Original Article

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Comparison of Single and Double Incision Repair Techniques in Distal Biceps Tendon Rupture

Distal Biseps Tendon Rüptüründe Tek İnsizyon ile Çift İnsizyon Tamir Tekniklerinin Karşılaştırılması

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ABSTRACT

Objective: The purpose of this study was to compare the complications and functional outcomes of single versus double-incision repair techniques for the treatment of distal biceps brachii tendon rupture

Methods: Between 2012 and 2018, patients with distal biceps brachii tendon rupture who were treated with a single or double-incision repair technique were included in this retrospective study. Range of motion (ROM) and Mayo elbow performance scores (MEPS) were evaluated.

Results: Seventeen patients with a mean age of 45.6±6.4 years (range: 34-58 years) who underwent single (n=9) and double (n=8) incision techniques were included in this study. The mean follow-up was 33±10.5 months (range: 24-62 months). Preoperative and postoperative ROM and MEPS were similar between two groups (p>0.05). In the single incision repair technique group, 3 patients had lateral antebrachial cutaneous nerve (LACN) palsy and 1 patient was re-operated due to re-rupture. In the double incision repair technique group, 1 patient had posterior interosseous nerve (PIN) palsy and 1 patient had hematoma that did not require surgical drainage. No significant differences were detected in terms of complications (p=0.62).

Conclusion: Good functional results were obtained after both single and double incision techniques for the treatment of distal biceps brachii tendon rupture. Both single and double incision techniques were reliable however LACN was at risk in single incision technique and PIN in double incision technique.

Keywords: Distal biceps tendon, tendon rupture, surgical repair, single incision, double incision

ÖZ

Amaç: Bu çalışmanın amacı, distal biseps brakii tendon rüptürünün tedavisinde tek ve çift insizyon tamir tekniklerinin komplikasyonlarını ve fonksiyonel sonuçlarını karşılaştırmaktı.

Yöntemler: Bu retrospektif çalışmaya 2012-2018 yılları arasında distal biseps brachii tendon rüptürü olan ve tek veya çift insizyon tamir tekniği ile tedavi edilen hastalar dahil edildi. Hareket açıklığı (HA) ve Mayo dirsek performans skorları (MEPS) değerlendirildi.

Bulgular: Çalışmaya tek (n=9) ve çift (n=8) insizyon tekniği uygulanan, yaş ortalaması 45,6±6,4 yıl (dağılım: 34-58 yıl) olan 17 hasta dahil edildi. Ortalama takip süresi 33±10,5 aydı (dağılım: 24-62 ay). Preoperatif ve postoperatif HA ve MEPS iki grup arasında benzerdi (p>0,05). Tek insizyon tamir tekniği grubunda 3 hastada lateral antebrakial kutanöz sinir (LACN) felci görüldü, 1 hasta ise tekrar rüptür nedeniyle tekrar ameliyat edildi. Çift insizyon tamir tekniği grubunda 1 hastada posterior interosseöz sinir (PIN) felci ve 1 hastada cerrahi drenaj gerektirmeyen hematom gelişti. Komplikasyonlar açısından anlamlı farklılık tespit edilmedi (p=0,62).

Sonuç: Distal biseps brachii tendon rüptürünün tedavisinde hem tek hem de çift insizyon tekniklerinden sonra iyi fonksiyonel sonuçlar elde edilmektedir. Her iki teknik güvenilirdir, ancak tek insizyon tekniğinde LACN, çift insizyon tekniğinde ise PİN risk altındadır.

Anahtar Sözcükler: Distal biseps tendonu, tendon rüptürü, cerrahi tamir, tek insizyon, çift insizyon

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Introduction

The frequency of distal biceps brachii tendon rupture (DBBTR) is 1-5/100,000 per year, and 96% of all traumatic DBBTRs originate from the long head, 1% from the short head, and 3% from the distal insertion of the biceps tendon (1). DBBTR usually occurs during weight lifting in men in their fourth or fifth decade of life and occurs in the dominant extremity as a result of eccentric loading of the muscle tendon unit (2). Smoking, anabolic steroid use, and intratendinal degeneration or hypovascularity are factors that increase the likelihood of this injury (3).

