Distal Biceps Repair Using Cortical Button Fixation

Paul M. Sethi, MD* and James E. Tibone, MD†

Abstract: Various techniques have been described to repair the distal biceps tendon. The optimal technique would incorporate a limited 1-incision technique with maximal strength and minimal gapping of the repair to allow early range of motion. We describe a modified use of a cortical button, the tension-slide technique, which allows for a transverse anterior incision and the ability to tension and dock the repair through the anterior incision. There is no need to predetermine the length of suture between the button and the biceps and elimination of the technical concern for the button flipping.

Key Words: distal biceps, tear, repair, cortical button, elbow

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Rupture of the distal biceps brachii tendon has received significant attention in the recent literature.[1] Conservative treatment has led to observed deficiencies in elbow supination, and to a lesser degree elbow flexion, providing the rationale for anatomic repair in the active patient with a distal biceps tendon rupture.[2,3]

The current controversies that surround distal biceps repair include a single versus dual incision, anatomic footprint restoration versus nonanatomic repair, and type of fixation and restrictions related to early range of motion.[4–6]

The distal biceps is a misunderstood tendon that inserts over a wide footprint. In fact, the biceps has a ribbonlike insertion that attaches on the ulnar side of the tuberosity over a 21 by 7-mm footprint, perhaps even narrower.[7–9] This anatomy is unlikely to be recreated by placing a tendon into a bone socket and tying over a bridge alone.

Bain et al revolutionized distal biceps repair with the initial description of repair using an endobutton, and the literature has supported the improved biomechanics of cortical button repair.[10,11] Using a 12-mm button, Bain et al[11] burred a cortical window in the radius and then passed and flipped the button percutaneously through the posterior forearm with excellent results in 12 patients. In the same study, the safe zone (to avoid the posterior interosseous nerve) was described, and radial divergence of more than 30 degrees was cautioned against. The fundamental problem with the existing cortical button technique is that the surgeon has to predetermine the length of suture between the button and the biceps, and this is often imperfect. When the current cortical button technique is performed flawlessly, the tendon will sit in the intramedullary canal of the bone, with an obligatory minimum 7 mm of suture bridging the tendon to the bone. Once this construct is cycled, if there is as little as 3 mm of additional displacement, the construct is separated by full 1 cm (Fig. 1). A diastasis between the bone and tendon could compromise the strength and subsequent healing of the tendon. Furthermore, this technique also hinges on flipping of the button without di culty and passing a beath pin without injuring the posterior interosseous nerve, which also can prove to be challenging (Figs. 2–4).

The tension-slide technique (TST) is a useful modification of existing techniques to repair distal biceps tendon ruptures. The theoretical advantages of the technique include a small 1-incision anterior approach, the ability to tension the repair from the anterior incision, and the utilization of the strength of cortical button fixation. There is no need to predetermine the length of suture between the button and the biceps and there is minimal concern about the button flipping. This technique restores the biceps anatomy to the ulnar side of the radial tuberosity and relies on bicortical fixation. This technique may eliminate the inherent flaws with the existing biceps repair using a cortical button.

Numerous clinical and biomechanical studies have reported on the approach, e cacy, strength, and gap formation of the di erent techniques, but none have comprehensively addressed all of the aforementioned issues.

We describe a distal biceps repair technique performed through a minimally invasive single anterior approach designed to restore the anatomic footprint, and to provide the optimal strength and biomechanical characteristics to allow immediate active range of motion.

