Repair Techniques for Acute Distal Biceps Tendon Ruptures
A Systematic Review

Jonathan N. Watson, MD, Vincent M. Moretti, MD, Leslie Schwindel, MD, and Mark R. Hutchinson, MD

Background: There is a lack of consensus regarding the optimal surgical approach and fixation method for distal biceps tendon ruptures. The purpose of this study was to conduct a systematic review comparing the results of the various surgical approaches and repair techniques for acute distal biceps tendon ruptures.

Methods: We searched the MEDLINE, Cochrane, and Embase databases for all published randomized controlled trials, prospective cohort studies, or case series that involved primary repairs of acute distal biceps tendon ruptures with use of a cortical button, intrasosseous screws, suture anchors, or bone tunnels for fixation. Exclusion criteria included case reports, cadaveric studies, repairs of partial ruptures, revision repairs, and multiple methods of fixation in the same patient. Statistical analysis was performed with use of the chi-square test.

Results: Twenty-two studies met the inclusion criteria. The total number of patients was 494 (498 elbows). The complication rate was 24.5% (122 of 498 elbows) overall, and it was 23.9% (seventy-eight of 327) for one-incision procedures and 25.7% (forty-four of 171) for two-incision procedures (p = 0.32). The complication rate was 26.4% (seventy-five of 284) for suture anchors, 20.4% (thirty-four of 167) for bone tunnels, 44.8% (thirteen of twenty-nine) for intrasosseous screws, and 0% (zero of eighteen) for cortical button fixation. The complication rate for use of bone tunnels was significantly lower than that for intrasosseous screws (p < 0.01). Similarly, the cortical button method proved superior to intrasosseous screws (p = 0.01). The most common complication was lateral antecubital cutaneous nerve neurapraxia (9.6% across all studies, 11.6% for one incision, and 5.8% for two incisions).

Conclusions: The complication rate did not differ significantly between one and two-incision distal biceps repairs; however, the bone tunnel and cortical button methods had significantly lower complication rates compared with suture anchors and intrasosseous screws. Further studies are needed to determine the optimal number of incisions.

Level of Evidence: Therapeutic Level IV. See Instructions for Authors for a complete description of levels of evidence.

Disclosure: None of the authors received payments or services, either directly or indirectly (i.e., via his or her institution), from a third party in support of any aspect of this work. None of the authors, or their institution(s), have had any financial relationship, in the thirty-six months prior to submission of this work, with any entity in the biomedical arena that could be perceived to influence or have the potential to influence what is written in this work. Also, no author has had any other relationships, or has engaged in any other activities, that could be perceived to influence or have the potential to influence what is written in this work. The complete Disclosures of Potential Conflicts of Interest submitted by authors are always provided with the online version of the article.
Although there is a lack of randomized trials comparing distal biceps tendon surgical approaches and fixation methods, we conducted a systematic review of the current literature on repair of acute ruptures in order to compare and contrast the complication rates associated with the various fixation methods and with the one and two-incision surgical approaches. Our hypothesis was that complications and outcome measures would not differ significantly among the fixation methods or incision techniques.

**Materials and Methods**

We performed searches of the MEDLINE, Cochrane, and Embase databases for “distal biceps tendon rupture” and for “distal biceps tendon repair” to identify all relevant published articles. The search was limited to English-language articles and was performed by the principal investigator (J.W.) and reviewed by the coinvestigators. The abstracts were then reviewed by the coinvestigators to identify articles involving the outcomes of repair of acute distal biceps tendon ruptures. The full text of those articles was then obtained and reviewed by the authors.

Inclusion criteria were established before data collection. Randomized controlled trials, prospective and retrospective cohort studies, and case series involving primary repair of acute ruptures with use of a cortical button, suture anchors, intraosseous screws, or bone tunnels for fixation were eligible for inclusion. Case reports and articles that included partial ruptures, revision repairs, or combined treatments on the same patient were excluded.