Surgical repair is applied as the first-line treatment in DBBTR, and tendon repair provides more successful and satisfactory results compared to conservative treatment (3-5). Therefore, surgical repair is recommended in active patients with DBBTR to restore elbow flexion and supination strength and to ensure limb endurance. Conventional single-incision or double-incision methods are used in distal biceps tendon repair (3).

The aim of this study was to compare the results of patients who underwent single incision cortical suspension system and tenodesis screw combination repair technique (6) and double incision bone tunnel repair technique (7) for distal biceps tendon repair. Our hypothesis was that the functional outcomes of treatments with different surgical techniques would be similar.

Methods

Before the start of the study, academic committee approval was obtained from the Bezmialem Vakıf University Orthopedics Department (no: 45446446-010.99-3655). The data of patients who underwent distal biceps tendon repair due to DBBTR between December 2012 and January 2018 were reviewed retrospectively. Patients with a follow-up of less than two years were excluded from the study. Acute injuries in active patients with a traumatic full-thickness tear on magnetic resonance imaging (MRI) and clinically accompanied by a decrease in supination muscle strength were considered as the indication for distal biceps tendon repair. Demographic information, extremity dominance, background and occupation of the patients participating in the study were documented. Consent was obtained from all patients for inclusion in the study. One of two different repair techniques was applied to all patients by a single surgeon (K.B.).

Preoperative Evaluation

Preoperative hook test (8) was performed on all patients with suspected distal biceps injury and MRI was requested for radiological evaluation of possible injury. Range of motions (ROM) of elbow flexion and extension, and forearm pronation and supination of the patients were measured preoperatively with a universal goniometer, and Mayo elbow performance scores (MEPS) were recorded. Patients without these assessments were not included in the study.

Surgical Technique

Informed surgical consent forms were obtained from all patients before surgery. All patients were operated in the supine position after full muscle relaxation was achieved under general anesthesia. Following the IV administration of 1 gram of cefazolin, the biceps muscle was stroked to the distal and a tourniquet was applied by extending the muscle length. All surgical procedures were performed on the swimsuit table after sterile staining and dressing. In patients with excessive biceps tendon retraction on MRI, a double incision technique was preferred, and in patients without tendon retraction, a single incision technique was preferred.

Anterior Single Incision

The skin and subcutaneous tissue were passed through a transverse 3-4 cm incision 3 cm distal to the elbow crease. After the skin incision, the lateral cutaneous antebrachial nerve adjacent to the cubital veins was dissected and suspended. The distal biceps tendon, which migrated proximally by blunt dissection, was found and the tendon tip was debrided and thinned. The tendon was prepared using the 4 cm Krackow suture technique with 2.0 Etibond (Ethicon, Somerville, NJ) suture. Then, to prepare the radial tuberositas, it was deepened by blunt dissection between the brachioradialis and pronator teres muscles. The bone was reached with the elbow extended and the forearm hypersupinated. The tendon stump was removed from the bone with the aid of a curette and a rongeur. After proper retraction, bone double cortex was drilled with a 3.2 mm drill bit for bone tunnel preparation. Then, the proximal single cortex was drilled 7-8 mm according to the tendon thickness. Tendon sutures were loaded onto the cortical suspension system (Smith & Nephew, Memphis, TN) and double cortex was bypassed. The sutures were stretched and the tendon was placed in the bone tunnel and tightened with a 1 mm thin tenodesis screw (Smith & Nephew, Memphis, TN) from the tendon at appropriate tension. Then, the tendon was sutured with the threads coming out of the cortical suspension system (Figure 1) (6).

Double Incision

With a 2-3 cm transverse incision made from the elbow bend, the skin and subcutaneous tissue were passed. After LACN dissection and tendon preparation, soft tissue resection was performed with blunt dissection. The location of the second 3-4 cm longitudinal incision to be made posterolaterally between the extensor carpi ulnaris and the extensor digitorum communis muscle interval with a blunt curved surgical instrument was determined using the inside-out method. The forearm was pronated and the posterior interosseous nerve (PIN) was removed. The radial tuberositas cortex was debrided with the aid of a rongeur and curette. The tunnel into which the tendon would enter was prepared with Burr. Three holes were drilled on the sides of the tunnel through which the sutures were to be passed, and 4 sutures, through which the tendon was sutured, were taken and passed through the posterolateral incision with the inside-out method. The tendon was fixed on the prepared place on the bone (Figure 2) (7).

