

Received: 2017.02.10
Accepted: 2017.04.19
Published: 2017.10.17

Retrospective Evaluation of Surgical Anatomical Repair of Distal Biceps Brachii Tendon Rupture Using Suture Anchor Fixation

Authors' Contribution:
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Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
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Source of support: Departmental sources

Background: To date, no consensus has been reached regarding the preferred fixation method to use in the repair of distal biceps brachii tendon rupture. The aim of this study was to clinically and functionally (Mayo Elbow Performance Index, MEPI) assess the upper limb after surgical anatomic reinsertion of the distal biceps brachii tendon with the use of suture anchor fixation method with regard to postoperative time and limb dominance, and to assess postoperative complications.





Material/Methods: The sample comprised 18 males (age 52.09±8.89 years) after surgical anatomical distal biceps brachii reinsertion using suture anchor fixation. A comprehensive clinical and functional evaluation and pain assessment were performed.

Results: In terms of postoperative complications, an isolated case of surgical site sensory disturbances was noted. Circumferences (p-value 0.21–1.00) and ROM (p-value 0.07–1.00) were similar in the operated and nonoperated limbs. The isometric torque (IT) values of muscles flexing and supinating the forearm were comparable in both limbs (p-value 0.14–0.95), but in patients with the operated dominant limb, the mean IT value was not higher than the value obtained in the nonoperated nondominant one. The MEPI indicated good and excellent results (80.00±15.00–90.00±8.66 points), but a detailed individual analysis showed that reported scores were not in line with objectively measured features.

Conclusions: The results of the comprehensive retrospective evaluation justify the clinical use of suture anchors fixation method in the surgical anatomical reinsertion of a ruptured distal biceps brachii tendon. The assessment of a patient should always report both subjective and objective measures.

MeSH Keywords: **Elbow Joint • Isometric Contraction • Soft Tissue Injuries • Torque**

Full-text PDF: <https://www.medscimonit.com/abstract/index/idArt/903723>

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Background

Distal biceps tendon rupture is a relatively uncommon injury, accounting for about 3% of all biceps tendon injuries [1]. An excessive eccentric contraction of the biceps brachii with the flexed and supinated forearm is the most commonly described mechanism of the injury [2]. The majority of patients with distal biceps tendon ruptures are males in their fourth to fifth decade of life, and the ruptures mainly occur in the dominant limb [3]. Among physical exam manoeuvres, the “hook” test and the squeeze test have high sensitivity and specificity for assessment of distal biceps tendon avulsions and have been described in the literature [4,5]. The biceps crease interval test validity and reliability as a diagnostic tool have also been analyzed [6]. In terms of imaging, ultrasound has been described as being useful, fast, and relatively inexpensive, but it is a user-dependent diagnostic tool (Figures 1, 2) [7].

Management options for distal biceps tendon rupture include nonoperative and operative treatment. Because of a significant operated limb forearm supination and flexion strength and endurance loss in patients treated nonoperatively in comparison to operatively treated groups [8–10], the nonoperative treatment concerns mainly older, low-demand patients and those with significant risks for surgery. Treatment options for the distal biceps tendon rupture also include either one- or two-incision techniques [11]. Several complications after surgical treatment have been reported, including nerve injuries, heterotopic ossification, and re-ruptures [1]. To date, no consensus has been reached regarding the preferred fixation method [12], including suture anchors [13–15], bone tunnels, interference screws [16,17], or cortical buttons [18–20]. The cortical button method has higher load to failure, as confirmed in biomechanical tests [21,22]. However, it still has not been proven clinically [23,24], and suture anchor repairs also performed very well [22,25–27].

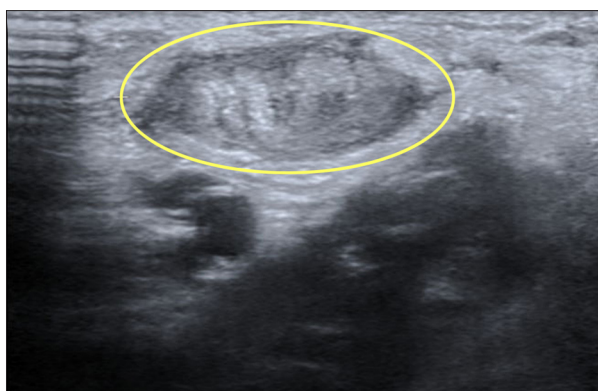


Figure 1. Transverse sonogram showing rupture of the distal biceps tendon fibers.

The aim of the study was three-fold: firstly, to clinically and functionally assess the upper limb after surgical anatomic reinsertion of the distal biceps brachii tendon with the use of suture anchor fixation method with regard to postoperative time and limb dominance; secondly, to feature postoperative complications; and thirdly, to analyze relationships between objective data and subjective outcome scores.

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 in the Department and Clinic of Traumatology and Hand Surgery, Medical University in Wrocław. The measurements were performed in 2016 in the Center of Rehabilitation and Medical Education in Wrocław and the College of Physiotherapy in Wrocław. The study was carried out according to the ethics guidelines and principles of the Declaration of Helsinki. All participants of the present study were informed about the goal of the study and approach to be used. The study was approved by the Bioethics Committee of the Medical University in Wrocław (KB – 515/2016) and written informed consent forms were signed by all of the participants prior to the study.

The initial sample consisted of 23 patients who were operated on between November 2009 and January 2016 and contacted for clinical and functional evaluation by phone. The mean age of participants in the initial sample at the time of injury was 45.96 ± 9.17 years. The initial sample comprised only male participants, as no females were diagnosed with distal biceps tendon rupture. The final sample comprised 18 patients who answered the phone and agreed to take part in the study. The exclusion criteria included any injuries to the operated limb ($n=0$) and/or contralateral limb ($n=0$) at the time between the surgery and performed measurements. The mean age of patients from the studied group at the time of measurements

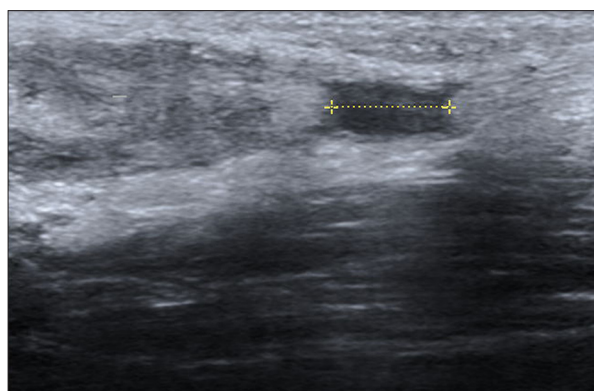


Figure 2. Longitudinal sonogram showing rupture of the distal biceps tendon fibers.