All data extraction was performed by the same author. Tabulated information included the year of publication, fixation method, number of patients, mean time between injury and surgery, mean patient age, mean duration of follow-up, sex distribution, and proportion of injuries involving the dominant extremity. Complications and outcome measures were also tabulated. The outcomes reported in one or more of the original articles were the DASH (Disabilities of the Arm, Shoulder and Hand), ASES (American Shoulder and Elbow Surgeons), PREE (Patient-Rated Elbow Evaluation), MEPS (Mayo Elbow Performance Score), modified Neer, EFA (Elbow Functional Assessment), and Andrews-Carson scores.

The complication rate was compared between one and two-incision techniques and among fixation methods with use of the chi-square test and one-tailed z test. A p value of <0.05 was considered significant.

**Results**

The MEDLINE searches with use of “distal biceps tendon rupture” and “distal biceps tendon repair” resulted in the identification of 226 and 186 abstracts, respectively. The corresponding Embase searches identified thirty-six and twenty-two abstracts, respectively, and both Cochrane database searches identified three abstracts. After elimination of duplicates, 281 abstracts were available for review. After articles that did not meet the previously stated criteria were excluded, twenty-two studies with a total of 494 patients (498 elbows) were included in the analysis (Fig. 1). The level of evidence was I for one randomized controlled trial, III for six retrospective cohort studies, and IV for fourteen retrospective case series (see Appendix). Four studies involved both one and two-incision techniques, fourteen involved only one incision, and four involved only two incisions. Eight studies involved only suture anchors, six involved only bone tunnels, three involved suture anchors and bone tunnels, one involved only intraosseous screws, three involved only cortical button fixation, and one involved screw fixation, suture anchors, and bone tunnels. The mean age of the 494 patients was 43.9 years, and thirty (6%) were female. Sixteen of the twenty-two studies reported the proportion of injuries that involved the dominant extremity; the overall proportion was 66.3% (240 of 362) in those studies.

The complication rate was 24.5% (122 of 498 elbows, with one elbow having two complications) overall, and it was 23.9% (seventy-eight of 327) for the one-incision technique and 25.7% (forty-four of 171) for the two-incision technique (p = 0.32). The complication rate was 26.4% (seventy-five of 284) for suture anchors, 20.4% (thirty-four of 167) for bone tunnels, 44.8% (thirteen of twenty-nine) for intraosseous screws, and 0% (zero of eighteen) for cortical button fixation (p = 0.03). Lateral antebrachial cutaneous nerve neurapraxia was the most common complication overall (9.6%) and for both the one-incision (11.6%) and two-incision (5.8%) techniques (p = 0.02). The rate of heterotopic ossification was 4.4% (twenty-two of 498) overall, and it was 3.1% (ten of 327) for one incision and 7.0% (twelve of 171) for two incisions (p = 0.06). Complications included stiffness in 3.2% (sixteen of 498) overall, and it was 1.8% (six of 327) for one incision and 5.7% (ten of 171) for two incisions (p = 0.01). The rerupture rate was 1.6% (eight of 498) overall, and it was 1.8% (six of 327) for one incision and 1.2% (two of 171) for two incisions. Infection occurred in 0.8% of the elbows (four of 498); the rate was 1.2% (four of 327) for one incision and 0% for two incisions. Synostosis occurred in 0.8% of elbows (four of 498); the rate was 0% for one incision and 2.3% (four of 171) for two incisions (Table I).

With the exception of the DASH, the instruments used in the original articles to determine functional outcomes were not homogeneous (i.e., ASES, PREE, MEPS, modified Neer, EFA, and Andrews-Carson) or no outcome score was reported; thus, statistical analysis to identify significant differences associated with outcome scores was not performed (see Appendix).
Although the present study appeared to show a small difference in the complication rate between one incision (23.9%) and two incisions (25.7%), this difference was not significant ($p = 0.32$). We are also unable to conclude that one particular method is safer, although the bone tunnel and cortical button methods were significantly safer than the suture anchor and screw methods. The cortical button method appeared safer than the other methods, but the sample size lacked the statistical power necessary to make the claim that it was superior to the bone tunnel method. If we posit that all one-incision techniques are similar and that all two-incision techniques are similar, then we can say that use of two incisions is significantly superior to one incision in avoiding lateral

