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A Retrospective Evaluation of Anatomical Reinsertion of the Distal Biceps Brachii Tendon Using an ACL TightRope® RT with a Titanium Cortical Button and Ultra High Molecular Weight Polyethylene Suture: A Preliminary Report

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A – research concept and design; **B** – collection and/or assembly of data; **C** – data analysis and interpretation; **D** – writing the article; **E** – critical revision of the article; **F** – final approval of the article

Abstract

Background. Various surgical techniques for treating distal biceps brachii tendon injury have been described, and to date there is no consensus regarding the preferred fixation method for the anatomic reinsertion of the ruptured tendon.
Objectives. The aim of the study was to clinically and functionally evaluate the upper limb after surgical anatomic reinsertion of the distal biceps brachii tendon using an ACL TightRope® RT with a titanium cortical button and ultra high molecular weight polyethylene (UHMWPE) suture, and to assess postoperative complications.
Material and Methods. The sample comprised 3 patients. Clinical examination (history, measurements of the active range of forearm motion, arm circumference, the maximum isometric forearm supination and flexion muscle torque), pain evaluation (on a visual analogue scale [VAS]) and functional assessment (the Mayo Elbow Performance Index [MEPI] and Quick Disabilities of the Arm, Shoulder and Hand [DASH]) were carried out. Complications were documented.
Results. The results of the range of motion measurements, arm circumferences and normalized isometric torque values of the muscle groups being studied were comparable in the involved and uninvolved limbs. The MEPI ($x = 95.00 \pm 10.42$) and Quick DASH ($x = 8.66 \pm 18.04$) scores revealed very good results. The VAS results were close to no pain ($x = 3.33 \pm 5.77$ mm). No complications were noted.
Conclusions. The preliminary comprehensive clinical and functional assessment of the upper limb justify the clinical use of the ACL TightRope® RT with a titanium cortical button and UHMWPE suture in surgical anatomic reinsertion of the distal biceps brachii tendon. The early results with a small sample were encouraging, but studies with a larger number of cases and longer follow-up are needed **(Polim. Med. 2016, 46, 2, 163–169).**

Key words: fixation method, flexion, supination, muscle torque, UHMWPE.

Distal biceps tendon ruptures are relatively uncommon injuries, comprising an average of 3% of all biceps tendon injuries [1]. The significant majority of these injuries affect males in their 4th decade of life [2]. The most commonly described mechanism of the injury is excessive eccentric contraction of the biceps brachii with a flexed and supinated forearm [3]. The ruptures mainly occur in the dominant limb [4].

Among the physical exam maneuvers used in the diagnostics of distal biceps tendon rupture, the "hook" test and the squeeze test [5, 6], as well as the biceps crease interval test [7], have been described in the literature. Ultrasound has been described as a useful, fast and relatively inexpensive diagnostic imaging tool, but is considered user-dependent [8].

The distal biceps tendon rupture treatment options include nonsurgical or surgical management. Nonsurgical treatment mainly involves older, low-demand pa-

tients and those with significant risks for surgery, due to a significant loss of forearm supination and flexion strength and endurance in patients treated nonsurgically in comparison to those treated surgically [9–11]. Surgical methods include 1- or 2-incision techniques [12]. The main complications after surgical treatment include nerve injuries, heterotopic ossification and traumatic ruptures [1]. To date, no consensus regarding the preferred fixation method has been reached.

The ACL TightRope® RT (Arthrex, Naples, USA) is a device designed for the reconstruction of the anterior cruciate ligament (ACL) of the knee joint. Generally, the TightRope® involves various configurations of 1 or 2 metal buttons, a metal or bioabsorbable anchor, and suture. The products are comprised of suture with or without a button, wedge or inserter.

The aim of this study was a preliminary clinical and functional evaluation of the upper limb after surgical anatomic reinsertion of the distal biceps brachii tendon using an ACL TightRope® RT with a titanium cortical button and ultra high molecular weight polyethylene (UHMWPE) suture, and to assess postoperative complications.

Material and Methods

The study was a retrospective cohort study in which the evaluation was performed in patients who underwent surgical anatomic reinsertion of the distal biceps brachii tendon at the eMKaMED Medical Centre in Wroclaw, Poland, in the years 2015–2016 using an ACL TightRope® RT. The measurements were performed in 2016 at the College of Physiotherapy in Wroclaw, Poland and the Center of Rehabilitation and Medical Education in Wroclaw, Poland. The study was carried out according to the ethics guidelines and principles of the Declaration of Helsinki. All the participants in the present study were informed of the goal of the study and the approach to be used. The study was approved by the Bioethics Committee of Wroclaw Medical University (KB – 515/2016) and written informed consent forms were signed by all of the participants prior to the study.

