J Shoulder Elbow Surg (2016) 25, 1717–1730

ELSEVIER

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

Distal biceps tendon history, updates, and controversies: from the closed American Shoulder and Elbow Surgeons meeting—2015

Christopher C. Schmidt, MD[a,*], Felix H. Savoie III, MD[b], Scott P. Steinmann, MD[c], Michael Hausman, MD[d], Ilya Voloshin, MD[e], Bernard F. Morrey, MD[c], Dean G. Sotereanos, MD[a], Emily H. Bero, BS[f], Brandon T. Brown, MME[g]

[a]*Department of Orthopaedic Surgery, School of Medicine, University of Pittsburgh, Pittsburgh, PA, USA*
[b]*Department of Orthopaedics, Tulane University, New Orleans, LA, USA*
[c]*Department of Orthopedic Surgery, Mayo Clinic, Rochester, MN, USA*
[d]*Department of Orthopaedics, Mount Sinai Hospital, New York, NY, USA*
[e]*Department of Orthopaedics, University of Rochester, Rochester, NY, USA*
[f]*Department of Mechanical Engineering and Materials Science, University of Pittsburgh, Pittsburgh, PA, USA*
[g]*Department of Bioengineering, University of Pittsburgh, Pittsburgh, PA, USA*

Understanding of the distal biceps anatomy, mechanics, and biology during the last 75 years has greatly improved the physician's ability to advise and to treat patients with ruptured distal tendons. The goal of this paper is to review the past and current advances on complete distal biceps ruptures as well as controversies and future directions that were discussed and debated during the closed American Shoulder and Elbow Surgeons meeting in 2015.

Level of evidence: Narrative Review

Keywords: History distal biceps tendon; anatomy distal biceps; anatomic biceps repair; posterior approach; anterior approach; high-flexion biceps repair; biceps tendon augmentation; endoscopically assisted repairs

History

The first known case of direct suture of the distal biceps tendon to the radial tuberosity occurred in 1898, and the first reported use of a tendon fixation device, a nail, happened in 1928.[21] Our current knowledge of distal biceps disease and surgical treatment arguably started in 1941 when Robert P. Dobbie reviewed the known 24 cases of complete distal biceps avulsions in the literature and reported on 51 new cases.[21] Dobbie's clinical observations were that the biceps tendon attaches posteriorly on the radial tuberosity and the tendon ruptures off bone with little remnant. An anterior approach between the brachioradialis and pronator teres provides good tendon exposure, however Dobbie believed a repair back to the radial tuberosity was "impractical and unwise" due to an unacceptable rate of radial nerve palsies, 4.4% (2/51), which is similar to today's rate, 3.2% (9/280).[21,63] Dobbie further recommended biceps to brachialis transfer to prevent radial nerve injury and to improve elbow flexion; he believed "the

*Reprint requests: Christopher C. Schmidt, MD, Department of Orthopaedic Surgery, School of Medicine, University of Pittsburgh, 9104 Babcock Blvd, Suite 5113, Pittsburgh, PA 15237, USA.
E-mail address: schmidtc@upmc.edu (C.C. Schmidt).

1058-2746/$ - see front matter © 2016 Journal of Shoulder and Elbow Surgery Board of Trustees. All rights reserved.
http://dx.doi.org/10.1016/j.jse.2016.05.025

supinative power of the biceps is of secondary importance and can be ignored."[21] Other early investigators also thought that repair to bone using an anterior approach was associated with an unacceptably high rate of radial nerve palsies, 50% (3/6), and therefore advised a biceps to brachialis transfer for definitive treatment.[57]

During the 1960s, a number of physicians advocated nonoperative treatment for biceps ruptures, prescribing weight training exercise.[13] Carroll and Hamilton reviewed the results of 100 patients with complete biceps ruptures; 10 of these injuries were distal injuries, and those 10 patients returned to work, on average, at 4 weeks without loss of supination strength at 1-year follow-up.[13] However, Friedmann noted weakness in elbow flexion and supination with conservative care but reported that a few patients were able to "overcompensate in satisfactory fashion."[29] Patients were observed adapting to their supination strength loss by excessively using the shoulder muscles.[57] They involuntarily abduct the shoulder and then adduct the arm while externally rotating the forearm to increase supination power. [57]

