Single Incision Distal Biceps Repair With Hemi-Krackow Suture Technique: Surgical Technique and Early Outcomes

Peter Goljan¹, Nimit Patel², Justin D. Stull¹, Brandon P. Donnelly¹, and Randall W. Culp¹

Abstract

Background: Many surgical methods exist for distal biceps repair. We present the technique and early outcomes of a series of distal biceps repairs completed with a novel suturing technique utilizing a hemi-Krackow locking stitch at the tendon-bone interface. **Methods:** A retrospective review was performed of patients who underwent primary distal biceps repair using a single anterior incision with 2 suture anchors utilizing a hemi-Krackow stitch. With both anchors, a locking stitch along the tendon edge was complimented by the other strand passing through the central aspect of the distal tendon and advanced to pull the tendon edge down to the bone with appropriate tension. Patients with revision surgery and the use of allograft were excluded. Clinical outcomes included elbow range of motion and grip strength. All patients completed a Quick Disabilities of the Arm, Shoulder and Hand (QuickDASH) questionnaire and reported satisfaction level, pain level, and any postoperative complications. **Results:** Fourteen patients with an average age of 51.3 years (range, 27.8–66.4 years) were included in the study. The dominant arm was injured in 9 cases. At an average of 16.4 months' follow-up (range, 6.8–34.3 months), all patients had elbow range of motion of 0° to >130°, and grip strength was 101.5% of the uninjured arm (range, 70.6%–121.4%). The Average QuickDASH score was 6.5 (range, 0–36.5). **Conclusion:** Single incision biceps repair with suture anchor fixation using our hemi-Krackow stitch provided a strong repair allowing easy tensioning of the biceps tendon to bone and showed satisfactory functional outcomes at early follow-up. No patients required revision surgery, and there was only 1 case of transient nerve complaints.

Keywords: distal biceps repair, biceps, surgery, outcomes, Krackow

Introduction

Although a relatively uncommon injury, rupture of the distal biceps tendon and the treatments available have gained increased attention in recent years.^{23,27,28,32} With a variety of treatment options, the decision between nonoperative therapy and surgical fixation depends on a multitude of factors, including the patient's age, functional demand, and chronicity of injury. In patients managed conservatively, studies have shown losses of 40% of forearm supination strength, 30% of elbow flexion strength, and up to 86% of supination endurance.^{2,15,18,28,29} Surgical intervention for distal biceps tears is indicated in young, active laborers.^{2,31} Numerous surgical approaches and fixation methods have been described and proven successful; each has its own advantages and disadvantages.

Regardless of the technique utilized, the overall goal of surgery remains the same: to recreate an anatomic insertion of the biceps tendon with adequate tension strength to allow for bone-tendon healing. Clinical and biomechanical studies

have evaluated incision number and fixation methods available for use, but as of yet, no one technique has demonstrated superior clinical outcomes.^{19,22,30} In the lab, when compared with suture anchor or interference screw fixation, biomechanical studies have shown suture button fixation to have the highest load to failure.^{7,21,23} However, clinical studies report similar outcomes regardless of the number of incisions or tendon fixation method.

The reported rate for complications of any distal biceps repair surgical technique ranges from 8% to 44%,^{4,6,7,12,20,24} with lateral antebrachial cutaneous nerve injury the most commonly reported. As one would expect, complication rates are higher for repairs of chronically injured biceps

¹Thomas Jefferson University, Philadelphia, PA, USA

²Hahnemann University Hospital, Philadelphia, PA, USA

Corresponding Author:

Peter Goljan, The Philadelphia Hand Center, Thomas Jefferson University, 834 Chestnut Street, Suite G114, Philadelphia, PA 19107, USA.

Email: peter.goljan@gmail.com

tendons.^{6,10,20} It is postulated that chronic injuries may require more extensive surgical dissection secondary to increased scar tissue, which in turn could increase the risk for nerve injury. Therefore, when clinically indicated, early surgical repair is preferred for acute distal biceps tendon tears.^{8,10}

In the present study, we describe a modified technique for the repair of distal biceps tendon. This approach uses a single anterior incision and double suture anchor fixation with a hemi-Krackow stitch through the ruptured tendon. This technique maintains the intimate bone-tendon interface necessary for healing while also allowing for appropriate tensioning of the distal biceps tendon. Short-term outcomes of 14 patients are presented utilizing this technique in both acute and chronic biceps tendon injury.

