Acta Orthop. Belg., 2022, **88**, 160-167

ORIGINAL STUDY

doi.org/ 10.52628/88.1.20

Distal biceps tendon ruptures: more efficient diagnostics for a better outcome

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Distal biceps tendon ruptures are a rare pathology, but can have significant functional repercussions. Rapid, accurate diagnosis and treatment are essential for a favorable prognosis.

During the diagnostic process of distal biceps tendon ruptures, several problems can emerge.

An answer to the following clinical questions is given based on an extensive literature review.

- **Which clinical tests are the most sensitive/ specific for clinical examination?**
- **Can ultrasound evaluation of the distal biceps tendon be optimized?**
- **Is ultrasound an equivalent alternative to MRI in the diagnosis of distal biceps tendon injuries?**

An extensive literature search was conducted through Pubmed and Embase. The search strategy was developed systematically in the Medline database (PubMed interface), using medical subject headings as well as free text words.

A standardized clinical examination of the distal biceps tendon consisting of the Hook test, the Passive Forearm Pronation Test and the Biceps Crease Interval test has a high accuracy for correct diagnosis of full-thickness ruptures. Furthermore, Cobra sign, Supinator view and Pronator view give an additional value to the standard ultrasound examination of the distal biceps tendon. Finally, ultrasound can be considered a trustworthy and cost-effective alternative to MRI in evaluation of distal biceps tendon ruptures.

Keywords: Distal biceps tendon; physical examination; diagnostic imaging; musculoskeletal ultrasound.

INTRODUCTION

Distal biceps tendon ruptures account for approximately 3 percent of the total number of biceps tendon rupture *(1, 2)*. Partial distal tendon ruptures present even a smaller fraction. These patients often present with vaguer symptomatology than patients with a total biceps tendon rupture*(1, 3-6)*. The incidence of distal biceps tendon ruptures is 1.2 per 100,000 in the general population and 8.5 per 100,000 in the working population *(1, 7)*. Distal biceps tendon ruptures occur mainly in middle-aged men (40 years-60 years) *(1-3, 5, 6)*. There has been an increase in incidence in recent years, which may be explained by increased sporting activity in society *(1, 3)*.The main risk factor is smoking,

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No benefits or funds were received in support of this study. None of the authors have a conflict of interest.

which is thought to increase the risk of rupture by up to 7.5 times *(1)*. Although distal biceps tendon ruptures only account for a small portion of all biceps tendon ruptures, it is important to diagnose them adequately in the acute phase. After all, early surgery is necessary for a good prognosis. Tendon repair within 6 weeks after trauma is recommended, but optimally within 7 days after rupture*(1, 2, 6, 8, 9)*. If inadequate repair or late re-insertion takes place, significant and permanent loss of strength can occur in both elbow flexion and forearm supination. This has a major impact on the overall functionality of the patient. Furthermore, an increase in the number of post-operative complications is also observed with late re-insertion *(1, 3, 9)*.

The biceps brachii muscle extends from the shoulder beyond the elbow, with the short head originating at the coracoid process and the long head originating at the supraglenoid tubercle *(1)*. These come together in the bicipital groove to form the actual biceps muscle. Distally, the tendon of the biceps first makes a 90° external rotation before inserting on the posterior ulnar part of the tuberositas radii *(1, 5)*. The biceps is the most important supinator and the second most important elbow flexor after the brachialis *(1, 7, 9)*.

The lacertus fibrosus, a bicipital aponeurosis with an insertion at the level of the epimysium and deep fascia of the muscles of the medial elbow, also originates from the short head *(7, 9)*. This structure acts as a stabilizing factor for the biceps brachii and assists with supination*(1, 5, 7, 9)*. Retraction of the distal biceps tendon after rupture is more pronounced when the lacertus fibrosus is also affected *(9)*.

