Technical Note

Tensionable Distal Biceps Tendon Repair With Intramedullary Knotless All-Suture Anchors and FiberLoop w/FiberTag Suture

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Abstract: Distal biceps tendon rupture is commonly repaired via bicortical drilling, extramedullary cortical button placement, and inlay tendon fixation. A retensionable technique with unicortical drilling, intramedullary knotless all-suture anchors placement, and onlay tendon fixation is presented, incorporating up-to-date advances in tendon-bone healing basic science, biceps tendon/radial tuberosity biomechanics, and knotless all-suture implant technology to facilitate radial tuberosity bone preservation, anatomic footprint restoration, improved suture-tendon connection security, and avoidance of drilling and implant-related injury to the posterior interosseous nerve.

Distal biceps tendon rupture typically occurs during elbow flexion against an excessive load. The injury significantly compromises forearm supination and flexion strength. Surgical treatment is typically indicated to restore elbow and forearm function.[1]

There is a lack of consensus on the optimal distal biceps tendon reattachment technique. Although bicortical drilling, extramedullary cortical button placement, tendon whipstitching, and inlay tendon placement (Distal BicepsButton; Arthrex)[2] have become popular since mid-2000s, recent in vivo and biomechanical investigations and advances in implant technology spotlight multiple opportunities to revamp the technique, to improve functional outcome and minimize complications.

This report describes a distal biceps tendon repair technique that improves radial tuberosity preservation and anatomic footprint reproduction through use of low-profile, all-suture anchors with intramedullary placement, reinforced tendon suturing, and onlay tendon fixation. With these features, the technique can potentially improve repair outcome and reduce complication risk.

Indications

Unless medically contraindicated, repair is indicated in patients with complete distal biceps tendon ruptures in order to restore forearm supination and elbow flexion strength.

Patient Evaluation and Imaging

Patients usually report a painful pop during forceful elbow flexion and forearm supination. Examination typically reveals a proximally retracted biceps muscle belly and absence of palpable distal biceps tendon in the antecubital fossa. Forearm supination strength is diminished, but elbow flexion may be less affected due to the compensatory actions of the brachioradialis and brachialis.

Radiographs are typically normal. Magnetic resonance imaging may be helpful to confirm the diagnosis or localize the retracted distal biceps tendon stump.

Surgical Technique

Patient Positioning and Setup

Place the patient supine, operative arm on a hand table, with a tourniquet proximally. Preoperative antibiotics and anesthesia are administered. Prep and drape the arm in standard fashion.

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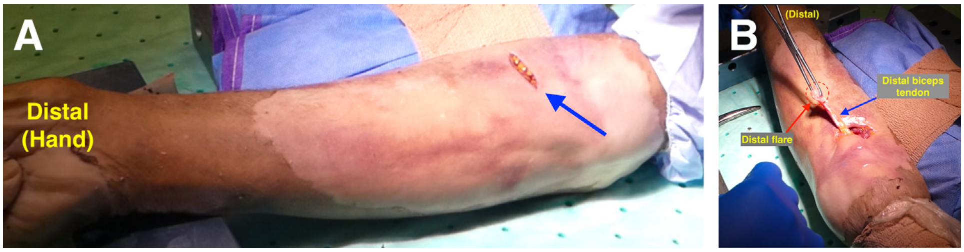

Fig 1. Right cadaver arm, volar surface facing up. (A) View from medial aspect toward the lateral aspect. Make a 3- to 4-cm transverse incision (blue arrow) in the proximal forearm, about 2 cm distal to the antecubital crease. (B) View from the proximal-medial aspect toward the distal aspect. Find the retracted distal biceps tendon proximal to the antecubital crease and deliver it out of the incision. Note the distal flare of the tendon: preserve it for later compressive fixation onto the radial tuberosity.

Initial Dissection

Make a 3- to 4-cm transverse volar incision, approximately 2 cm distal to the antecubital crease and centered over the radial tuberosity (Fig 1A). Bluntly dissect and follow the void left by the retracted biceps tendon through the interval between the brachioradialis and pronator teres, to the radial tuberosity.

Dissect proximally under the antecubital crease. Find the distal biceps tendon within the seroma/hematoma, bluntly dissect to improve mobilization, and deliver it out of the incision (Fig 1B). Debride and remove scar tissue, but preserve the distal tendon flare that corresponds to the elongated footprint on the radial tuberosity.

