" movement of the biceps muscle belly when one is passively pronating the forearm from a starting supinated position. Most important, we have observed that this movement of the muscle belly is both consistent and "dose dependent" in both quantity and speed of movement; for example, small amounts of pronation result in equally small distal advancements of the muscle belly, and rapid rotations of the forearm result in equally rapid movements of the muscle belly, as long as the distal tendon insertion is intact. Harding noted 100% sensitivity and specificity in 7 patients with MRI-documented complete distal biceps ruptures and 14 patients with elbow problems other than confirmed distal biceps avulsion.[9] The author did not evaluate the maneuver on patients with partial tears. In our study, we applied the test on 48 patients with suspected distal biceps injury and demonstrated 95% sensitivity and 100% specificity. The 2 false negatives with PFP were both chronic cases examined an average of 162 ± 42.4 days after injury (Table 2). A scarred tendon sheath that remains somewhat functionally contiguous with the retracted distal biceps tendon and its normal attachment site on the radial tuberosity might explain the false negatives in these chronic cases.

The BCI test evaluates the extent of tendon retraction associated with a complete rupture. When the BCI is abnormal, there is a high suspicion of a rupture that not only is complete but also is likely associated with a bicipital aponeurosis rupture, leading to visibly quantifiable tendon retraction significant enough to compromise surgical results if it is not quickly referred for surgery.[6] As noted earlier, not all complete tears reveal a visible deformity. Application of the BCI test, which provides an objective measure of muscle/tendon retraction, was negative in 5 cases of complete rupture in our sample and positive in 3 cases of partial rupture (Tables 2 and 3). A false negative for complete rupture on the BCI test can be explained by the presence of an intact bicipital aponeurosis, which can act like a tether on the ruptured tendon, preventing observable proximal migration of the muscle belly. In the case of discordant results during the physical examination, palpation of an intact bicipital aponeurosis may help to explain the absence of the expected "hallmark" sign of proximal retraction of the biceps muscle belly.

Although none of the special tests described are 100% diagnostically accurate in isolation, our results suggest that thorough patient history and physical examination, combined with the application of all 3 special tests, provide sufficient diagnostic accuracy to address the variability in subtle signs and symptoms associated with distal biceps tendon injuries. This assessment algorithm limits the use of confirmatory soft tissue imaging and its associated cost, delays, and occasional inaccuracy[3,15,24] to instances when the outcomes on the special tests are discordant. In our sample, the special tests were in agreement and consistent with the remainder of the clinical examination in 35 of 48 patients (73%). For those 35 patients, the diagnostic efficacy was 100%. In Canada, where an MRI costs $641 (with a median wait time of 47 days), this diagnostic improvement for 35 patients would save more than $22,000 CDN, and surgical treatment would be expedited for each case of complete rupture identified.[11,27]

A number of authors have suggested use of MRI only in the evaluation of partial tears.[1,4,8,15] A comparison of MRI diagnosis with the hook test in O'Driscoll's study[15] showed 92% sensitivity and 85% specificity for MRI detection of complete and partial tears, respectively. A report by Festa et al[7] on MRI effectiveness in detecting partial and complete DBTR demonstrated sensitivity and specificity of 100% and 83%, respectively, for complete tears and 59% and 100%, respectively, for partial tears. These values for MRI are not as diagnostically accurate as the application of all 3 of our described special tests as part of a single clinical examination. Therefore, relying solely on MRI for confirmative diagnosis seems impractical, particularly given the timing and costs associated with its use. Following our clinical algorithm should identify clear cases of complete rupture versus partial tears, eliminating routine ordering of MRI in these cases. Even in instances of equivocal results, where the BCI test is falsely negative while the other 2 special tests are truly positive for complete rupture, the observed minimal amount of tendon retraction associated with the BCI test is likely associated with similarly minimal atrophy and scarring of the tendon despite its complete rupture. Therefore, even if a diagnosis of complete tear in these cases is delayed as a result of confirmatory imaging, a primary surgical repair is still safe and viable.

Limitations

Our study meets the first criterion of a valid, clinically useful diagnostic strategy—we conducted an independent, blind comparison of "special test" physical examination maneuvers with a gold standard of diagnosis (ie, soft tissue imaging and/or surgery).[21,22] However, gaining a sample size with sufficient power remains challenging given the infrequent occurrence of distal biceps tendon injuries. Although the assessors were blinded to the results from the physical examination compared with imaging results, blinding of intraoperative outcomes did not occur in all cases, as the same surgeon (A.E.) performed the initial assessment in addition to the surgical repair in the majority of complete rupture cases. We also did not compare interrater reliability of each special test, although ElMaraghy et al[6] did demonstrate an acceptable intraclass correlation coefficient (>0.75) with the BCI test.

The demographic characteristics of our study participants are consistent with results of other authors who evaluated distal biceps tendon injuries.[14-16,20,23,25] The majority of patients were middle-aged men (average age, 47 ± 8.4 years; mode, 39 years). The single female presentation reinforces reports that this injury occurs predominantly, although not exclusively, in men. However, the prevalence rate for complete distal tendon rupture was high (87%) in our sample as it was made up of patients referred from frontline clinicians who already possessed a high suspicion of distal biceps injury. Therefore, although these results are promising, further investigation of this protocol should be undertaken in a broader patient population, across different age groups, and with different assessors, to further evaluate the reliability and accuracy in diagnosing complete rupture of the distal biceps tendon. We encourage other clinicians to incorporate our described assessment techniques into their practices to further test the validity of this protocol.

CONCLUSION

Development of an effective, clinically applicable assessment protocol for identifying patients with complete rupture of the distal biceps tendon can facilitate rapid referral for patients most likely to benefit from surgical repair. We have shown that the performance in a sequence of 3 easy to apply, validated special tests—the hook test, the passive forearm pronation test, and the biceps crease interval test—combined with other important factors from the patient history and physical examination results in 100% sensitivity and specificity when the outcomes on all 3 special tests are in agreement. If the results of the clinical examination are unequivocally positive for complete rupture, the patient can confidently be referred for surgical repair. If the results are unequivocally negative, the distal biceps tendon is strained or partially torn and can confidently be managed nonoperatively. Only in instances of equivocal results is referral for confirmatory soft tissue imaging (preferably MRI) recommended. Application of this protocol on 48 patients resulted in reduced MRI costs of more than $22,000 CDN (no imaging required in 35 cases) and expedited surgical referral in 32 of 35 cases.

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A Video Supplement for this article is available in the online version or at http://ajsm.sagepub.com/supplemental.

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