Treatment of chronic biceps tendon ruptures

Mark T. Dillon · Jeffrey C. King

Published online: 16 October 2013
© American Association for Hand Surgery 2013

Abstract Repair of distal biceps tendon ruptures has become widely accepted. Unfortunately, care of chronic injuries remains a challenge to the orthopedic surgeon. Patients with chronic ruptures often present complaining of weakness in elbow flexion and supination. Nonoperative management of these injuries does not restore function to the elbow. Tenodesis of the biceps tendon to the brachialis may improve flexion strength but does not reliably improve supination weakness. Addressing these injuries through restoration of anatomy, either with direct repair of the tendon to the radial tuberosity or with the use of a tendon graft to regain length, results in improved functional outcomes. Complications rates appear to be increased when surgery is performed in chronic injuries compared to those operated upon acutely.

Keywords Biceps tendon · Chronic rupture · Elbow

Introduction

Ruptures of the distal biceps tendon are relatively uncommon injuries, accounting for only 3 % of biceps ruptures encountered [26]. This injury usually is seen in the dominant arm of middle-aged men who describe a sudden extension force to an elbow held in flexion. Repair of the ruptured tendon to the radial tuberosity is now widely accepted as necessary to prevent loss of flexion and supination strength of the elbow [5, 16, 53, 56,

62]. Single incision and two incision repair techniques have both been described in the literature, with methods such as bone tunnels, suture anchors, cortical buttons, and interference screws used to attach the ruptured tendon to the radial tuberosity [4, 6, 11, 23, 28, 29, 33, 37, 46, 47, 53, 61, 68]. Whatever the fixation method employed, complication rates appear to be lower [9, 12, 39], and surgery is technically easier, when these injuries are fixed acutely. Treatment of chronic tendon injuries, however, remains challenging. The purpose of this review is to examine the different options available for treating chronic biceps tendon ruptures.

Anatomy

The biceps brachii is primarily a supinator of the elbow and secondarily a flexor. The muscle arises from two sites in the shoulder. The long head originates from the supraglenoid tubercle of the scapula, with the short head arising from the coracoid process. It is not uncommon for there to be two distinct muscle bellies along the length of the arm with muscle fibers from the short head on the ulnar side of the arm and those from the long head located radially, although often these two muscle bellies will interdigitate distally [3, 22]. The bicipital aponeurosis originates at the level of the musculotendinous junction and attaches to the superficial fascia ulnarly [22]. This is a key structure in the management of chronic distal biceps tendon ruptures, as an intact bicipital aponeurosis may make tendon repair much easier, regardless of length of time from injury.

Distally, the tendon attaches to the bicipital tuberosity of the radius. Mazzocca et al. [48] studied 178 cadaveric radii and determined the distance of the biceps tuberosity to be an average of 25 mm from the radial head. They categorized the osseous anatomy of the tuberosity into those with no ridge, a single ridge, or a bifid ridge, with the overwhelming majority

M. T. Dillon (✉)
Department of Orthopedic Surgery, The Permanente Medical Group,
2025 Morse Avenue, Sacramento, CA 95825, USA
e-mail: mark.t.dillon@kp.org

J. C. King
Western Michigan School of Medicine, Bronson Healthcare Midwest
Hand and Elbow Specialist, 601 John Street, Suite M-230,
Kalamazoo, MI 49007, USA

being single in nature. The bicipital tuberosity has been shown to have a length of 22 to 24 mm and width of 12 to 15 mm [36, 48], with the tendon appearing to insert onto the most ulnar aspect of the tuberosity [3, 36, 43, 48].

Recent cadaveric studies [22, 43] have examined the anatomy of the tendon as it inserts onto the bicipital tuberosity. Kulshreshtha et al. [43] examined 74 cadaver specimens and noted a reproducible twisting of the tendon, with the tendon twisting counterclockwise in right elbows and clockwise in left elbows. It was noted that the anteromedial fibers predictably traveled straight to attach inferiorly on the tuberosity, while the posterolateral fibers traveled underneath to insert superiorly. The authors concluded that each of these portions of the tendon originated from the separate heads of the biceps brachii muscle, with the short head attaching inferiorly and the long head attaching superiorly. Eames et al. [22] later confirmed this arrangement, stating that the two heads are often held together with loose areolar tissue. The authors suggest that the short head inserts distally on the tuberosity and is likely to be a primary contributor to elbow flexion, while the long head fibers attach furthest from the center of rotation and would therefore be more important in supination (Fig. 1).

The innervation of the biceps brachii and the brachialis muscles is from the musculocutaneous nerve. In roughly 60 % of patients, a single motor branch supplies innervation to the biceps and originates approximately 126 mm below the tip of the acromion, or 45 % of the distance between the acromion and lateral epicondyle. Forty percent of patients have an additional motor branch roughly 3 cm distal to this proximal branch [58]. In all patients, the nerve continues distally between the biceps and brachialis to form the lateral antebrachial cutaneous nerve, which supplies sensation to the volar aspect of the forearm. Understanding this anatomy is of paramount importance, as the lateral antebrachial cutaneous nerve is a key landmark in the approach when performing a single incision repair. Failure to ensure that the nerve is lateral to the tendon when reinsertion is performed can lead to significant pain should it become entrapped below the tendon.