Materials

The initial sample comprised 6 patients who had undergone anatomical reinsertion of the distal biceps tendon using an ACL TightRope® RT between January 2015 and February 2016 and who had been invited to the evaluation by phone. No females had been diagnosed with distal biceps tendon rupture, so the initial sample consisted only of males. Ultimately, 3 patients agreed to take part in the study.

The mean age of patients in the study group at the time the measurements were taken was 40.67 ± 2.08 years (Table 1). The mean body mass was 84.33 ± 13.59 kg and body height 176.33 ± 9.07 cm. In 67% of the patients the limb involved was the dominant one. Two left limbs and 1 right limb were treated. The mean follow-up was 46.81 ± 40.76 weeks, ranging from 15 to 93 weeks.

Surgical Procedure

Anatomical reinsertion of the distal biceps tendon was performed using an ACL TightRope® RT with a titanium cortical button and UHMWPE suture (Fig. 1). The decision regarding the surgical procedure was made by the operating surgeon and the patient after

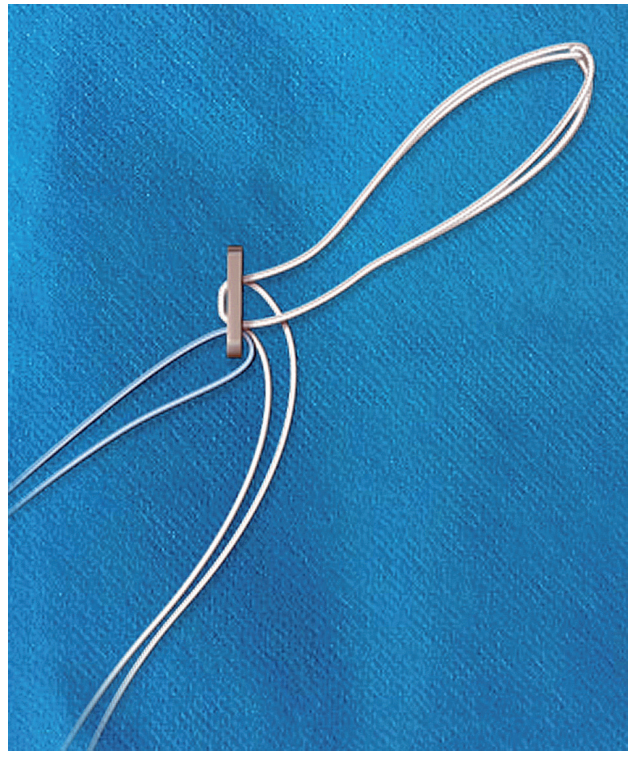

Fig. 1. ACL TightRope® RT with titanium cortical button and ultra high molecular weight polyethylene (UHMWPE) suture

Table 1. The patients' physical data

	Gender	Age (years)	Body Mass (kg)	Body Height (cm)	Dominant Limb	Operated Limb
1	male	39	76	168	right	left
2	male	40	84	186	right	right
3	male	43	93	175	left	left

educating the patient about the risks and benefits of the surgical technique. All of the patients provided written informed consent before undergoing the operation.

The surgical approach was single-incision. The technique involved a transverse incision 2–3 cm distally to the antecubital fossa crease. The ruptured biceps brachii tendon was visualized (Fig. 2), after which minor debridement was performed. The brachioradialis muscle and lateral cutaneous nerve of the forearm were identified. Then, with the forearm in full supination and extension, the bicipital tuberosity was exposed, allowing the surgeon to visualize the footprint of the biceps tendon for reattachment and to protect the posterior interosseous nerve. Using UHMWPE suture, the ruptured tendon was attached to a titanium cortical button by a Krackow suture. A 4.5 mm drill was then used to make holes in both cortices to allow a 4 mm cortical button to pass through them. A pin was run through both cortices from the volar to the dorsal side, and the cortical button with the distal biceps tendon were pulled through the hole. When the fluoroscopy monitor showed that the cortical button was outside the bone, the trailing suture was pulled and the cortical button was turned 90°. The distal biceps tendon was then pulled as far as possible through the first cortex (Fig. 3).

Postoperative Physiotherapy

Postoperatively, a sling or elbow immobilizer was used. The patients were advised that it could be removed after 4 weeks, and the elbow mobilized as tolerated. Passive and active assisted range-of-motion exercises were initiated 7–10 days postoperatively. Strengthening exercises were avoided for 6 weeks. The patients were advised to avoid non-contact sports activities for at least 3 months and contact sport activities for at least 6 months postoperatively.