A rupture of the biceps tendon often occurs at the distal 2cm. Research on cadavers has shown two possible theories for this *(10)*. First, there is a hypovascular zone at an average of 2.14 cm proximal to the insertion. This part of the tendon is situated between the proximal part of the distal biceps, vascularized by a branch of the brachial artery, and the distal insertion, where the blood supply is provided by the interosseous recurrent artery *(1, 2, 10)*. Furthermore, a mechanical impingement of the distal tendon occurs when moving from full supination to full pronation. A 50% reduction of the space of the proximal radio-ulnar joint is noted *(1, 2, 10)*. Eventually, 85% of the joint space of the proximal radio-ulnar joint is occupied by the biceps tendon*(10)*. The combination of reduced blood flow and mechanical impingement would make this part of the tendon susceptible to rupture.

Distal biceps tendon ruptures typically occur during eccentric loading of a flexed elbow or when lifting heavy weights *(1-3, 5, 6, 9)*. Patients report a sudden, sharp pain localized at the level of the forearm or antecubital fossa and sometimes a "snap" can be felt or heard *(1, 3-5, 9)*. On clinical examination a visible deformity with retraction of the biceps proximally, called the reversed popeye-sign, can sometimes be seen. Furthermore, haematoma formation can be noted at the level of the antecubital fossa*(1, 3-5, 8)*. Palpation over the course of the tendon is painful and resistance testing shows markedly reduced strength with elbow flexion and forearm supination *(1, 3, 4, 8)*. These clinical signs are less present or even absent in patients with partial ruptures.

A distinction is made in the treatment of distal biceps tendon ruptures between low-grade partial ruptures (<50%) and high-grade partial (>50%) to complete ruptures *(4, 6)*. Low-grade distal biceps tendon ruptures can be treated conservatively. With complete or high-grade injuries, surgical repair should be performed quickly, ideally within 7 days and preferably within 3-6 weeks *(1, 3, 6, 8, 9)*. A conservative approach should only be considered in the elderly or in patients who have no strenuous activities to the biceps *(1, 2)*. Surgical repair consists of reinsertion of the distal biceps tendon at the tuberosity with fixation or tenodesis to the brachialis *(1, 2)*. Post-operative rehabilitation consists of an initial immobilization phase in 90° flexion using a cast or splint for 7 to 10 days, followed by the use of a brace with an extension block for up to 6 weeks post-operatively. Afterwards, slowly progressive loading can be started. On average 6 months post-operatively, unlimited activity is possible.

The most important indicator for a good prognosis is the time interval between the occurrence of the injury and surgical repair. When diagnosis is delayed, there is an increased risk of complications or an unsuccessful reintegration. The most important complication is a significant and permanent loss

of strength for both elbow flexion and forearm supination *(1)*.

During the diagnostic process of distal biceps tendon ruptures, several problems can emerge. This prompted further literature study regarding the diagnosis of distal biceps tendon ruptures. The following clinical questions were sought to be answered:

1) Clinical examination can confirm the diagnosis of a complete distal biceps tendon rupture, but it must be performed correctly. Which clinical tests are the most sensitive/specific? Which clinical tests can facilitate efficient referral and timely therapeutic treatment?

2) Ultrasound evaluation using the classical anterior longitudinal/transverse view *(11, 12)* is not always sufficient to evaluate the distal biceps tendon and to assess the degree of rupture due to several factors. Are there alternative approaches for better ultrasound visualization of the distal biceps tendon?

3) Rapid surgical repair is necessary to obtain a good prognosis. MRI is still often considered the "gold standard" for diagnosis, despite the long waiting time. After providing optimizations, is ultrasound an equivalent alternative to MRI in the diagnosis of distal biceps tendon injuries?

MATERIAL AND METHODS

An extensive literature search was conducted through Pubmed and Embase. The search strategy was developed systematically in the Medline database (PubMed interface), using medical subject headings as well as free text words. A broad search term, including an extensive number of synonyms was preferred to decrease the likelihood of missing relevant articles.

RESULTS

In literature, several specific tests have been described to evaluate the distal biceps tendon.

Devereaux et al. *(3)* showed in 2013 that a test battery consisting of the Hook test, the Passive Forearm Pronation Test (PFP test) and the Biceps Crease Interval Test (BCI test) has a high sensitivity and specificity for the diagnosis of a distal biceps tendon rupture. When all three tests show the same result (positive or negative), there is a 100% sensitivity/specificity for diagnosis or exclusion of a total distal biceps tendon rupture (Table I). If there is a discrepancy in the results of the 3 tests, further imaging in the form of MRI or ultrasound is indicated.