Presentation

Distal biceps tendon ruptures tend to occur in the dominant extremity of middle-aged men, with an incidence of 1.2 tendon ruptures per 100,000 persons per year and a 7.5 times increased risk of complete ruptures in those who smoke [65]. There is no consensus on what timeframe constitutes a delayed or chronic rupture, with opinions ranging from 3 weeks [2, 14, 39, 62] to 3 months [45, 51]. Late presentation may be due to a delay in diagnosis, or simply a desire by the patient to try to avoid surgery. Patients who present with chronic ruptures often will recall an acute episode of pain that eventually gives way to a chronic aching sensation. This is often

Fig. 1 Diagram demonstrating the different areas of insertion onto the radius of the long head (LH) and short head (SH) of the biceps. Reprinted, with permission, from Eames et al. [22]

accompanied with weakness and endurance fatigue in elbow flexion and especially supination. As swelling subsides, a deformity of the biceps may be present with proximal retraction of the muscle, depending upon if the aponeurosis is intact. Rarely, there may also be accompanying dysesthesias in the distribution of the lateral antebrachial cutaneous nerve [17].

The biceps squeeze test [63] and the hook test [57] have both been shown to aid in diagnosing ruptures of the distal biceps tendon. While neither study specifically looked at ruptures occurring within a certain time period, both tests appear to have a role in evaluating patients in the chronic setting.

Ruland et al. [63] performed the biceps squeeze test on a seated patient with the forearm flexed between 60° and 80°. The biceps brachii is then squeezed with both hands, and lack of supination of the arm is a positive test indicating rupture of the distal biceps tendon. The authors found this test to be 96 % sensitive in 24 patients with distal biceps tendon ruptures. Two patients who declined surgery continued to have a positive test at a minimum of 3 months following their injury, while a third patient with a chronic rupture was also noted to lack supination with the biceps squeeze test.

The hook test [57] is performed with the elbow flexed 90° and in full supination. The examiner's finger attempts to hook the tendon from the lateral side of the elbow. When the tendon is intact, it is easily able to be “hooked” by a finger, whereas in the presence of a rupture, there will be no palpable tendinous structure (Fig. 2). In this initial study, over 50 % of the patients in the study population were greater than 3 weeks out from injury. The hook test was noted to have 100 % sensitivity and specificity, which the authors stated was better than magnetic resonance imaging (MRI).

Imaging

Imaging studies play a limited role in the diagnosis of distal biceps tendon ruptures. Radiographs are generally of little

Fig. 2 Hook test demonstrating an intact biceps tendon

help in diagnosing chronic ruptures, although they may be helpful in excluding other diagnoses. Plain X-rays may show enlargement or irregularity of the biceps tuberosity in those patients with tendon ruptures [18], and rarely an avulsion of the tuberosity may be seen [52]. Ultrasound may be used to evaluate the distal biceps tendon, although this modality is very operator dependent. MRI perhaps yields the most information of all imaging techniques. In acute injuries, the balled up tendon can often be palpated proximally, but in more chronic situations, this can prove difficult due to the formation of scar tissue. MRI can quantify the amount of proximal retraction, helping the surgeon to decide if tendon grafting is more likely to be needed.

Giuffre and Moss [27] have described positioning the arm in order to allow optimal visualization for MRI of the biceps tendon. Known as the “FABS” view, the patient is placed prone with the affected arm in full abduction, and the elbow is flexed to 90° and supinated. The authors report that using this protocol in 22 patients allowed for visualization of the entire biceps tendon in usually one section (Fig. 3).

Treatment

Once the diagnosis of a chronic biceps tendon rupture is made, it is important for the surgeon to have a detailed discussion with the patient in order to decide how to best proceed. Overall health, hand dominance, occupation, and goals of the patient should all be taken into account to determine the best course of action. Options include nonoperative treatment, nonanatomic repair of the biceps to the brachialis, direct repair of the tendon to the radial tuberosity, and reconstruction with a tendon graft.

Fig. 3 MRI with FABS view demonstrating distal biceps rupture with tendon retraction from the radius (arrow)

Nonoperative Treatment

Early opinion on the need for repair of distal biceps tendon ruptures was mixed [13, 21, 24, 52, 53]. In 1985, Morrey et al. [53] demonstrated that conservative treatment resulted in an average loss of flexion strength of roughly 30 % normal, with a loss of supination strength of 40 %. Baker and Bierwagen [5] showed a similar loss of strength in flexion and supination when patients were treated nonoperatively, but more impressively also demonstrated a 79 % loss of supination endurance in patients treated nonoperatively when compared to those who underwent operative repair. Nesterenko et al. [56] noted that while strength deficits were significant (30 % loss of flexion strength and 50 % loss in supination strength), endurance did not appear to be effected. As a result, they recommended a physical therapy program focusing on strength, rather than endurance, in patients with tears treated nonoperatively.

Recent studies have confirmed improved results with surgical fixation and supported the trend of operative repair of this injury, although these studies tend to overwhelmingly examine surgical repair of acute injuries [15, 25, 34]. In a comparison of 12 patients who underwent early surgical repair with 10 patients who had nonoperative treatment, Hetsroni et al. [34] found statistically significant higher patient satisfaction in those who underwent surgery. The authors also noted improved elbow flexion strength, supination strength, and supination endurance in those who underwent anatomic repair. Chillemi et al. [15] compared five patients who underwent acute repair via a two incision technique with four patients who were treated nonsurgically, and outcome scores reflected improved results with surgery. Freeman et al. [25] demonstrated a median of 95 % flexion strength and 92 % supination strength in operative extremities compared to the contralateral side. However, in those patients who elected nonoperative treatment, median flexion

strength was 93 % of the opposite side, while median supination strength was only 63 %.