Materials and Methods

Study Design

Institutional review board approval was obtained prior to initiation of this study. A retrospective review of all patients treated surgically by a single surgeon for distal biceps rupture between January 2011 and June 2013 was performed. Patients who had primary distal biceps repair using a single anterior incision with 2-suture anchor fixation with the hemi-Krackow technique and at least 6-month follow-up were considered for inclusion in the study. Exclusion criteria consisted of any patient whose distal biceps tear was treated using any other surgical technique, the use of graft tendon, revision surgery, or insufficient follow-up.

Patient charts were reviewed, and patient age at injury, mechanism of injury, side injured, hand dominance, and time from injury to operative treatment were recorded. Prospectively collected data from routine clinical follow-up, including range of motion, grip strength, and any reported complications, were also collected.

All patients were then contacted by telephone and asked a series of questions regarding their current work status, if any further surgeries were needed, general satisfaction with surgery performed, general satisfaction with cosmesis of surgery performed, and overall pain level. A Quick Disabilities of Arm, Shoulder and Hand (QuickDASH) questionnaire was completed at this time by each patient.

Operative Technique

The patient is placed supine on the operating table with the operative extremity on a hand table. A sterile tourniquet is utilized in all cases. An anterior longitudinal skin incision approximately 6 cm in length is made just distal to the elbow flexion crease and medial to the mobile wad. The lateral antebrachial cutaneous nerve is identified and retracted laterally.

In the acute setting, the torn biceps tendon is frequently found superficially in the antecubital fossa, and the antecubital bursa is filled with serous fluid. In the delayed setting, the distal end of the tendon can retract more proximal above the elbow crease. In these instances, a curvilinear incision transversely across the antecubital fossa and then longitudinally proximal or a separate incision proximal to elbow crease can be used to retrieve the ruptured tendon. Once located, the distal tendon stump is debrided to healthy appearing tendon. A stay suture is placed to provide traction, and adhesions of the tendon and biceps muscle belly are released to allow maximum tendon excursion. If the tendon is still unable to reach its insertion after adhesion release and traction, an alternative surgical method must be utilized.

The radial tuberosity is then exposed with the forearm in full supination, delivering the tuberosity and protecting the posterior interosseous nerve. The radial recurrent vessels are preserved if possible. Narrow Cobra or Bennett retractors are gently placed around the proximal radius to enhance exposure. Any tendon remnants are removed, and the bicipital tuberosity is curetted to bleeding bone.

Two Mitek GII suture anchors (Depuy Mitek, Inc, Raynham, Massachusetts) with No. 2 Ethibond (Ethicon, Somerville, New Jersey) are placed proximal and distal into the bicipital tuberosity making sure to have at least a 1-cm bone bridge between anchors (Figure 1). Fluoroscopy is used to confirm appropriate placement, and the area is copiously irrigated to remove any bone debris.

Distal traction is placed on the tendon ensuring adequate excursion, while allowing the tendon to approximate to the bicipital tuberosity with elbow flexion. With the tendon sufficiently mobile, suture fixation is performed.

The suture limbs from each anchor are toggled within the anchors confirming easy advancement of the suture, as this is paramount to the technique by allowing the suture to bring the tendon to its insertion. After ensuring suture mobility, the limbs of both anchors are brought to a position in which one limb accounts for two-thirds the length of suture. This longer limb is used for tendon fixation and the smaller limb for tensioning.

The longer limb of the proximal anchor is brought through the medial side of distal tendon beginning approximately 5 mm from the edge. Three running-locking (Krackow) throws are made with 8 to 10 mm between each throw with the last throw having the suture coming out from deep to superficial laying on top of the tendon. The shorter limb from this same anchor is then passed through the tendon from deep to superficial approximately 5 mm from the distal edge and between the running suture and the middle of the tendon. These sutures are clamped while fixation from the other anchor is done (Figure 2).