### TABLE I Summary of Complications *

<table>
<thead>
<tr>
<th>Study</th>
<th>Patients</th>
<th>Incisions</th>
<th>Fixation Method</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gupta, 2012⁶⁶</td>
<td>8 (9 elbows)</td>
<td>1</td>
<td>IM cortical button</td>
<td>None</td>
</tr>
<tr>
<td>Grewal, 2012⁷⁷</td>
<td>47</td>
<td>1</td>
<td>Suture anchors</td>
<td>19 LABC neurapraxia, 3 tendon rerupture, 2 long-term nerve deficit requiring reoperation, 1 HO, 1 superficial infection</td>
</tr>
<tr>
<td>Citak, 2011⁸⁸</td>
<td>15</td>
<td>1</td>
<td>Intraosseous screws</td>
<td>2 LABC neurapraxia, 2 delayed wound-healing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Bone tunnels</td>
<td>3 LABC neurapraxia, 1 tendon rerupture, 1 HO</td>
</tr>
<tr>
<td>Siebenlist, 2011⁹⁹</td>
<td>3</td>
<td>1</td>
<td>IM cortical button</td>
<td>None</td>
</tr>
<tr>
<td>Eardley, 2010¹⁰¹</td>
<td>14</td>
<td>1</td>
<td>Intraosseous screws</td>
<td>8 LABC neurapraxia, 1 long-term nerve deficit, 1 HO</td>
</tr>
<tr>
<td>Grégory, 2009¹⁰²</td>
<td>23 (25 elbows)</td>
<td>1</td>
<td>Suture anchors</td>
<td>1 PIN palsy, 2 HO, 1 median nerve palsy requiring surgery</td>
</tr>
<tr>
<td>Arbuthnot, 2009¹⁰³</td>
<td>6</td>
<td>1</td>
<td>Cortical button</td>
<td>None</td>
</tr>
<tr>
<td>Bisson, 2008¹⁰⁴</td>
<td>45</td>
<td>2</td>
<td>Suture anchors</td>
<td>5 LABC neurapraxia, 3 HO, 3 synostosis, 2 stiffness, 1 tendon rerupture, 1 AIN injury, 1 ulnar injury, 1 RSD</td>
</tr>
<tr>
<td>Johnson, 2008¹⁰⁵</td>
<td>12</td>
<td>1</td>
<td>Suture anchors</td>
<td>1 LABC neurapraxia, 1 HO</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>2</td>
<td>Bone tunnels</td>
<td>1 HO</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>Bone tunnels</td>
<td>1 median nerve neurapraxia, 1 PIN neurapraxia</td>
</tr>
<tr>
<td>Niemeyer, 2008¹⁰⁶</td>
<td>18</td>
<td>1</td>
<td>Bone tunnels</td>
<td>1 radial neurapraxia, 1 infected hematoma</td>
</tr>
<tr>
<td>John, 2007¹⁰⁷</td>
<td>53</td>
<td>1</td>
<td>Suture anchors</td>
<td>2 HO, 1 superficial radial neurapraxia</td>
</tr>
<tr>
<td>Chillemi, 2007¹⁰⁸</td>
<td>5</td>
<td>2</td>
<td>Suture anchors</td>
<td>2 PIN neurapraxia, 2 HO</td>
</tr>
<tr>
<td>Kamath, 2005¹⁰⁹</td>
<td>5</td>
<td>1</td>
<td>Suture anchors</td>
<td>1 superficial radial neurapraxia, 1 superficial infection requiring reoperation</td>
</tr>
<tr>
<td>McKee, 2005¹¹⁰</td>
<td>53</td>
<td>1</td>
<td>Suture anchors</td>
<td>2 LABC neurapraxia, 1 PIN neurapraxia, 1 superficial infection</td>
</tr>
<tr>
<td>El-Hawyary, 2003¹¹¹</td>
<td>9</td>
<td>1</td>
<td>Suture anchors</td>
<td>3 LABC neurapraxia, 1 HO, 1 postop stiffness</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>2</td>
<td>Bone tunnels</td>
<td>1 superficial radial neurapraxia</td>
</tr>
<tr>
<td>Karunakar, 1999¹¹²</td>
<td>20 (21 elbows)</td>
<td>2</td>
<td>Bone tunnels</td>
<td>1 flexion contracture, 4 decreased rotation, 3 HO, 1 LABC neurapraxia</td>
</tr>
<tr>
<td>Woods, 1999¹¹³</td>
<td>3</td>
<td>1</td>
<td>Suture anchors</td>
<td>none</td>
</tr>
<tr>
<td>Strauch, 1997¹¹⁴</td>
<td>3</td>
<td>1</td>
<td>Suture anchors</td>
<td>1 median neurapraxia</td>
</tr>
<tr>
<td>Davison, 1996¹¹⁵</td>
<td>8</td>
<td>2</td>
<td>Bone tunnels</td>
<td>1 synostosis, 3 decreased rotation</td>
</tr>
<tr>
<td>Louis, 1986¹¹⁶</td>
<td>8</td>
<td>1</td>
<td>Bone tunnels</td>
<td>1 HO, 1 decreased motion</td>
</tr>
<tr>
<td>Friedmann, 1963¹¹⁷</td>
<td>8</td>
<td>1</td>
<td>Bone tunnels</td>
<td>1 radial paresthesia, 2 lack of extension, 1 PIN palsy</td>
</tr>
</tbody>
</table>