Patients with chronic distal biceps tendon ruptures need to have realistic expectations if they are to undergo nonoperative treatment. While some patients can have acceptable outcomes when treated nonoperatively, many end up seeking care due to functional limitations of their elbow. It is unclear at this time which patients will tolerate nonoperative treatment of chronic ruptures. As a result, patients with chronic ruptures treated nonoperatively should be counseled about the possibility of weakness and reduced endurance, mostly with supination activities.

Nonanatomic Repair (Tenodesis)

While tenodesis of the biceps tendon to the brachialis tendon is mostly of historical interest in the setting of acute injuries, some authors advocate its use as an option for chronic injuries [31, 55]. In 1941, Dobbie [21] first described a method of repairing the biceps tendon to the brachialis at its insertion into the coronoid, lessening the risk of injury to the neurovascular structures in the area. The author felt that direct attachment to the radius was unnecessary and equal outcomes could be obtained by repairing the ruptured tendon to either the radius or the “adjacent upper forearm soft parts” [21]. Meherin and Kilgore [52] also stated that repair of the biceps to either the brachialis or the radius was equally effective, and the authors felt both surgeries had superior outcomes when compared to nonoperative treatment.

Baker and Bierwagen [5] disagreed with this philosophy, advocating instead for anatomic repair when possible. They emphasized the importance of the biceps tendon as a supinator, especially in patients who were heavy laborers. Morrey et al. [53] reported on one patient who underwent tenodesis to the brachialis 5 months after injury who had 87 % restoration of flexion strength but only 43 % restoration of supination strength. Likewise, Le Huec et al. [44] reported on 10 patients who underwent surgical treatment for distal tendon ruptures, with 2 patients having surgery 6 months after their injury. One patient underwent reattachment to the brachialis due to excessive retraction of the tendon, although it is unclear if this was a chronic injury. This patient had a loss of power of 50 % compared to the other arm. Hand dominance may also be a factor contributing to outcomes following tenodesis. Bell et al. [8] performed isokinetic testing on patients who underwent biceps tenodesis and found greater strength deficits in dominant extremities when compared to nondominant extremities [8].

Klonz et al. [42] performed isokinetic testing on six patients who underwent anatomic repair and compared the results to eight patients who underwent tenodesis of the biceps to the brachialis. Both groups had excellent return of flexion strength (96.8 % in the anatomic group versus 96 % in the nonanatomic group). The authors noted supination power

averaged 91 % of the contralateral side. Interestingly, supination strength ranged from 42 to 56 % in four of the patients who underwent tenodesis, while the other four had supination strength that ranged from 80 to 150 %. The authors were unclear as to what accounted for the restoration in supination strength in half of their patients who underwent tenodesis, but concluded that tenodesis is a viable option for treating distal biceps ruptures. However, a meta-analysis looking at 147 patients with tendon ruptures revealed better outcomes with repair to the radial tuberosity. The authors reported good or excellent results in only 60 % of patients who underwent nonanatomic repair compared to 90 % of those who underwent anatomic repair of the tendon [62].

Direct Repair

Few studies have specifically examined the role of direct repair in treating chronic distal biceps tendon injuries [10, 19, 62, 64, 67, 68]. Such patients are often few in number and included in larger series evaluating the outcomes of operative repair in general. Patients with chronic injuries and retraction of the muscle have historically been treated nonoperatively or with tendon grafting, and it is only recently that direct repair of chronic ruptures has become more widely advocated. Some authors [46, 57] believe that the presence of an intact bicipital aponeurosis limits retraction of the tendon, increasing the chance of direct repair regardless of how far out the patient is from injury. O'Driscoll et al. [57] recommend using a variation of the hook test to check for the presence of an intact bicipital aponeurosis, stating that when absent a tendon graft is more likely to be required.

Rantanen and Orava [62] were one of the first to report on the results of repairing chronic ruptures. The authors reviewed their results of 19 patients with distal biceps tendon ruptures, 10 of which were treated greater than 3 weeks out from injury, with the longest being 5 months. The authors performed both single and double incision repairs, and all tendons were able to be repaired anatomically to the tuberosity. Nine of the 10 chronic ruptures reported good or excellent results at an average of 5.1 years follow-up, although 4 patients did have a loss of elbow extension of up to 25°.

The decision to perform a single or double incision ultimately rests with the comfort of the surgeon, as both are acceptable options. Ryhanen et al. [64] reported on 15 patients that underwent repair via both single and double incision techniques, 11 of which were greater than 5 weeks from injury. The authors noted 10 % weakness in flexion and 22 % weakness in supination in those patients having undergone chronic repairs, but did not feel this was significantly different from those patients who undergo acute repair. They did feel that chronic direct repairs did better than those patients who required tendon grafting, as the latter did not consistently regain supination strength. When grafts were used, supination

strength decreased as much as 54 % compared to the nonoperative extremity.