Placement of FiberLoop w/FiberTag in the Distal Tendon

The FiberLoop w/FiberTag suture (Arthrex) is a reinforced No. 2 loop suture (FiberLoop), with an incorporated straight needle and a 5-cm integrated tape suture (FiberTag) at the end (Fig 2 A and B).

Mark the tendon twice, at the junction of the distal flare and the cylindrical section, and 2.5 cm proximal to that (Fig 3A). Pass the FiberLoop w/FiberTag straight needle through the tendon at the distal mark, and pull all of the FiberLoop and half of the FiberTag through (Fig 3 B and C). Pass the needle back through the tendon at the proximal mark and through the end of the tape, locking the FiberTag in a distally based U shape (Fig 3 D and E). Next, pass the straight needle back through all 3 FiberTag/tendon/FiberTag structures in 1 pass, cinch the FiberLoop strands, and then flip the FiberLoop back over. Repeat the whipstitch process 4 to 5 more times, each time passing through all 3 tape/tendon/tape structures, from proximal to distal direction, then back proximally (Fig 3F-I). Once there are 5 to 6 well-cinched, overlapping whipstitches placed, tie the FiberLoop strands over the tendon (Fig 3J-M).

Placement of Knotless FiberTak All-Suture Anchors

Debride the radial tuberosity for healing enhancement (Fig 4 A and B). With the forearm maximally supinated, place the drill guide for the 2.6 Knotless FiberTak (Arthrex) as low (posterior) as possible on the proximal radial tuberosity, aim 45° distally, and drill unicortically into the canal (Fig 4C). Hold the guide securely, remove the drill, and tap the FiberTak into the canal. Alternatively, use a self-punching FiberTak for deeper insertion without the guide (Fig 4 D and E). Release the suture bundle and remove the inserter. Pull back to set the intramedullary FiberTak (Fig 4F). Place and set another 2.6 Knotless FiberTak at the distal aspect of the radial tuberosity, separated by 1 to 1.2 cm from the first anchor location.

Passage of FiberTak Repair Sutures Through FiberTag

With a free needle, pass the distal FiberTak repair suture through the distal flare of the biceps tendon from

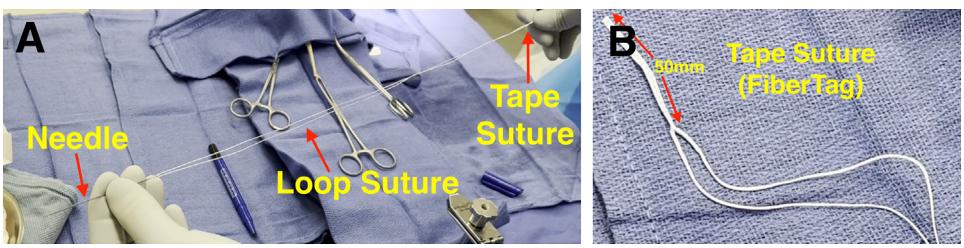

Fig 2. (A) The FiberLoop w/FiberTag suture (Arthrex) features a reinforced No. 2 loop suture, an incorporated straight needle, and an integrated 50-mm-long terminal tape suture. (B) Closeup view of the integrated 50-mm tape suture.

