Primary Repair of Traumatic Distal Biceps Ruptures in a Military Population: Clinical Outcomes of Single- Versus 2-Incision Technique

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Purpose: To determine the success of distal biceps repair in a high-demand military population and to comparatively evaluate the perioperative risk profile, functional results, and adverse patient outcomes of a single- versus 2-incision technique within this high-risk group. **Methods:** Between 2007-2013, all military service members undergoing primary surgical repair for distal biceps rupture through the Military Health System were isolated. Patients with allograft tendon reconstruction, revision procedures, nonmilitary status, and/or follow-up of less than 24 month were excluded. Demographic data (age, limb dominance) and surgical variables (time to surgery, surgical technique) were extracted, and rates of perioperative complications, rerupture, reoperation, revision, and inability to return to preinjury function were recorded. Logistic regression analysis was performed to evaluate for prognostic risk factors, whereas the Fisher exact test was used for comparative analysis. **Results:** A total of 290 patients met the inclusion criteria, including 44 (15.2%) with a delayed presentation; all patients were men, with an average age of 38.9 years (range, 20-61 years). A single-incision technique was performed in 75.4% (n = 214) versus a 2-incision technique in 24.6% (n = 70), and a cortical button was the predominant fixation construct (73.4%). Reruptures occurred in 7 patients (2.4%), and 3 individuals (1.0%) had significant elbow dysfunction postoperatively. When we compared the overall complication rates, the 2-incision technique (7.1%, n = 5) was not significantly different from the single-incision repair (16.4%, n = 35; $P = .0732$). Tobacco use was significantly associated with risk of rerupture (odds ratio, 4.86; $P = .0423$) or combined surgical and clinical failures (odds ratio, 5.64; $P = .0091$), whereas age, limb dominance, time to surgery, fixation construct, and surgical technique were not statistically significant ($P > .05$). **Conclusions:** Among active patients, a single−volar incision technique and a 2-incision technique showed similar complication profiles. Rerupture and persistent elbow dysfunction were uncommon, but adverse outcomes were significantly more likely among patients who used tobacco. Anatomic distal biceps repair is a safe surgical procedure with excellent clinical outcomes and a 96.6% rate of return to preoperative military function without restrictions. **Level of Evidence:** Level III, retrospective comparative study.

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Distal biceps tendon ruptures are uncommon among aging athletes, with a reported incidence between 2% and 10% in selected groups and an incidence of 1.2 to 5.4 per 100,000 within the general population.[1,2] With distal biceps injury, forearm supination and, to a lesser extent, elbow flexion strength and endurance can be compromised by over 40%,[3-6] and significant pain can result due to persistent traction on the lacertus fibrosus or residual tendon. Consequently, direct primary repair of distal biceps rupture remains the hallmark for treatment, particularly with more acute injuries. However, there is no consensus currently on the optimal method for surgical management.[7] Several proponents have separately recommended a single- or dual-incision approach and several different fixation constructs, but rates of perioperative complications and rerupture vary widely

according to specific surgical technique and patient demographic characteristics.[7]

The purposes of this study were to determine the success of distal biceps repair in a high-demand military population and to comparatively evaluate the perioperative risk profile, functional results, and adverse patient outcomes of a single- versus 2-incision technique within this high-risk group. The null hypothesis was that there would be no significant difference in the rates of perioperative complications between these surgical approaches. We hypothesized that active-duty military service members would show a high rate (>90%) of return to previous level of occupational function after primary distal biceps repair.

Methods

After approval from the institutional review board, a retrospective comparative study of all US military service members with consecutive primary anatomic surgical repair (Current Procedural Terminology code 24,342) of confirmed distal biceps tendon rupture (*International Classification of Diseases, Ninth Revision* code 727.61, 727.62, 727.69, 840.8, 841.8, and/or 905.8) between October 1, 2007, and February 1, 2014, was conducted using the Military Health System Management Analysis and Reporting Tool. The exclusion criteria were as follows: biceps tendon ruptures requiring allograft tendon reconstruction, revision procedures, nonmilitary beneficiary status, insufficient clinical follow-up (i.e., <24 months), and/or inadequate clinical documentation to ascertain selected clinical and surgical variables.