Based on the information obtained from the patients' histories, the unsupervised postoperative physiotherapy lasted an average of 9.33 ± 4.62 weeks (Table 2).

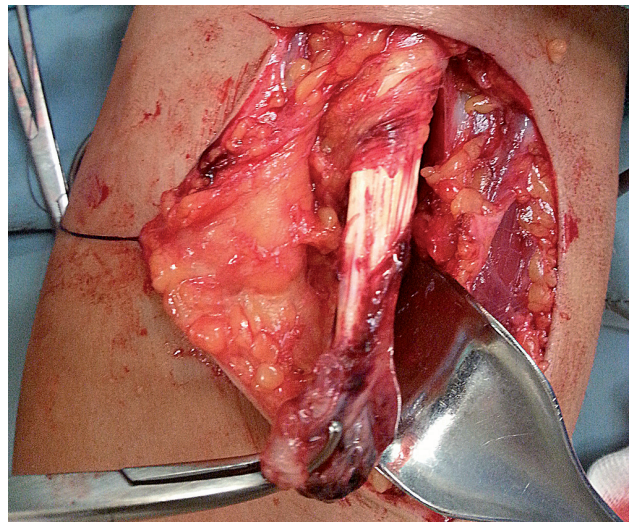

Fig. 2. Intraoperative exposition of a ruptured distal biceps brachii tendon

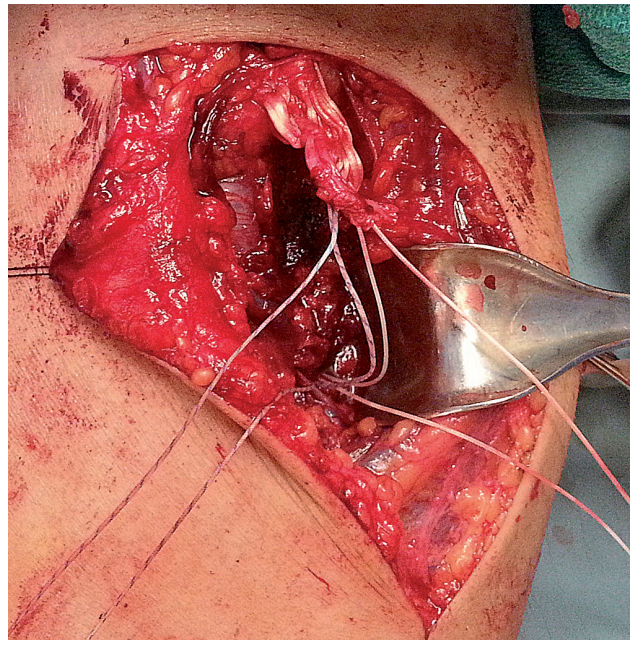

Fig. 3. Intraoperative reinsertion of a distal biceps brachii tendon using an ACL TightRope® RT with a titanium cortical button and UHMWPE suture

Table 2. The patients' profession, mode of injury, interval between injury and surgery, follow-up and duration of postoperative physiotherapy

	Profession	Mode of injury	Interval between injury and surgery (days)	Follow-up (weeks)	Postoperative physiotherapy duration (weeks)	Postoperative complications
1	sales assistant	boxing (recreationally)	13	15	12	none
2	installation electrician	home renovation	2	93	4	none
3	farmer	working in the field	7	33	12	pain of the surgical site

Clinical, Functional and Pain Assessment

Clinical Assessment

The clinical assessment started with a detailed history concerning the circumstances of the injury, the interval between the injury and surgical treatment, and the postoperative physiotherapeutic procedure. Postoperative complications were also documented. This was followed by a physical examination, including inspection, palpation, elbow joint stability assessment, and measurements of arm circumference, the active range of forearm motion (ROM) and strength. The physical examination was supported by specific diagnostic maneuvers to exclude potential reinjury of the distal biceps tendon. Diagnostic imaging such as radiographs and ultrasound were also performed [13].

The arm circumference, active ROM and strength measurements were carried out bilaterally starting with the uninvolved limb. The arm circumference was measured at its thickest level with the olecranon distance as a reference. Forearm ROM was measured using a standard goniometer. Measurements of the maximal isometric torque (IT) of the forearm flexor and supinator muscles were carried out using the Biodex 3 System (Biodex Medical Systems, Inc, Shirley, USA). The measurements were performed with the patient in a seated position, stabilized with shoulder and waist straps. The arm being studied was slightly abducted, the elbow joint rested on a limb support and was stabilized with a securing strap. The IT measurement of the muscles flexing the forearm was performed with the elbow flexed 75° and the forearm in the neutral position. The IT measurements of the muscles supinating the forearm were performed with the elbow flexed 90° and neutral forearm position. For each muscle group studied, 2 maximal 5-second-long contractions, divided by a break that lasted for 10 s, were performed. The contraction with the higher IT value was used in the analysis.

