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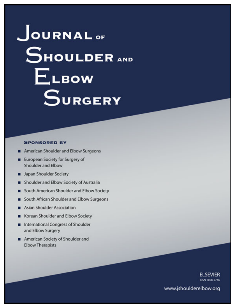

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Effect of Time from Injury to Surgery on Surgical Technique and Complication Rate in Distal Biceps Tendon Repair

Short Running Title: Distal Biceps Timing

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Structured Abstract

Background: Surgical treatment options for distal biceps tendon ruptures vary based on time from injury to surgery. While direct repair (DR) is preferred for acute injuries, high flexion angle repair (HFA) and allograft reconstruction (AR) are alternatives for chronic cases. This study examines the relationship between time to surgery, surgical technique selection, and complication rates.

Methods: A retrospective chart review was conducted on patients treated surgically for distal biceps tendon ruptures at a single center from January 2012 to June 2023. Cases were identified through electronic medical records and included patients ≥18 years with unilateral ruptures. Demographics, time to surgery, surgical techniques (DR, HFA, AR), and complications were recorded. Descriptive statistics and multinomial logistic regression were used to assess the association between time to surgery and surgical technique.

Results: A total of 373 patients were included, with 90% undergoing DR (n=334), 6% HFA (n=22), and 5% AR (n=17). The mean (standard deviation) time from injury to surgery was 16 (±30) days for DR, 82 (±162) days for HFA, and 274 (±455) days for AR. Surgical technique selection was significantly associated with time to surgery (Kruskal Wallis $p<0.001$), with DR favored in acute cases and HFA/AR in chronic presentations. The inflection point for equal probabilities of DR, HFA, and AR occurred at 25-27 weeks post-injury. The overall complication rate was 12% (n=45), with nerve injuries being the most common (7%, n=25).

Conclusion: Timing significantly impacts surgical technique selection in distal biceps tendon ruptures. DR remains the standard for acute injuries, while HFA and AR are viable options for chronic cases. The multinomial probability graphic (Figure 2) can be used to educate and council patients on surgical decision making for chronic distal biceps ruptures.

Level of Evidence: Level III; Retrospective Cohort Comparison; Prognosis Study

Keywords: distal biceps tendon rupture, direct repair, high flexion angle repair, allograft reconstruction, chronic injuries, surgical timing, complication rates, upper extremity surgery.

Distal biceps tendon ruptures occur at a rate of 2.55 per 100,000 patients and can incur functional deficits for activities of daily living.[17,18] Timely diagnosis and treatment of distal biceps tendon ruptures are important as missed injuries can lead to decreased strength in flexion and supination as well as decreased resistance to fatigue of the biceps muscle.[19] Surgery is typically recommended to allow patients to regain full function, although lower demand patients may choose to proceed with non-surgical treatment.[1,11,13]

Delayed diagnosis and increased time from injury to surgery present a challenge for treating surgeons. A distal biceps tendon rupture is considered "chronic" if greater than four weeks from the time of injury, although definitions vary from two to six weeks in the literature.[6,19,20] Chronic injuries may result from a missed diagnosis or the failure of conservative treatment.[10] Missed or delayed diagnosis can lead to shortening of the muscle-tendon unit and scarring of the surrounding tissue. This makes latent surgical repair more technically demanding.[2,12] A delay as small as three weeks may lead to considerable retraction and scarring.[14] The timing of the surgical intervention is therefore crucial to a successful surgery and satisfactory clinical outcomes.

When a patient presents with an acute injury, a direct repair (DR) is usually possible. The distal biceps tendon is reattached directly to the radial tuberosity, its anatomical location, using suspensory or screw fixation (Figure 1A).[3] It provides satisfactory flexion and supination strength recovery, and no loss to the range of motion.[5] In some cases, chronic injuries may still be amenable to direct repair if the lacertus fibrosis is intact and has tethered the tendon end from significantly retracting.[9] However, when direct repair is not possible due to retraction or scarring, alternative surgical techniques such as a high flexion angle repair (HFA) or allograft reconstruction (AR) may be used.[8,15]

An HFA repair is defined as a direct repair that necessitates over 60 and up to 100 degrees of elbow flexion to reattach the native tendon to its anatomic location (Figure 1B).[4,13,15,17] This is performed when scarring or retraction limits initial tendon excursion, but the tendon quality is still adequate. Range of motion is gradually increased in the postoperative period using physiotherapy and stretching. Despite the initial flexed positioning, one retrospective case-control study demonstrated that HFA repairs have similar outcomes to DR in terms of range of motion, as well pain, strength, return to work and complications.[17] In some cases where the muscle tendon unit is unable to be mobilized from adhesions or scar tissue, or the quality of the tendon stump is poor, an allograft may be required (Figure 1C). Allograft reconstruction involves procuring a donor graft such as an achilles tendon.[6] Some authors advocate for the use of freely harvested autograft such as a palmaris longus or semitendinosus.[7] Allograft reconstruction is a useful option in chronic presentations with a significant delay from injury to treatment; however, the procedure is technically demanding, relies on graft availability and may produce inferior clinical outcomes and higher complication rates compared to DR.[7]