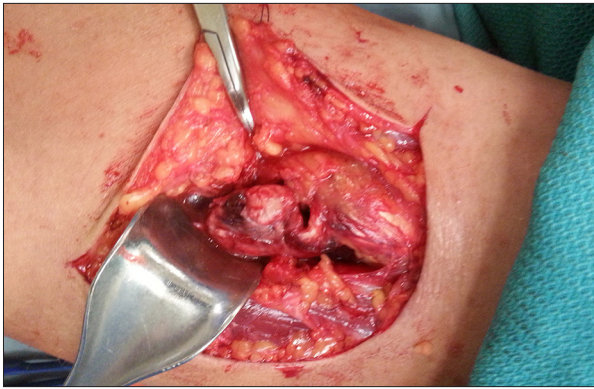


Figure 3. Intraoperative visualization of a ruptured distal biceps brachii tendon.

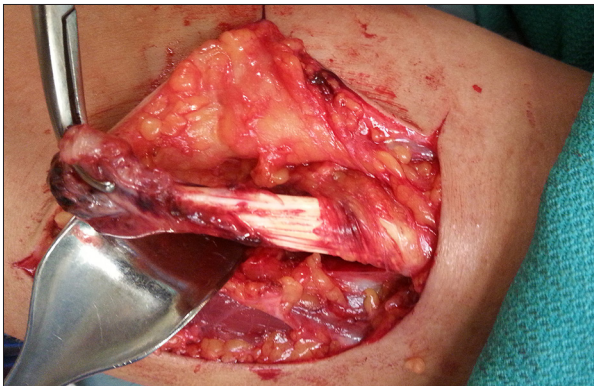


Figure 4. Intraoperative exposition of a ruptured distal biceps brachii tendon.

was 52.09 ± 8.89 years. The mean body mass was 93.18 ± 13.59 kg and body height was 175.27 ± 4.47 cm. In 82% of patients, the dominant upper limb was a right one. The dominant limb was operated on in 27% of patients. The mean follow-up was 47 months, ranging from 7 months up to 88 months; thus, for the purposes of data interpretation, the patients were first divided into 2 groups: patients less than 2 years postoperative and patients more than 2 years postoperative. Additionally, among the 2 studied groups, the patients were divided regarding the limb dominance into patients with operated dominant limb and patients with operated nondominant limb. In the group of patients less than 2 years postoperative, there were no patients with operated dominant limb; thus, finally there were analyzed 3 groups: patients less than 2 years postoperative with operated nondominant limb (Group I), patients more than 2 years postoperative with operated dominant limb (Group II), and patients more than 2 years postoperative with operated nondominant limb (Group III).

Surgical procedure

The surgical approach was single-incision. A transverse incision 2–3 cm distally to the antecubital fossa crease was performed.

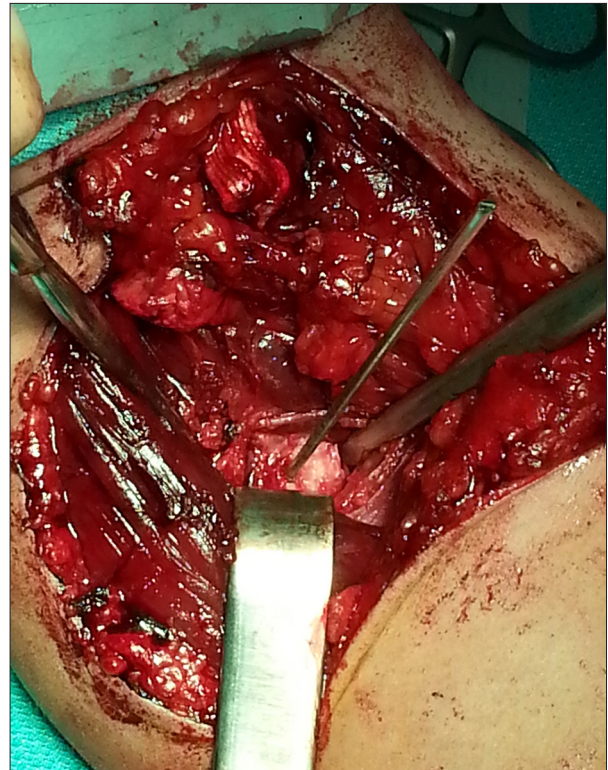


Figure 5. Intraoperative visualization of the radial bicipital tuberosity.



Figure 6. Intraoperative fluoroscopic image of the 5.0 mm suture anchor fixation on the radial bicipital tuberosity.

Ruptured biceps brachii tendon was visualized (Figures 3, 4) and small debridement was performed. Consecutively, the brachioradialis muscle and lateral cutaneous nerve of the forearm were identified. Then, with the forearm in full supination and extension, the radial bicipital tuberosity was exposed (Figure 5), which allowed us to visualize the footprint for reattachment of the biceps tendon and to protect the posterior nerve interosseous (PIN). Then, one 5.0 mm titanium suture anchor (Figure 6) or two 3.0 mm titanium anchors (Ti-Screw Suture Anchor, The Biomet Sports Medicine, USA) were inserted. With the forearm positioned in full range of supination and

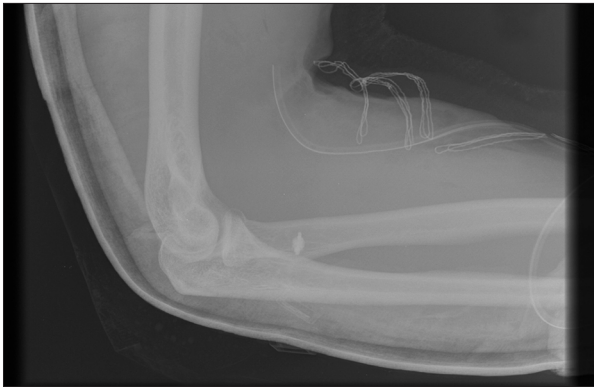


Figure 7. A postoperative radiograph showing one 5.0 mm suture anchor fixated on the proximal cortex of the radius.



