Reliability and Validity of the Hook Test for Diagnosis of Distal Biceps Tendon Ruptures

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Purpose Although the initial description of the distal biceps tendon (DBT) hook test (HT) reported 100% sensitivity (Sn) and specificity (Sp), subsequent retrospective series have demonstrated imperfect validity. The purpose of this investigation was to prospectively assess the validity and reliability of the HT for complete DBT ruptures. We aimed to determine the Sn/Sp and interrater reliability for the HT.

Methods A consecutive series of adult patients presenting to our outpatient clinics with an elbow complaint was prospectively examined. Patients were included if they had undergone advanced imaging (magnetic resonance imaging or ultrasound) that imaged the DBT and underwent DBT repair. There were four participating surgeons, all of whom were blinded to magnetic resonance imaging/ultrasound prior to performing the HT. To determine the Sn/Sp of the HT and advanced imaging, intraoperative findings served as the primary reference standard. The interrater reliability of the HT was calculated for cases in which a primary examiner (surgeon) and secondary examiner (physician assistant or resident) performed the HT.

Results Of 64 patients who had undergone advanced imaging, 28 (44%) underwent DBT surgery and were included in the assessment of Sn/Sp. The mean age was 49 years, and all patients were men. The Sn and Sp of the HT were 96% and 67%, respectively. Advanced imaging demonstrated 100% Sn and Sp. Twenty-five patients were evaluated by a primary and secondary examiner. The interrater reliability was substantial (Cohen kappa, 0.71).

Conclusions The Sn and Sp of the HT were 96% and 67%, respectively, when assessed prospectively. Advanced imaging findings (magnetic resonance imaging/ultrasound) demonstrated 100% Sn and Sp. The HT can be performed reliably by examiners with varying experience levels. Considering the imperfect validity of the HT, we caution against the use of this examination alone to diagnose DBT ruptures. *(J Hand Surg Am. 2023;48(11):1091−1097. Copyright © 2023 by the American Society for Surgery of the Hand. All rights reserved.)*

Type of study/level of evidence Diagnostic II.

Key words Distal biceps tendon, elbow surgery, hook test, physical examination, sensitivity.

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Distal biceps tendon (DBT) injuries generally occur in the dominant arm of middle-aged men.[1] These are relatively rare injuries, with a historical incidence of 1.2−2.5 ruptures per 100,000 patients; however, the incidence seems to be increasing.[1−3] Nonsurgical management can be successful, particularly for patients with lower functional demands, but can be associated with decreases in supination strength and endurance.[4] Surgical treatment is typically indicated in patients with higher functional demands who may not tolerate decreases in strength.[5] Sensory neuropraxias are common after repair, and the rerupture rate after surgical treatment is approximately 5%.[6−10] The rate of complications increases with the interval between injury and surgery.[11] Therefore, prompt and accurate diagnosis of DBT ruptures is important.

Physical examination is an important diagnostic component in the diagnosis of DBT ruptures. Some clinical signs of DBT ruptures include proximal retraction of the muscle belly, change in muscle contour, ecchymosis, weakness, and pain with supination and flexion.[11,12] Occasionally, these clinical signs are absent or equivocal, and clinicians often rely on physical examination maneuvers to aid in diagnosis. The distal biceps hook test (HT), among other provocative tests, is frequently used in clinical practice. In cases of DBT ruptures, radiographs are generally unremarkable. Magnetic resonance imaging (MRI) is reliable in identifying distal bicep tears with 92% sensitivity (Sn) and 85% specificity (Sp).[13] Positioning the elbow in flexion, the shoulder in abduction, and the forearm in supination ("flexion, abduction, supination" view) may increase the Sn of MRI, although this is controversial.[14,15] Ultrasound (US) has been reported to have 95% Sn, 71% Sp, and 91% accuracy; however, this modality can be operator and technique dependent.[16] Devereaux and ElMaraghy[17] reported that the cost of advanced imaging can be mitigated in the majority of patients using a nuanced approach to clinical examination.