Citing concerns over heterotopic ossification, Sotereanos et al. [68] recommended a single incision approach. The authors reported they were able to perform a primary repair with suture anchors in 8 of 10 chronic ruptures greater than 6 weeks out from injury, with 2 patients requiring tenodesis to the brachialis tendon due to “severe tendon degeneration.” To help get full excursion of the tendon, complete mobilization of the tendon with release of all scar tissue was performed. The authors even cited pulling tension on the tendon for 10–20 min to help stretch the tendon to regain length.

A proximal “retrieval” incision over the retracted stump can also be used to mobilize the tendon. Bosman et al. [10] utilized a transverse retrieval incision to prepare the tendon,

then flexed the elbow up to 110° and repaired it to the tuberosity through a distal incision. The authors reported on six consecutive patients who were between 5 and 16 weeks out from injury, and they did not note significant difficulty in regaining extension. As an alternative, we use the proximal portion of a S-incision for retrieving the tendon, allowing for more extensile exposure if needed (Fig. 4).

The use of a cortical button is becoming an increasingly popular technique for primary repairs of chronic ruptures [10, 19, 60, 67]. Biomechanical studies have demonstrated that a cortical button has the highest load to failure when compared to other fixation methods [28, 40, 41, 49, 69]. Sharma et al. [67] were the first to report specifically on anatomic repair of chronic ruptures using a cortical button without graft augmentation. Three patients underwent surgery a minimum of 6 weeks out from injury, and all were “highly satisfied” after surgery and able to return to their employment. Dillon et al. [19] compared 17 patients who had an acute distal biceps tendon repaired within 4 weeks from surgery with 9 patients who underwent chronic repair (range 6 weeks to 6 months). The authors did not notice any statistically significant difference between the two groups in regards to flexion strength, flexion endurance, supination strength, or supination endurance.

Tendon Grafting

Reconstruction with tendon grafting is used when there has been rupture of the bicipital aponeurosis and proximal retraction of the biceps muscle, resulting in the need to restore tendon length in order to allow repair to the bicipital tuberosity. Since first described in the English literature in 1977 by Hovelius and Josefsson [35], multiple techniques for chronic reconstruction utilizing a graft have been described, with no technique appearing superior. Published reports have examined using semitendinosis autograft [30, 32, 50, 72], flexor carpi radialis autograft [45], Achilles tendon allograft [17, 31, 59, 66, 73], tensor fascia lata autograft [7, 35, 38, 64], lacertus fibrosis [31], palmaris longus autograft [64, 70], plantaris longus autograft [70], and long extensors of the second and third toes [70] (Table 1).

The decision to proceed with tendon grafting is often made when the tendon stump is simply not long enough to reach the tuberosity. However, exactly how much the elbow can be flexed to help bring the tuberosity to the tendon is unclear. Wright [73] recommends tendon grafting if it is necessary to flex the elbow more than 30° to 40° for the tendon to reach the tuberosity, otherwise he stated a contracture potentially could develop that would limit extension. However, other authors [12, 17, 39] attempt repair only when more than 70° of flexion is required for the tendon to reach the tuberosity, while Wiley et al. [72] would augment with graft when more than 90° of flexion was required to perform anatomic repair. Once the decision to use tendon graft is made, many authors

Fig. 4 Single incision repair of chronic ruptures. Distally, an incision is made parallel to the medial aspect of the mobile wad (*closed arrow*). If a retrieval incision is required, a longitudinal incision is made over the medial arm in the area of the palpable tendon stump (*open arrow*). These two incisions may be connected to form a long S-incision, which may prove helpful if further exposure is required for tendon grafting (**a**). Mobilization of the biceps tendon through a proximal retrieval incision (**b**)

Table 1 Case series reporting on the results of tendon grafting for chronic ruptures

Study	Number of cases	Graft	Approach	Results with complications
Darlis and Sotereanos [17]	7	Achilles allograft	Single incision with suture anchors	6 excellent and 1 good result; 1 with clinically insignificant heterotopic ossification
Hallam and Bain [30]	9	Semitendinosis autograft	Single incision with EndoButton	All patients satisfied; no complications reported
Kaplan et al. [38]	3	Fascia lata autograft with ligament augmentation device	Two incision with bone tunnels	All patients satisfied; 2 with persistent weakness
Levy et al. [45]	5	Flexor carpi radialis autograft	Single incision with suture anchors	All patients satisfied; 2 with adhesions to graft
Sanchez-Sotelo et al. [66]	4	Achilles allograft	Two incision with bone tunnels	All patients with MEPS of 100; no complications reported
Vastamaki and Vastamaki [70]	14	Plantaris longus autograft (7) Long extensors of second and third toes (6) Palmaris longus autograft (1)	Single incision with bone tunnels (7) Single incision with suture anchors (7)	13 of 14 with MEPS of 100; 1 with symptomatic heterotopic ossification and MEP of 95
Wiley et al. [72]	7	Semitendinosis autograft	Two incision with bone tunnels	All patients satisfied; 3 with minor cosmetic differences

MEPS Mayo Elbow Performance Score [54]

recommend that the elbow should be flexed at approximately 45° when tensioning the graft [17, 31, 32, 38, 61, 66, 73]. Whether the graft is attached to the tuberosity or the muscle first seems to be a matter of surgeon preference. In practice, these intraoperative decisions can be difficult to make, as a graft that is too tight may rupture or cause a contracture, while weakness with supination results when the graft is not tight enough.