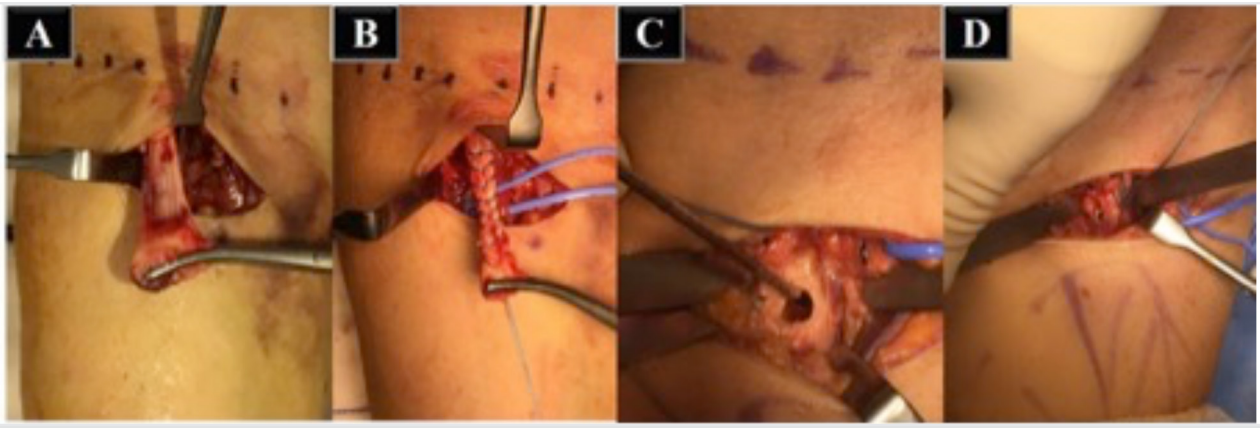

Figure 1. A) Finding the ruptured biceps tendon from the anterior incision, B) Preparing the tendon with Krackow suture technique while preserving the LACN, C) Preparing the radial tuberositas before tenodesis, D) Applying the tenodesis screw

Postoperative Rehabilitation

Postoperatively, the upper extremity of all patients was placed in a long arm plaster splint with the elbow in 90° flexion and the forearm in supination. Wound dressing was recommended every three days as a standard to the patients. The plaster splint was removed 2 weeks after the operation. Exercises to increase ROM with the support of gravity were started and the patients were recommended to use a shoulder arm sling for 2 weeks. Thirty degrees of active extension until the sixth week and full elbow extension at the second month were aimed. Active flexion and strengthening exercises were started in the second month. The patients returned to their daily lives after 3 months and were released for sports activities at 6 months.

Postoperative Functional Evaluation

Postoperative ROM and MEPS of all patients at the latest clinical follow-up were evaluated by a single physiotherapist. The two surgical techniques were compared with each other in terms of complications of heterotropic ossification (HO), radioulnar synostosis, infection, nerve damage, fracture, dislocation of the cortical suspension system, and re-rupture of the distal biceps tendon during clinical follow-ups.

Statistical Analysis

All statistical analyzes were performed using the SPSS statistical software package (IBM Corp.© Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.). Conformity of continuous data to normal distribution was