REPAIR TECHNIQUE

The patient is placed supine on a standard operating room table. A tourniquet is applied, not regularly inflated. A 4-cm incision is made transversely approximately 4 cm distal to the elbow flexion crease (Fig. 5). The lateral antebrachial cutaneous nerve is identified and retracted laterally. (Fig. 6) The retracted distal end of the biceps tendon is identified, often preceded by a small

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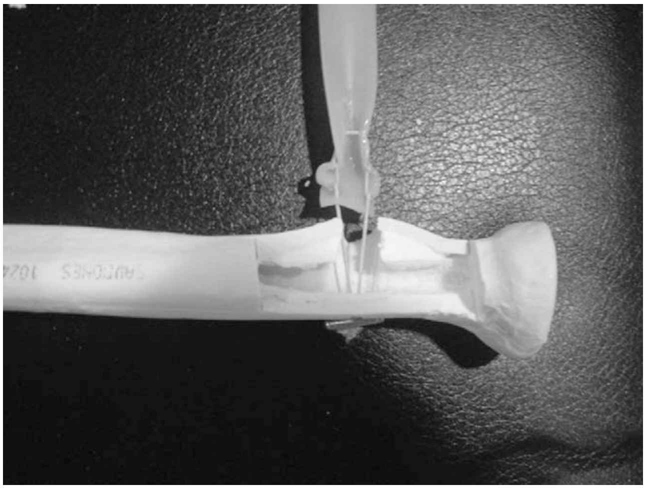

FIGURE 1. Cross sectional image of diastasis between biceps and radial tuberosity after cycling. This gapping can result in catastrophic failure of the cortical button construct if the tendon is not well seated in the bone.

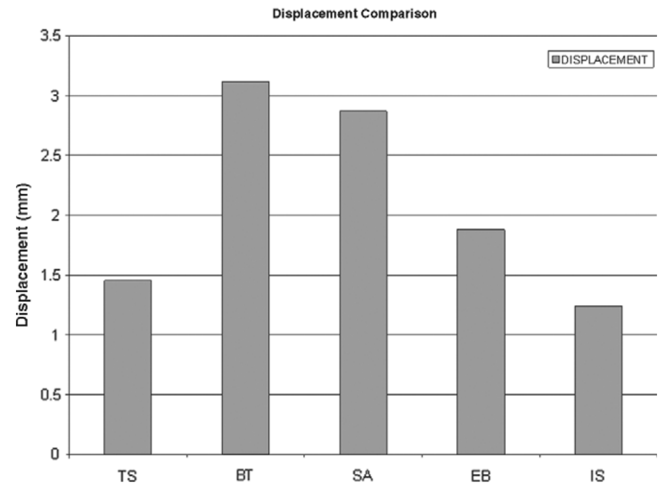

FIGURE 3. This graphic representation shows the amount of displacement after 3600 cycles at 50 N load. The TS and IS had the lowest gap formation. BT indicates bone tunnel; EB, endobutton with 2 fiberwire sutures; IS, interference screw; SA, 2 suture anchors; TS, tension slide with 1 fiberwire suture.

hematoma or seroma. The biceps tendon may be ‘‘milked’’ from the wound when not readily identified. The distal end of the biceps tendon is minimally debrided. One no. 2 polyester suture is used to secure the distal 2.5 cm of the biceps tendon in Krackow locking loop fashion (Fig. 7). Care should be taken to have even suture tails at the end of the repair.

The suture is then threaded through the button. The first strand is fed through the right hole and then back through the left hole. Then, the opposite is performed with the other tail of the same suture with the strand being fed through the left hole and then back through the right hole. The end result is to have the strands facing toward the distal biceps tendon. Approximately 4 to 5 cm of space between the button and the end of the biceps tendon should be available to allow for manipulating the button through the radial tuberosity.

With the elbow in full extension and full supination, the radial tuberosity is exposed and debrided of remaining tissue (Fig. 8). The suture is then threaded through the button. The first strand is fed through the right hole and then back through the left hole. Then, the opposite is performed with the other tail of the same suture with the strand being fed through the left hole and then back through the right hole. The end result is to have the strands facing toward the distal biceps tendon (Figs. 9 and 10).