Figure 8. A postoperative radiograph showing two 3.0 mm suture anchors fixated on the proximal cortex of the radius.

30° of elbow flexion, the distal biceps tendon was reattached by Krakow suture. In all cases, postsurgical radiological imaging was performed aiming to confirm the accurateness of 1 suture anchor (Figure 7) or 2 suture anchors fixation (Figure 8). There were 11 patients operated on with the use of 1 anchor and 7 patients with 2 anchors.

Postoperative physiotherapeutic procedure

On the day when patients were discharged from the hospital, they were provided with a sling and advised that it can be removed after 4 weeks, and the elbow mobilized as tolerated. The patients were also directed to out-patient clinics to undergo physiotherapy.

Based on the information gained from patient histories, the time of postoperative supervised physiotherapeutic procedure lasted 3.55 ± 3.98 weeks, including physical treatments like local cryotherapy, low-level laser therapy, and magnetic therapy, and exercise of the operated elbow joint.

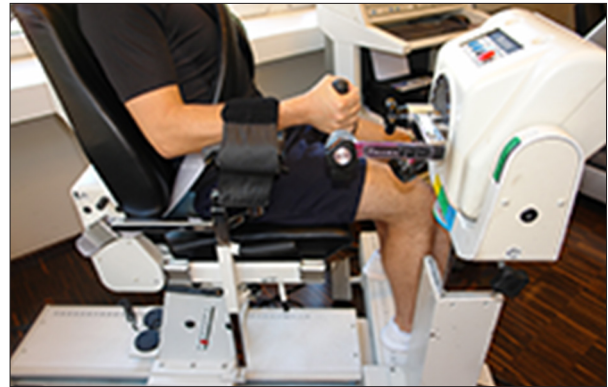


Figure 9. The measurement position of isometric torque of muscles flexing the forearm.

Clinical and functional assessment

Clinical assessment

The clinical assessment started with a detailed history. Information concerning the injury circumstances and the time between the injury and surgery was gained. Also, information about the postoperative physiotherapeutic procedure was recorded. Postoperative complications were documented. Subsequently, the physical examination was carried out (inspection, palpation, elbow joint stability evaluation, the measurements of arm circumference, range of motion, and strength measurements). The physical examination was followed by specific diagnostic manoeuvres excluding eventual reinjury of the distal biceps tendon, and diagnostic imaging like radiographs and ultrasound were performed. The clinical examination was supported by functional evaluation of an elbow, based on pain assessment and elbow self-report measures [28]. The arm circumference was measured bilaterally on its thickest level starting with the nonoperated limb and carried out on the same level in the operated one, with olecranon distance as the reference. Circumferences were measured in a seated position with relaxed arms along the trunk and extended elbow joints. Active range of motion (ROM) of the elbow and forearm were measured bilaterally using a standard goniometer [29]. The patients underwent the measurements of the maximal isometric torque (IT) of forearm flexors and supinators muscles with the use of the Biodex 3 System. The measurements were carried out in a seated position. Patients were stabilized with shoulder and waist straps. The arm of the measured limb was slightly abducted and the elbow joint was resting on a limb support with securing strap. Consistent verbal commands were used. The measurements were performed bilaterally starting with the uninvolved limb. Between the measurements of particular muscle groups there was a break lasting 15 min. The IT measurement of muscles flexing the forearm were performed with the studied elbow flexed at 75° and forearm in the neutral position (Figure 9). Patients performed



Figure 10. The measurement position of isometric torque of muscles supinating the forearm.

2 maximal 5-s contractions divided by a break that lasted for 10 s. The torque measurements of muscles supinating the forearm were carried out with the elbow flexed at 90° and neutral forearm position (Figure 10). Patients also performed 2 maximal 10-s contractions with a 40-s break between them. The contraction with the higher obtained IT value was analyzed.

Pain assessment

The level of pain intensity of the operated limb at the day of measurements was evaluated using a 100-mm visual analogue scale (VAS) [30,31]. Additionally, patients were asked to describe the intensity of pain at the moment of injury, with the use of VAS.

Functional assessment

Functional patient-oriented evaluation used the Mayo Elbow Performance Index (MEPI). MEPI scores were obtained only from the operative extremity. The final score in MEPI ranges from 5 to 100 points, with the higher scores indicating better function [32]. A total score of 90–100 points indicates an excellent result, 75–89 good, 60–74 fair, and less than 60 considered as a poor result [33].

Statistical analysis

Statistical analysis was performed with IBM SPSS Statistics 20. The mean value (\bar{x}) and standard deviation (SD) were calculated for studied features. Obtained IT values [Nm] of muscles flexing and supinating the forearm were normalized to body mass and expressed in $\text{Nm}\cdot\text{kg}^{-1}$. Prior to the intra-group analysis, for the comparison of the operated and nonoperated limb, the Shapiro-Wilk test was used to examine distribution of studied features [34]. When the p-value was <0.05 , the non-parametric Wilcoxon signed-rank test was used, and when p-value was >0.05 the paired t-test for 2 related samples was used. A p-value of <0.05 was considered statistically significant.

Results

Circumstances of the Injury

All patients had a trauma mechanism of injury. Forty-five percent of patients were office workers with injury resulting from leisure activity and domestic duties such as gardening with a strong pull or catching action. The rest of the studied patients (55%) were manual workers with work-related injury (83%) or domestic-related injuries (27%); the most often described injury circumstances were lifting, catching, pulling, and pushing a heavy object. The pain intensity at the moment of injury was estimated by patients to exceed 64.55 ± 38.30 mm. All of the studied patients were treated acutely. The mean time between the injury and surgery was 6.82 ± 9.90 days.

Postoperative complications

In Group I, there was 1 case of surgical site pain (VAS=10 mm) occurring during maximal biceps brachii contraction and 1 patient reported pain (VAS=10 mm) occurring in the surgical site after high-level physical effort. Because the result of 10 mm in the VAS is close to no pain, it does not seem to have any clinical relevance. In Group II, in 1 case sensory disturbances like tingling in the surgical site was observed (paraesthesia). One patient in Group III reported tenderness in the soft tissue of the surgical site. There were no abnormalities in terms of ultrasound examination and radiographic imaging of the surgical site any of the studied patients. No distal biceps tendon rerupture was noted.