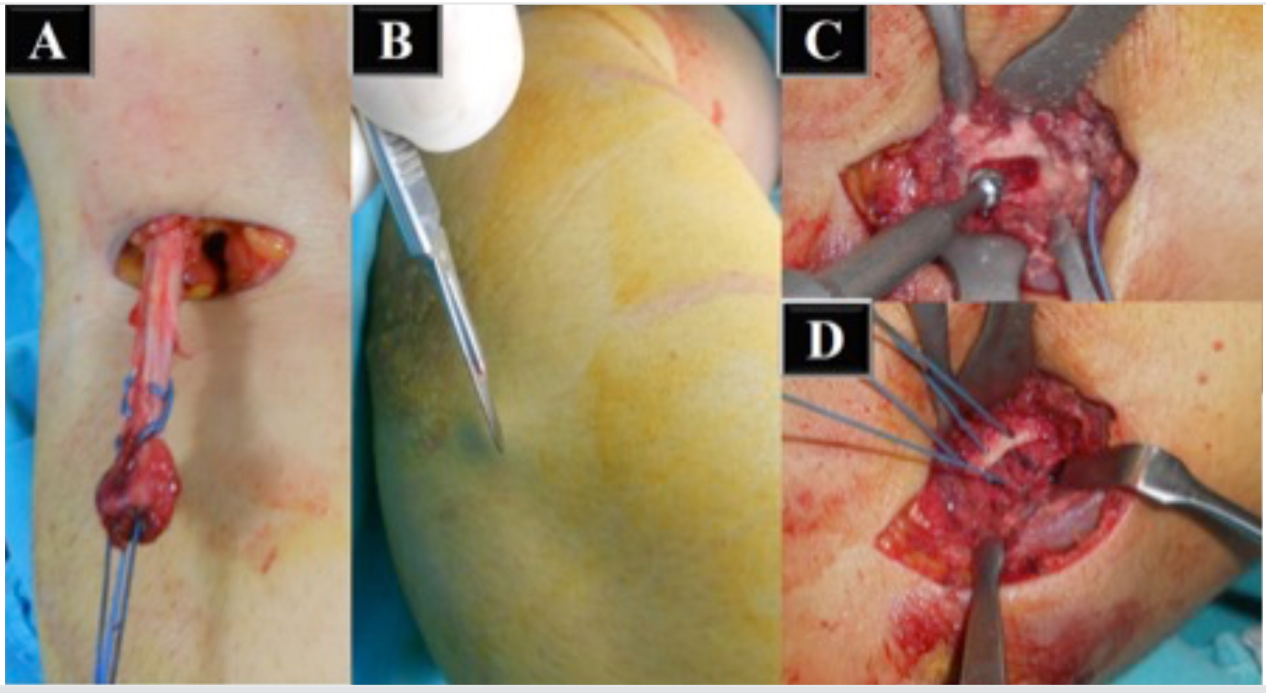

Figure 2. A) Preparing the biceps tendon, B) Determining the location of the second incision using the inside-out method, C) Preparing the radial tuberosity with a burr, D) Passing the threads through the holes

evaluated by Kolmogorov-Smirnov test. Continuous variables were expressed as median (minimum-maximum) and mean ± standard deviation. Categorical variables were expressed as frequency (percentage) values. Continuous comparisons were made using the Mann-Whitney U test, and categorical comparisons were made using the Fisher-exact test. The results were reported as the respective p-values. P<0.05 was considered statistically significant.

Results

Demographic Results

The data of 28 patients who underwent surgery for DBBTR were reviewed retrospectively. Four patients with a follow-up period of less than 24 months, 3 patients who did not comply with the standard postoperative rehabilitation protocol, 2 patients who were operated for chronic tears, and 2 patients whose postoperative follow-up was not documented were excluded from the study. A total of 17 patients, 9 of whom were treated with the single incision technique and 8 with the double incision technique, with a follow-up period of at least 24 months were included in the study. The mean age of the patients was 45.6±6.4 (34-58), and the mean follow-up time was 33±10.5 (24-62). All patients with DBBTR were male. 13/18 (72%) of the patients were physically active working or doing sports. The dominant arms of 10 and the non-dominant arms of 7 of the patients participating in the study were injured. The mean time from injury to surgery was 2.1±1 (1-4) weeks. There was no difference between the two groups in terms of demographic characteristics (Table 1).

Functional Results

The mean MEPS of the patients increased from 78.2±12.2 preoperatively to 97.6±5.3 postoperatively. There was no significant difference between the groups in terms of pre- and postoperative ROM and MEPS (p>0.05) (Table 2).

Complications

No complications such as fracture, wound problem, infection, stiff elbow, HO, and synostosis occurred in any of the patients who underwent surgical repair due to DBBTR. Transient LACN palsy developed in 3 patients who were operated with a single incision technique and were followed up with conservative treatment. Revision distal biceps tendon repair was performed in 1 patient due to re-rupture in the second month after surgery. Transient PIN palsy developed in 1 patient who was operated with the double incision technique and recovered in three months with conservative treatment. One patient had a hematoma that did not require surgical drainage. There was no significant difference between the two groups in terms of complications (p=0.62).