The surgical technique selected for distal biceps tendon repair typically depends on the time from injury to surgery, as well as the quality of the tissue. It is unclear which surgical technique supports the greatest clinical outcomes at each timepoint. This retrospective chart review was to performed to answer the following questions: (1) Is there a relationship between the time from injury to surgery and the type of repair technique selected? (2) What is the probability of employing a specific surgical technique at a given time point? (3) What is the complication rate for each technique?

Methods

A retrospective chart review was conducted using electronic medical records from a single center. Cases were identified from Accuro EMR (Version No. 2017.661.) with the search terms "biceps" and "distal biceps" on December 6th, 2023. All charts were then manually searched to identify patients who were treated surgically. Patients were included in the study if they were over 18 years of age, had a unilateral biceps rupture and were treated surgically between January 2012 and June 2023. Patients were excluded if they had a bilateral injury or had a previous injury to the same arm. All surgeries were performed by a group of surgeons at a single center, with similar practice patterns and indications for surgical management. All surgeons used a single incision technique and secured the tendon using an endobutton for direct repairs.

Demographic and clinical information were recorded in a password-protected Microsoft Excel sheet designed *a priori*. Clinical information included diagnostic assessment, imaging characteristics, date of injury, date of surgery, surgical technique, postoperative clinical assessment, and complications. Complications identified to be of interest *a priori* included: lateral antebrachial cutaneous nerve (LABCN) injury, superficial radial nerve (SRN) injury, posterior interosseus nerve (PIN) injury, ulnar nerve injury, re-rupture, superficial wound infection, deep infection, synostosis, heterotopic ossification, radius fracture, vascular injury, complex regional pain syndrome (CRPS), and compartment syndrome. This study was institutionally approved by the Conjoint Health Research Ethics Board (REB21-1851).

Statistical Analysis

Descriptive statistics including counts and percentages for categorical variables, and means/SD and quantiles for continuous variables, were used to summarize demographic data and complication rates. A Kruskal Wallis test was used to test for any difference among the three surgical techniques versus weeks from injury to surgery. A multinomial logistic regression model was fit in order to estimate the probabilities of each surgical technique versus weeks from injury to surgery, with the three probabilities constrained to sum to 1 at each time point. The model included a quadratic terms in weeks to allow for non-linearity. A cubic term was also tested, but found to be non-significant, so was removed from the final model. Analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA).

Results

A total of 373 participants were included. All were male. Demographic information is summarized in Table 1.

Time from Injury to Surgery and Technique Performed

Most participants underwent DR (90%, n=334), followed by HFA (6%, n=22) and AR (5%, n=17). There was a statistically significant association between time from injury to surgery and surgical technique performed (Kruskal Wallis $p<0.001$). The mean (standard deviation) number of days between injury and surgery was 16 (±30) for DR, 82 (±162) for HFA and 274 (±455) for AR. The multinomial model probabilities demonstrating this relationship between technique choice and time from injury are shown in Figure 2. For example, a patient presenting immediately post-injury has a 95% probability of undergoing a DR and respectively a 4% or 2% probability of undergoing HFA or AR. However, a patient presenting at 52 weeks post-injury has a 2% probability of undergoing DR, a 39% probability of undergoing an HFA and a 58% probability of undergoing AR. The inflection point occurs between 25-27 weeks post-injury, where a patient has a roughly equal probability of undergoing DR versus HFA versus AR.

Complication Rates

The overall complication rate was 12% (n=45). The most common complication was an isolated sensory nerve injury of LABCN or SRN (7%, n=25), followed by re-rupture (3%, n=12), and PIN palsy (2%, n=6). Nerve injuries by surgical technique are summarized in Table 2. There were no significant differences in re-rupture rates between groups (DR [3%, n=9] vs. HFA [5%, n=1] vs AR [12%, n=2], exact chi-square test p=0.125). The mean follow-up time was 108 days (±88 days).

Discussion

Distal biceps tendon ruptures present a significant challenge in orthopedic surgery due to their impact on crucial upper limb functions such as elbow flexion and forearm supination. The timely diagnosis and appropriate surgical intervention are essential to achieving optimal functional outcomes. Our findings reveal a clear association between the time elapsed from injury to surgery and the surgical technique employed. Direct repair was predominantly used for acute injuries, while high flexion angle repair and allograft reconstruction were utilized for chronic cases. Specifically, DR was performed within an average of 16 days from injury, while HFA and AR were more common with increasing delays, averaging 82 and 274 days, respectively.