By use of the military outpatient and inpatient electronic medical record systems (AHLTA [Armed Forces Health Longitudinal Technology Application] and Essentris system; CliniComp), line-by-line analysis of all orthopaedic surgery, physical and/or occupational therapy, and primary care documentation was performed for all identified patients. Demographic data and patient-based variables, including age, gender, branch of military service, laterality, hand dominance, tobacco use, and specific military treatment facility, were extracted. In addition, injury characteristics and surgical variables, such as time interval between injury and surgery, specific surgical technique (single incision vs 2 incisions), and method of fixation (suture anchor, cortical button, bone bridge, and/or interference screw), were identified. For this study, subacute or chronic injuries were defined as distal biceps ruptures undergoing surgical management at greater than 4 weeks after index injury.[8]

Clinical and functional outcomes were recorded, and the primary outcome measure in this study was the rate of adverse patient outcomes, including perioperative complications and inability to return to full preoperative upper extremity function. Perioperative complications were classified accordingly as neurovascular, infectious, fracture related, heterotopic ossification (HO), and partial or complete rerupture after primary repair as indicated by the operative surgeon. Postoperative rehabilitation regimens varied depending on treating physician and were nonstandardized. Postoperative upper extremity limitations affecting specific aspects of military performance were extrapolated from the electronic medical record and/or Physical Profile system (DA Form 3349) or electronic tracking system (eProfile electronic profiling system, version 3.18; Medical Operation Data System, Falls Church, VA), whereas more significant, rate-limiting cases of elbow dysfunction warranting medical discharge were identified from the Defense Manpower Data Center or US Army Physical Disability Agency. The cumulative failure rate was defined as the presence of postoperative rerupture (i.e., surgical failure) or inability to return to full preoperative military function (i.e., clinical failure).

Statistical Analysis

Means with standard deviations were calculated for continuous variables, whereas frequencies with associated percentages were used for categorical variables. To discern significant differences between single- and 2-incision surgical techniques, perioperative complication rates were compared by the Fisher exact *t* test. In addition, logistic regression analysis was used to evaluate the association between potential risk factors and the outcomes of interest, including clinical, surgical, and cumulative failure (i.e., surgical or clinical failure). Relative risk was quantified through odds ratios (ORs) with 95% confidence intervals (CIs), and $P < .05$ was deemed statistically significant.

Results

Demographic Characteristics

After review of 393 patients, a total of 290 patients with primary distal biceps repair at 66 separate medical treatment facilities were isolated at a mean of 3.2 years' follow-up (range, 2.0-10.0 years) (Table 1). Patients with triceps tendon (n = 37), proximal biceps tendon (n = 5), pectoralis major (n = 2), and/or proximal wrist extensor ruptures (n = 1) were excluded because of miscoding, and 34 patients with distal biceps reconstruction were also omitted. An additional 34 patients (8.7%) had inadequate documentation or follow-up. The average patient age was 38.9 years (standard deviation, 7.3 years; range, 20-61 years), and 81.7% of patients were aged between 30 and 49 years. The patient series was exclusively male patients and predominately comprised Army service members (45.9%). Tobacco use was identified in 22.5% of patients. Right hand dominance was identified in 69% of patients, but left-sided injuries were common (53.4%).

Table 1. Demographic Characteristics of Patients With Primary Repair of Distal Biceps Ruptures (N = 290)

Risk Factor	Data
Age, mean ± SD, yr	38.9 ± 7.3
Age group, n (%)	
20-29 yr	33 (11.4)
30-39 yr	112 (38.6)
40-49 yr	125 (43.1)
50-61 yr	20 (6.9)
Male sex, n (%)	290 (100)
Branch of service, n (%)	
Army	133 (45.9)
Navy	72 (24.8)
Air Force	45 (15.5)
Marines	36 (12.4)
Coast Guard	4 (1.4)
Tobacco use, n (%)	60 (22.5)
Hand dominance, n (%)	
Left	30 (10.3)
Right	200 (69.0)
Ambidextrous or unknown	60 (20.7)
Injured side, n (%)	
Left	155 (53.4)
Right	135 (46.6)
Type of fixation, n (%)	
Anchors	12 (5.4)
Cortical buttons	163 (73.4)
Bone tunnels	34 (15.3)
Buttons with screws	13 (5.9)
Unknown	62 (21.4)
Time from injury to surgery, d	
Mean ± SD	31.1 ± 79.2
Median (range)	12 (0-565)
No. of incisions, n (%)	
1	214 (75.4)
2	70 (24.6)
Unknown	6 (2.1)

SD, standard deviation.

Surgical Technique

Among all repairs, the median time from injury to surgery was 12 days (range, 0-565 days), and 44 patients (15.2%) were classified as having subacute or chronic ruptures with presentation beyond 4 weeks after injury. Among patients in whom the surgical technique was known (n = 284), a single−volar incision approach was used in 75.4% (n = 214) whereas a 2-incision technique was performed in 24.6% (n = 70), most commonly with a modified Boyd-Anderson approach.[9] Cortical button fixation accounted for 73.4% of all repairs, followed by bone tunnels with a bone bridge (15.3%), combined interference screw and cortical fixation (5.8%), and suture anchors (5.4%).