Discussion

The important finding of our study is that both single incision and double incision techniques are reliable in the surgical treatment of DBBTR and these two techniques have similar results in terms of ROM, functional results and complication rates. The complication rate of both surgical techniques is low, and patients treated with the single incision technique are at risk for LACN and those treated with the double incision technique are at risk for PIN. In the case of neuropraxia due to injury to

Table 1. Demographic data of patients

	Single incision (n=9)	Double incision (n=8)	P value
Age	45.3±7.8	45.9±4.8	0.868[a]
Dominance (dominant/non-dominant)	6/3	4/4	0.637[b]
Gender (male/female)	9/0	8/0	1[b]
Sportsman and worker (n)	7	6	1[b]
Preoperative time (weeks)	2.4±1	1.8±0.9	0.194[a]
Post-operative follow-up (weeks)	30.9±6.1	35.4±14.1	0.398[a]

[a]: Mann-Whitney U test; [b]: Fisher Exact test

Table 2. Functional results

	Single incision (n=9)		Double incision (n=8)		P value	
	Preoperative value	Postoperative value	Preoperative value	Postoperative value	Preoperative value	Postoperative value
Flexion (°)	140.6±5.3	141.7±2.5	143.1±2.6	143.8±2.3	0.963	0.743
Extension (°)	1.1±3.3	2.2±6.7	1.3±3.5	0±0	0.37	0.167
Pronation (°)	84.5±3.9	86.1±3.3	78.1±3.7	78.8±3.5	0.084	0.112
Supination (°)	84.4±4.6	85±4.3	88.1±3.7	88.8±2.3	0.136	0.93
MEPS	80.6±15.7	98.3±5	75.6±6.8	96.9±5.9	0.815	0.673

MEPS: Mayo Elbow Performance score

these nerves, successful results are obtained with conservative follow-up.

In cadaveric studies comparing the single and double incision technique in the treatment of DBBTR, it was claimed that the footprint restoration of the tendon with a single incision tended to be made more forward and this led to supination weakness. In addition, it was reported that footprint restoration with double incision repair was more anatomical (9,10). In contrast, Grewal et al. (11) found no difference in terms of ROM, functional score and supination strength between the two techniques, but flexion strength was found to be significantly higher in the double incision group in a randomized clinical study. Castioni et al. (12) showed that more flexion and pronation were obtained with the single incision technique in a meta-analysis comparing single and double incisions in which they included 2,622 patients. We found no significant difference in terms of postoperative ROM (pronation: 86.1°-88.8°, supination 85°-88.8°, flexion 141.7°-143.8°) and functional MEPS scores (98.3-96.9) between the two techniques.

The PIN injury is one of the most important complications of distal biceps repair (13,14). Amarasooriya et al. (15) reported that post-repair motor nerve injuries were found around 2% and most of them were PIN injuries in their systematic review of acute distal biceps tendon repair. However, they showed that 92% of PIN injuries healed with conservative follow-up. There was no difference between single incision (2/233) and double incision (6/411) in terms of PIN injury. Luthringer et al. (16) showed that the PIN injury due to single anterior incision in the repair of the distal biceps tendon might result from placing an improperly distal retractor, and that forearm supination during instrumentation was protective against this injury in an MRI study investigating the relationship between altered forearm rotation and the distance of the PIN from the radial tuberositace. Similarly, Dunphy et al. (17) reported that PIN damage was significantly higher in the double incision technique (3.4% vs 0.8%). In contrast, Amin et al. (14) found that PIN damage was more common in patients with single anterior incision compared to double incision (2.7-0.2%). In our study, although we did not find any postoperative PIN damage in 9 patients in whom we made a single anterior incision, transient PIN palsy developed in 1 of 8 patients who were repaired with a double incision. The patient recovered within 3 months with conservative follow-up. Similar to the literature, we think that a retractor should not be used towards the distal radius of the radius neck in order to protect from PIN damage and that long-term use of retractors should be avoided.