Major complication rates (re-rupture and PIN palsy) were less than 3%, with cutaneous nerve injuries being the most frequently reported complication at 7%. There were no significant differences in complication rates between groups. This is supported by recent comparative studies suggest that tendon grafting provides similar failure rates, complication rates, reoperation rates, final range of motion, and patient-reported outcomes scores as those treated without a graft.[7,12] In the case of chronic injuries, scar tissue and adhesions may place the patient at higher risk of nerve injury despite meticulous dissection, although this was not identified in this study.[6]

Our results suggest that both HFA and AR are both reliable options available to surgeons for chronic distal biceps tendon ruptures, even in cases of delayed presentation beyond six months. This information may be used to help inform clinical discussions with patients and to aid in surgical preparation and decision making. For example, while discussing the various treatment options, surgeons may wish to reference the patient-oriented visual resource which is an adaption of Figure 2 (see Supplemental File 1). These results may also help inform the surgeon of when it is necessary to have an allograft available versus when there is a low likelihood of conversion to AR. For example, there is less than a 10% chance of requiring an AR if performing surgery twelve weeks or less from the date of injury. This is particularly relevant for centers which may incur a wasted cost if an allograft is ordered and not used.

While not addressed specifically in this study, it is also prudent to consider the evolving landscape of non-operative treatments. Modern conservative strategies and rehabilitation techniques continue to improve outcomes for those who opt against surgical intervention.

Furthermore, the question of “Which treatment strategy is the best option for patients, surgical versus non-surgical?” has been identified as a top 10 research priority in the United Kingdom by the British Elbow and Shoulder Society.[16] A recent systematic review and meta-analysis reported that although strength and endurance parameters were statistically significantly higher for surgical versus non-surgical treatment, which is consistent with historic data, there were no clinically important differences in any of the patient reported outcome measures used.[3,12] For the subgroup of patients who opt for non-surgical treatment initially but are dissatisfied with their results, this study may help to inform these patients of their delayed reconstruction options.

This study is not without its limitations. As a retrospective review, it is subject to potential inaccuracies in the recorded data. For instance, cutaneous nerve injuries may be underrepresented due to incomplete documentation, and the use of HFA might be similarly underreported if not explicitly noted in surgical records. Follow-up times varied among patients, with a mean follow-up time of approximately three months. At this center, patients who return to clinic with no concerns at the three-month time point are typically offered “prn follow-up”. We assume that patients with a complication will follow-up with their treating surgeon; however, it is possible they could have presented to another site and thus would have not been captured. Furthermore, two of the surgeons in this group routinely see follow-up visits beyond two weeks postop at an offsite location. These also would not have been captured in our search and may have artificially lowered the average follow-up. There were also several outliers which led to large standard deviations in our multinomial logistic regression data. Lastly, a power analysis was not conducted for this study, and the sample size is relatively small, therefore some comparisons that are not statistically different may be due to a lack of statistical power.

Future research should focus on large-scale clinical trials comparing surgical and non-surgical treatment options for both acute and chronic distal biceps tendon ruptures. Such studies are necessary to provide comprehensive insights into the functional outcomes and complication rates associated with each approach, thereby informing more evidence-based treatment strategies. In conclusion, while timely surgical intervention remains crucial, HFA offers a viable alternative to AR for chronic injuries. Addressing the limitations of retrospective studies and pursuing prospective clinical trials will enhance our understanding and management of distal biceps tendon ruptures.

Conclusion:

This study investigated the relationship between time from injury to surgery and the surgical technique selected for distal biceps tendon repair, as well as the associated complication rates. The findings demonstrate that direct repair was most commonly performed for acute injuries, whereas high flexion angle repair and allograft reconstruction were more frequently used in chronic cases. These results highlight the importance of timely diagnosis and may help inform patients of surgical treatment options when they present in a delayed fashion.