1) Hook test *(3, 8, 13)* (Fig. 1A):

The patient holds the arm in 90° of shoulder elevation, 90° of elbow flexion and the forearm in full active supination. This can be achieved by asking the patient to "Look at their palm". This causes a contraction of the biceps muscle and a concurrent relaxation of the underlying brachialis muscle. At that moment, the distal biceps tendon is hooked by the examiner at the level of the antecubital fossa and from laterally. If no structure can be hooked, the test is positive and this indicates a complete distal biceps tendon rupture. It is important to always come from the lateral side, because sometimes the lacertus fibrosus is still intact medially. If the test is performed incorrectly, this can lead to a false negative Hook test. The lacertus cannot be hooked as easily and feels much thinner and sharper. O'Driscoll et al. *(10)* recommend that after hooking the intact tendon, traction is applied to the tendon. If this causes

Table I. — Diagnostic Accuracy (in Percentages) of Special Tests *(20)*

Diagnosic Accuracy (in percentages) of special tests [a]			
Special tests	Sensitivity	Specificity	Coments
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 test unequivoval (N=48)	100	100	3 false-negative

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

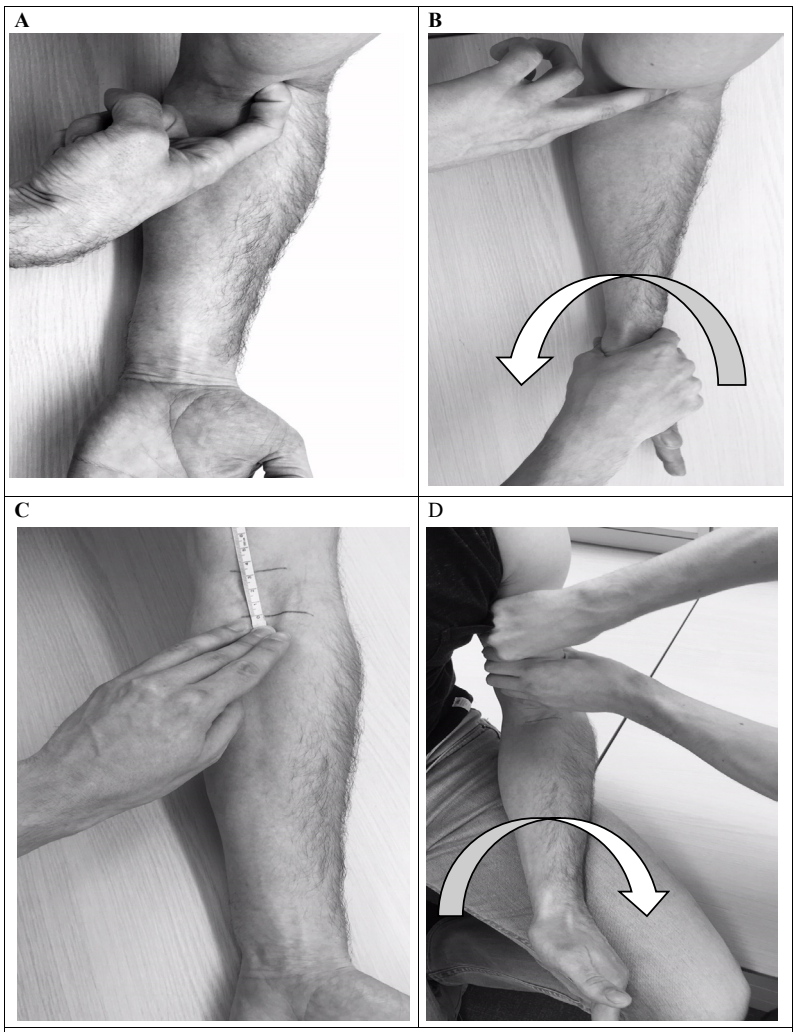

Figure 1. — : Clinical tests. A. Hook test. B. PFP test: passive forearm pronation. C. BCI test D. Biceps squeeze test: supination movement secondary to squeezing of the biceps muscle.

pain, it may indicate an underlying tendinopathy or partial rupture of the distal biceps tendon.

