Musculoskelet Surg
DOI 10.1007/s12306-017-0515-7

ORIGINAL ARTICLE

The utility of botulinum toxin A in the repair of distal biceps tendon ruptures

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Received: 24 April 2017 / Accepted: 8 October 2017

Abstract
Purpose The purpose of our study is to report the outcomes and complications in patients who underwent distal biceps tendon repair with the use of Botulinum toxin A (BoNT-A) as an adjunct to surgery.
Methods A retrospective review of 14 patients who underwent 15 distal biceps tendon repairs was performed. All repaired tendons had their correlating muscle bellies injected intraoperatively with a mixture of 100U of BoNT-A and 10 ml of normal saline. Each patient was evaluated for surgical and post-operative complications and followed with Disabilities of the Arm, Shoulder and Hand (DASH) Disability Scores.
Results The cohort was exclusively male, 14/14 (100%). The mean age at procedure was 52.1 years (range: 29–65 years). Types of injuries repaired included: 12 acute biceps tendon ruptures, one chronic partial (> 50% of tendon) biceps tear, and two chronic biceps ruptures. Average final follow-up was 32.9 months (SD: 19.6; range: 7.07–61.72). Average time to repair of chronic injury was 5.75 months (range: 2–12 months). There were no intraoperative complications, and all patients were discharged home on the day of surgery. Average DASH score at latest follow-up was 4.9 (range: 0.0–12.5). All patients had return of function of paralyzed muscle prior to final follow-up. One patient required an incision and drainage for a deep infection 1 week post-operatively, without any further complications. Another patient required operative removal of heterotopic ossification located around the tendon fixation site, which was the result of a superficial infection treated with antibiotics 2 weeks post-operatively. This patient later healed with improvement in supination/pronation range-of-motion and no further complications.
Conclusions Injection of BoNT-A is safe and effective to protect distal biceps tendon repair during the early phases of bone-tendon healing.
Clinical relevance BoNT-A may is safe and effective to protect distal biceps tendon repair. The utility of BoNT-A as an adjunct to surgical repair may be applicable to acute or chronic tears as well as repairs in the non-compliant patient without decreases in functional scores after return of function of the biceps muscle.
Level of evidence Level 4.

Keywords Distal biceps · Botox · Botulinum toxin · Biceps rupture · Biceps rupture repair · BoNTA · Distal biceps rupture · Biceps tendon rupture · Biceps tendon repair · Biceps tendon protect · Biceps tendon post-operative course

Introduction

Distal biceps tendon ruptures typically occur as a result of a forceful eccentric muscle contraction and are injuries that are becoming increasingly prevalent in orthopedic practice [1, 2]. These injuries tend to occur in men during the 4th–6th decade of life and may be associated with smoking and systemic conditions such as diabetes, rheumatoid arthritis, renal insufficiency, and anabolic steroid use [3, 4].

Research has shown improved outcomes in patients with operative repair of distal biceps ruptures compared to

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Published online: 13 October 2017

non-operative management [5]. Healing of repaired tendons is dependent upon the strength of fixation method and the prevention of repair-site gapping. Increasing strength of the repair at the repair site can be done via the use of transosseous sutures, suture anchors and/or button fixation [5, 6]. Recent literature has also advocated for rehabilitation protocols emphasizing early motion [7]. As repair techniques evolve, there continues to be a need for adjuncts to aid in healing and protection of repairs to diminish complications in both acute and chronic ruptures.

Botulinum toxin A (BoNT-A) is a protein and neurotoxin produced by the bacterium *Clostridium Botulinum*. This toxin inhibits release of acetylcholine at the neuromuscular junction causing chemical denervation of the muscle and cessation of muscle contraction. Studies have demonstrated a consistent decrease in muscle force generation in the injected muscle, weakening the effected muscle by 75% 3 days after injection with subsequent return to full strength at 3–6 months [8, 9].

BoNT has already been demonstrated as an effective treatment option for a variety of orthopedic conditions [10]. Previous studies have reported the use of BoNT-A as an adjunct to the repair of tendons in rat models and for the use in finger flexor tendon repair [11–14]. To our knowledge, no previous literature has been published regarding the use of BoNT-A as a protective modality in the repair of distal biceps tendon ruptures. The purpose of this study was to assess the outcomes of patients that underwent distal biceps tendon repair with the use of BoNT-A as an intramuscular adjunct.