The two most common tendon grafting techniques include oversewing an Achilles tendon or weaving a hamstring graft to restore tendon length. When using an Achilles tendon allograft, the proximal portion of the tendon is sewn over the distal portion of the biceps muscle belly, while the distal tendinous portion is used to secure the graft to the bone (Fig. 5). As described by Sanchez-Sotelo et al. [66], a piece of calcaneal bone can be used to obtain bony fixation into a trough created in the radius, or simply excised and the graft simply repaired to the radius. The authors reported on four patients who underwent this technique, all of whom had full range of motion and a Mayo Elbow Performance Score [54] of 100. Patterson et al. [59] described a case report utilizing an Achilles tendon allograft fixed with a cortical button at 4 months after injury. The patient had no pain and was fully satisfied with his elbow function, and strength testing at almost 6 months after surgery showed 85.6 % flexion strength and 91.5 % supination strength when compared to the other side. Darlis and Sotereanos [17] reported on seven patients fixed with an Achilles tendon allograft, although this tendon graft was weaved through the musculotendinous stump as opposed to being oversewn.

Alternatively, autograft hamstring tendon (usually semitendinosis) may be utilized by taking a curved clamp

and passing the tendon through the area of the remaining stump, as first described by Hang et al. [32]. Hallam and Bain [30] reported on using a cortical button in nine patients to achieve graft fixation to the radial tuberosity. All patients were satisfied with their outcome, and all were able to return to their prior occupation. More recently, Wiley et al. [72] reported on seven patients treated in this manner utilizing a two incision technique. The authors compared their cohort of patients to seven patients with chronic ruptures treated without surgery and noted that those who had nonoperative treatment lacked about 20 % of strength in both flexion and supination.

If a reconstruction is to be performed by passing a graft through the biceps, it is important to incorporate the entire muscle into the repair. With the distal biceps tendon consisting of two discrete portions (one from fibers of the short head and another from those the long head), the surgeon should be certain to include both portions of the muscle when passing the graft [22].

Postoperative Regimen

While there is a trend toward early range of motion following repair of acute injuries [14, 33], there is no agreed upon protocol for rehabilitation following surgery for chronic injuries. Much depends upon the quality of the tendon at the time of surgery and if tendon grafting was required. When treating chronic ruptures, it is not unusual to immobilize the affected extremity for a minimum of 10–14 days, with several authors advocating the use of a brace with an extension block for several weeks after removal from the splint [17, 38, 45, 50, 59, 66, 68, 72]. Others approach these repairs with more caution,

Fig. 5 Reconstruction of a chronic rupture using an Achilles allograft. In chronic injuries, there may be insufficient tendon present making primary repair impossible (a). The allograft is prepared by removing the calcaneal bone and a cortical button is sewn into place (b). The trough in the proximal radius is prepared, being careful to protect adjacent neurovascular structures (c). The graft is fixed to the radius initially. The remaining native tendon is grasped by the clamp (d). Final construct with sutures tied through allograft tendon into native biceps muscle and tendon (e)

immobilizing patients in a plaster splint for 6 weeks [67, 70]. Following this, it is usual to start formal strengthening at 3 months, with delaying return to vigorous lifting at no sooner than 6 months following surgery.

Complications

Complications following repair of chronic ruptures appear to be similar to those described when performing surgery for acute injuries. It has been suggested, however, that complication rates may be increased when surgery is delayed [9, 12, 39]. Kelly et al. [39] noted a 41 % complication rate when using a two incision repair done more than 21 days after injury, while those operated on in under 10 days had a 24 % complication rate. More recently, Cain et al. [12] reported on 198 patients with a 46 % complication rate in patients operated upon greater than 4 weeks out from injury compared to a rate of 30 % in those operated upon acutely. In examining complications using the two incision technique, Bisson et al. [9] reported a 20 % complication rate in those repairs performed under 2 weeks from injury and a 40 % rate in those operated on outside this time period, though the results did not reach statistical significance.

Nerve injuries have been reported more frequently with surgery for chronic distal biceps tendon ruptures [9, 12, 19, 39, 64]. Looking at two incision repairs, Kelly et al. [39] reported a six times increased rate of superficial nerve paresthesias in repairs performed greater than 10 days out from injury. Cain et al. demonstrated a trend toward increased risk of posterior interosseous nerve and lateral antebrachial cutaneous nerve injuries in chronic repairs, with a statistically

significant increase in radial sensory nerve palsies [12]. Increased lateral antebrachial sensory deficits were also noticed by Dillon et al. [19]. They theorized that this increased risk of nerve injury may be due to the dissection needed with chronic repairs, or due to increased tension on the repair that resulted in stretching of the nerve. The authors recommended warning patients of this potential complication when performing direct repair of a chronic rupture. Ryhanen et al. reported on 16 patients with chronic injuries, 3 of which sustained transient nerve injuries (2 lateral antebrachial cutaneous and 1 radial). The authors did not feel that nerve injuries depended upon the exposure utilized [64].