Arm circumference measurements results

In Group I, the mean obtained value of arm circumference in the operated limb was comparable to the mean value obtained in the nonoperated one (p-value=1.00). In Group II (p-value=1.00) and Group III (p-value=0.21), the obtained mean value in the operated limb was insignificantly lower than the value of arm circumference in the nonoperated limb (Table 1).

Range of motion measurements results

The results of ROM measurements were comparable in the operated and nonoperated limbs in patients in Group I (p-values 0.18–1.00), Group II (p-values 0.32–1.00), and Group III (p-values 0.07–0.66), (Table 2). In Group I, one patient had a flexion contracture of 2°. In Group III, one patient had a flexion contracture 6° and 2 had a 1° flexion contracture. One of the patients in the Group I did not regain full ROM of flexion in the operated limb (110°). In patients in Group II, in the operated limb ROM of supination 70° was noted in 1 participant. In Group III, the full ROM was not regained in 1 patient in the operated limb (118°). The full ROM of supination was not restored

Table 1. The comparison of obtained arms circumferences values between operated and nonoperated limbs with regard to postoperative time and limb dominance.

	Arm circumference (cm)				p-value
	Operated limb		Nonoperated limb		
	x	SD	x	SD	
Group I	38.33	6.03	38.33	5.03	1.00
Group II	31.00	2.65	31.00	3.00	1.00
Group III	35.80	1.10	37.20	2.95	0.21

Group I – patients less than two years postoperatively with operated nondominant limb; Group II – patients more than two years postoperatively with operated dominant limb; Group III – patients more than three years postoperatively with operated nondominant limb; p-value – significance level; SD – standard deviation; x – arithmetic mean.

Table 2. The comparison of obtained range of motion values between operated and nonoperated limbs with regard to postoperative time and limb dominance.

		Range of motion (°)				p-value
		Operated limb		Nonoperated limb		
		x	SD	x	SD	
Group I	Extension	0.67	1.15	0.00	0.00	0.32
	Flexion	124.00	12.17	127.33	4.62	0.66
	Supination	90.00	0.00	90.00	0.00	1.00
	Pronation	65.00	21.79	86.67	5.77	0.18
Group II	Extension	0.00	0.00	0.00	0.00	1.00
	Flexion	127.67	8.74	131.00	3.61	0.42
	Supination	80.00	10.00	86.67	5.77	0.32
	Pronation	80.00	10.00	86.67	5.77	0.32
Group III	Extension	1.60	2.51	0.20	0.45	0.10
	Flexion	131.80	4.60	130.00	0.00	0.66
	Supination	69.00	14.32	86.00	5.48	0.07
	Pronation	76.00	19.49	86.00	5.48	0.19

Group I – patients less than two years postoperatively with operated nondominant limb; Group II – patients more than two years postoperatively with operated dominant limb; Group III – patients more than three years postoperatively with operated nondominant limb; p-value – significance level; SD – standard deviation; x – arithmetic mean.

in 4 cases in Group III. Those 4 patients obtained 50° (n=1), 65° (n=1), and 70° (n=2) of forearm supination.

Muscle strength measurements results

We found no statistically significant differences between the operated and nonoperated limbs in obtained and normalized to body mass IT values of muscles flexing the forearm in Group I (p-value=0.29), Group II (p-value=0.95), and Group

III (p-value=0.14), (Table 3). The comparison of normalized to body mass IT values of muscles supinating the forearm also showed no differences between the operated and nonoperated limb in Group I (p-value=0.21), Group II (p-value=0.60), and Group III (p-value=0.17). The values obtained in Group I and Group III in case of operated nondominant limbs were lower comparing to nonoperated dominant limbs. However, in Group II, the values obtained in operated dominant limbs were not higher than values obtained in nonoperated nondominant

Table 3. The comparison of obtained normalized maximal isometric torque values of muscles flexing and supinating the forearm between operated and nonoperated limbs with regard to postoperative time and limb dominance.

		Normalized maximal IT of muscles flexing and supinating the forearm (Nm*kg ⁻¹)				p-value
		Operated limb		Nonoperated limb		
		x	SD	x	SD	
Group I	Flexion	0.55	0.09	0.61	0.14	0.29
	Supination	0.09	0.02	0.13	0.04	0.21
Group II	Flexion	0.48	0.22	0.49	0.14	0.95
	Supination	0.10	0.03	0.12	0.04	0.60
Group III	Flexion	0.40	0.14	0.46	0.14	0.14
	Supination	0.08	0.03	0.10	0.03	0.17

Group I – patients less than two years postoperatively with operated nondominant limb; Group II – patients more than two years postoperatively with operated dominant limb; Group III – patients more than three years postoperatively with operated nondominant limb; IT – isometric torque; p-value – significance level; SD – standard deviation; x – arithmetic mean.

ones, which means that even though the operated limbs were dominant ones, they did not regain strength on a higher level in comparison to the second limb.

Pain and functional assessment results

On the day of measurements, the patients from Group I, Group II, and Group III estimated pain intensity to be 3.33 ± 5.77 mm, 1.67 ± 2.89 mm and 4.00 ± 5.48 mm, respectively. The results were close to no pain and were clinically irrelevant. The MEPI results (Figure 11) were excellent (90.00 ± 8.66) in Group I and good (83.33 ± 12.58 and 80.00 ± 15.00) in Group II and Group III.