A 3.2-mm guide pin is then drilled through the central aspect of the radial tuberosity from anterior to

FIGURE 2. Cross-section of the radius and distal biceps with a tension slide repair using 2 no. 2 sutures and a button. The biceps tendon is flush against the posterior cortex of the bone, with no suture diastasis.

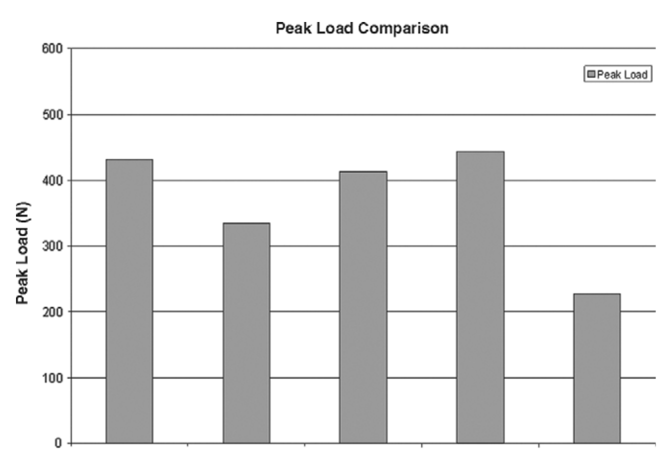

FIGURE 4. This graphic demonstrates peak load to failure for various repair techniques. EB and TS had the strongest repairs. BT indicates bone tunnel; EB, endobutton with 2 fiberwire sutures; IS, interference screw; SA, 2 suture anchors; TS, tension slide with 1 fiberwire suture.

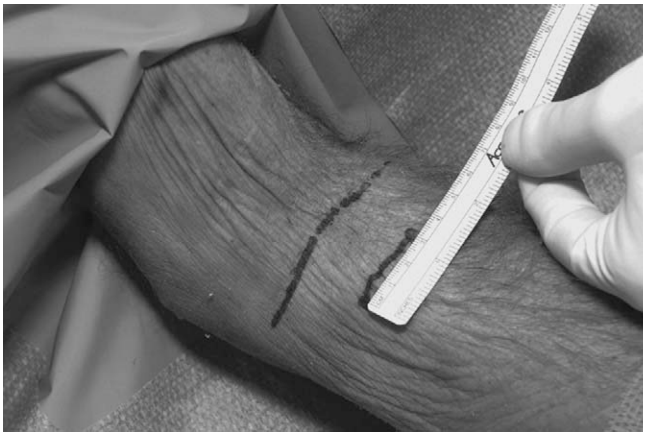

FIGURE 5. Transverse incision distal to antecubital fossa associated with repair, distal to marked flexion crease.

FIGURE 7. The distal end of the tendon is debrided and whipstiched.

posterior. Using an 8.0-mm cannulated reamer, the anterior cortex and intramedullary canal is then reamed to allow for flush seating of the end of the distal biceps tendon. Copious irrigation of the wound to remove bone dust and fragments is routinely performed at this point. A button inserter (or the blunt end of the guide pin), which holds the button, is then used to pass the retrobutton through the tuberosity, minimizing the risk of nerve injury. The button is released from the holder and a tactile release of the button is appreciated. Fluoroscopy may be used to visualize the button at the end of this step. The button is tested at this point by pulling back on the suture limbs.

One limb of each suture is then grasped in each hand and slowly tensioned. As this is performed, the biceps will dock itself in the prepared bone socket. It helps to flex the arm to 20 to 30 degrees so that the tendon slides into the bony socket (Fig. 11).

In a low demand patient, a free needle may then be used to pass 1 end of the no. 2 polyester sutures through the biceps tendon closest to the biceps tuberosity and tied.

In higher demand patients, a 7 by 10 mm interference screw is then inserted on the radial side, and the suture limbs are additionally tied over the screw. This screw is left flush with the anterior cortex (Fig. 12). The elbow should be taken through a full range of motion to ensure that the tendon is secure.