In a similar fashion, the longer suture from the second more distal anchor is placed through the distal end of the lateral side of the tendon 2 to 3 mm from the edge. Again 3

Figure 1. Two Mitek G2 suture anchors placed in bicipital tuberosity longitudinally to better reproduce anatomic footprint.

Figure 2. Distal biceps tendon following bilateral Krackow stitching.

Note. The corresponding free sutures of each suture anchor will next be thread through the inner aspect of the tendon before being tied to their corresponding ends.

Krackow sutures are placed with the suture limb left on top of the tendon. Similarly to the first anchor, the shorter limb of the distal second anchor is passed deep to superficial through the midline of the tendon at approximately 5 mm from the distal tendon edge (Figure 3).

With the arm in full supination and 90° flexion, the “shorter” limb of the proximal anchor is then pulled tight bringing the biceps tendon down to the tuberosity. The 2 sutures from this proximal anchor are tied to each other securing the tendon to bone (Figure 4). This is repeated for the distal anchor, further bringing the tendon down to bone. The 2 distal anchor limbs are tied to each other, providing sufficient fixation and recreating the insertional footprint (Figure 5). Patients are placed in a long arm splint with the elbow in 90° of flexion and neutral rotation.

Figure 3. Positioning of the 2 shorter suture anchor limbs (noted by *) on the inner aspect of the tendon prior to tying each suture to its corresponding Krackow component.

Figure 4. The repaired biceps tendon following tensioning. Satisfactory bone-tendon interface is observed with the arm in both (a) pronation and (b) supination.

Postoperative Protocol

At the first postoperative visit (7-10 days), the cutaneous sutures are removed and a long arm thermoplast splint is made keeping the elbow in 90° of flexion and neutral rotation. A

Figure 5. Illustration of suture positioning.

Note. Note that the inner running stitch of each suture anchor will be tied to its matching Krackow limb.

therapy program is also initiated at this time focusing on initial passive elbow flexion and supination and active elbow extension up to 60°. Active extension and pronation are advanced depending on the intraoperative tension on the repair. Full active and passive range of motion is usually achieved by the 6-week mark and splinting is discontinued. Strengthening begins 10 to 12 weeks postoperative.

Patient Selection

Twenty consecutive patients were treated using this surgical technique between January 2011 and June 2013. Two patients were excluded from the study (1 revision case, 1

inadequate follow-up). In total, 18 patients met the necessary inclusion criteria and follow-up contact was attempted. Two patients refused to participate, and 2 patients could not be reached by any form of contact. Outcome data were available for the remaining 14 patients.

Results

All study members were male, and the average age at surgery was 51.3 years (range, 27.8-66.4 years). The dominant arm was affected in 9 out of the 14 patients. Data from routine clinical follow-up and subsequent telephone contact for study purposes were available at an average of 5.4 months (range, 3.1-11.4 months) and 16.4 months (range, 6.8-34.3 months), respectively. Postoperative radiographs were not routinely obtained in our institution and thus were unavailable for review. Complete results for each patient can be found in Table 1.

The average time from injury to surgery was 6.7 weeks (range, 1.1-21.6 weeks). Eight out of 14 patients had surgery greater than 4 weeks postinjury. The average QuickDASH score was 6.5 (range, 0-36.5). At final contact, patients' average pain was 0.3/10 (range, 0-2.5), and all reported satisfaction with the surgical result. Only 1 patient was dissatisfied with his arm's cosmetic appearance. No patient required any further surgery. When contacted, 3 patients reported persistent nerve issues. One patient reported self-limited persistent paresthesias in the lateral antebrachial cutaneous nerve distribution. A second reported that "his hand falls asleep at night"; however, he had also been diagnosed with mild carpal tunnel syndrome. A third patient reported medial forearm numbness and tingling, which interfered with work capabilities. In this patient, a nerve conduction study performed at the time of most recent clinical follow-up demonstrated evidence of cervical spine radiculopathy. No patient reported symptoms indicative of posterior interosseous nerve injury.

Eleven of 14 patients had returned to the preinjury level of functionality when questioned via telephone. Two of those patients reported intentionally avoiding heavy lifting with the injured arm but otherwise had normal function. In addition, the patient with diagnosed cervical radiculopathy had not yet returned to complete preinjury activity levels.