Pain Assessment

The level of pain intensity in the involved limb on the day the measurements were taken was evaluated using a 100-mm visual analog scale on which higher scores indicate higher pain intensity [14, 15].

Functional Assessment

The patients were scored using the Mayo Elbow Performance Index (MEPI) and the Quick Disability of the Arm, Shoulder, and Hand (Quick DASH) questionnaire. The scores were taken only for the involved limb. A total MEPI score ranging between 90 and 100 points indicates an excellent result, 75–89 is good, 60–74 is fair and less than 60 is considered as a poor result. On the Quick DASH a final score ranges between 0, indicating no disability, and 100, meaning the greatest possible disability [16].

Statistical Analysis

The statistical analysis was performed using IBM SPSS Statistics 20 software. Mean values (x) and standard deviations (SD) were calculated for the features examined. Maximal IT of the muscles flexing and supinating the forearm were normalized to body mass and expressed as $Nm*kg^{-1}$. Because the study sample consisted of 3 individuals, the Shapiro-Wilk test was used to examine distribution as described by Royston [17]. In cases when the result was $p < 0.05$ (the results of arm circumferences and ROM), a nonparametric test for dependent samples was used, and when $p > 0.05$ (the results of the maximal IT measurements), a paired t-test for two related samples was carried out. A p-value of < 0.05 was considered statistically significant.

Results

Injury Circumstances

Trauma was the mechanism of injury for all the patients (Table 2). All of them were physical workers. In 1 case the injury happened at work. In 1 case the injury happened during a leisure activity (boxing) and in one case during home renovation. The most frequently described circumstances of injury were lifting, pulling and pushing. All of the study participants were treated acutely (7.33 ± 5.51 days between the injury and the surgical treatment).

Postoperative Complications

In 1 case pain at the surgical site (10 mm on the VAS) after strenuous physical effort was reported (Table 2). However, because a score of 10 on the VAS is close to no pain, this result seem to have no clinical relevance. No abnormalities were found in ultrasound or radiographic imaging of the surgical site in any of the patients, and no distal biceps tendon rerupture was diagnosed.

Clinical Assessment Results

Arm Circumferences

The results of the arm circumference measurements were comparable in the involved limb and uninvolved limbs (Table 3).

Forearm Active Range of Motion

The results of the ROM measurements of forearm flexion, supination and pronation were comparable in the involved and uninvolved limbs. One patient had a flexion contracture of 15° that significantly influenced the mean value of forearm extension in the study group (Table 4).

Table 3. The results of the measurements of forearm circumference: between-limbs comparison

Arm Circumference (cm)				
operated limb		nonoperated limb		
x	SD	x	SD	p
33.33	2.31	33.00	1.00	0.66

p – level of significance; SD – standard deviation; x – arithmetic mean.

Table 4. The results of the measurements of the active range of forearm motion: between-limbs comparison

Active Range Of Forearm Motion (°)					
	operated limb		nonoperated limb		p
	x	SD	x	SD	
Extension	5.00	8.66	0.00	0.00	0.32
Flexion	128.33	7.64	131.67	2.89	0.32
Supination	83.33	5.77	86.67	5.77	0.32
Pronation	83.33	5.77	86.67	5.77	0.32

p – level of significance; SD – standard deviation; x – arithmetic mean.

Muscle Strength Measurements

No statistically significant differences between the involved and uninvolved limbs in the IT values (normalized to body mass) of the muscles flexing and supinating the forearm were found (Fig. 4).

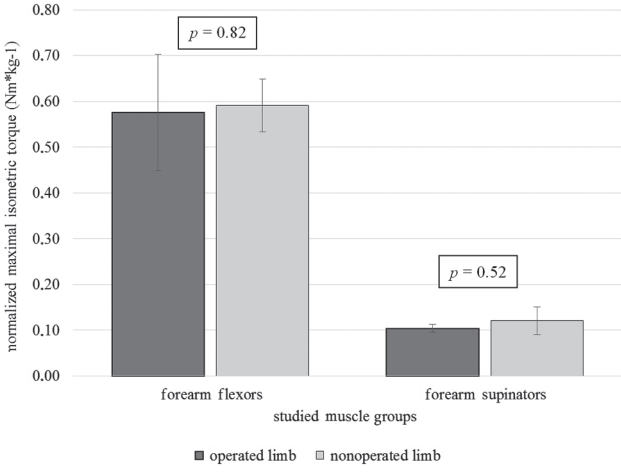

Fig. 4. The results (normalized to body mass) of the maximal isometric torque measurements of the muscles flexing and supinating the forearm: the between-limbs comparison (p – level of significance)

Pain and Functional Assessment Results

The results of the pain assessment performed using a VAS revealed close to no pain. The functional assessment based on patient-oriented scores indicated an excellent MEPI result and a Quick Dash score showing close to no disability (Table 5).