Some surgeons began to recognize the importance of repairing the ruptured tendon to the radial tuberosity in an attempt to recover lost supination strength and endurance.[5,10,11,29] This breakthrough came in 1961, when Boyd and Anderson published a case series of 3 patients using a 2-incision approach that, in theory, limits radial nerve injury while providing ample room to reattach the tendon to the radius.[11] An anterior incision is made to harvest the retracted tendon, the tendon is passed from front to back between the pronator teres and brachioradialis, and a second posterior incision is made between the ulna and anconeus to retrieve the tendon and suture it to bone. Their procedure was revolutionary because unlike the biceps to brachialis transfer, the repair addressed the loss of supination strength.[11] Two landmark articles in 1985, published back-to-back in *Journal of Bone and Joint Surgery*, clearly showed that the 2-incision approach was superior to nonoperative care.[5,60] Patients treated nonoperatively experienced difficulties with activities that required repetitive forceful supination and flexion, like turning a screwdriver or swinging a baseball bat.[5] Mechanical testing showed a 40% loss of supination strength, 79% loss of supination endurance, 30% loss of flexion strength, and 30% loss of flexion endurance.[60]

With dissemination of the 2-incision approach, other investigators started to report a concerning occurrence of motion-limiting heterotopic bone (HO) formation between the proximal radius and ulna.[18,25,45,50,60] Morrey and coinvestigators noted that a traditional Boyd and Anderson approach raises the anconeus off the ulna and in doing so damages its periosteum and possibly the interosseous membrane.[25,59] The injury to the periosteum and interosseous membrane was postulated to cause excessive HO formation. To prevent symptomatic HO, the authors recommended splitting the extensor carpi ulnaris (ECU) or the extensor digitorum communis (EDC) instead of elevating the anconeus.[25,59] In addition, further effort was made to remove all bone debris created during trough burring.[25,59] They named the new surgical approach the modified 2-incision technique.[25,59] To be consistent with modern-day terminology, the remaining parts of this article refer to the modified 2-incision approach as the posterior approach. In a subsequent study using their posterior approach, the authors reported no motion-limiting HO (0% [0/74]).[46] This technique is the current "gold standard" repair.[78] However, a subsequent retrospective review questioned the success of the posterior approach by reporting a 7% (3/45) occurrence of motion-limiting HO.[8] Of note, HO limiting forearm rotation has also been reported in association with an anterior approach.[2,92] A recent randomized clinical trial comparing anterior to posterior approaches in repairing the distal biceps reported no clinically significant occurrence or statistical difference ($P = .7$) in HO formation between the groups (anterior, 1/47 mild HO; posterior, 1/43 mild HO).[31] Unless it is contraindicated, indomethacin 25 mg 3 times daily was prescribed for 3 weeks postoperatively in both groups.[31]

Invention of new fixation devices, fear of HO, and the belief that early active motion might improve clinical results revitalized interest in the anterior approach.[4,6,30,44,52,56,86,89] The search for the strongest fixation device led to a plethora of time-zero cyclic and load-to-failure studies.[7,30,41,47,48,55,67,81,82,87] The results of the mechanical strength studies demonstrated that cortical buttons are mechanically superior to suture anchors or interference screws.[30,48,55,81-83] However, clinical studies using suture anchors, cortical buttons, and combinations of a button and interference screw all reported similar rerupture rates (0% to 4%) with acceptable clinical results and return of peak strength tested in a neutral forearm position.[16,31,38,65]

Accelerated motion using both anterior and posterior approach programs has reduced the risk of elbow stiffness after repair, but early motion must be balanced against the risk of rerupture. Studies vary widely, with postoperative protocols ranging from 6-week cast immobilization to immediate active range of motion with a 6-week 1-pound weight restriction.[12,15,16,30,31,35,38,77] Rerupture tends to occur during the first 14 days after repair as a result of a traumatic accident or the patient's noncompliance.[16,31,38,44] To our knowledge, rerupture 6 weeks after repair has not been reported.[16,38] No method of initial fixation has proved superior over another to prevent a rerupture.[12,16,31,38,56] It stands to reason that patients should be instructed to avoid lifting or turning any object weighing >1 pound for the first 6 weeks after repair.

Anatomy, tendon force transmission, and repair biology

The distal biceps tendon is composed of a long and a short head, which attaches to the posterior aspect of the radial tuberosity[3,21,22,42] (Fig. 1). On axial imaging, it can clearly be seen that the center of the biceps tendon attaches 24.0° ± 8.0° anterior to the apex of the radial tuberosity or 6.7 mm ± 1.4 mm anterior to the apex[74,77] (Fig. 2). The short head is medial to the long head at the myotendinous junction; the tendon then