Caution must be taken for tears that are more than 4 weeks old or tears that have inelastic tendons when using this technique. To avoid suture breakage, it is important to pull the suture in line with the tendon (much like aligning a cannula with arthroscopic knots) and to avoid the suture dragging over the posterior cortex of the radius.

In situations where the construct does not slide easily, a "rescue suture" is applied. After the aforementioned

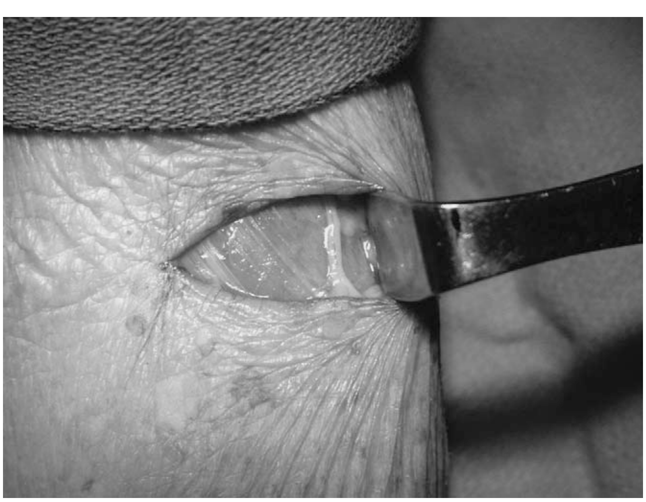

FIGURE 6. Identification of the lateral antebrachial cutaneous nerve.

FIGURE 8. The radial tuberosity is identified. Care taken not to overzealously retract the tissue. Subperiosteal placement of Hohmann decreases nerve injury; inadvertent placement of a retractor laterally risks injury to the PIN. The original biceps attachment is marked with ink. PIN indicates posterior interosseous nerve.

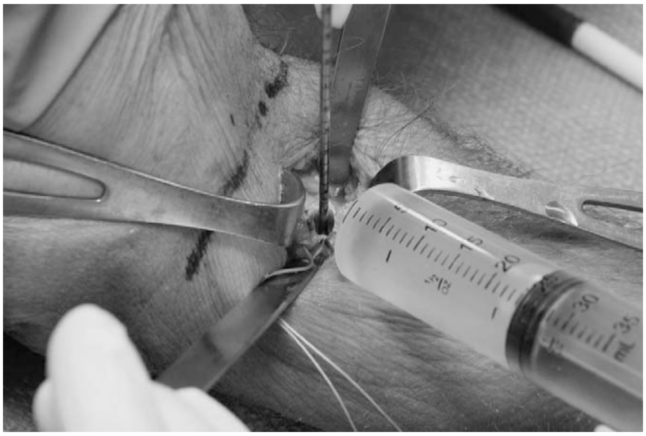

FIGURE 9. A bicortical guide pin is placed through the tuberosity, and then one 8-mm unicortical hole is created. Copious irrigation to remove all debris is important.

preparation, a single heavy suture is placed through the tendon. Care is taken to make sure that the suture slides. The rescue suture is then passed through the hole in the radial tuberosity with a Keith needle and pulled out percutaneously. The rescue suture can then be tensioned (in line with the biceps) to help guide the reduction. Once the construct is a xed, the rescue suture can be pulled out of the forearm and discarded.

The wound is closed and a soft dressing applied. The patient may be placed in a sling only for comfort.

We elected to use only 1 suture for the repair. Most studies have used 2 sutures, but the use of 1 suture simplifies this procedure. Furthermore, our data with this model did not show any yield strength or gap formation advantage with 2 no. 2 sutures as compared with 1 no. 2 suture.

FIGURE 10. The suture is then threaded through the button. The first strand is fed through the right hole and then back through the left hole. Then, the opposite is performed with the other tail of the same suture with the strand being fed through the left hole and then back through the right hole. The end result is to have the strands facing toward the distal biceps tendon.