*IM = intramedullary, LABC = lateral antebrachial cutaneous nerve, HO = heterotopic ossification, PIN = posterior interosseous nerve, AIN = anterior interosseous nerve, and RSD = reflex sympathetic dystrophy.

### Discussion

Although the present study appeared to show a small difference in the complication rate between one incision (23.9%) and two incisions (25.7%), this difference was not significant ($p = 0.32$). We are also unable to conclude that one particular method is safer, although the bone tunnel and cortical button methods were significantly safer than the suture anchor and screw methods. The cortical button method appeared safer than the other methods, but the sample size lacked the statistical power necessary to make the claim that it was superior to the bone tunnel method. If we posit that all one-incision techniques are similar and that all two-incision techniques are similar, then we can say that use of two incisions is significantly superior to one incision in avoiding lateral
antibrachial nerve neurapraxia, whereas use of two incisions is significantly superior in avoiding stiffness.

Since approximately 1961, there has been controversy regarding the use of a one or two-incision surgical approach for repair. The original one-incision technique developed by Dobbie resulted in a high rate of radial nerve injury, which resulted in permanent disability in two of the patients in that report. The two-incision technique was developed by Boyd and Anderson to decrease the complication rate seen with one-incision repairs. The three patients in their series had no nerve injuries and no heterotopic ossification or synostosis. In the first case series of distal biceps repairs, Friedmann reported that two patients had a neurapraxia and one had loss of elbow extension after use of the one-incision technique with bone tunnel fixation. In 1986, Louis et al. reported loss of elbow extension in one of eight patients treated with the one-incision technique with bone tunnel fixation and heterotopic ossification in another patient. Davison et al. reported similar results in 1996, with three patients having decreased forearm rotation and one developing a radioulnar synostosis, after use of a two-incision technique with bone tunnel fixation. In 1997, Strauch et al. reported one case of median nerve neurapraxia after use of a one-incision technique with suture anchors, and in 1999, Woods et al. reported no complications with use of the same technique, but both series had only three patients. Karunakar et al. reported one case of elbow flexion contracture, four of decreased forearm rotation, three of heterotopic ossification, and one of lateral antibrachial cutaneous nerve palsy after use of a two-incision bone tunnel technique. McKee et al. reviewed fifty-three patients treated with one incision and suture anchors and reported only two transient lateral antibrachial cutaneous nerve palsies and one posterior interosseous nerve palsy; all patients lost £5° of elbow motion compared with preoperatively, and DASH scores were comparable with those of healthy control subjects. In a similar study, Kamath et al. reviewed five patients who underwent one-incision distal biceps repair with suture anchors and reported only one transient superficial radial nerve palsy; all patients regained full elbow motion. John et al. retrospectively reviewed fifty-three patients who underwent one-incision repair with suture anchors and reported two cases of heterotopic ossification and one of transient radial nerve palsy. Forty-six of the patients had an excellent outcome, and the complication rate of 5.6% was relatively low compared with other reports; however, there was no control group with which the results could be compared. Balabaud et al. prospectively reviewed nine ruptures repaired with use of a one-incision approach and suture anchors or bone tunnels. Three patients developed heterotopic ossification, but no neurovascular injuries occurred. Cain et al. found no significant difference in complication rates between one and two-incision repairs, although their two-incision group was noticeably smaller than the one-incision group. Grewal et al. also compared one and two-incision groups and showed no significant difference in the overall complication rate; however, the one-incision group had more early transient lateral antibrachial cutaneous nerve neurapraxias. El-Hawary et al. compared one-incision repair with a modified two-incision repair and found significantly greater elbow flexion in the one-incision group. Isokinetic and isometric elbow flexion strength were also significantly greater in the one-incision group up to six months postoperatively, but the two groups equalized at one year. The complication rate was lower in the two-incision group; however, all patients were given heterotopic ossification prophylaxis (indomethacin for six weeks). In a cadaveric study, Hasan et al. compared the ability of one and two-incision techniques to achieve an anatomic repair; 73.4% of the virtual bone tunnels in the two-incision group but only 9.60% in the one-incision group were located within the anatomic footprint of the biceps insertion (as determined with a microscribe and computer modeling). However, only one fixation method was examined. Greenberg et al. performed a two-incision cortical button repair in fourteen patients. Postoperatively, supination and pronation were 100% and 98% of that of the nonoperative side, respectively; 97% of flexion strength and 82% of supination strength were recovered. There were three transient lateral antibrachial cutaneous nerve palsies and no cases of heterotopic ossification. On the basis of the studies noted above, it appears that two-incision techniques can replicate the biceps footprint more anatomically, with equal or lower complication rates, compared with one-incision techniques. However, as the number of patients who underwent two-incision repair was small, the studies were too underpowered to permit an accurate comparison between the two groups.