Objective data vs. subjective scores

For the purposes of objective data vs. subjective scores, the patients with the highest and the lowest subjective assessment values were selected from each group and presented in Table 4. The comparison reveals that in some cases the functional assessment results is better in comparison to objectively measured data, while on other cases the functional assessment is considered worse than the results of objective physical assessment. In Group I, the MEPI result of a patient with a flexion contracture of 2° and 25° less ROM pronation in comparison to the nonoperated limb was 100. Another patient from Group I with a full ROM of extension, pronation, and supination, and 12° of difference of flexion between operated and nonoperated limbs, resulted with a good score in MEPI. One of the patients from the same group, with a good MEPI result, had a full ROM, except for a 40° difference in supination compared to the nonoperated limb. Nevertheless, the patients with good MEPI result had pain in the surgical site during maximal biceps brachii contraction or after high-level physical effort. In Group II, a patient with the highest “excellent” MEPI result (95

scores) had full ROM and reported no complications, while another patient with full ROM and no complications had a “good” MEPI result. The lowest MEPI value obtained in the same group was noted in a patient with 10° of difference in flexion, 20° of pronation, and 20° of supination in comparison to the nonoperated limb, and tenderness at the surgical site. None of the patients in Group II had 100 scores in the MEPI. In Group III, the patient with the highest (100) MEPI result had a 20° difference in ROM of supination in comparison to the nonoperated limb, and reported sensory disturbances like tingling in the surgical site (paraesthesia). Two patients with the lowest MEPI result (65 scores) did not report any postoperative complications; one of them had a 6° flexion contracture, 30° of ROM of pronation and supination difference between operated and nonoperated limb, and the second one had a 20° difference in ROM of supination.

Discussion

The etiology of the injury

According to a study by Safran and Graham (2002), the distal biceps tendon rupture affects mostly males in their fourth decade of life [35]. The findings of the present study were in a line with other authors, as the mean age of participants at the time of injury was 46 years and the initial sample comprised only male participants. However, in the Safran and Graham (2002) study, the dominant extremity was involved in 86% of patients, while in the present study the dominant limb was the operated one only in 27% of patients enrolled into the study. Nevertheless, the disproportion might be a result of a small sample and does not seem to be clinically relevant. In all studied participants, the distal biceps brachii tendon injury had a

Table 4. The individual detailed analysis of patients with the highest and lowest subjective scores results obtained in each group.

Studied group	I*	I	I**	II	II	II	III***	III
Age (years)	41	42	43	57	68	55	43	60
Body weight (kg)	93	78	110	92	123	77	96	81
Body height (cm)	180	170	176	172	182	175	170	182
Operated limb	R	R	L	L	L	R	L	R
Dominant limb	L	L	R	R	R	R	R	R
Operated limb arm circumference (cm)	39	32	44	34	36	32	37	28
Nonoperated limb arm circumference (cm)	39	33	43	34	36	31	42	28
Operated limb ROM extension (°)	0	2	0	6	1	0	0	0
Nonoperated limb ROM extension (°)	0	0	0	1	-1	0	0	0
Operated limb ROM flexion (°)	130	132	110	130	130	135	129	130
Nonoperated limb flexion (°)	130	130	122	130	130	135	130	130
Operated limb pronation (°)	50	55	90	50	90	90	90	80
Nonoperated limb pronation (°)	90	80	90	80	90	90	90	80
Operated limb supination (°)	90	90	90	50	70	90	70	80
Nonoperated limb supination (°)	90	90	90	80	90	90	90	80
VAS (mm)	10	0	0	0	0	0	10	0
Postoperative physiotherapy duration (weeks)	2	12	0	8	6	0	2	3
MEPI	85	100	85	65	65	95	100	85
IT of forearm flexors, operated limb (Nm*kg ⁻¹)	0.57	0.77	0.48	0.43	0.19	0.49	0.45	0.70
IT of forearm flexors, nonoperated limb (Nm*kg ⁻¹)	0.49	0.65	0.50	0.52	0.22	0.51	0.60	0.62
IT of forearm supinators, operated limb (Nm*kg ⁻¹)	0.06	0.10	0.10	0.11	0.10	0.14	0.05	0.08
IT of forearm supinators, nonoperated limb (Nm*kg ⁻¹)	0.11	0.10	0.17	0.11	0.10	0.11	0.09	0.16

* Pain in the surgical site occurring during maximal biceps contraction (VAS=10 mm/close to none pain); ** Pain in the surgical site occurring after high level activity (VAS=10 mm/close to none pain); *** Tingling in the surgical site. IT – normalized maximal isometric torque; MEPI – Mayo Elbow Performance Index; VAS – visual analogue scale; I – group of patients less than two years postoperatively with operated nondominant limb; II – group of patients more than two years postoperatively with operated dominant limb; III – group of patients more than two years postoperatively with operated nondominant limb.

trauma mechanism (e.g., lifting, catching, pulling, and pushing a heavy object), and occurred mostly in physical workers (55%) while at work (83%).

Postoperative complications

The surgical approaches utilizing in the distal biceps tendon repair can be divided into either one-incision or two-incision technique. The two-incision technique is most commonly used in bone tunnel fixation and the one-incision technique utilizing several fixation techniques like suture anchors or cortical buttons [11]. The two-incision approaches are considered

to recreate the normal anatomy more accurately, but there is still no clear evidence suggesting that this approach has a significant advantage [11]. In the present study, the one-incision technique was used. Originally, the one-incision technique was associated with a high rate of nerve palsies [36]. In 1993, Barnes et al. introduced and evaluated a new technique using anatomical reinsertion of a ruptured distal biceps brachii tendon through a single incision with the use of suture anchors fixation (3 Mitek anchors) in 4 patients an average of 7 months after the operation [37]. The study results indicated suture anchors are comparable with other techniques and minimize the possibility of radio-ulnar synostosis, and

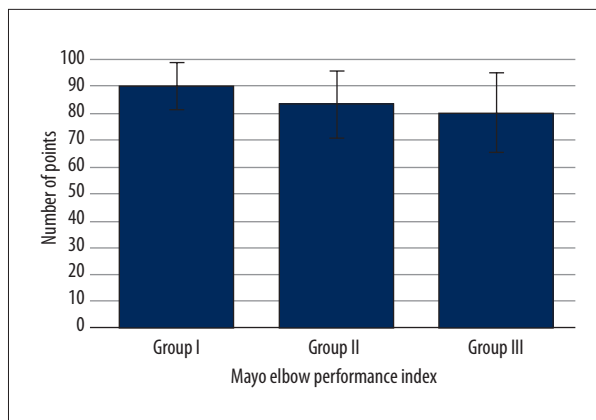


Figure 11. Mayo Elbow Performance Index scores obtained from the operated upper limb with regard to postoperative time and limb dominance. Group I – patients less than 2 years postoperatively with operated nondominant limb; Group II – patients more than 2 years postoperatively with operated dominant limb; Group III – patients more than 2 years postoperatively with operated nondominant limb.