Materials and methods

After approval from the institutional review board and ethics committee at our institution, patients were identified using a database search of the electronic medical record system as well as surgeon case logs. Those patients who underwent operative repair of distal biceps tendon injuries with use of BoNT-A adjunct by a single senior surgeon [XX] between January 2007 and March 2013 were included. Patients were identified using Current Procedural Terminology (CPT) code 24341 and 24342, which signify: Repair, tendon or muscle, upper arm or elbow, each tendon or muscle, primary or secondary and reinsertion of ruptured biceps or triceps tendon, distal, with or without tendon graft, respectively. All cases in which BoNT-A was not used as an adjunct were excluded from the study. Repairs were considered acute if they were done within 6 weeks of injury. Injuries were considered chronic if they occurred > 6 weeks before surgical fixation (Fig. 1).

Patient medical charts were then extensively reviewed for return of muscle function and post-operative complications including: re-rupture, heterotopic ossification, nerve injury, infection and local wound complications. Patients were also asked to complete a Disability of the Arm, Shoulder and Hand (DASH) questionnaire.

Surgical technique

The suture anchor technique (GII Mitek anchor; Warsaw, Indiana) was used to repair acute biceps tendon ruptures.

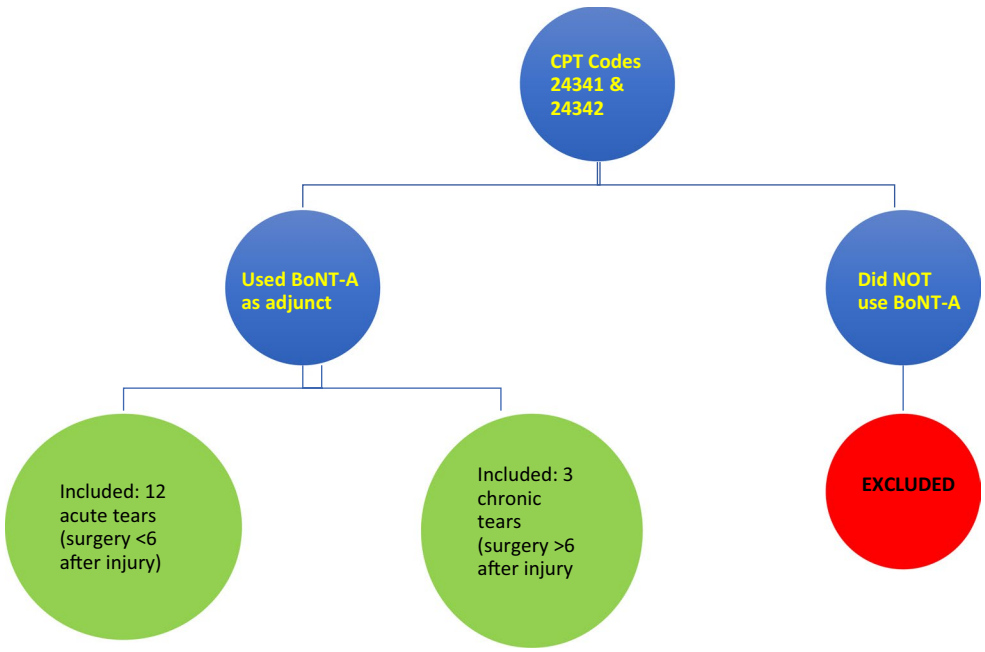

Fig. 1 Inclusion and exclusion criteria

One chronic partial (> 50% of tendon) biceps tendon tear was repaired via completion of tear debridement and suture anchor repair. Two chronic tears were repaired via suture anchor with augment of flexor carpi radialis (FCR) autograft.

Injection protocol

The biceps tendon stump was found through a short transverse incision proximal to the elbow flexion crease. The tendon was retrieved with a clamp and delivered outside of the initial incision. Adhesions were then released and the muscle was pulled out to length. A mixture of 100 units of BoNT-A diluted to 10 mL with 0.9% normal saline was prepared. With the muscle tensioned to expose the junction between the lower third and upper two-thirds of the muscle belly, the BoNT-A solution was injected into the muscle in a dispersed, fanned, fashion with a 22-gauge needle. The biceps was also lifted anteriorly in order to inject the posterior muscle belly as well. The locations and method of injection are based on the richest distribution of biceps motor endplates which are located at the junction between the lower third and the upper two-thirds of the muscle belly in an inverted V-shaped band [15]. Once the BoNT-A solution had been injected, the biceps tendon was repaired to the radial tuberosity using a GII Mitek anchor (Warsaw, Indiana).