Table 5. The results of the functional evaluation and pain assessment

Functional Evaluation and Pain Assessment		
	x	SD
MEPI (n of scores)	95.00	10.42
Quick DASH (n of scores)	8.66	18.04
VAS (mm)	3.33	5.77

MEPI – Mayo Elbow Performance Index; n – number; SD – standard deviation; Quick DASH: – Quick Disability of the Arm, Shoulder, and Hand; VAS – Visual Analogue Scale; x – arithmetic mean.

Discussion

The comprehensive retrospective evaluation of patients an average of a year after anatomical repair of distal biceps brachii tendon rupture using an ACL TightRope® RT with a titanium cortical button and UHMWPE suture revealed very good results in terms of clinical and functional assessment, as well as pain evaluation. No significant postoperative complications were noted.

There is still no consensus regarding the best surgical approach for surgical anatomical reinsertion of a ruptured distal biceps tendon; both single-incision and double-incision techniques are used [18]. The tendon stabilization methods used, including suture anchors, bone tunnels, interference screws or cortical buttons, also remain debatable issues; there is no clear clinical evidence supporting one fixation method over another [19].

Distal biceps rupture repair using a cortical button for fixation was first introduced by Bain et al. [20]. Greenberg et al. then reported on the higher load to failure of cortical buttons in biomechanical models [21]. Peeters et al. noted excellent results in terms of the clinical and radiological assessment of patients an average of 16 months after distal biceps tendon repair with the EndoButton [22].

Native tension on the biceps brachii tendon with the elbow joint flexed 90° against gravity has been noted to be 50 N [23], while the mean failure strength required to rupture an intact biceps tendon amounts to around 204 N [24]. A comparison of biomechanical models of 4 different stabilization methods revealed that the

EndoButton method had the highest load to failure (440 N) in comparison to the suture anchor (381 N), bone tunnel (310 N) and interference screw (232 N); the superiority of the EndoButton in this regard was statistically significant [25]. Biomechanical tests by other authors have also revealed that the EndoButton fixation method has a higher load to failure [21, 25], but it still has not been proven clinically [26, 27]. Since it has been shown to be the strongest form of tendon stabilization when compared with other fixation methods, the EndoButton is seen as enabling early active mobilization. A comparison of EndoButton and suture anchor repair of distal biceps ruptures in a human bone-tendon model revealed comparable fixation strengths [28]. On the other hand, the standard technique for cortical button usage is associated with a higher mean gap formation between the tendon and bone after cyclical loading, which has led some authors to develop and assess a tension slide technique [29, 30]. As bone mineral density correlates with the load to failure of the fixation of the tendon [31], the favorable biomechanical properties of the EndoButton fixation technique may be explained by the fact that it is based on the cortical bone on the dorsal aspect of the radius, while in case of the suture anchor, the strength of fixation of the tendon is based on the density of the cancellous bone at the radial tuberosity.

A systematic review by Panagopoulos et al. concerning the outcomes of cortical button distal biceps repair divided the postoperative complications into major ones (such as posterior interosseous nerve palsy, rerupture, reoperation and symptomatic heterotopic ossification) and minor ones (temporary paresthesia in the lateral antebrachial cutaneous nerve or superficial radial nerve, superficial infection, problems with wound healing and irritation from the cortical button) [32]. In the present study no meaningful postoperative complications were found.

A weakness of this study is its retrospective design and the lack of follow-up. The small sample size is also a drawback. However, this is the first study reporting the clinical and functional results of surgical anatomic reinsertion of the distal biceps brachii tendon with the use of the relatively new ACL TightRope® RT system. Studies with a larger number of cases and longer follow-up are needed to assess the long-term outcome and efficiency of this technique.

Conclusions

This is the first study reporting the clinical and functional results of surgical anatomic reinsertion of the distal biceps brachii tendon with the use of the relatively new ACL TightRope® RT system. Preliminary comprehensive clinical and functional assessments justify the clinical use of the ACL TightRope® RT in this procedure. The early results with a small sample an average of one year after surgery were quite encouraging; nevertheless studies with a larger number of cases and longer follow-up are needed.

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