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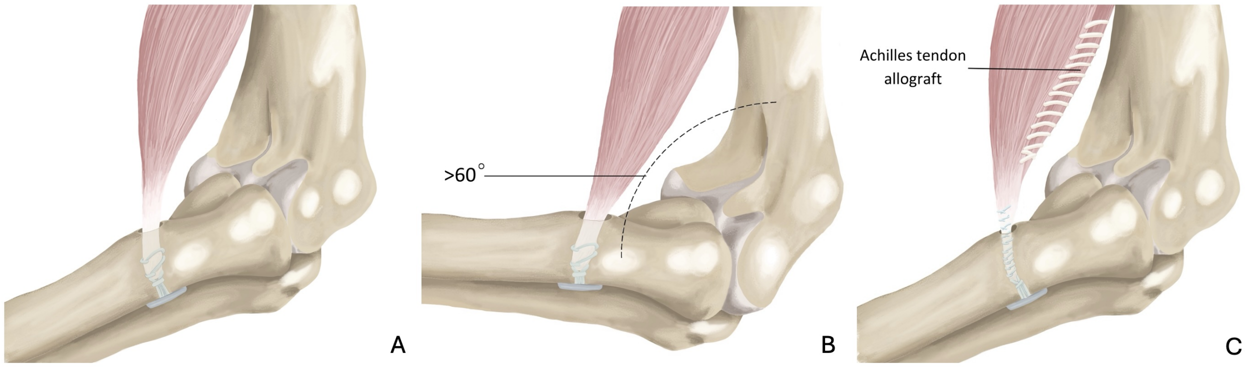
Figure 1A: Direct repair
Figure 1B: High flexion angle repair
Figure 1C: Allograft reconstruction
Figure 2: Probability of surgical technique based on time from injury to surgery

Table 1: Patient demographics
Table 2: Complication rates by surgical technique

		DR	HFA	AR	Total	%
Patients		334	22	17	373	100
Male		334	22	17	373	100
Handedness						
	Right	222 (66%)	13 (59%)	12 (71%)	247	66
	Left	27 (8%)	2 (9%)	2 (12%)	31	8
	Ambidextrous	3 (1%)	0	0	3	0
	Not Reported	82 (25%)	7 (32%)	3 (18%)	92	25
Mechanism						
	Work	64 (19%)	4 (18%)	1 (6%)	69	18
	Sport	90 (27%)	6 (27%)	7 (41%)	103	28
	Trauma	26 (8%)	2 (9%)	0	28	8
	Other	154 (46%)	10 (45%)	9 (53%)	173	46
Smoker		28 (8%)	4 (18%)	3 (18%)	35	9
Steroid Use		5 (1%)	2 (9%)	0	7	2
Imaging Confirmed Rupture					256	69
	US	209 (63%)	14 (64%)	12 (71%)	235	92
	MRI	15 (5%)	3 (14%)	3 (18%)	21	8

Nerve Injury	DR (n=334)	HFA (n=22)	AR (n=17)	p-value*
LABCN	15	0	2	0.184
SRN	6	1	0	0.541
PIN	5	1	0	0.487

* Fisher's exact test



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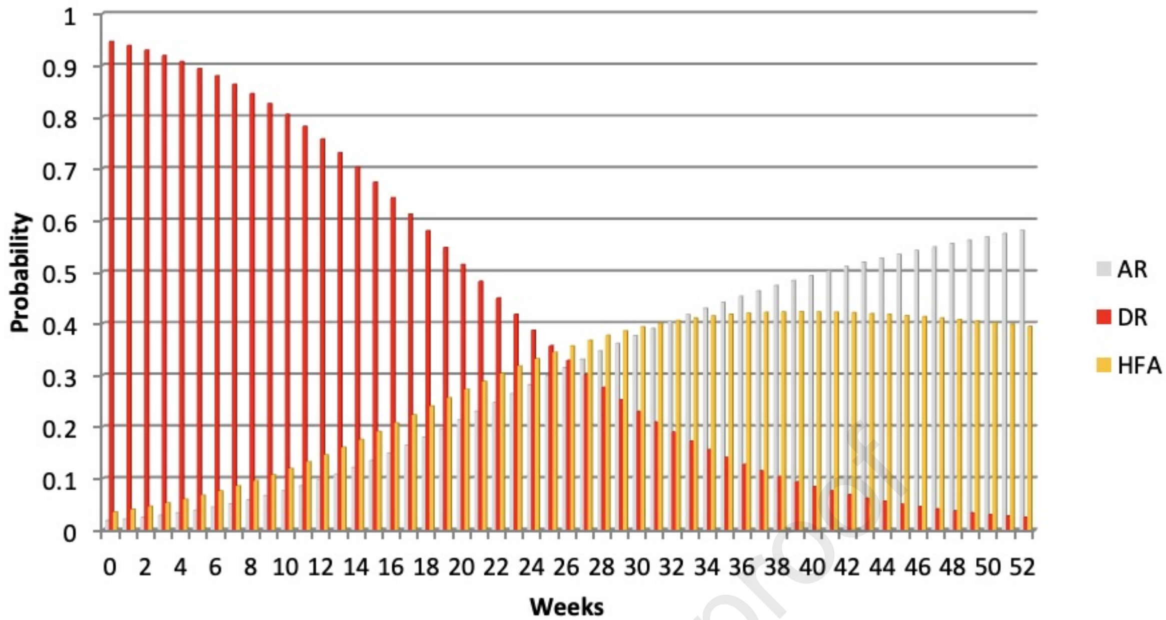
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