FIGURE 11. One limb of each suture is then grasped in each hand and slowly tensioned. As this is performed, the biceps will dock itself in the prepared bone socket. It helps to flex the arm to 20 to 30 degrees so that the tendon slides into the bony socket.

The aforementioned technique is a variation of Bain et al's original description.[11] Bain et al described the same operative approach, but used a no. 5 suture and left a 2-mm gap between the end of the tendon and the endobutton. After burring a unicortical channel (and a bicortical hole to pass the button), he then manipulated the button through the bony aperture by pulling a lead suture percutaneously through the posterior forearm. Although we had success with this original procedure, we found di- culty in judging the exact right distance between tendon and bone, and found that the construct could significantly change after tension was pulled on it. This technique relies on Bain et al's innovation, but allows the surgeon to visualize the tendon docking in the bony socket.

DISCUSSION

Most authors agree that the distal biceps should be repaired in healthy active individuals.[1–3] The current

FIGURE 12. Repaired distal biceps, the interference screw is placed on radial side of the bone tunnel to recreate the ulnar sided attachment.

controversies that surround distal biceps repair include a single versus dual incision, anatomic footprint restoration versus nonanatomic repair, and type of fixation and restrictions related to early range of motion.

Advocates of a dual incision approach suggest than an extensive dissection is required to expose the radial tuberosity that has led to radial nerve complications.[4] The anterior transverse incision was used by Balabaud et al[12] and had no radial nerve complications nor radio-ulnar synostoses. Sixty-two patients were evaluated in a study by McKee et al[13] reviewing the results of a single anterior transverse incision approach. There were no cases of proximal radioulnar heterotopic ossification, synostosis, motion loss, tendon rerupture, or permanent nerve injury. Their conclusion was that this (anterior approach) is a safe technique.[12] It is also our experience that the single incision technique is safe. The addition of a button passer in our technique, which eliminates the need to pass a beath pin or needle through the forearm, further minimizes the risk of nerve injury. In contrast, the 2-incision technique can be associated with proximal radio-ulnar synostosis. This may be caused by injury to the interosseous membrane, in combination with bone debris and hematoma lying between radius and ulna and stimulation of the ulnar periosteum by the dorsal exposure.[4] Finally, dual incision proponents also believe that supination strength may be compromised because of nonanatomic position of the tendon repair, although biomechanical data has not confirmed this.[6]

The understanding of the distal biceps anatomy has also been recently elucidated. The distal biceps is not a cylindrical tendon that inserts over a wide footprint. It is a ribbonlike insertion that attaches on the ulnar side of the tuberosity over a 21 by 7 mm footprint. Although the clinical importance of recreating normal biceps anatomy is unclear, it stands to reason that accurate restoration of the intact biceps is desirable.[7,8] This anatomy is unlikely to be recreated by placing a tendon into a bone socket and tying over a bridge alone. As such, the placement of an interference screw in the tuberosity (on the radial side of the tendon) may be important to restore the preinjury anatomy, with particular respect to the ulnar position of the tendon. The screw further allows for proximal cortical fixation and the button completes bicortical fixation of the tendon, the long time goal for fracture fixation. Furthermore, interference screw fixation has been histologically linked with direct tendon to bone healing.[1] The supination moment of the biceps may be improved by accurate footprint recreation, although this requires further study.