Although care is taken to preserve the LACN during distal biceps repair, the most common postoperative complication is related to this nerve. Although LACN injury is usually in the form of neuropraxia, the frequency of persistent LACN palsy ranges between 0.6% and 26% in the literature (18-21). Castioni et al. (12) found significantly less LACN injuries in patients who underwent double incision than in patients who underwent single incision. Amarasooriya et al. (15) found significantly more LACN damage in patients who underwent repair with a single incision compared to those who underwent double incision (9.3-5.8%). In our study, in parallel with the current literature, LACN damage was found in 3 of the patients who underwent repair with a single incision, and the nerve damage was healed within 3 months in all of these patients. LACN damage was not observed in any of the patients who underwent double incision. We think that double incision prevents traction damage.

Finally, regarding the method of fixing the tendon to the bone, the cost of materials such as screws, anchors (22,23) or cortical suspension system (24,25), which are more expensive than standard sutures, should be considered. In our study, the cortical suspension system and tenodesis screw used in the single incision technique caused additional costs. In this regard, Grant et al. (26) investigated whether the use of implants in DBBTR provided a shortening of the operation time enough to cover the additional cost of the implants. They found that there was no significant difference between the transosseous group and the anchored group in terms of operation time. However, they emphasized that the cost of the anchor should be taken into account.

Study Limitations

There are many limitations of our study. First of all, a limited number of patients were included in the study and the data were reviewed retrospectively. The fact that all surgeries were performed by a single surgeon could also be considered as a limitation. Another limitation was the inability to measure muscle strength before and after surgery. Another limitation was that double incision was preferred in injuries with excessive tendon retraction and single incision repair in injuries without tendon retraction. Finally, the physiotherapist's inability to be blinded to the treatment performed in the postoperative functional evaluation due to the existing incision scars could be considered as a limitation.

Conclusion

Both single and double incision techniques are reliable in DBBTR. The results of both techniques are similar in terms of functional score, ROM and complications, but PIN in double incision technique and LACN in single incision technique are at risk. In the future, prospective, randomized studies with more patients will shed light on which technique is more advantageous.

Ethics

Ethics Committee Approval: Before the start of the study, academic committee approval was obtained from the Bezmialem Vakıf University Orthopedics Department (no: 45446446-010.99-3655).

Informed Consent: Informed surgical consent forms were obtained from all patients before surgery.

Informed Consent:

Peer-review: Externally peer reviewed.

Authorship Contributions

Concept: M.K., A.P., V.U., O.T., K.B., Design: M.K., A.P., V.U., O.T., K.B., Data Collection or Processing: M.K., A.P., V.U., O.T., K.B., Analysis or Interpretation: M.K., A.P., V.U., O.T., K.B., Literature Search: M.K., A.P., V.U., O.T., K.B., Writing: M.K., A.P., V.U., O.T., K.B.

Conflict of Interest: No conflict of interest was declared by the authors.