As described by O'Driscoll et al,[11] the DBT HT has a reported 100% Sn and Sp with respect to the diagnosis of complete DBT ruptures, as initially described in a retrospective single-surgeon series of 45 patients, which used intraoperative findings as the reference standard. A subsequent retrospective series assessing the HT found a lower Sn (83%) in complete tears.[18] There is a paucity of prospective investigations assessing both the reliability and validity of the HT with respect to complete DBT ruptures.[19] Understanding the reliability and validity (performance as assessed using Sn/Sp) of this physical examination maneuver may have implications for the utilization of advanced imaging as part of the routine diagnostic workup of DBT injuries.

The purpose of this investigation was to assess the validity and reliability of the HT for complete DBT ruptures. We aimed to prospectively determine the Sn, Sp, and interrater reliability (IRR) of this physical examination maneuver. We hypothesized that although the Sn/Sp of this examination would be high, neither Sn nor Sp would be 100% as previously reported when using a prospective and blinded methodology that incorporates multiple examiners.[11]

MATERIALS AND METHODS

Institutional review board approval was obtained for this investigation, which was started as a department quality improvement initiative.

Prospective examinations were performed on a consecutive series of adult patients presenting to our outpatient upper-extremity clinic from June 2021 to August 2022. There were four participating surgeons (M.P., H.P.O., A.A., L.C.G.), all of whom were considered as having level 4 expertise (specialist-highly experienced), as described by Tang and Giddins.[20] Two surgeons were fellowship-trained hand and upper-extremity (A.A., L.C.G.) surgeons, and two surgeons were fellowship-trained in sports medicine (M.P., H.P.O.). Patients were seen at one of two centers within our integrated health care system, which contains an academic level 1 trauma center in the northeastern United States.

Patients were considered for inclusion if they presented with a chief complaint involving the elbow. Patients with an elbow complaint who presented to the clinic with advanced imaging of the elbow (MRI or US that included the DBT) ordered by a referring provider were included if they underwent DBT repair surgery for either a partial or complete tear (Fig. 1). In addition, we included patients who were evaluated at our clinics for an elbow complaint and ultimately underwent advanced imaging ordered by the treating surgeon. In the cases of patients without advanced imaging at the time of our initial consultation, MRI or US was ordered at the discretion of the treating physician as part of routine patient care. Patients were included for the assessment of Sn/Sp if they had undergone advanced imaging that included the DBT and underwent surgery. In all cases, the treating surgeon (primary examiner) was blinded to

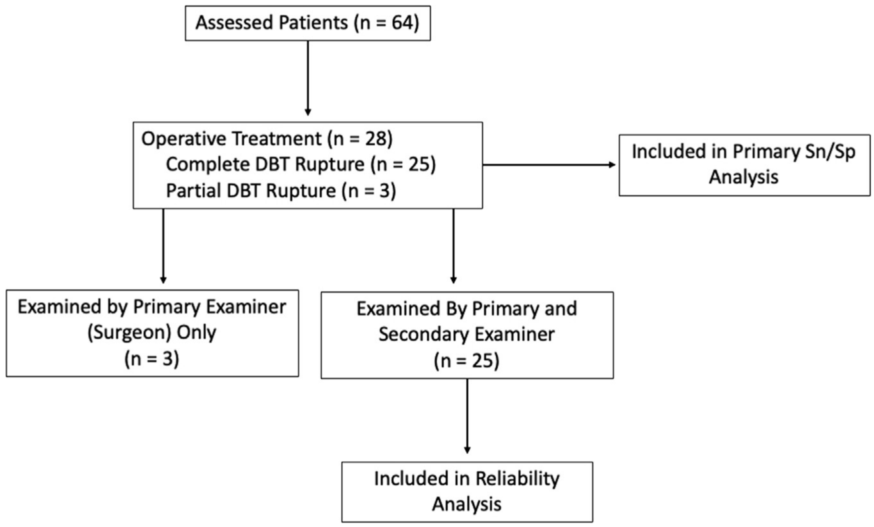

FIGURE 1: Flowchart demonstrating the number of patients included for the assessment of Sn, Sp, IRR, and DBT.

the advanced imaging before examining the patient and performing the HT. A secondary examiner (either a physician assistant or an orthopedic resident) also performed the HT, when available. The examiners were blinded to each other with respect to results of the HT. Figure 1 details the patients included in the assessments of Sn/Sp and IRR.