reported that the one-incision method provided excellent exposure [37]. One of the firsts suture anchors fixation assessments was by Lintner and Fischer (1996) (n=5), indicating excellent results in terms of ROM and subjective scores 5 months postoperatively [38]. No associated nerve injuries, heterotopic bone formation, or olecranon tenderness were noted [38]. Most of the postoperative complications noted in the studies evaluating the one-incision approach with the use of suture anchors fixation included nerve palsies and heterotopic ossification [14,39–42]. In the study of Balabaud et al. (2004), no radial nerve injuries and no radio-ular synostoses were noted [14]. The McKee et al. (2005) study revealed a 7.5% rate of complications (e.g., wound infection, transient paraesthesias in the lateral cutaneous nerve distribution posterior interosseous nerve palsy that resolved in 6 weeks) and no cases of rerupture [39]. In the John et al. (2007) study, postoperative complications were noted in 5.7% of studied patients (3.8% heterotopic ossification resulting in a mild loss of forearm rotation and mild pain, and 1.9% a temporary radial nerve palsy resolving completely within 8 weeks) [40]. There were postoperative complications in 12% of studied patients in the study by Khan et al. (2008) [41]. The noted complications involved transient superficial radial nerve palsy (6%) and heterotopic ossification (6%) [41]. In the Gallinet et al. (2011) study, the complications rate obtained 40%, including radial motor palsy, which had resolved completely by one year's follow-up (3.7%), reflex sympathetic dystrophy syndromes, which resolved after 6 months' medical treatment (7.4%) radial sensory nerve paraesthesia (11%) and lateral antebrachial cutaneous nerve paraesthesia, which all resolved spontaneously [42]. In the same study, heterotopic ossification was found in more than 50% of

studied participants, but according to authors, it didn't seem to affect the final clinical result [42]. In the present study, we found isolated cases of pain in the surgical site occurring during maximal biceps brachii contraction (VAS=10 mm) or after high-level physical effort (VAS=10 mm), and sensory disturbances like tingling in the surgical site and tenderness in the soft tissue of the surgical site. As the results of VAS were close to no pain, they were considered as clinically irrelevant. No abnormalities were found in terms of ultrasound examination and radiographic imaging of the surgical site. No distal biceps tendon rerupture was noted.

Postoperative arm circumferences, range of motion, and muscle strength

In a comprehensive evaluation of an elbow treatment, the use of clinical examination including measures of circumferences, ROM, muscle strength supported by pain assessment, and patient reported functional evaluation are required [28].

The arm circumferences were comparable in operated and non-operated limbs in the groups of patients less than 2 years and more than 2 years postoperatively (p-values 0.21–1.00). The intra-group analysis of ROM did not show statistically significant differences between the operated and nonoperated limbs (p-values 0.07–1.00); nevertheless, some significant differences between limbs were found in a detailed individual analysis. There were no statistically significant differences between the operated and nonoperated limb in terms of IT of muscles flexing and supinating the forearm (p-values 0.14–0.95). However, in patients with an operated nondominant limb, the nonoperated dominant obtained better results, while in patients with the operated dominant limb, the obtained mean value was not higher than the value obtained in the nonoperated nondominant one, which suggests that the dominant limb did not regain its preoperative dominance in strength.

Postoperative pain and upper limb function

In regards to pain assessment, the VAS results were close to no pain in patients less than 2 years (3.33 ± 5.77 mm) and more than 2 years postoperatively, irrespective of limb dominance (1.67 ± 2.89 mm in Group II, and 4.00 ± 5.48 mm in Group III). The results of patient-reported evaluation revealed good and excellent results, but a detailed individual analysis showed that reported scores were not in line with objectively measured features, demonstrating that evaluation of patients after repair of distal biceps brachii tendon injury should use both subjective and objective measures.

The one-incision approach with the use of suture anchors fixation has been evaluated in retrospective studies of Balabaud et al. (2004), McKee et al. (2005), John et al.

(2007), Khan et al. (2008), and Gallinet et al. (2011), showing it to be a safe and effective fixation method [14,39–42]. Balabaud et al. (2004) revealed the treatment clinical results were satisfactory for patients (n=8) [14]. All of the patients regained full ROM of elbow and forearm, a 6% strength deficit in isokinetic testing, 7% higher endurance in the operated limb for the flexion-concentric testing, and no strength deficit, and a 13% higher endurance for supination was noted [14]. The McKee et al. (2005) study (n=53), mainly based on the patient-oriented DASH questionnaire, revealed no loss of more than 5° of flexion-extension and forearm rotation and DASH results comparable to healthy individuals according to the DASH User Manual [39]. The John et al. (2007) study comprised 53 patients evaluated an average of 38 months postoperatively [40]. The assessment of patients after surgical anatomical reinsertion of the distal biceps tendon with the use of 2 suture anchors was based on the physical examination, radiographs, and Andrews-Carson elbow score tabulations, indicating an excellent result in 87% of patients and a good result in 13% of studied participants [40]. Khan et al. (2008) evaluated 17 patients an average of 45 months after reinsertion using G4 SuperAnchors [41]. In comparison to the nonoperated limb, in the operated one there was a 5.3° mean loss of extension, a 6.2° mean loss of flexion, a 11° mean loss of pronation, and a 6.4° mean loss of supination. The supination strength obtained in the operated limb was 82.1% of the strength in the nonoperated one [41]. In the Gallinet et al. (2011) study carried out in 27 patients an average of 22 months postoperatively, mobility was fully restored in most patients [42]. The force was not fully restored, but according to the authors it was sufficient to avoid any sequelae affecting daily activities [42].