The development of symptomatic heterotopic ossification does not appear to be dependent upon time to surgery [9, 12, 39], and it is only rarely reported with recent anterior single incision techniques [1, 20, 71]. Cain et al. [12] noted a 3 % rate of symptomatic heterotopic ossification regardless of when surgery was performed. Vastamaki and Vastamaki [70] reported on two patients fixed with a tendon graft through an anterior approach that developed heterotopic ossification, including one with a substantial loss of motion resulting in a motion arc of 25–120°. In the absence of heterotopic ossification, loss of motion, both with elbow extension [17, 68] and rotation [9], has been reported as well in patients undergoing surgery in the chronic setting.

Re-rupture following surgery for a distal biceps tendon injury is relatively uncommon, with an incidence between 1 and 2 % [9, 12, 39]. Cain et al. [12] did not notice a difference in rate of re-rupture in those patients operated upon more than 4 weeks after injury compared to those operated upon acutely. None of the 11 patients in their study who required tendon augmentation ruptured the repair. Ryhanen et al. [64] noted

one re-rupture in a patient repaired without tendon grafting 63 days after his injury. This was revised with the use of a tensor fascia lata graft, but due to stretching of the graft required additional surgery to shorten the tendon. This particular case highlights the difficulties that can be encountered when treating these challenging injuries.

Conclusion

Ruptures of the distal biceps tendon may impair a patient's ability to use his or her upper extremity, and it is unclear as to which patients will tolerate nonoperative treatment of this injury. In the past, few options were available to patients that had the potential to improve their strength when patients did not present acutely following an injury. Should surgery be elected, both direct repair of the tendon to the tuberosity and augmenting the repair with a tendon graft are viable surgical options when dealing with this difficult injury. However, complication rates appear to be higher when surgery is performed in the chronic setting, and patients need to be counseled specifically regarding the increased risk of nerve injury.

Statement of Human and Animal Rights This article does not include any studies with human or animal subjects.

Conflict of Interest The authors declare that they have no conflicts of interest.

Statement of Informed Consent No identifying patient information is present in this manuscript.

References

1. Agrawal V, Stinson MJ. Case report: heterotopic ossification after repair of distal biceps tendon rupture utilizing a single-incision EndoButton technique. *J Shoulder Elbow Surg.* 2005;14:107–9.
2. Aldridge JW, Bruno RJ, Strauch RJ, et al. Management of acute and chronic biceps tendon rupture. *Hand Clin.* 2000;16:497–503.
3. Athwal GS, Steinmann SP, Rispoli DM. The distal biceps tendon: footprint and relevant clinical anatomy. *J Hand Surg.* 2007;32-A:1225–9.
4. Bain GI. Repair of distal biceps tendon avulsion with the EndoButton technique. *Tech Shoulder Elbow Surg.* 2002;3:96–101.
5. Baker BE, Bierwagen D. Rupture of the distal tendon of the biceps brachii. Operative versus non-operative treatment. *J Bone Jt Surg.* 1985;67-A:414–7.
6. Balabaud L, Ruiz C, Nonnenmacher J, et al. Repair of distal biceps tendon ruptures using a suture anchor and an anterior approach. *J Hand Surg.* 2004;29-B:178–82.
7. Bayat A, Neumann L, Wallace WA. Late repair of simultaneous bilateral distal biceps brachii tendon avulsion with fascia lata graft. *Br J Sports Med.* 1999;33:281–3.
8. Bell RH, Wiley WB, Noble JS, et al. Repair of distal biceps brachii tendon ruptures. *J Shoulder Elbow Surg.* 2000;9:223–6.
9. Bisson L, Moyer M, Lanighan K, et al. Complications associated with repair of a distal biceps rupture using the modified two-incision technique. *J Shoulder Elbow Surg.* 2008;17:67S–71S.
10. Bosman HA, Fincher M, Saw N. Anatomic repair of chronic distal biceps brachii tendon rupture without interposition graft. *J Shoulder Elbow Surg.* 2012;21:1342–7.
11. Boyd HB, Anderson LD. A method for reinsterion of the distal biceps brachii tendon. *J Bone Jt Surg.* 1961;43-A:1041–3.
12. Cain RA, Nydick JA, Stein MI, et al. Complications following distal biceps repair. *J Hand Surg.* 2012;37-A:2112–7.
13. Carroll RE, Hamilton LR. Rupture of biceps brachii—a conservative method of treatment. *J Bone Jt Surg.* 1967;49-A:1016.
14. Cheung EV, Lazarus M, Taranta M. Immediate range of motion after distal biceps tendon repair. *J Shoulder Elbow Surg.* 2005;14:516–8.
15. 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;127:705–8.
16. D'Alessandro DF, Shields Jr CL, Tibone JE, et al. Repair of distal biceps tendon ruptures in athletes. *Am J Sports Med.* 1993;21:114–9.
17. Darlis NA, Sotereanos DG. Distal biceps tendon reconstruction in chronic ruptures. *J Shoulder Elbow Surg.* 2006;15:614–9.
18. Davis WM, Yassine Z. An etiological factor in tear of the distal tendon of the biceps brachii: report of two cases. *J Bone Jt Surg.* 1956;38:1365–8.
19. Dillon MT, Bollier MJ, King JC. Repair of acute and chronic distal biceps tendon ruptures using the EndoButton. *Hand.* 2011;6:39–46.
20. Dillon MT, Lepore DJ. Heterotopic ossification after single-incision distal biceps tendon repair with an EndoButton. *J Surg Orthop Adv.* 2011;20:198–201.
21. Dobbie RP. Avulsion of the lower biceps brachii tendon: analysis of fifty-one previously unreported cases. *Am J Surg.* 1941;51:662–83.
22. Eames MHA, Bain GI, Fogg QA, et al. Distal biceps tendon anatomy: a cadaveric study. *J Bone Jt Surg.* 2007;89-A:1044–9.
23. El-Hawary R, MacDermid JC, Faber KJ, et al. Distal biceps tendon repair: comparison of surgical techniques. *J Hand Surg.* 2003;28-A:496–502.
24. Fischer WR, Shepanek LA. Avulsion of the insertion of the biceps brachii: a report of a case. *J Bone Jt Surg.* 1956;38-A:158–9.
25. Freeman CR, McCormick KR, Mahoney D, et al. Nonoperative treatment of distal biceps tendon ruptures compared with a historical control group. *J Bone Jt Surg.* 2009;91-A:2329–34.
26. Gilchrist EL. The common syndrome of rupture, dislocation and elongation of the long head of the biceps brachii: an analysis of one hundred cases. *Surg Gynecol Obstet.* 1934;58:322–40.
27. Giuffre BM, Moss MJ. Optimal positioning for MRI of the distal biceps brachii tendon: flexed abducted supinated view. *AJR.* 2004;182:944–6.
28. Greenberg JA, Fernandez JJ, Wang T, et al. EndoButton-assisted repair of distal biceps tendon ruptures. *J Shoulder Elbow Surg.* 2003;12:484–90.
29. Gregory T, Roure P, Fontes D. Repair of distal biceps tendon rupture using a suture anchor: description of a new endoscopic procedure. *Am J Sports Med.* 2009;37:506–11.
30. Hallam P, Bain GI. Repair of chronic distal biceps tendon ruptures using autologous hamstring graft and the Endobutton. *J Shoulder Elbow Surg.* 2004;13:648–51.
31. Hamer MJ, Caputo AE. Operative treatment of chronic distal biceps tendon ruptures. *Sports Med Arthrosc Rev.* 2008;16:143–7.
32. Hang DW, Bach BR, Bojchuk J. Repair of chronic distal biceps brachii tendon rupture using free autogenous semitendinosus tendon. *Clin Orthop Relat Res.* 1996;323:188–91.
33. Heinzlmann AD, Savoie III FH, Ramsey JR, et al. A combined technique for distal biceps repair using a soft tissue button and biotenodesis interference screw. *Am J Sports Med.* 2009;37:989–94.