The HT was performed in the manner described by O'Driscoll et al.[11] Patients actively flexed the involved elbow to 90° while fully supinating the forearm. The examiner's index finger was brought in from the lateral border of the biceps tendon in the antecubital fossa and "hooked" beneath the tendon (if present). With an intact DBT, the examiner's finger hooked the tendon while drawing it anteriorly. In this scenario, an intact DBT was noted (negative HT). Care was taken to distinguish between intact biceps tendon and lacertus fibrosus (or bicipital aponeurosis). In cases in which the examiner could not hook their finger under the tendon to draw it anteriorly (no cord-like structure), the HT result was considered abnormal (positive HT).

Baseline demographics were also recorded for each patient. For alcohol and tobacco, current use was defined as any current alcohol or tobacco consumption, regardless of the amount. Findings from the advanced imaging studies were recorded with respect to the DBT. We assessed the status of the DBT on imaging in a binary manner for the purpose of comparison with the HT. The DBT was considered "intact" if there was no tear or there was a partial DBT tear and was considered "not intact" only if there was a complete DBT rupture. All US studies were performed by either experienced musculoskeletal radiologists or fellowship-trained primary care sports medicine physicians with extensive experience using US. Magnetic resonance imaging studies were not standardized because some were obtained at facilities outside of our institution prior to referral. Flexion, abduction, supination view was not obtained for all MRI studies. The status of the tendon (intact vs not intact) on imaging was determined by either the radiologist or primary care sports medicine physician. Partial DBT tears on advanced imaging were considered "intact" with respect to comparisons for the HT.

Statistics

The status of the tendon at the time of surgery was the reference standard for this investigation. We used 2 × 2 congruency tables to calculate the Sn and Sp for the primary examiners (surgeons) and advanced imaging. Cohen kappa coefficient was used to report IRR for the HT between the two examiners. When discussing agreement levels for Cohen kappa coefficient, the following guidelines were used: slight (0.01−0.20), fair (0.21−0.40), moderate (0.41−0.60), substantial (0.61−0.80), and near perfect (>0.80).[21,22]

RESULTS

Table 1 includes the baseline demographics of all patients who underwent advanced imaging and those ultimately included in the investigation. A total of 28 patients were included in the Sn/Sp analysis. Of them, 25 cases (89%) were evaluated by two examiners (an attending physician and either a physician assistant or an orthopedic resident) and included in the assessment of IRR (Fig. 1). Overall, 100% of the

TABLE 1. Baseline Demographics for All Patients With Advanced Imaging and All Included Patients

Demographic Variable	All Patients (n = 64)	Included (Surgical) Patients (n = 28)
Age (y), mean (SD)	43 (15)	49 (11)
Men, n (%)	48 (75)	28 (100)
Race, n (%)		
Black	2 (3)	1 (4)
White	62 (97)	27 (96)
Right laterality, n (%)	38 (59)	16 (57)
Current tobacco use, n (%)	8 (13)	4 (14)
Current alcohol use, n (%)	26 (41)	15 (54)
Employed, n (%)	48 (75)	17 (61)
BMI, mean (SD)	31 (7.5)	34 (7.8)
Insurance status, n (%)		
Medicare	6 (9)	3 (11)
Medicaid	0 (0)	0 (0)
Private	53 (83)	23 (82)
Worker's compensation	1 (1.5)	0 (0)
Uninsured	3 (5)	2 (7)
Government/military	1 (1.5)	0 (0)
Advanced imaging modality, n (%)		
MRI	53 (83)	22 (79)
US	11 (17)	6 (21)
Advanced imaging finding, n (%)		
Intact biceps tendon	31 (48)	0 (0)
Partial biceps tendon tear	7 (11)	3 (11)
Complete biceps tendon tear	26 (41)	25 (89)
Clinical diagnosis		
Complete DBT tear	26 (41)	25 (89)
Partial DBT tear	7 (11)	3 (11)
Epicondylosis	10 (16)	0 (0)
UCL injury	7 (11)	0 (0)
Biceps tendenosis	3 (4.7)	0 (0)
LCL injury/PLRI	2 (3.1)	0 (0)
Arthritis	2 (3.1)	0 (0)
Stiffness/contracture	1 (1.6)	0 (0)
Peripheral compressive neuropathy	1 (1.6)	0 (0)
Radial head fracture	1 (1.6)	0 (0)
Triceps tendon rupture	1 (1.6)	0 (0)
Brachialis strain	1 (1.6)	0 (0)
Mass	1 (1.6)	0 (0)
Dislocation	1 (1.6)	0 (0)

(Continued)

TABLE 1. Baseline Demographics for All Patients With Advanced Imaging and All Included Patients (Continued)

BMI, body mass index; LCL, lateral collateral ligament; PLRI, posteriolatereal rotatory instability; UCL, ulnar collateral ligament.

included patients were men, and the mean age was 49 years. Twenty-five patients (89%) had evidence of a complete DBT on advanced imaging (MRI or US), and all these patients were evaluated within 8 weeks of injury.