2) PFP test *(3)* (Fig. 1B):

The patient holds the elbow in 90° flexion and the forearm in full supination. A passive pronation of the forearm is performed by the examiner. During this movement, the movement of the biceps muscle belly from proximal to distal is observed visually and palpatory. In case of a complete distal biceps tendon rupture, no movement is visible and the test is considered positive.

3) BCI test *(3, 14)* (Fig. 1C):

In this test, the patient is asked to first bend the elbow so that the examiner can identify the flexion crease in the antecubital fossa. The patient is then asked to fully extend the elbow and supinate of the forearm. The flexion crease is marked with a pen. In the next step, the distal end of the biceps muscle is palpated. The point where the curve of the muscle belly turns most sharply towards the antecubital fossa is marked as the second line. The distance between these two lines is measured. The steps are repeated on the contralateral side. If the distance is more than 6.0

cm, the test should be considered positive. This test evaluates the degree of tendon retraction. If this test is positive, it indicates a complete biceps tendon rupture with concomitant rupture of the lacertus fibrosus.

Using these three tests, patients with a complete distal biceps tendon rupture can be identified more quickly and a faster surgical referral for anatomical repair can be made.

Another test described in the literature is the "Biceps squeeze test" *(15)* (Fig. 1D). This test shows a 100% sensitivity for the diagnosis of a complete distal biceps tendon tear. The elbow is brought into 60-80° flexion with the forearm in slight pronation. The examiner places one hand at the level of the distal myotendinous junction and his other hand at the level of the biceps muscle. With both hands, the biceps muscle is squeezed simultaneously. If no supination of the forearm is seen, this indicates a discontinuity of the distal biceps tendon.

The gold standard for diagnosing distal biceps tendon ruptures is still MRI. A standardized protocol with FABS position is used. The patient is positioned in the prone position in the MRI with the elbow in flexion, abduction and the forearm in supination (FABS) (Fig. 2) *(16)*. In this way, a good visualization of the distal biceps tendon up to its insertion site is possible *(1-3, 5, 6, 8)*. Although there is no significant difference in sensitivity and specificity for the FABS view MRI compared with standard MRI in the detection of distal biceps injuries, FABS view MRI is more accurate in grading when distal biceps injury is present *(17)*. Disadvantages of MRI are the high social cost, the long waiting time, the static nature of this examination and the fact that there are certain contraindications for undergoing this examination *(2, 3, 5, 6)*.

Figure 2. — FABS Position MRI.The patient is positioned in the prone position in the MRI with the elbow in flexion, abduction and the forearm in supination (FABS).
Note: From Giuffre et al, 2004 *(15)*.

Ultrasound examination of the distal biceps tendon is mainly performed using the classic anterior longitudinal/transverse approach *(11, 12)*. However, given the complex anatomical course of the distal part of the tendon in which it bends and rotates around its axis before inserting on the radial tuberosity, this technique often leads to a pronounced anisotropy of the tendon. Anisotropy is a hypoechogenic configuration of the tendon when the ultrasound waves do not pass through the tendon perpendicularly. As a result, the distal 2cm of the tendon, which is the most vulnerable location for rupture, is not always easy to visualize. This makes correct diagnosis and differentiation of low-grade versus high-grade lesions difficult. Furthermore, it is difficult to visualize the true insertion at the level of the tuberosity radii, because of its ulnar-posterior localization (Fig. 3) *(1, 6)*. Advantages of ultrasound over MRI are its rapid availability, the possibility of dynamic evaluation, no contraindications and its much lower cost *(1, 2, 5, 9)*. However, the result is highly operator-dependent and difficult to interpret afterwards by others *(1, 2, 9)*. Comparative studies are small and scarce due to the low incidence of this pathology. When MRI is compared with ultrasound in the diagnosis of biceps tendon rupture, similar results are obtained. MRI has a sensitivity of 92.4% and specificity of 100% while ultrasound has 97% sensitivity and 100% specificity *(4)*.