Clinical Outcomes

At final follow-up, 96.6% of patients had successfully returned to full preoperative function and unrestricted military duties (Table 2). Three patients (1%) with single-incision repair had persistent pain and/or dysesthesia and underwent subsequent elbow-related medical discharge from the military; however, only 1 patient (0.3%) had documented strength deficits and significant difficulties with activities of daily living.

A total of 44 perioperative complications (15.2%) were identified (Table 3), including 39 complications in 35 patients (16.4%) with a single-incision approach and 5 complications in 5 patients (7.1%) with a 2-incision technique. Among patients with a single-incision repair, transient traction neurapraxia accounted for 30 of the complications, most commonly involving the lateral antebrachial cutaneous nerve (LACN; n = 16, 7.5%) and superficial branch of the radial nerve (SBRN; n = 6, 2.8%). Secondary radial neck fractures occurred in 2 cases after accidental falls from a standing height at 59 and 236 days postoperatively, but both were managed successfully without surgery. In addition, in 2 patients, superficial infections developed that responded to oral antibiotics. One patient had residual pain and limited range of motion at over 3 months after injury, and subsequent imaging showed HO. With continued physical therapy, the painful symptoms diminished and the patient established a physiological range of motion without limitations. Conversely, traction neurapraxia developed in only 5 patients (7.1%) with a 2-incision technique, including 4 patients (5.7%) with transient LACN injury and 1 (1.4%) who had a permanent sensory deficit of the SBRN, and there were no instances of rerupture, fracture, or other complications. When we compared the complication rates of the individual techniques, the single-incision technique (16.4%, n = 35) showed an over 2-fold higher rate of least 1 complication than the 2-incision technique (7.1%, n = 5) but failed to achieve statistical significance ($P = .0732$).

A total of 7 secondary reruptures (2.4%) occurred at an average of 33 days (range, 3-113 days) postoperatively because of rehabilitation noncompliance, of which 4 were complete and 3 were partial at the time of revision surgery. All patients underwent early successful revision repair, including 1 patient with tendo-Achilles allograft augmentation, and 6 of 7 patients (85.7%) returned to full preoperative upper extremity function without further reinjury or activity limitations at 3.2 years' follow-up. There were no statistically significant differences in rates of rerupture ($P = .20$) or other specific complication between surgical techniques.

Table 2. Adverse Outcomes After Primary Repair of Distal Biceps Ruptures

Outcome Variable	n (%)
Surgical failure (rerupture)	7 (2.4)
Clinical failure	3 (1)
Surgical or clinical failure	10 (3.4)

Table 3. Perioperative Complications and Rerupture by Surgical Technique

Complication	1-Incision Technique, n (%)	2-Incision Technique, n (%)	*P* Value
Nerve injury			
LACN	16 (7.5)	4 (5.7)	.7902
SBRN	6 (2.8)	1 (1.4)	>.99
Radial	2 (0.9)	0	>.99
MABCN	1 (0.5)	0	>.99
Median	3 (1.4)	0	>.99
PIN	2 (0.9)	0	>.99
Infection	2 (0.9)	0	>.99
Fracture	2 (0.9)	0	>.99
HO	1 (0.5)	0	>.99
≥1 complication	35 (16.1)	5 (7.1)	.0732
Rerupture	7 (3.3)	0	.1995
Total surgical procedures	214	70	

HO, symptomatic heterotopic ossification with loss of range of motion; LACN, lateral antebrachial cutaneous nerve; MABCN, medial antebrachial cutaneous nerve; PIN, posterior interosseous nerve; SBRN, superficial branch of radial nerve.

Risk Factor Analysis

Table 4 shows the multivariate analysis evaluating the association between several demographic characteristics and surgical variables and the rates of rerupture or cumulative failure. Although there was no statistically significant difference by age, limb dominance, time to surgery, single- versus double-incision technique, or fixation construct, tobacco use was found to be a strong independent risk factor for rerupture (OR, 4.86; 95% CI, 1.06-22.34; $P = .04$) and cumulative failure (OR, 5.64; 95% CI, 1.54-20.70; $P = .009$) after primary distal biceps repair.

Discussion

The principal findings of this study show that nearly 97% of patients returned to full preoperative activity without upper extremity restrictions after primary repair of traumatic distal biceps rupture at short-term to midterm follow-up and only 1 patient showed significant limitations with activities of daily living, namely resisted forearm supination. Furthermore, only 2.4% of patients sustained a rerupture after the index repair, and 13.8% of patients had 1 or more perioperative complications, with a trend toward an increased rate among single-incision repairs (16.4% vs 7.1%). Given its size and the rigors of its athletic patient population, this investigation may serve as a useful benchmark for preoperative patient counseling.

