Ultrasound of the elbow with emphasis on the sonoanatomy of the distal biceps tendon and its importance for the surgical treatment of tendon lesions

Giorgio Tamborrini¹, Magdalena Müller-Gerbl², Nicole Vogel³, David Haeni³

¹ UZR, Ultrasound Center and Institute for Rheumatology, EULAR Network of Imaging Center, Basel, Switzerland
² Institute of Anatomy, University of Basel, Basel, Switzerland
³ LEONARDO, Hirslanden Clinic Birshof, Münchenstein, Baselland, Switzerland

Correspondence: Giorgio Tamborrini, UZR, Aeschenvorstadt 68, 4051 Basel, Switzerland; tel.: +412251010, e-mail: ultrasound@irheuma.com

DOI: 10.15557/JoU.2020.0021

Abstract

Degenerative or traumatic ruptures of the distal biceps tendon are less common than proximal lesions. Distal lesions lead to a significant loss of function with usually considerable discomfort for patients. Therefore, precise diagnostics using operator-dependent high-resolution musculoskeletal ultrasound with illustration of the extent of the affected tendon lesion are important for optimizing patient management. In this article, we discuss the precise high-resolution musculoskeletal ultrasound and sonoanatomy of the distal biceps tendon and emphasize its importance for the surgical treatment of tendon lesions. In this review and pictorial essay, we first focus on the description of the precise anatomy and ultrasound anatomy of this clinically important region. Furthermore, we highlight different ultrasound scanning techniques for the correct assessment of the distal biceps tendon. Various approaches for optimal sonographic assessment of the distal biceps tendon have been suggested in the literature: the anterior approach, the lateral access, the medial access and the posterior approach. In the second part of the article, we focus on the evaluation of surgical repair techniques of distal biceps tendon lesions considering the extent of the rupture zone of the distal biceps tendon based on the ultrasound findings. Surgical techniques are explained from the orthopedic surgical point of view.

Ultrasound of the distal biceps tendon

The distal biceps tendon (dBT) is an elbow flexor, and it is involved in supination. The biceps muscle is innervated by the musculocutaneous nerve (C5, C6). Performing ultrasound diagnostics of the dBT, the patient ideally lies in the supine position on an examination couch with padding of the arm, if necessary. Alternatively, the examination can be performed in the sitting position. The arm is initially positioned in extension for static side comparison and dynamic analysis (flexion-extension, pronation-supination) of all structures on the anterior (cubital) elbow. The forearm is in the supination position. It is recommended to start the examination in the middle of the upper arm, and examine the structures continuously up to the ventral/anterior fore-arm in the transverse plane. This involves assessing both the osseous structures and the complete soft tissue. The easy-to-find trochlea humeri and the capitulum humeri with the hypoechoic hyaline cartilage serve as landmarks when assessing, for example, the soft tissue, the joint capsule or the joint cavity in the anterior elbow. The biceps tendon, the brachial artery, the median nerve, the deep brachial muscle, the ulnar-sided pronator teres muscle and the radial sided supinator muscle, the radial nerve (Fig. 1),
and the anterior interosseous nerve can be assessed. The authors do not examine in consideration of probe positions, because we focus exclusively on the ultrasound image and orient ourselves to the anatomical landmarks in ultrasound images. The examination is dynamic and functional, so it must be documented on video (Video 1 – available at www.jultrason.pl).

The flat dBT is approximately 6 to 7 cm long, 6 mm wide, and 3 mm thick\(^4\). The distal biceps tendon moves obliquely from anterior to posterior, and from medial to lateral, with the dBT rotating 90°, so that the anterior surface points to the side. As the forearm moves from supination to pronation, the radial tuberosity shifts from posterior to anterior position. The biceps tendon winds around the radius and compresses the bursa situated in between. The dBT is covered by an extrasynovial paratenon and by the bicipitoradial bursa. The bursa is normally not visible by high-resolution musculoskeletal ultrasound, unless it is filled with some amount of synovial fluid.

Various approaches for optimal sonographic assessment of the dBT have been suggested in the literature\(^4\):
- anterior approach (we do not recommend it for the completely distal sections, the reason being that it is often painful for the patient and not sensitive enough, with too many anisotropy artifacts)
- lateral access (through the brachio-radialis muscle and the supinator muscle = supinator window)
- medial access (through the pronator teres muscle = pronator window)
- posterior approach (through the anconeus muscle)

The dBT is most easily examined at the beginning of medial longitudinal in the supination position of the forearm, in an approx. 20 to 30° flexion position in the elbow joint. We examine through the musculus pronator teres, with evaluation of the dBT up to the distal insertion at the radius. We recommend using the radius as a bony landmark. Generally, simple visualization of the distal biceps tendon at the radial insertion point is possible by visualizing the radial artery simultaneously with the radius (Fig. 2).

The assessment of the insertion at the radius below the supinator muscle is ideally performed by scanning through the supinator muscle. The forearm is maximally pronated, and the wrist is flexed. Both the lateral and posterior approaches are suitable for this purpose.