Of 26 cases with a complete DBT rupture on advanced imaging, 25 (96%) elected for surgery, and all 25 had intraoperative evidence of a complete DBT rupture. For seven cases with a partial DBT rupture on advanced imaging, three (43%) elected for surgery, and all three cases had intraoperative evidence of a partial DBT rupture. Magnetic resonance imaging was performed in 25 included patients (89%), and US was performed in 3 included cases (11%). Among all cases that underwent surgical treatment, there were no cases in which the imaging findings with respect to DBT differed from the intraoperative findings.

Table 2 includes the Sn/Sp assessment for the HT by the attending physician. For the DBT HT by the attending surgeon, the Sn was 96% and the Sp was 67%. For attending surgeons evaluating 25 complete DBT ruptures, a negative HT result was recorded in one case (4% false negative rate). For the secondary examiner, the Sn was 87% and the Sp was 95%. The advanced imaging studies demonstrated 100% Sn and Sp when intraoperative findings were used as the reference standard.

Twenty-five patients underwent the HT performed by the primary and secondary examiner and were included in the IRR analysis (Fig. 1). Using intraoperative findings as the reference standard, the IRR between the two examiners was substantial (Cohen kappa, 0.71). The attending surgeon and secondary examiner documented the same HT result in agreement with the intraoperative findings in 21 of the 25 cases (84%). In two cases (8%), both the attending surgeon and secondary examiner had HT results that differed from that of the reference standard. In the remaining two cases, the attending surgeon and

TABLE 2. Sn and Sp Analyses for Attending Surgeons Performing the DBT HT Using Intraoperative Findings as the Reference Standard for Diagnosis

HT Result	Complete DBT Rupture During Surgery	Partial or No DBT Rupture During Surgery
(+) HT	24	1
(−) HT	1	2
	25	3
Sn and Sp analyses		
	Sn = 96%	Sp = 67%

secondary examiner documented different HT results (the attending surgeon was correct in both instances).

DISCUSSION

In this prospective, blinded assessment of the validity and reliability of the HT for DBT ruptures, we found that this examination maneuver had a high Sn (96%), with a lower Sp (67%) among attending surgeons. Advanced imaging in the form of MRI or US demonstrated 100% Sn/Sp when intraoperative findings were used as the reference standard. These results stand in contrast to the initial description of this test by O'Driscoll et al,[11] who reported 100% Sn and Sp in their retrospective series. Luokkala et al[18] reported 83% Sn in complete tears in their retrospective study of 234 tears. Our results may differ from those previously reported because of the prospective nature of our study compared with the previous retrospective studies. Additionally, we included multiple examiners, all of whom were blinded to the advanced imaging results prior to performing the HT. Although we found high levels of Sn of the HT for complete DBT ruptures, both Sn and Sp were less than 100%, and surgeons can occasionally be misled by the results of this examination maneuver alone. For attending surgeons evaluating 25 complete DBT ruptures, a negative HT result was recorded in one case (4% false negative rate). In this context, advanced imaging for suspected DBT ruptures may be appropriate, especially considering the increased morbidity with delayed diagnosis.