Post-operative care

Patients were placed in a posterior mold plaster splint in 70 degrees of flexion with a non-weight bearing restriction for 7–10 days. At the first post-operative visit, the splint was removed and the patient was transitioned into a sling with the following restrictions: controlled active and passive flexion and extension of the elbow in the sling and a 5-pound weight restriction for lifting. One month post-operative, patients were progressed to full active and passive range-of-motion of the arm with weight limit restriction removed.

Results

A total of 15 repairs were identified from an exclusively male cohort of 14 patients. The mean age at procedure was 52.1 years (range: 29–65 years). Average time to repair of chronic injury was 5.75 months (range: 2–12 months; Table 1). Chronicity and type of injuries included: 12 (85.7%) acute biceps tendon ruptures, 1 (6.7%) chronic partial (> 50% of tendon) biceps tendon tear, and 2 (13.3%) chronic biceps tendon ruptures.

There were no intraoperative complications. All patients were discharged home on the day of surgery. Appropriate paralysis of the BoNT-A treated muscle was achieved in 14/15 (93.3%) patients. All patients (15/15) had return of function of the repaired muscle prior to final follow-up. Average final post-operative follow-up was at 33.4 months (range: 7.1–61.7). At final follow-up: 14/15 (93.3%) patients had no pain, 1/15 (6.7%) patients had minimal/occasional pain, no patients had moderate/everyday pain. DASH scores, collected at final follow-up, had a mean of score of 4.9 (SD: 4.85; range: 0.0–12.5; Table 1).

Two patients, both of whom underwent acute biceps tendon repairs, developed post-operative wound infections. One

Table 1 Patient age, injury, repair type, follow-up and quick DASH scores

Patient age (years)	Injury	Type of repair	Final follow-up (months)	DASH score
55	Right distal biceps rupture	Anchor repair	51.2	5
53	Right distal biceps rupture	Anchor repair	5.9	8.3
38	Right chronic distal biceps rupture	Anchor repair with FCR augment	35.2	6.9
56	Right distal biceps rupture	Anchor repair	20.8	0
47	Left distal biceps rupture	Anchor repair	49.8	0
65	Right distal biceps rupture	Anchor repair	58.6	7.5
41	Right chronic > 50% partial distal biceps rupture	Tear completion with anchor repair	61.7	11.7
53	Left distal biceps rupture	Anchor repair	18	4.5
42	Left chronic distal biceps rupture	Anchor repair with FCR tendon augment	58.1	5
29	Right distal biceps rupture	Anchor repair	7.1	0
44	Right distal biceps rupture	Anchor repair	24.3	0
45	Left distal biceps rupture	Anchor repair	36.7	0
53	Right distal biceps rupture	Anchor repair	21	12.5
53	Right distal biceps rupture	Anchor repair	27	0
51	Left distal biceps rupture	Anchor repair	25	12.5

of these patients was discovered to have a deep wound infection that was found 1-week post-surgery. He was brought back to the OR for incision and drainage with subsequent resolution of infection. The second patient had a superficial wound infection that was found 2-weeks post-operatively and was successfully treated with a 5-day course of oral antibiotic with complete resolution of infection. Despite resolution of the infection, however, this patient developed significant restrictions to supination and pronation range-of-motion. At the 3-month follow-up, significant heterotopic ossification (HO) was identified which required surgical excision approximately 6 months after initial repair. This patient later healed with improvement in supination/pronation range-of-motion and no further complications.

Discussion

This study's findings suggest that the use of BoNT-A as an augment to surgical repair of distal biceps tendon ruptures is safe with acceptable results without the need for increased post-operative cost and surveillance. Literature suggests that distal biceps tendon ruptures are prevalent injuries treated by orthopedic surgeons [1, 2, 4, 5]. Surgical repair of distal biceps tendon ruptures is recommended in order to preserve function [1, 5]. Post-operative protocols involve use of splints, braces, and controlled supervised therapy, all of which involve increased cost and immobilization. Use of BoNT-A in orthopedic procedures has previously been shown to be safe and effective but has yet to be described for the protection of a large tendon after surgical repair [10].