Similar to the debate regarding use of one or two incisions for repair, there is also controversy regarding the best method of fixation for distal biceps repair. In the initial series reported by Dobbie, the majority of repairs were performed with sutures, drill holes, or a combination of both. Boyd and Anderson also utilized bone tunnels in their initial description of the two-incision technique. In recent years, suture anchors, intraosseous interference screws, and cortical buttons have all been developed. However, there have been few studies directly comparing the complication rates among fixation methods. In a retrospective review, Cain et al. compared the complication rates among bone tunnels, suture anchors, and cortical button fixation. Neurapraxias were more common with cortical button fixation, and rerupture rates were greater with suture anchors. They found no significant difference in the overall complication rate among the fixation methods; however, their study was underpowered and some patients had a chronic rather than an acute rupture. These results were in contrast to those in the present study, which indicated bone tunnel and cortical button fixation to have lower complication rates compared with the other methods. Although the present study included only a small percentage of patients treated with intramedullary cortical buttons for fixation, no complications occurred in any of those patients.

The present study has several strengths. We performed an extensive review of the literature regarding complications associated with the various fixation methods and incision types, and we used strict inclusion and exclusion criteria, which led to the inclusion of 494 patients in our study.

The present study also has several limitations. First, the level of evidence of the available studies was generally low, with
only one Level-I study comparing incision techniques or fixation methods. It was also not possible to compare the functional outcomes of the various repair methods; either the outcome scores were not reported or the inconsistency in score reporting across all of the studies was too great. There were a limited number of comparative studies available, as the majority examined only one fixation method or incision type. Finally, few of the studies used cortical button fixation, resulting in a sample size that may have been inadequate for comparing complication rates between this and the other techniques.

Future studies should be directed at prospectively comparing complication rates between one and two-incision techniques and between fixation methods. Future studies could also prospectively compare fixation methods with respect to the biomechanical strength of the repair and the ability of the method to achieve an anatomic repair that restores the biceps footprint.

In conclusion, one and two-incision techniques for distal biceps tendon repair appear to be equally safe treatment options. Bone tunnels and intramedullary cortical buttons appeared to have the lowest complication rates, although further exploration into the outcomes of intramedullary cortical buttons is warranted.

Appendix

A Tables summarizing the characteristics of the included studies and the resulting functional outcomes are available with the online version of this article as a data supplement at jbjs.org.

References