34. Hetsroni I, Pilz-Burstein R, Nyska M, et al. Avulsion of the distal biceps brachii tendon in middle-aged population: is surgical repair advisable? A comparative study of 22 patients treated with either nonoperative management or early anatomical repair. *Injury*. 2008;39:753–60.
35. Hovelius L, Josefsson G. Rupture of the distal biceps tendon: a report of five cases. *Acta Orthop Scan*. 1977;48:280–2.
36. Hutchinson HL, Gloystein D, Gillespie M. Distal biceps tendon insertion: an anatomic study. *J Shoulder Elbow Surg*. 2008;17:342–6.
37. Idler CS, Montgomery WH, Lindsey DP, et al. Distal biceps tendon repair: a biomechanical comparison of intact tendon and 2 repair techniques. *Am J Sports Med*. 2006;34:968–74.
38. Kaplan FTD, Rokito AS, Birdzell MG, et al. Reconstruction of chronic distal biceps tendon rupture with use of fascia lata combined with a ligament augmentation device: a report of 3 cases. *J Shoulder Elbow Surg*. 2002;11:633–6.
39. Kelly EW, Morrey BF, O'Driscoll SW. Complications of repair of distal biceps tendon with the modified two incision technique. *J Bone Joint Surg*. 2000;82-A:1575–81.
40. Kettler M, Lunger J, Kuhn V, Mutschler W, et al. Failure strengths in distal biceps tendon repair. *Am J Sports Med*. 2007;35:1544–8.
41. Kettler M, Tingart MJ, Lunger J, et al. Reattachment of the distal tendon of biceps: factors affecting the failure strength of the repair. *J Bone Jt Surg*. 2008;90-B:103–6.
42. Klonz A, Loitz D, Wohler P, et al. Rupture of the distal biceps brachii tendon: isokinetic power analysis and complications after anatomic reinsertion compared with fixation to the brachialis muscle. *J Shoulder Elbow Surg*. 2003;12:607–11.
43. Kulshreshtha R, Singh R, Sinha J, et al. Anatomy of the distal biceps brachii tendon and its clinical relevance. *Clin Orthop*. 2006;456:117–20.
44. Le Huec JC, Moinard M, Liqueois F, et al. Distal rupture of the tendon of biceps brachii: evaluation by MRI and the results of repair. *J Bone Jt Surg*. 1996;78-B:767–70.
45. Levy HJ, Mashoof AA, Morgan D. Repair of chronic ruptures of the distal biceps tendon using flexor carpi radialis tendon graft. *Am J Sports Med*. 2000;28:538–40.
46. Limpisvasti O, Singer DI. Single-incision suture anchor repair of distal biceps tendon rupture. *Tech Hand Up Extrem Surg*. 2003;7:82–6.
47. Lintner S, Fischer T. Repair of the distal biceps tendon using suture anchors and an anterior approach. *Clin Orthop Relat Res*. 1996;322:116–9.
48. Mazzocca AD, Cohen M, Berkson E, et al. The anatomy of the bicipital tuberosity and distal biceps tendon. *J Shoulder Elbow Surg*. 2007;16:122–7.
49. Mazzocca AD, Burton KJ, Romeo AA, et al. Biomechanical evaluation of 4 techniques of distal biceps brachii tendon repair. *Am J Sports Med*. 2007;35:252–8.
50. McCarty III LP, Alpert JM, Bush-Joseph C. Reconstruction of a chronic distal biceps tendon rupture 4 years after initial injury. *Am J Orthop*. 2008;37:579–82.
51. McKee MD, Hirji R, Schemitsch EH, et al. Patient-oriented functional outcome after repair of distal biceps tendon ruptures using a single-incision technique. *J Shoulder Elbow Surg*. 2005;14:302–6.
52. Meherin JM, Kilgore Jr ES. The treatment of ruptures of the distal biceps brachii tendon. *Am J Surg*. 1960;99:636–40.
53. Morrey BF, Askew LF, An KN, et al. Rupture of the distal tendon of the biceps brachii: a biomechanical study. *J Bone Jt Surg*. 1985;67-A:418–21.