Discussion

The present study describes a modified surgical technique that provides effective fixation of a distal biceps tendon rupture that is useful in both the acute and chronic setting and demonstrates satisfactory results in short-term follow-up.

Table 1. Individual Patient Outcomes.

	Age at surgery, y	Injury to surgery, weeks	Elbow ROM	Grip strength (percentage of the contralateral arm)	QuickDASH score	Length of follow-up (clinical/telephone), months
Patient 1	56.8	11.1	0-130	112.5	0	5.0/34.3
Patient 2	56.6	9.3	0-130	93.3	0	3.4/27.1
Patient 3	47.9	2.6	0-130	105.9	0	11.4/25.7
Patient 4	45.5	1.6	0-125	119.0	0	3.1/21.8
Patient 5	53.3	3.6	0-130	121.1	2.3	6.2/20.0
Patient 6	45.6	4.3	0-130	70.6	13.6	5.0/16.3
Patient 7	47.1	1.1	0-130	105.0	0	3.4/15.7
Patient 8	47.9	2.9	0-130	100.0	36.4	5.9/14.0
Patient 9	27.8	7.0	0-130	100.0	0	10.3/12.3
Patient 10	66.4	21.6	0-130	100.0	0	3.9/11.2
Patient 11	58.4	2.3	0-130	95.2	11.4	5.0/8.0
Patient 12	59.2	5.1	0-130	92.6	2.3	5.0/8.9
Patient 13	42.1	17.6	0-130	78.3	15.9	3.6/7.0
Patient 14	63.4	4.3	0-135	106.7	9.1	3.9/6.8

Note. ROM, range of motion; QuickDASH, Quick Disabilities of the Arm, Shoulder and Hand.

Table 2. Studies Evaluating Single Incision Distal Biceps Repair Techniques Using Anchoring Sutures.

Author, year	N	Mean follow-up (range), months	DASH score (range), points	% failure
Gasparella et al ¹⁷	14	26 (—)	4.7 (0 to 20)	0
Al-Taher and Wouters ¹	7	35 (8 to 65)	4.4 (0 to 10.8)	0
Grewal et al ¹⁹	47	— (24 to —)	7.8 (—)	6
Citak et al ⁹	24	30 (—)	10.5	10
Our study	14	16 (7 to 34)	6.5 (0 to 36.4) ^a	0

Note. N, number of patients; DASH, Disabilities of the Arm, Shoulder and Hand.

^aQuickDASH was used in our study.

Distal biceps injuries were originally repaired using a single incision and drill holes through the radial tuberosity.^{11,26} However, this technique resulted in a high incidence of posterior interosseous and radial nerve complications secondary to difficult exposure for suture tying.^{11,12,26} Boyd and Anderson then devised a 2-incision technique,⁵ which was subsequently modified by Morrey²⁸ after early results demonstrated radioulnar synostosis and heterotopic ossification.^{7,13} With advancements in fixation devices, including the development of the suture anchor, single incision repair popularity has risen again, and there are now many single incision surgical options available.^{3,14,19,22,23,33}

In addition to the fixation device chosen, the ability to secure the tendon down to bone to allow tendon to bone healing is of paramount importance. The use of a locking stitch, such as the Krackow stitch allows for adequate tensile strength,²⁵ which potentially minimizes the risk of suture pull-out from the tendon. With any locking stitch, however, there is the risk that the tendon will be tied in place without sufficient bony-tendon contact, ultimately decreasing the effectiveness of the repair. With that in

mind, the senior author devised the surgical technique used in the current cohort of patients. By employing one limb of the suture in a Krackow fashion and the other as a sliding post, the tendon can still be advanced to snugly interface with its insertion site. The nature of this suture technique also allows for the knot to be tied proximally on the tendon, which serves to further reinforce the repair as well as minimize the size of the window required for knot tying.