Our cohort experienced no intraoperative complications or re-rupture. Two patients did develop post-operative wound infections, one of whom also developed HO. Reported complications after distal biceps tendon repair include: lateral antebrachial cutaneous nerve (LABCN) and posterior interosseous nerve (PIN) palsies, HO, and tendon re-rupture [16, 17]. Re-rupture is relatively uncommon with the incidence ranging between 1 and 2%, but is a difficult complication requiring revision surgery with possible augmentation [17, 18]. Cain et al. reported four re-ruptures after repair of 198 biceps tendon ruptures. Of their re-ruptures, two of the four occurred less than 2 months after repair and another occurred "shortly after the patient returned to normal activity" [17]. Although the rate of re-rupture is low, there are times where an augment to support a repair may be required, for example, a non-compliant patient or tenuous fixation of a chronic or revision tendon rupture. Our findings suggest that BoNT-A may be safely used as a supplement to protect repairs throughout the early bone-to-tendon healing phase and should be considered if not in routine acute tendon repairs then chronic or more tenuous repairs that would benefit from more protection.

Overall, this cohort had very favorable outcomes in regard to disability scores with a mean DASH score of 4.9 ± 4.85. In a previous prospective, randomized study by Grewal et al., 91 distal biceps ruptures were repaired via single and double incision techniques. In their cohorts, they found mean DASH scores of 7.8 ± 12.9 and 5.5 ± 11.8 for single and double incision repairs, respectively [19]. Similarly, a retrospective review performed by McKee and colleagues retrospectively reviewed patient oriented functional outcomes in 53 patients who underwent single incision distal biceps repair. They found their patients had a mean DASH score of 8.2 ± 11.6 [20]. In comparison with these aforementioned studies, our subjects had very similarly low disability scores, suggesting no significant negative consequence with use of limited post-operative restrictions after BoNT-A augmentation.

In general, tendon healing parallels the phases of normal wound healing: it begins with a short inflammatory phase, followed by a proliferative phase that lasts from a few weeks to a month and then ends with a remodeling phase, which can continue for multiple months. In non-compliant or otherwise high-risk for re-rupture patients, the paralytic effect of BoNT-A may be a beneficial adjunct to protect a repair preventing tendon-bone interface gapping and catastrophic re-rupture during the tenuous early stages of healing. There has been limited research in regard to BoNT-A use, or other adjunctive intraoperative treatments, in tendon repair. In a prospective study with match controls, De Aguiar et al. prospectively followed 18 patients with surgical repair of zone 2 flexor tendon injury of the hand with BoNT-A injection adjunct and compared these patients with 53 matched controls. They found that 94% of the BoNT-A group had excellent results, 6% had good results, and no patients had fair or poor results compared to 81% excellent, 6% good, 7% fair, and 6% poor in the control group [12]. Mah and colleagues reviewed the temporary and controlled reduction of muscle forces as a result of BoNT-A injection in a rat Achilles tendon repair model. Their results found that BoNT-A treatment prevented gap formation and rupture compared to controls [11].

There are several limitations to this study. First, this is a retrospective review without a control group. Ideally, a prospective randomized control trial that compares outcomes of tendon repair with and without BoNT-A as an adjunct may provide greater evidence for the utility of BoNT-A. In addition, the sample size of the population was relatively small and larger cohorts would be required for adequate power to find statistical significant treatment effects. Finally, this case series was performed by a single surgeon. To unequivocally demonstrate the utility of BoNT-A success, a prospective multi-surgeon trial should be performed. Strengths of this study included providing an initial, innovative method, utilizing BoNT-A in the repair of distal biceps tendon ruptures

as well as providing lengthy follow-up and patient-reported outcomes.

In conclusion, BoNT-A may be a safe and efficacious supplemental modality to distal biceps tendon repair providing additional protection during the early phases of bone-tendon healing. The utility of BoNT-A as a supplement may be applicable to acute or chronic tears as well as repairs in the non-compliant patient without decreases in functional scores after return of function of the biceps muscle.

Acknowledgements This project was approved by the Henry Ford Hospital Institutional Review Board.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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