The suture anchors vs. other fixation methods

Multiple fixation methods and biomechanical studies have been proposed, aiming to compare the load to failure of suture anchors, button fixation, and interference screws, revealing variable results [17,22,43–45]. Clinical and functional results comparing bioabsorbable and nonabsorbable screws in distal biceps tendon repair where an interference screw is combined with transosseous button revealed similar widening of the bone tunnel in both studied groups at short follow-up [24]. The comparison of suture anchor fixation and bone tunnel fixation in a cadaveric biomechanical study presented by Lemos et al. (2004) revealed superior yield strength of 2 suture anchors fixation obtaining 263 N over the bone tunnel fixation (203 N) [26], while the mean failure strength required to rupture intact biceps tendon was around 204 N [46]. Most failures noted in the Lemos et al. (2004) study were caused by suture damage and there was a correlation between bone density and greater yield strength of the repair [26]. Krushinski et al. (2007) compared suture anchors fixation with the use of 2×3.5 mm metallic anchors to bio-tenodesis interference screws in a

cadaveric study and found no significant difference between the pull-out strength of interference screw repair in comparison to the suture anchor fixation that, according to authors of the study, could potentially allow more aggressive rehabilitation and faster return to function [47]. They found no differences in the constructs [47]. The suture anchor fixation has been also evaluated among the most commonly used fixation methods: cortical buttons, bone tunnels, and interference screws in a Mazzocca et al. (2007) biomechanical cadaveric study [22]. The highest load to failure was found in case of cortical buttons repair, with no significant differences between the 4 methods in displacement rates after cyclical loading [22]. However, the cortical button repair associated with drilling to the posterior cortex involved an increased risk of posterior interosseous nerve (PIN) injury that led some authors, like Sethi et al. (2008) [48] and Siebenlist et al. (2011) [49], to develop further modifications of the technique. The Siebenlist et al. (2011) method of double intramedullary cortical button [49] was compared to suture anchor fixation for distal biceps tendon repair in a biomechanical cadaveric study [50]. The study showed small tendon-bone displacement in case of double intramedullary cortical button fixation during cyclic testing and reliable fixation strength to the bone in load to failure. The novel constructs passed cyclic loadings without failure, which led the authors to suggest a more aggressive postoperative rehabilitation to be allowed for the double intramedullary cortical button fixation in clinical use [50].

The suture anchor fixation has been compared by Olsen et al. (2014) to tension slide technique with the use of cortical button and interference screw [51]. The patients with a suture anchor fixation had higher but clinically unimportant differences in DASH scores. The patients with suture anchor fixation had slightly better ROM in comparison to the group of patients operated on with the use of cortical button in terms of flexion and supination, but the authors considered it as clinically unimportant as the difference was less than 6° [51]. The pronation was slightly better in the group of patients with the cortical button [51]. No differences in the flexion and supination strength between the studied groups were found, and the tendon slide technique with the cortical button and interference screw, led authors to conclude that they are comparable to suture anchor repair technique clinical outcomes and complications [51].

Limitations of the study

The retrospective design of the study might be considered as its limitation as patients' follow-up visits were at varying times from surgical intervention. Another limitation of the study is its small sample size, as not all of the operated patients were available for measurement. The lack of a unified, comprehensive, and fully supervised physiotherapeutic postoperative

procedure in the studied group of patients is also a study limitation; thus, future studies should involve patients who underwent a comprehensive, standardized, and fully supervised physiotherapy, and the results of patients after anatomical reinsertion of the distal biceps brachii tendon should be compared to appropriately matched healthy individuals.

Conclusions

The comprehensive retrospective evaluation of patients after anatomical reinsertion of distal biceps brachii tendon using the suture anchors justify the clinical use of this fixation method in the surgical treatment of distal biceps tendon ruptures. In

patients with the operated dominant limb, the torque of muscles flexing and supination the forearm was not higher than in the nonoperated nondominant one, suggesting that the dominant limb did not regain its preoperative dominance in strength. In terms of postoperative complications, an isolated case of surgical site sensory disturbances was noted. The detailed individual analysis showed that reported scores were not in line with objectively measured features, showing that an evaluation of a patient after repair of distal biceps brachii tendon injury should report both subjective and objective measures.

Conflict of interest

There is no conflict of interest.

References:

1. Sarda P, Qaddori A, Nauschutz F et al: Distal biceps tendon rupture: Current concepts. *Injury*, 2013; 44(4): 417–20
2. Schmidt CC, Jarrett CD, Brown BT: The distal biceps tendon. *J Hand Surg*, 2013; 38(4): 811–21; quiz 21
3. D'Alessandro DF, Shields CL Jr., Tibone JE, Chandler RW: Repair of distal biceps tendon ruptures in athletes. *Am J Sports Med*, 1993; 21(1): 114–19
4. O'Driscoll SW, Goncalves LB, Dietz P: The hook test for distal biceps tendon avulsion. *Am J Sports Med*, 2007; 35(11): 1865–69
5. 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
6. El Maraghy A, Devereaux M, Tsoi K: The biceps crease interval for diagnosing complete distal biceps tendon ruptures. *Clin Orthop Relat Res*, 2008; 466(9): 2255–62
7. Belli P, Costantini M, Mirk P et al: Sonographic diagnosis of distal biceps tendon rupture: a prospective study of 25 cases. *J Ultrasound Med*, 2001; 20(6): 587–95
8. Baker BE, Bierwagen D: Rupture of the distal tendon of the biceps brachii. Operative versus non-operative treatment. *J Bone Joint Surg Am*, 1985; 67(3): 414–17
9. Morrey BF, Askew LJ, An KN, Dobyns JH: Rupture of the distal tendon of the biceps brachii. A biomechanical study. *J Bone Joint Surg Am*, 1985; 67(3): 418–21
10. 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(8): 705–8
11. Ward JP, Shreve MC, Youm T, Strauss EJ: Ruptures of the distal biceps tendon. *Bull Hosp Jt Dis* (2013), 2014; 72(1): 110–19
12. Miyamoto RG, Elser F, Millett PJ: Distal biceps tendon injuries. *J Bone Joint Surg Am*, 2010; 92(11): 2128–38
13. Citak M, Backhaus M, Seybold D et al: Surgical repair of the distal biceps brachii tendon: A comparative study of three surgical fixation techniques. *Knee Surg Sports Traumatol Arthrosc*, 2011; 19(11): 1936–41
14. 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 Br*, 2004; 29(2): 178–82
15. 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(3): 506–11
16. Khan W, Agarwal M, Funk L: Repair of distal biceps tendon rupture with the Biotenodesis screw. *Arch Orthop Trauma Surg*, 2004; 124(3): 206–8
17. Heinzelmann AD, Savoie FH 3rd, 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(5): 989–94
18. Recordon JAF, Misur PN, Isaksson F, Poon PC: Endobutton versus transosseous suture repair of distal biceps rupture using the two-incision technique: A comparison series. *J Shoulder Elbow Surg*, 2015; 24(6): 928–33
19. Ranelle RG: Use of the Endobutton in repair of the distal biceps brachii tendon. *Proc (Bayl Univ Med Cent)*, 2007; 20(3): 235–36
20. Siebenlist S, Elser F, Sandmann GH et al: The double intramedullary cortical button fixation for distal biceps tendon repair. *Knee Surg Sports Traumatol Arthrosc*, 2011; 19(11): 1925–29
21. Greenberg JA, Fernandez JJ, Wang T, Turner C: EndoButton-assisted repair of distal biceps tendon ruptures. *J Shoulder Elbow Surg*, 2003; 12(5): 484–90
22. 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(2): 252–58
23. Fox JA, Fernandez JJ: Single incision technique for distal biceps tendon repair: Using the endobutton. *Operative Techniques in Sports Medicine*, 2003; 11(1): 42–46
24. Kettler M, Tingart MJ, Lunger J, Kuhn V: Reattachment of the distal tendon of biceps: Factors affecting the failure strength of the repair. *J Bone Joint Surg Br*, 2008; 90(1): 103–6
25. Henry J, Feinblatt J, Kaeding CC et al: Biomechanical analysis of distal biceps tendon repair methods. *Am J Sports Med*, 2007; 35(11): 1950–54
26. Lemos SE, Ebramzadeh E, Kvitne RS: A new technique: *In vitro* suture anchor fixation has superior yield strength to bone tunnel fixation for distal biceps tendon repair. *Am J Sports Med*, 2004; 32(2): 406–10
27. Pereira DS, Kvitne RS, Liang M et al: Surgical repair of distal biceps tendon ruptures: A biomechanical comparison of two techniques. *Am J Sports Med*, 2002; 30(3): 432–36
28. Skirven TM: *Rehabilitation of the Hand and Upper Extremity*: Elsevier Mosby; 2011
29. Norkin CC, White DJ: *Measurement of joint motion: A guide to goniometry*: F.A. Davis; 2009
30. Bijur PE, Silver W, Gallagher EJ: Reliability of the visual analog scale for measurement of acute pain. *Acad Emerg Med*, 2001; 8(12): 1153–57
31. Boonstra AM, Schiphorst Preuper HR et al: Reliability and validity of the visual analogue scale for disability in patients with chronic musculoskeletal pain. *Int J Rehabil Res*, 2008; 31(2): 165–69
32. Longo UG, Franceschi F, Loppini M et al: Rating systems for evaluation of the elbow. *Br Med Bull*, 2008; 87: 131–61
33. Doornberg JN, Ring D, Fabian LM et al: Pain dominates measurements of elbow function and health status. *J Bone Joint Surg Am*, 2005; 87(8): 1725–31
34. Royston P: Remark AS R94: A Remark on Algorithm AS 181: The W-test for Normality. *Journal of the Royal Statistical Society Series C (Applied Statistics)*, 1995; 44(4): 547–51
35. Safran MR, Graham SM: Distal biceps tendon ruptures: Incidence, demographics, and the effect of smoking. *Clin Orthop Relat Res*, 2002; (404): 275–83
36. Dobbie PR: Avulsion of the lower biceps brachii tendon: Analysis of fifty-one previously unreported cases. *Am J Surg*, 1941; 51(3): 662–683
37. Barnes SJ, Coleman SG, Gilpin D: Repair of avulsed insertion of biceps. A new technique in four cases. *J Bone Joint Surg Br*, 1993; 75(6): 938–39

38. Lintner S, Fischer T: Repair of the distal biceps tendon using suture anchors and an anterior approach. *Clin Orthop Relat Res*, 1996; (322): 116–19
39. 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(3): 302–6
40. John CK, Field LD, Weiss KS, Savoie FH 3rd: Single-incision repair of acute distal biceps ruptures by use of suture anchors. *J Shoulder Elbow Surg*, 2007; 16(1): 78–83
41. Khan AD, Penna S, Yin Q et al: Repair of distal biceps tendon ruptures using suture anchors through a single anterior incision. *Arthroscopy*, 2008; 24(1): 39–45
42. Gallinet D, Dietsch E, Barbier-Brion B et al: Suture anchor reinsertion of distal biceps rupture: Clinical results and radiological assessment of tendon healing. *Orthop Traumatol Surg Res*, 2011; 97(3): 252–59
43. Bain GI, Prem H, Heptinstall RJ et al: Repair of distal biceps tendon rupture: A new technique using the Endobutton. *J Shoulder Elbow Surg*, 2000; 9(2): 120–26
44. Cusick MC, Cottrell BJ, Cain RA, Mighell MA: Low incidence of tendon rerupture after distal biceps repair by cortical button and interference screw. *J Shoulder Elbow Surg*, 2014; 23(10): 1532–36
45. Sethi P, Obopilwe E, Rincon L et al: Biomechanical evaluation of distal biceps reconstruction with cortical button and interference screw fixation. *J Shoulder Elbow Surg*, 2010; 19(1): 53–57
46. Idler CS, Montgomery WH 3rd, Lindsey DP et al: Distal biceps tendon repair: A biomechanical comparison of intact tendon and 2 repair techniques. *Am J Sports Med*, 2006; 34(6): 968–74
47. Krushinski EM, Brown JA, Murthi AM: Distal biceps tendon rupture: Biomechanical analysis of repair strength of the Bio-Tenodesis screw versus suture anchors. *J Shoulder Elbow Surg*, 2007; 16(2): 218–23
48. Sethi PM, Tibone JE: Distal biceps repair using cortical button fixation. *Sports Med Arthrosc*, 2008; 16(3): 130–35
49. Siebenlist S, Lenich A, Buchholz A et al: Biomechanical *in vitro* validation of intramedullary cortical button fixation for distal biceps tendon repair: A new technique. *Am J Sports Med*, 2011; 39(8): 1762–68
50. Siebenlist S, Buchholz A, Zapf J et al: Double intramedullary cortical button versus suture anchors for distal biceps tendon repair: A biomechanical comparison. *Knee Surg Sports Traumatol Arthrosc*, 2015; 23(3): 926–33
51. Olsen JR, Shields E, Williams RB et al: A comparison of cortical button with interference screw versus suture anchor techniques for distal biceps brachii tendon repairs. *J Shoulder Elbow Surg*, 2014; 23(11): 1607–11