Another, smaller study gives significantly lower values for both techniques. Results are mainly

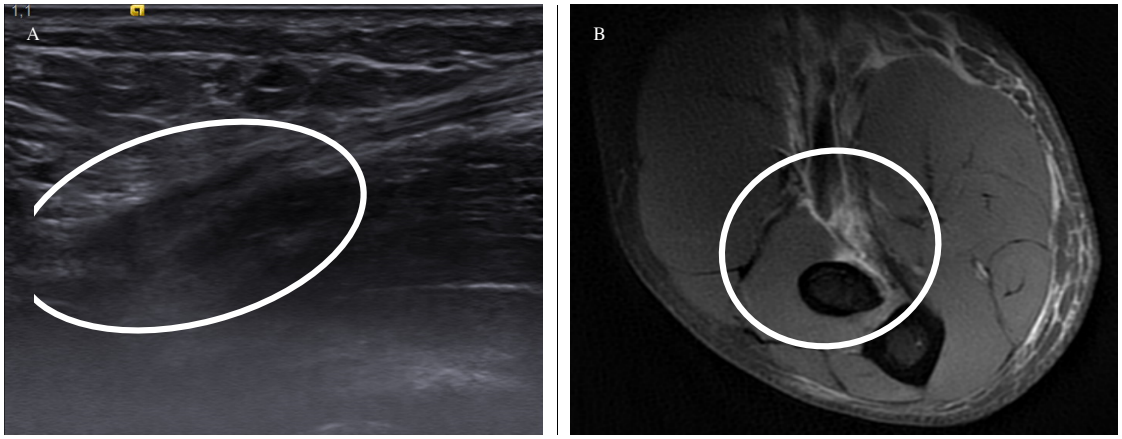

Figure 3. — High-grade Distal biceps tendon rupture. A. Ultrasound image of the left elbow, anterior longitudinal view (white circle: hypoechogenic configuration distal part of the biceps tendon, difficult differentiation between anisotropy/tendinosis/rupture). B. MRI coronal PD sequence of the left elbow (white circle: subtotal rupture of the distal biceps tendon with a few fibres still inserting at the level of Tuberositas Radii).

influenced by the small sample size, the retrospective nature of most studies, the presence of interobserver variability and the difference in expertise of the radiologist *(4, 5)*. Ultrasound seems to be better suited than MRI for grading partial distal biceps tendon ruptures *(2, 9)*.

In recent years, much research has been done on the role of ultrasound in diagnosing distal biceps tendon ruptures. This has led to new alternative approaches of visualizing the tendon and increasing the accuracy of diagnosis *(6, 18, 19)*.

As already described, the classical "Anterior Approach" (Fig. 4A) consists of a longitudinal and transverse visualization of the tendon along the volar side of the forearm. The patient is asked to perform maximal extension and supination *(11)*. This positioning is not always possible, since acute trauma to the biceps tendon often results in haematoma/swelling of the elbow and painful maximal extension/supination is. Because of the anatomical course of the tendon a good visualization of the distal part of the tendon and its insertion at the level of the radius is not always possible. This makes it difficult to differentiate between a complete or partial distal tendon rupture. Especially when there is no retraction of the tendon.

In 2005 *(18)*, a new "Posterior Approach" (Fig. 4B) is described, namely the "Cobra Sign". The patient is asked to keep the elbow in flexion and to pronate the forearm. The probe is placed transversally 3 to 4 cm distal to the olecranon above the radius. After performing the pronation movement the tuberosities radii with the distal part of the tendon come into view. A dynamic evaluation through passive pro-supination is possible. A disadvantage of this technique is that the zone where most tears are located (1 to 2 cm proximal to the insertion, "hypovascular zone") cannot be visualized.

In 2009 *(19)* the "Lateral Approach" (Fig. 4C), also called the "Supinator View", was described for the first time. For this view, the patient holds the elbow in 90° flexion and the forearm in supination. The probe is placed on the lateral aspect of the elbow in the coronal plane. The tendon is visualized underneath the supinator muscle. Under the tendon lies the brachial artery. A great advantage of this technique is the fact that the tendon and the probe run parallel, so there is no anisotropy. A disadvantage is that the distal insertion on the tuberosity radii cannot be seen as it is hidden behind the radius. Dynamic evaluation of the tendon is also possible with this technique.