The IRR of the HT between the two groups of examiners was substantial (Cohen kappa, 0.71). To our knowledge, the IRR has not been previously reported for the HT; however, it does correlate well to the previously described IRR of the biceps crease interval IRR of 0.79.[23] Our IRR result compares well with that of other upper-extremity examinations, such as carpal tunnel syndrome-6, in the diagnosis of carpal tunnel syndrome, with a Fleiss kappa of 0.73.[24] In our prior study, individual provocative examination maneuvers within the carpal tunnel syndrome-6, such as the Phalen test, Tinel sign, two-point discrimination, and assessment of thenar atrophy/weakness, had either moderate or substantial IRR for examiners of differing experience levels.[24] Our present study also investigated the diagnostic accuracy of providers of differing clinical experience. Although there are a limited number of prior studies that analyzed diagnostic accuracy between providers with varying experience levels in elbow surgery, similar assessments have been performed in hip and hand surgeries.[24,25] Springer et al,[25] in their study, compared hand therapists, orthopedic residents, and hand surgeons and found that there was no difference in the accuracy of diagnosing hip labral pathology after completing a series of five different physical examination maneuvers. Our results indicate that the distal biceps HT can be reliably used as a screening and diagnostic tool by clinicians with a variety of experience levels and without specific fellowship training in hand/upper-extremity or sports surgery. However, in our current investigation, advanced imaging appeared to demonstrate higher diagnostic validity relative to the HT.

The imperfect Sn/Sp of the distal biceps HT demonstrated in our study has implications for advanced imaging utilization. Devereaux and ElMaraghy[17] concluded that combining the distal biceps HT, passive forearm pronation test, and biceps crease interval test for identifying complete rupture can maximize true-positive diagnosis of complete DBT ruptures without the need for confirmatory soft-tissue imaging. They demonstrated 100% Sn and Sp when all three physical examinations yielded positive results.[17] Advanced imaging was only used when the three physical examination maneuvers were in disagreement. Of 13 patients who had equivocal examination results in their study, soft-tissue imaging suggested complete rupture in 10 and partial rupture in 3.[17] Four percent of complete DBTs were missed on examination in our series, and these data support the fact that the HT should not be used alone for the diagnosis of DBT ruptures. Zwerus et al[19] similarly found that the Sn and Sp for the HT alone were 86% and 95%, respectively, in acute cases; however, this increased to 94% and 100%, respectively, with the addition of the biceps crease interval. Although prospective with respect to validity, the authors did not report findings regarding reliability.[19]

Our investigation has a number of limitations that need to be considered. It is important to note that intraoperative findings were the reference standard for this investigation. The use of surgical findings as the reference standard provides a direct, visual assessment of the tendon but limits the assessment to patients who elect for surgery. Inclusion of mostly patients with complete DBT ruptures increases disease prevalence in the sample and may overestimate examination performance characteristics. Given the relatively high prevalence of complete DBT ruptures in this series, examination performance may have been overestimated. There would have been substantial limitations in the use of advanced imaging as the reference standard because prior studies have noted imperfect Sn/Sp for both MRI and US when using intraoperative findings as the reference standard.[13–16] Inclusion of patients with a normal biceps tendon could better establish physical examination or imaging as the reference standard but would require operating on patients with a normal biceps tendon, which would be impractical. We chose to use either MRI or US as an advanced imaging modality; however, prior studies have demonstrated differences in accuracy between MRI and US in the diagnosis of DBT ruptures.[13–16] Both imaging modalities were used based on surgeon preference or which imaging study the patient had completed prior to presentation to our clinic. Although there was a relatively small number of included cases, all cases with a complete or partial DBT rupture on advanced imaging that underwent surgery in our series had intraoperative findings that agreed with imaging findings (100% Sn and Sp). In this context, revisiting the diagnostic performance of these modalities with respect to the integrity of the DBT may be worthwhile, especially considering the imperfect Sn/Sp of physical examination.

Additional limitations are related to our study design, which used groups of examiners to assess IRR. It did not account for potential variation between examiners, and we did not measure intraobserver agreement. Although agreement within each group was assumed to be high, it is unknown with respect to the DBT HT. We believe that our results are generalizable because the examinations were performed by multiple providers of different levels of training; however, we recognize that this can potentially alter IRR and can be more reflective of examiner skill than the examination itself. In addition, this study did not investigate specific patient characteristics such as morbid obesity. It remains uncertain how body habitus, swelling, and edema or guarding/pain affect the results of physical examination in cases of suspected DBT ruptures.

In conclusion, the Sn and Sp for the DBT HT was 96% and 67%, respectively, with substantial IRR. Advanced imaging modalities demonstrated 100% Sn and Sp. The DBT HT can be reliably used as a screening and diagnostic tool by clinicians with a variety of experience levels and without specific fellowship training in hand/upper-extremity or sports surgery. Considering the imperfect validity of the HT, we caution against the use of this examination alone to diagnose DBT ruptures.

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