Regarding distal biceps repair, the debate over single- and 2-incision techniques has been longstanding. Given the high rates of morbidity with early 1-incision approaches,[9-11] Boyd and Anderson[12] initially developed their 2-incision technique to mitigate the risk of local neurovascular insult and facilitate more precise and anatomic repair of the distal biceps tendon. However, in response to the significant prevalence of HO and radioulnar synostosis from aggressive handling of the interosseous membrane, modifications of the original 2-incision technique were subsequently introduced to diminish these complications through use of a muscle-splitting approach.[13,14] Similarly, advancements in the

Table 4. Risk Factors for Surgical Failure (Rerupture) and Combined Surgical and Clinical Failures After Primary Distal Biceps Repair

Risk Factor	Surgical Failure (Rerupture)			Surgical or Clinical Failure		
	OR	95% CI for OR	*P* Value	OR	95% CI for OR	*P* Value
Age	0.99	0.89-1.09	.7727	0.97	0.89-1.06	.4988
20-29 yr	Referent	—	—	Referent	—	—
30-39 yr	2.78	0.14-55.21	.4549	1.11	0.17-7.20	.5956
40-49 yr	1.92	0.09-39.59	.8707	0.8	0.12-5.43	.956
50-61 yr	1.64	0.03-92.64	.9664	0.53	0.02-14.63	.6916
Branch of service						
Army	8.6	0.48-155.70	.1455	3.64	0.63-21.09	.1499
Air Force	1.59	0.03-84.66	.8182	0.52	0.02-13.57	.697
Marines	1.99	0.04-106.40	.7355	0.65	0.03-17.08	.798
Navy	Referent	—	—	Referent	—	—
Coast Guard	16.12	0.22-1,001.00	.2053	5.29	0.14-203.77	.371
Tobacco use	4.86	1.06-22.34	.0423	5.64	1.54-20.70	.0091
Hand dominance: yes vs no	1.12	0.13-9.60	.9211	1.71	0.35-8.49	.5089
Injured side: left vs right	0.34	0.07-1.78	.2016	0.36	0.09-1.42	.1457
Type of fixation						
Anchors	1.98	0.21-19.18	.5542	1.98	0.21-19.19	.554
Cortical buttons	0.18	0.02-1.42	.1035	0.34	0.05-2.36	.2773
Bone tunnels	0.37	0.03-4.18	.4239	0.37	0.03-4.19	.4241
Button and IF screw	Referent	—	—	Referent	—	—
Time from injury to surgery	0.95	0.87-1.05	.308	0.97	0.92-1.03	.3639
No. of incisions: 2 vs 1	0.19	0.01-3.43	.2606	0.13	0.01-2.35	.1692

CI, confidence interval; IF, interference; OR, odds ratio.

single-incision technique have been proposed, particularly those using newer fixation constructs and minimally invasive surgical approaches,[15-18] with reproducible clinical results in small existing clinical series.[19,20] Contemporary cortical button use has shown greater ease of use and biomechanical superiority over suture anchors, transosseous sutures, and interference screw fixation alone.[21-23]

Yet, despite the current controversy over which technique is superior, few large-scale studies[24] or prospective randomized controlled trials[25] have evaluated the comparative clinical and functional outcomes between 1- and 2-incision techniques. In a 2008 systematic review, Chavan et al.[23] showed no statistically significant differences in the incidence of complications with single-incision (18%) and 2-incision (16%) techniques, although they noted that there was a significantly greater prevalence of loss of forearm rotation and a nearly 8-fold higher rate of unsatisfactory clinical outcomes with a 2-incision technique. Conversely, Beks et al.[24] evaluated 373 patients treated at 3 selected hospitals, documenting a 22% adverse event rate with 5.3% identified as major complications (e.g., symptomatic HO, rerupture, deep-space infection, or motor nerve deficits). After multivariate analysis, they found that a single anterior incision had an over 2 times higher rate of the occurrence of a perioperative complication than a combined, 2-incision technique. In a prospective randomized clinical trial, Grewal et al.[25] showed no significant differences in the American Shoulder and Elbow Surgeons function score or Disabilities of the Arm, Shoulder and Hand score between the techniques among 44 patients at final 24-month follow-up. However, they did note a significantly higher preponderance of transient neurapraxia (40.4% vs 7.0%) in the single-incision group, most commonly involving the LACN, whereas the 2-incision technique showed significantly higher (10%) final isometric flexion strength.