Our present study shows that clinical outcomes are comparable to those reported previously in the literature^{1,7,9,17,19,24} (see Table 2). All patients regained full elbow range of motion at an average of 5.4 months and demonstrated satisfactory functionality with an average QuickDASH score of 6.5. The low number of complications is also similar to other reported studies as well, with 1 patient reporting self-limiting transient lateral antebrachial cutaneous nerve paresthesias. This patient also reported that he was “very satisfied” with the overall surgical result. Two other patients reported nerve complaints; however, they also had concomitant diagnoses of cervical radiculopathy and carpal tunnel

syndrome on the affected side. There were no instances of damage to the posterior interosseous nerve.

The proposed surgical technique resembles one previously published¹⁶; however, there is a key difference between the 2. In Galatz's technique, although a Krackow stitch is utilized from each end of the suture anchor, those proximal strands are then tied to one another, and the distal ends of each suture are then tied directly to the bone. This differs from our method, in which each Krackow limb is tied directly to its corresponding shorter limb after it has been run centrally through the tendon. This is felt to improve suture-tying capabilities by allowing for direct visualization during knot tying, as well as placing the knot on top of the tendon maximizing the amount of tendon-bone interface.

There are limitations to this study, including a shorter duration of clinical follow-up compared with QuickDASH follow-up. Due to the retrospective nature of this study, it was difficult to have all patients return to clinic for a clinical examination for study purposes. As such, beyond the clinical outcomes recorded during routine postoperative care, only telephone questionnaire data were collected. The study also lacked measurement of upper extremity flexion and supination strength, and only grip strength was recorded. Despite these limitations, the low QuickDASH scores, return to preinjury activity, and overall patient satisfaction demonstrate acceptable strength and motion among patients. The small sample size also limited statistical interpretation. However, it was felt that the potential for this technique to improve patient outcomes warranted early reporting despite the size of the cohort.

In this small patient subset, the hemi-Krackow technique had positive clinical and subjective outcomes, as well as minimal postprocedural complications. These satisfactory results were found both in acute as well as chronic bicep rupture repairs. This hemi-Krackow suturing technique can be an alternative to other single incision techniques, as it provides excellent control over tension and restoration of the native anatomy, as well as demonstrates satisfactory early clinical outcomes and patient satisfaction.

Ethical Approval

This study was approved by our institutional review board.

Statement of Human and Animal Rights

All study procedures were followed in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000 and 2008.

Statement of Informed Consent

Informed consent was obtained from all patients included within the study.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

References

1. Al-Taher M, Wouters DB. Fixation of acute distal biceps tendon ruptures using Mitek anchors: a retrospective study. *Open Orthop J*. 2014;8:52-55.
2. Baker BD, Bierwagen D. Rupture of the distal tendon of the biceps brachii. Operative versus non-operative treatment. *J Bone Joint Surg Am*. 1985;67:414-417.
3. Balabaud L, Ruiz C, Nonnenmacher J, Seynaeve P, Kehr P, Rapp E. Repair of distal biceps tendon ruptures using a suture anchor and an anterior approach. *J Hand Surg Br*. 2004;29:178-182.
4. Bisson L, Moyer M, Lanighan K, Marzo J. Complications associated with repair of a distal biceps rupture using the modified two-incision technique. *J Shoulder Elbow Surg*. 2008;17:67S-71S.
5. Boyd HB, Anderson LD. A method for reinsertion of the distal biceps brachii tendon. *J Bone Joint Surg Am*. 1961;43:1041-1043.
6. Cain RA, Nydick JA, Stein MI, Williams BD, Polikandriotis JA, Hess AV. Complications following distal biceps repair. *J Hand Surg Am*. 2012;37:2112-2117.
7. Chavan PR, Duquin TR, Bisson LJ. Repair of the ruptured distal biceps tendon: a systematic review. *Am J Sports Med*. 2008;36:1618-1624.
8. Chillemi C, Marinelli M, De Cupis V. Rupture of the distal biceps brachii tendon: conservative treatment versus anatomic reinsertion—clinical and radiological evaluation after 2 years. *Arch Orthop Trauma Surg*. 2007;127:705-708.
9. Citak M, Backhaus M, Seybold D, Suero EM, Schildhauer TA, Roetman B. Surgical repair of the distal biceps brachii tendon: a comparative study of three surgical fixation techniques. *Knee Surg Sports Traumatol Arthrosc*. 2011;19:1936-1941.
10. Dillon MT, Bollier MJ, King JC. Repair of acute and chronic distal biceps tendon ruptures using the Endobutton. *Hand (N Y)*. 2011;6:39-46.
11. Dobbie RP. Avulsion of the lower biceps brachii tendon: analysis of fifty-one previously reported cases. *Am J Surg*. 1941;51:662-683.
12. El-Hawary R, Macdermid JC, Faber KJ, Patterson SD, King GJ. Distal biceps tendon repair: comparison of surgical techniques. *J Hand Surg Am*. 2003;28:496-502.
13. Failla JM, Amadio PC, Morrey BF, Beckenbaugh RD. Proximal radioulnar synostosis after repair of distal biceps brachii rupture by the two-incision technique. Report of four cases. *Clin Orthop Relat Res*. 1990;253:133-136.
14. Fox JA, Fernandez JJ. Single incision technique for distal biceps tendon repair: using the Endobutton. *Op Tech Sports Med*. 2003;11:42-46.