The insertion of the dBT is located at the radial tuberosity and a part at the fascia antebraehii (lactertus fibrosus). The entheseal medial insertion can be divided anatomically and sonographically into two sections. The distal tendon of the long head (lBT) inserts in the proximal section of the radial tuberosity, while the distal tendon of the short head (sBT) is located more distally (Fig. 3)\(^2\). In addition, the double tendon insertion allows an element of independent function of each section of the biceps\(^3\):
Ultrasound of the elbow with emphasis on the sonoanatomy of the distal biceps tendon and its importance for the surgical treatment of tendon lesions

**Fig. 2.** Anterior/medial elbow, longitudinal image, B-Mode, 11 MHz. >1 – distal biceps tendon (long head), >2 – distal biceps tendon (short head), >3 – lacertus fibrosus, *1 – radius, *2 – biceps muscle, long head, *3 – pronator teres muscle

**Fig. 3.** Posterior/lateral elbow, longitudinal image in maximal pronation, B-Mode, 11 MHz. >1 – distal biceps tendon (long head), >2 – distal biceps tendon (short head), *1 – insertion of the long head of the biceps tendon at the footprint/radial tuberosity, *2 – insertion of the short head of the biceps tendon at the footprint/radial tuberosity, *3 – radial head, *4 – supinator muscle, *5 – flexor carpi radialis muscle
• the distally inserting sBT is a stronger flexor of the elbow
• the proximally inserting lBT is a stronger supinator when
  viewed from the axis of rotation of the forearm

The lacertus fibrosus (part of the aponeurosis which usually
develops at the height of the myotendinous junction, pulling
onto the fascia antebrachii) originates from the dBT
of the short head (Fig. 1)(3). The lacertus fibrosus covers the
median nerve and the brachial artery, and has the function
of keeping the biceps tendon in the correct position.

The biceps tendon insertion is located on average approx.
23 mm distally to the articular edge of the radial head. The
average length of the biceps tendon insertion at the tubera-
sity is approx. 21 mm, with an average width of 7 mm
(Fig. 2, Fig. 3, Fig. 4). The average total area of the enthesis
(footprint) is about 108 mm² (footprint of the long head:
48 mm², footprint of the short head: 60 mm²)(1–3).

Ruptures of the dBT are best visualized in the long axis,
and they appear as an anechoic or hypoechogenic dis-
continuity of tendon fibers with or without retraction and
surrounding hypoechogenic fluid (e.g. inside the bicipitora-
dial bursa) or isoechoic hematoma (Fig. 5). The degree
of tendon retraction is not necessarily an indicator of the
condition of the lacertus fibrosus, so it must be assessed
separately(4). The detailed assessment of the biceps tendon
footprint supports, due to high anatomical variation of the
position and shape of the tuberosity and insertion of the
long biceps tendon, among other things, surgical recon-
struction (including bone tunnels, suture anchors)(5–7).

We are convinced that the importance of sonography is
underlined by the contributions of the elbow surgeons in
the following section.

Treatment options

A partial or complete rupture of the dBT can be visualized
by high-resolution musculoskeletal ultrasound or MR. In
cases of partial tears (less than 50% affected)(5), patients
are usually treated conservatively(6,7). However, there is a
high failure rate (up to 56%) in patients with partial rup-
tures involving more than 50% of the dBT and in patients
with a high physical load and repetitive activities(8). For
this reason, surgical treatment of partial lesions involving
more than 50% of the dBT is recommended.

In cases of complete rupture, open refixation is recommended
in most patients. Surgically treated patients have a better func-
tion(9–11). Various factors should be considered when deciding
on therapy, including the activity level, comorbidities, hand
dominance, and risk-benefit ratio(10). Conservative treatment
is an option for patients with low functional demands and
needs (“low functional demands”) or with relevant comorbid-
ities. These patients, however, show clinically relevant deficits
in various activities(10) e.g. 40% loss of supination power, and
30% loss of flexion power(12).

A number of open and endoscopic surgical techniques
have been described and suggested in the literature. The
so-called open “single incision” technique is more widely

---

Fig. 4. Posterior/lateral elbow, transverse image in maximal pronation, B-Mode, 11 MHz. >1 – distal biceps tendon, *1 – insertion of the
distal biceps tendon at the footprint / radial tuberosity, *2 – ulna, *3 – extensor digitorum communis muscle, *4 – supinator muscle,
*5 – extensor carpi ulnaris muscle, *6 – anconeus muscle
Ultrasound of the elbow with emphasis on the sonoanatomy of the distal biceps tendon and its importance for the surgical treatment of tendon lesions

Intraoperative and postoperative complications may occur in up to 25% of cases\(^{15}\). A postoperative rupture is described in approximately 2.5% of cases\(^{16}\). Neuroapraxia of the N. cutaneus lateralis antebrachii (a sensitive branch of the N. musculocutaneus) can occur in up to 10% of cases with excessive traction during surgery. The complication is usually temporary, with restitutio ad integrum. Other complications, such as injury to the interosseus posterior nerve (PIN), heterotopic ossifications, and radio-ulnar synostoses, are possible. Heterotopic ossifications occur less commonly with the above mentioned “single incision” technique compared to the “double incision” technique (7%), but are often clinically irrelevant\(^{17}\).