Within the context of an athletic military population, our study indicates no significantly higher rates of overall complications among 214 patients with a single-incision versus 2-incision technique (16.4% vs 7.1%, $P = .073$). Furthermore, LACN neurapraxia accounted for most of the complications with both single-incision (7.5%) and 2-incision (5.7%) techniques. Despite an overall 13.8% complication rate, the functional repercussions of these largely transient, short-term neurologic complications must also be questioned, particularly when rates of perioperative complications can approach 40%.[1,25-27] The presence of complications (13.8%) did not correlate with final clinical outcomes within this patient subset, as nearly 97% returned to full preoperative function without revision surgery. Only 1 patient had persistent sensory deficits of the SBRN from the 2-incision technique, and only 2 patients with fall-related fractures of the proximal radius required extended observation until osseous healing. This risk profile reflects the relative safety of this procedure, although care should be exercised with retractor placement, manipulation of soft tissues, and transosseous drilling to limit the risk of iatrogenic neurovascular injury.

According to existing series,[24,28] rerupture after primary distal biceps repair may occur variably depending on patient characteristics, level of activity, chronicity of injury, tissue quality, method of fixation, and compliance with rehabilitation. However, these rates remain relatively low, with rates generally reported between 0% and 3.7%.[1,24,29] In our series 7 patients (2.4%) sustained short-term rerupture, including 3 partial and 4 total reruptures, because of noncompliance with early rehabilitation. All patients underwent secondary revision, and 6 of 7 patients (85.7%) returned to their prior level of activity, including 1 patient with distal biceps reconstruction with tendo-Achilles allograft.

Consistent with the only known prior series,[1] tobacco use was the only factor significantly associated with surgical failure by rerupture (n = 7, 2.4%) or clinical failure due to persistent deficits (n = 3, 1.0%), with an approximately 5-fold higher risk of major adverse patient outcomes (OR of 4.86 for rerupture, $P = .042$, and OR of 5.64 for combined failure, $P = .009$). This may be attributable to compromised early neovascularization and tissue remodeling associated with nicotine use, as has commonly been described with rotator cuff or other tendon injuries.[8,30,31] In interesting finding was that injury chronicity (i.e., time to surgery), fixation construct, laterality, and surgical approach were not significantly associated with rates of rerupture or unsatisfactory clinical outcomes. This contrasts with the work of Kelly et al.,[9] who showed higher rates of complications and residual pain with delayed (i.e., >21 days) versus acute (i.e., <10 days) repair. However, there were no distinct trends in terms of reruptures, as seen in our study when time from injury to surgery was examined as a continuous variable (OR, 0.95; $P = .308$). On the other hand, the 2-incision surgical technique had a lower rate of rerupture (0% vs 3.3%, $P = .26$), although this failed to achieve statistical significance (Table 3).

Limitations

The limitations of this study are those inherent to any retrospective study. Surgical technique—either 1 or 2 incisions—and postoperative rehabilitation were not standardized, which may introduce confounding. Similarly, surgeon experience, clinical volume, and/or subspecialty training were not recorded, thus contributing to performance bias. However, this may also reflect the clinical outcomes within a broader, pluralized surgeon sample caring for active patients or

competitive athletes. Of additional importance, our investigation relies on clinical variables documented in the electronic medical record from orthopaedic, physical therapy, and primary care providers, which may introduce recording bias. Immediate postoperative images were typically obtained at between 6 and 12 weeks but not at more prolonged follow-up periods unless persistent pain, limitations in range of motion, or other functional impairments developed. In these circumstances, repeat imaging was obtained and the radiographs or certified radiology reports were evaluated. Under this framework, only patients with symptomatic HO would be identified, which may under-represent its true incidence. This study did not feature validated patient-reported outcome measures or physical fitness performance testing scores. In addition, assessments of flexion-extension or pronation-supination arcs of motion, strength measurements, and radiographic studies for pertinent data (e.g., presence of HO) were inconsistently available, so this may serve to underestimate more subtle complications related to range of motion or side-to-side strength deficits. Lastly, even with one of the largest patient series, the potential for statistical underpowering remains for certain variables because a power analysis was not performed. Moreover, 8.7% of patients were lost to follow-up without sufficient documentation, thus contributing to potential nonresponder bias.

Conclusions

Among active patients, a single−volar incision technique and a 2-incision technique showed similar complication profiles. Rerupture and persistent elbow dysfunction were uncommon, but adverse outcomes were significantly more likely among patients who used tobacco. Anatomic distal biceps repair is a safe surgical procedure with excellent clinical outcomes and a 96.6% rate of return to preoperative military function without restrictions.

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