Biomechanical studies evaluating the mean failure strength have been reported in the literature, and a few of these studies also examined cyclical loading and gap formation of the repairs.[5,7] Prior studies have suggested that cortical button fixation and suture anchor fixation both have high yield strengths, but that interference screw fixation had the lowest gap formation.[7,13,14] Mazzocca et al[7] compared 4 techniques of distal biceps repair. Using a biomechanical model, bone tunnel, endobutton, suture anchor, and interference screw techniques were compared. The endobutton technique had a statistically significant highest load to failure (440 N) as compared with suture anchor (381 N), bone tunnel (310 N), and the interference screw (232 N). The endobutton has had the highest load to failure in other studies as well.[9,15,16]

Biomechanical data on the tension slide (pending publication) suggest a very favorable performance. Our loads to failure were between 328.76 for a single fiberwire suture and button and 432.23 with the addition of an interference screw; all of these were associated with very low standard deviations. This is very consistent with our previous reported data; the combination of the button and screw allowed us to have excellent strength with only 1 suture and minimal gap formation. A single suture simplifies the procedure, leaves less foreign body in the native tendon, and, combined with the screw, virtually eliminates gap formation with cyclical loading.

Displacement after cyclical loading has important consequences in the setting of early postoperative range of motion and on healing. Standard techniques with cortical button fixation (ie, not using a tension slide) have reported 2.59 mm after only 1000 cycles.[17] Mazzocca et al[7] reported that the endobutton had the second highest displacement (3.42 mm) as compared with the bone tunnel (3.55 mm), suture anchor (2.33 mm), and interference screw (2.14 mm). Close to 30% of suture anchor repairs in this series failed during cyclical loading. A recent study comparing 2 di erent suture types fixed to a bone tunnel yield 6.8 to 6.9 mm of tendon displacement before failure, noting failure of bone tunnel fixed with fiberwire during cyclical loading.[5] All of these methods suggest that pistoning of the tendon occurs during early motion. This macromotion could certainly delay or inhibit direct tendon healing. These data also suggest that early motion with the suture anchor technique should be used with caution.

In our TST, gap formation between the biceps tendon and radial tuberosity is minimized. Gapping was measured between 1.25 and 1.63 mm after 3600 cycles; this result is superior to all other tested and reported studies that evaluated gap formation. The ability to tension the distal biceps tendon/button complex through the anterior incision and dock the tendon flush against the posterior aspect of the radial tuberosity is unique to this procedure and may play an important role in minimizing gap formation. By minimizing the gap formation and maintaining the highest load to failure, the TST seems to be an optimum procedure to repair a distal biceps tendon rupture. None of the specimens tested failed during cyclical loading o ering advantage over both suture anchor and bone tunnel fixation. This suggests that our repair is very durable under cyclical conditions, designed to mimic early postoperative range of motion.

The addition of the interference screw added to the ultimate tensile load, reduced the gap formation, and improved the sti ness of the construct in our study (pending publication). It may be argued that these increases were marginal, and the screw is not required.

However, our postoperative goal is immediate active range of motion. These marginal improvements may be beneficial for this purpose. Furthermore, interference screw fixation had been histologically linked with direct tendon to bone healing, which may allow for a more rapid return to sports.[7]

We have used this technique in clinical practice with excellent results. We place only a soft dressing at the time of surgery to allow immediate active range of motion, and allow the patient directed range of motion. We do restrict the patient from lifting anything more than 5 pounds before the first postoperative visit, typically 10 days after surgery. We have had no failures at the time of this report. This technique is very useful for the acute tear, and a wider exposure and alternate techniques may be more useful in tears >4 weeks old.

The TST is a useful modification of existing techniques to repair distal biceps tendon ruptures. The theoretical advantages of the technique include a small 1-incision anterior approach, the ability to tension the repair from the anterior incision, and the utilization of the strength of cortical button fixation. There is no need to predetermine the length of suture between the button and the biceps, and there is minimal concern about the button flipping. This, when combined with the superior biomechanical performance of the repair, has encouraged us to use this technique on acute distal biceps repairs. We have started all of our patients on immediate activity of daily livings and unrestricted range of motion with no brace or sling after surgery, without any clinical failures.

We present a technique that restores the biceps anatomy to the ulnar side of the radial tuberosity, takes advantage of superior biomechanics, relies on bicortical fixation, and allows immediate postoperative range of motion. Our early experience with this technique has yielded superior clinical results.

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