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References

1. Baker BE, Bierwagen D. Rupture of the distal tendon of the biceps brachii. Operative versus non-operative treatment. J Bone Joint Surg Am 1985;67:414-7.
2. Safran MR, Graham SM. Distal biceps tendon ruptures: incidence, demographics, and the effect of smoking. Clin Orthop Relat Res 2002:275-83.
3. Morrey ME, Abdel MP, Sanchez-Sotelo J, Morrey BF. Primary repair of retracted distal biceps tendon ruptures in extreme flexion. J Shoulder Elbow Surg 2014;23:679-85.
4. Morrey BF. Distal biceps tendon rupture. In: The elbow and its disorders. 3rd edition. Philadelphia: WB Saunders Co 2000. p.468-78.
5. Nesterenko S, Domire ZJ, Morrey BF, Sanchez-Sotelo J. Elbow strength and endurance in patients with a ruptured distal biceps tendon. J Shoulder Elbow Surg 2010;19:184-9.
6. Rios CG, Mazzocca AD. Interference screw with Cortical button for distal biceps repair. Sports Med Arthrosc Rev 2008;16:136-42.
7. Boyd H, Andersan L. A method for reinsertion of the distal biceps brachii tendon. The Journal of bone & joint surgery 1961;43:1041-3.
8. O'Driscoll SW, Goncalves LB, Dietz P. The hook test for distal biceps tendon avulsion. Am J Sports Med 2007;35:1865-9.
9. Hasan SA, Cordell CL, Rauls RB, Bailey MS, Sahu D, Suva LJ. Two-incision versus one-incision repair for distal biceps tendon rupture: a cadaveric study. J Shoulder Elbow Surg 2012;21:935-41.
10. Forthman CL, Zimmerman RM, Sullivan MJ, Gabel GT. Cross-sectional anatomy of the bicipital tuberosity and biceps brachii tendon insertion: relevance to anatomic tendon repair. J Shoulder Elbow Surg 2008;17:522-6.
11. Grewal R, Athwal GS, MacDermid JC, Faber KJ, Drosdowech DS, El-Hawary R, et al. Single versus double-incision technique for the repair of acute distal biceps tendon ruptures: a randomized clinical trial. J Bone Joint Surg Am 2012;94:1166-74.
12. Castioni D, Mercurio M, Fanelli D, Cosentino O, Gasparini G, Galasso O. Single- versus double-incision technique for the treatment of distal biceps tendon rupture. Bone Joint J 2020;102-B:1608-17.
13. Mazzocca AD, Burton KJ, Romeo AA, Santangelo S, Adams DA, Arciero RA. Biomechanical evaluation of 4 techniques of distal biceps brachii tendon repair. Am J Sports Med 2007;35:252-8.
14. Amin NH, Volpi A, Lynch TS, Patel RM, Cerynik DL, Schickendantz MS, et al. Complications of Distal Biceps Tendon Repair: A Meta-analysis of Single-Incision Versus Double-Incision Surgical Technique. Orthop J Sports Med 2016;4:2325967116668137.
15. Amarasooriya M, Bain GI, Roper T, Bryant K, Iqbal K, Phadnis J. Complications After Distal Biceps Tendon Repair: A Systematic Review. Am J Sports Med 2020;48:3103-11.
16. Luthringer TA, Bloom DA, Klein DS, Baron SL, Alaia EF, Burke CJ, et al. Distance of the Posterior Interosseous Nerve From the Bicipital (Radial) Tuberosity at Varying Positions of Forearm Rotation: A Magnetic Resonance Imaging Study With Clinical Implications. Am J Sports Med 2021;49:1152-9.
17. Dunphy TR, Hudson J, Batech M, Acevedo DC, Mirzayan R. Surgical Treatment of Distal Biceps Tendon Ruptures: An Analysis of Complications in 784 Surgical Repairs. Am J Sports Med 2017;45:3020-9.
18. Miyamoto RG, Elser F, Millett PJ. Distal biceps tendon injuries. J Bone Joint Surg Am 2010;92:2128-38.
19. Camp CL, Voleti PB, Corpus KT, Dines JS. Single-Incision Technique for Repair of Distal Biceps Tendon Avulsions With Intramedullary Cortical Button. Arthrosc Tech 2016;5:e303-7.
20. Garon MT, Greenberg JA. Complications of Distal Biceps Repair. Orthop Clin North Am 2016;47:435-44.
21. Cain RA, Nydick JA, Stein MI, Williams BD, Polikandriotis JA, Hess AV. Complications following distal biceps repair. J Hand Surg Am 2012;37:2112-7.
22. Barret H, Winter M, Gastaud O, Saliken DJ, Gauci MO, Bronsard N. Double incision repair technique with immediate mobilization for acute distal biceps tendon ruptures provides good results after 2 years in active patients. Orthop Traumatol Surg Res 2019;105:323-8.
23. McKee MD, Hirji R, Schemitsch EH, Wild LM, Waddell JP. Patient-oriented functional outcome after repair of distal biceps tendon ruptures using a single-incision technique. J Shoulder Elbow Surg 2005;14:302-6.
24. Peeters T, Ching-Soon NG, Jansen N, Sneyers C, Declercq G, Verstreken F. Functional outcome after repair of distal biceps tendon ruptures using the endobutton technique. J Shoulder Elbow Surg 2009;18:283-7.
25. Legg AJ, Stevens R, Oakes NO, Shahane SA. A comparison of nonoperative vs. Endobutton repair of distal biceps ruptures. J Shoulder Elbow Surg 2016;25:341-8.
26. Grant JA, Bissell B, Hake ME, Miller BS, Hughes RE, Carpenter JE. Relationship between implant use, operative time, and costs associated with distal biceps tendon reattachment. Orthopedics 2012;35:e1618-24.