The last approach is the "Medial Approach" (Fig. 4D) or the "Pronator View". This was first described by Smith et al. in 2010 *(6)*. The patient is asked to perform an elbow flexion of 90° and a forearm supination. The transducer is placed at the level of the medial elbow in the coronal plane with the caudal end of the probe at the level of the medial epicondyle. The transducer is then moved anteriorly

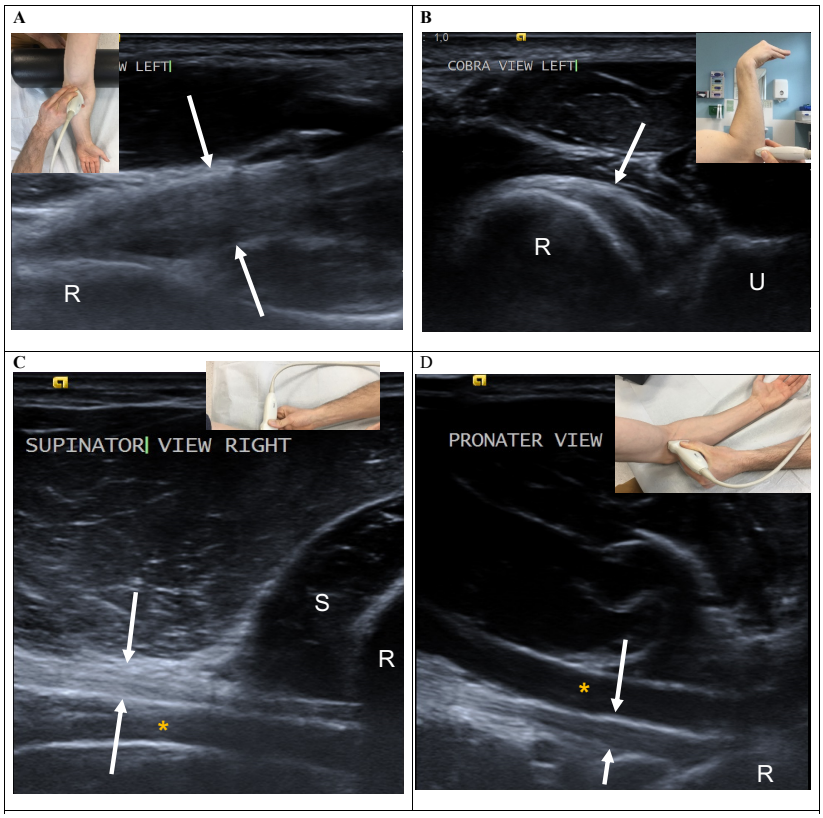

Figure 3. — Different Ultrasound approaches. A. Anterior longitudinal approach (left). B. Posterior approach or "Cobra view" (left). C. Lateral approach or "Supinator view" (left). D. Medial approach or "Pronator view" (left). R. Radius; U. Ulna; S. Supinator muscle; Yellow asterisk: Brachial Artery; White arrow: Biceps tendon.

until the pronator muscle and the biceps tendon underneath it are visible. With this technique, the tendon can be visualized over its entire length up to its insertion on the radial tuberosity. The brachial artery is located superficial to the tendon, which provides acoustic amplification resulting in better visualization. This technique also allows for dynamic evaluation of the tendon.

CONCLUSION

An extensive literature review was performed in order to optimize the diagnostic process in distal biceps tendon ruptures and to search for an answer to the clinical questions mentioned above:

1) Standardized clinical examination for the distal biceps tendon should consist of the Hook test, PFT test and BCI test, which have been shown to have high specificity and sensitivity. This may be supplemented by the biceps squeeze test.

2) Cobra sign, Supinator view and Pronator view should be added to the standard ultrasound examination of the distal biceps tendon for a thorough evaluation of the whole tendon and its insertion.

3) Ultrasound is a good alternative to MRI in the evaluation of distal biceps tendon ruptures. It is a cheaper and faster imaging modality that allows for dynamic evaluation.

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