Conclusions

High-resolution musculoskeletal ultrasound with an axial and lateral resolution of up to 0.1 mm allows a differentiated assessment of the two parts of the distal biceps tendon, and thus the detection of different pathologies (Tab. 1)\(^{18}\). Due to high diagnostic accuracy of high-resolution musculoskeletal ultrasound, isolated lesions of one of the two components of the dBT can be distinguished, which may determine the clinical management of e.g. young patients from surgical to conservative treatment. A timely and accurate diagnosis allows earlier refixation, which in turn leads to better functional results with a low postoperative complication rate.

Acknowledgment

Considering “The Code of Ethics of the Word Medical Association” (Declaration of Helsinki), for experiments involving...
humans, the samples were taken from body donors who contributed their body to science and research only to the departments. All ultrasound images were taken by author 1, while anatomical images and sections were produced by authors 1 and 2.

**Conflict of interest**

The authors do not report any financial or personal connections with other persons or organizations which might negatively affect the contents of this publication and/or claim authorship rights to this publication.

**References**

1. Walton C, Li Z, Pennings A, Agur A, Elmaraghy A: A 3-dimensional anatomic study of the distal biceps tendon: implications for surgical repair and reconstruction. Orthop J Sports Med 2015; 3: 2325967115585113.
2. Athwal GS, Steinmann SP, Rispoli DM: The distal biceps tendon: footprint and relevant clinical anatomy. J Hand Surg Am. 2007; 32: 1225–1229.
3. Eames MH, Bain GI, Fogg QA, van Riet RP: Distal biceps tendon anatomy: a cadaveric study. J Bone Joint Surg Am: 2007; 89: 1044–1049.
4. Konin GP, Nazarian LN, Walz DM: US of the elbow: indications, technique, normal anatomy, and pathologic conditions. Radiographics 2013; 33: E125–E147. Doi: 10.1148/rg.334125059.
5. de la Fuente J, Blasi M, Martínez S, Barceló P, Cachán C, Miguel M et al.: Ultrasound classification of traumatic distal biceps brachii tendon injuries. Skeletal Radiol 2018; 47: 519–532.
6. Stucken C, Ciccotti MG: Distal biceps and triceps injuries in athletes. Sports Med Arthrosc Rev 2014; 22: 153–163.
7. Dürr HR, Stäbler A, Pfahler M, Matzko M, Relior HJ: Partial rupture of the distal biceps tendon. Clin Orthop Relat Res 2000; (374): 195–200.
8. Bauer TM, Wong JC, Lazarus MD: Is nonoperative management of partial distal biceps tears really successful? J Shoulder Elbow Surg 2018; 27: 720–725.
9. Chillemi C, Marinelli M, De Cupis V: Rupture of the distal biceps brachii tendon: conservative treatment versus anatomic reinsertion-clinical and radiological evaluation after 2 years. Arch Orthop Trauma Surg 2007; 127: 705–708.
10. Savin DD, Watson J, Youderian AR, Lee S, Hammarstedt JE, Hutchinson MR et al.: Surgical management of acute distal biceps tendon ruptures. J Bone Joint Surg Am 2017; 99: 785–796.
11. Sutton KM, Dodds SD, Ahmad CS, Sethi PM: Surgical treatment of distal biceps rupture. J Am Acad Orthop Surg 2010; 18: 139–148.
12. Morrey BF, Asken LJ, An KN, Dobyns JH: Rupture of the distal tendon of the biceps brachii. A biomechanical study. J Bone Joint Surg Am 1985; 67: 418–421.
13. Wirth J, Bohnsack M: Distale Bizepssehnenruptur und Refixation der Sehne über zwei Zugänge. Oper Orthop Traumatol 2003; 15: 415.
14. Legg AJ, Stevens R, Oaks NO, Shahane SA: A comparison of nonoperative vs. Endobutton repair of distal biceps ruptures. J Shoulder Elbow Surg 2016; 25: 341–348.
15. Watson JN, Moretti VM, Schwindel L, Hutchinson MR: Repair techniques for acute distal biceps tendon ruptures: A systematic review. J Bone Joint Surg Am 2014; 96: 2086–2090.
16. Amin NH, Volpi A, Lynch TS, Patel RM, Cerynuk DL, Schickendantz MS et al.: Complications of distal biceps tendon repair: a meta-analysis of single-incision versus double-incision surgical technique. Orthop J Sports Med 2016; 4: 2325967116688137.
17. Behun MA, Geeslin AG, O’Hagan EC, King JC: Partial tears of the distal biceps brachii tendon: a systematic review of surgical outcomes. J Hand Surg Am 2016; 41: e175–e189.
18. Tamborrini G, Bruyn GAW, Staerkle-Baer A: Musculoskeletal Ultrasound Sonoanatomy Guidelines. Irheuma.com. ISBN 978-3-7460-6295-2.