54. Morrey BF, An K. Functional evaluation of the elbow. In: Morrey BF, editor. *The elbow and its disorders*. 3rd ed. Philadelphia: WB Saunders; 2000. p. 74–83.
55. Morrison KD, Hunt III TR. Comparing and contrasting methods for tenodesis of the ruptured distal biceps tendon. *Hand Clin*. 2002;18:169–78.
56. Nesterenko S, Domire ZJ, Morrey BF, et al. Elbow strength and endurance in patients with a ruptured distal biceps tendon. *J Shoulder Elbow Surg*. 2010;19:184–9.
57. O'Driscoll SW, Goncalves LBJ, Dietz P. The hook test for distal biceps tendon avulsion. *Am J Sports Med*. 2007;35:1865–39.
58. Pacha Vicente D, Forcada Calvet P, Carrera Burgaya A, et al. Innervation of biceps brachii and brachialis: anatomical and surgical approach. *Clin Anat*. 2005;18:186–94.
59. Patterson RW, Sharma J, Lawton JN, et al. Distal biceps tendon reconstruction with tendoachilles allograft: a modification of the EndoButton technique utilizing an ACL reconstruction system. *J Hand Surg*. 2009;34-A:545–52.
60. Peeters T, Ching-Soon NG, Jansen N, et al. Functional outcome after repair of distal biceps tendon ruptures using the EndoButton technique. *J Shoulder Elbow Surg*. 2009;18:283–7.
61. Ramsey ML. Distal biceps tendon injuries: diagnosis and management. *J Am Acad Orthop Surg*. 1999;7:199–207.
62. Rantanen J, Orava S. Rupture of the distal biceps tendon: a report of 19 patients treated with anatomic reinsertion, and a meta-analysis of 147 cases found in the literature. *Am J Sports Med*. 1999;27:128–32.
63. Ruland RT, Dunbar RP, Bowen JD. The biceps squeeze test for diagnosis of distal biceps tendon ruptures. *Clin Orthop Relat Res*. 2005;437:128–31.
64. Ryhanen J, Kaarela O, Siira P, et al. Recovery of muscle strength after late repair of distal biceps brachii tendon. *Scand J Surg*. 2006;95:68–72.
65. Safran MR, Graham SM. Distal biceps tendon rupture: incidence, demographics, and the effect of smoking. *Clin Orthop Relat Res*. 2002;404:275–83.
66. Sanchez-Sotelo J, Morrey BF, Adams RA, et al. Reconstruction of chronic ruptures of the distal biceps tendon with use of an Achilles tendon allograft. *J Bone Joint Surg*. 2002;84-A:999–1005.
67. Sharma DK, Goswami V, Wood J. Surgical repair of chronic rupture of the distal end of the biceps brachii. A modified anterior surgical repair technique. *Acta Orthop Belg*. 2004;70:268–72.
68. Sotereanos DG, Pierce TD, Varitimidis SE. A simplified method for repair of distal biceps tendon ruptures. *J Shoulder Elbow Surg*. 2000;9:227–33.
69. Spang JT, Weinhold PS, Karas SG. A biomechanical comparison of EndoButton versus suture anchor repair of distal biceps tendon injuries. *J Shoulder Elbow Surg*. 2006;15:509–14.
70. Vastamaki M, Vastamaki H. A simple grafting method to repair irreparable distal biceps tendon. *Clin Orthop Relat Res*. 2008;466:2475–81.
71. Vidal AF, Koonce RC, Wolcott M, et al. Extensive heterotopic ossification after suspensory cortical fixation of acute distal biceps tendon ruptures. *Arthroscopy*. 2012;28:1036–40.
72. Wiley WB, Noble JS, Dulaney TD, et al. Late reconstruction of chronic distal biceps tendon ruptures with a semitendinosis autograft technique. *J Shoulder Elbow Surg*. 2006;15:440–4.
73. Wright TW. Late distal biceps repair. *Tech Hand Up Extrem Surg*. 2004;8:167–72.