15. Freeman CR, McCormick KR, Mahoney D, Baratz M, Lubahn JD. Nonoperative treatment of distal biceps tendon ruptures compared with a historical control group. *J Bone Joint Surg Am.* 2009;91:2329-2334.
16. Galatz LM, Jani MM, Yamaguchi K. Single anterior incision exposure for distal biceps tendon repair. *Tech Shoulder Elbow Surg.* 2002;3:63-67.
17. Gasparella A, Katusic D, Perissinotto A, Miti A. Repair of distal biceps tendon acute ruptures with two suture anchors and anterior mini-open single incision technique: clinical follow-up and isokinetic evaluation. *Musculoskelet Surg.* 2015;99:19-25.
18. Geaney LE, Brenneman DJ, Cote MP, Arciero RA, Mazzocca AD. Outcomes and practical information for patients choosing nonoperative treatment for distal biceps ruptures. *Orthopedics.* 2010;33:391.
19. Grewal R, Athwal G, MacDermid JC, et al. Single versus double-incision technique for repair of acute distal biceps tendon ruptures: a randomized clinical trial. *J Bone Joint Surg Am.* 2012;94:1166-1174.
20. Kelly EW, Morrey BF, O'Driscoll SW. Complications of repair of the distal biceps tendon with the modified two-incision technique. *J Bone Joint Surg Am.* 2000;82-A:1575-1581.
21. Kettler M, Lunger J, Kuhn V, Mutschler W, Tingart MJ. Failure strengths in distal biceps tendon repair. *Am J Sports Med.* 2007;35:1544-1548.
22. Lemos SE, Ebrahimzadeh 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;32:406-410.
23. 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;35:252-258.
24. 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;14:302-306.
25. McKeon BP, Heming JF, Fulkerson J, Langeland R. The Krackow stitch: a biomechanical evaluation of changing the number of loops versus the number of sutures. *Arthroscopy.* 2006;22:33-37.
26. Meherin JM, Kilgore ES. The treatment of ruptures of the distal biceps brachii tendon. *Am J Surg.* 1960;99:636-640.
27. Miyamoto RG, Elser F, Millett PJ. Distal biceps tendon injuries. *J Bone Joint Surg Am.* 2010;92:2128-2138.
28. 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;67:418-421.
29. 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;19:184-189.
30. Pereira DS, Kvitne RS, Liang M, Giacobetti FB, Ebrahimzadeh E. Surgical repair of distal biceps tendon ruptures: a biomechanical comparison of two techniques. *Am J Sports Med.* 2002;30:432-436.
31. Ramsey ML. Distal biceps tendon injuries: diagnosis and management. *J Am Acad Orthop Surg.* 1999;7:199-207.
32. Safran MR, Graham SM. Distal biceps tendon ruptures: incidence, demographics, and the effect of smoking. *Clin Orthop Relat Res.* 2002;404:275-283.
33. Sprang JT, Weinhold PS, Karas SG. A biomechanical comparison of EndoButton versus suture anchor repair of distal biceps tendon injuries. *J Shoulder Elbow Surg.* 2006;15:509-514.