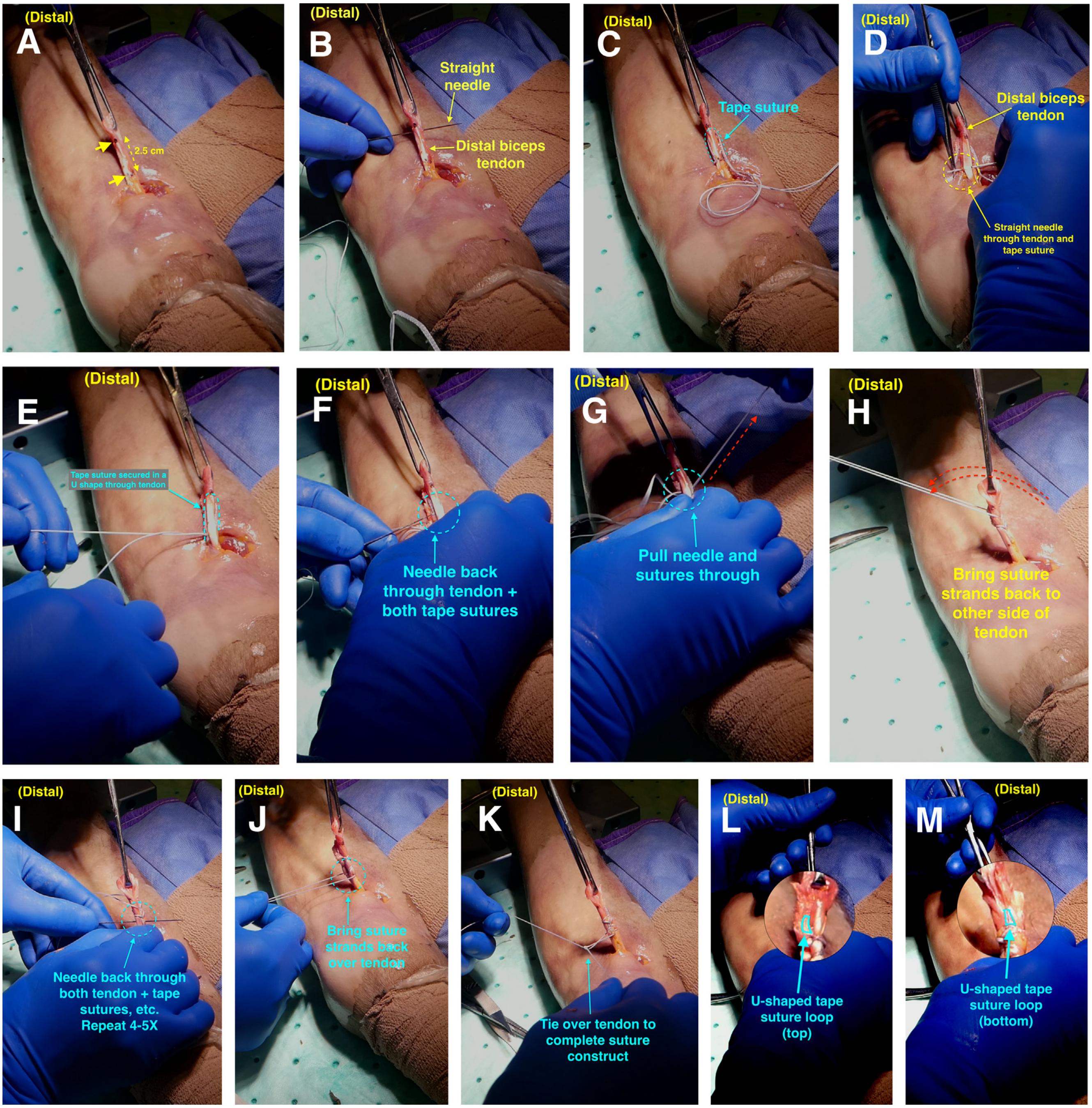

Fig 3. Right cadaver arm, volar surface facing up. View from the proximal aspect toward the distal aspect. (A) Mark the tendon twice (arrows), at the junction of the distal flare and the cylindrical section, and 2.5 cm proximal to that. (B) Pass the straight needle of the FiberLoop w/FiberTag (Arthrex) through the tendon at the distal mark. (C) Pull half (2.5 cm) of the tape suture (FiberTag) through, and bring the FiberTag up along both sides of the tendon (dotted line). (D) Pass the needle back through the tendon at the proximal mark and through the end of the FiberTag. (E) Pull the loop sutures through, locking the FiberTag in a distally based U shape. (F-I) Pass the straight needle back through all 3 tape/tendon/tape layers, then flip the loop of suture back over, and pass through again. Repeat the process 4 to 5 more times, each time passing through all 3 tape/tendon/tape layers, from proximal to distal direction, then back proximally. (J) Once there are 5 to 6 well-cinched, overlapping whipstitches placed, bring the suture strands back over the tendon. (K) Tie the sutures over the tendon to complete the suture construct. (L, M) Top and bottom views of the completed suture construct at the distal biceps tendon. The distally based U-shape FiberTag placement within the tendon allows the repair sutures of the FiberTaks to connect to the tendon and the suture construct, as well as secure the tendon in the subsequent steps.

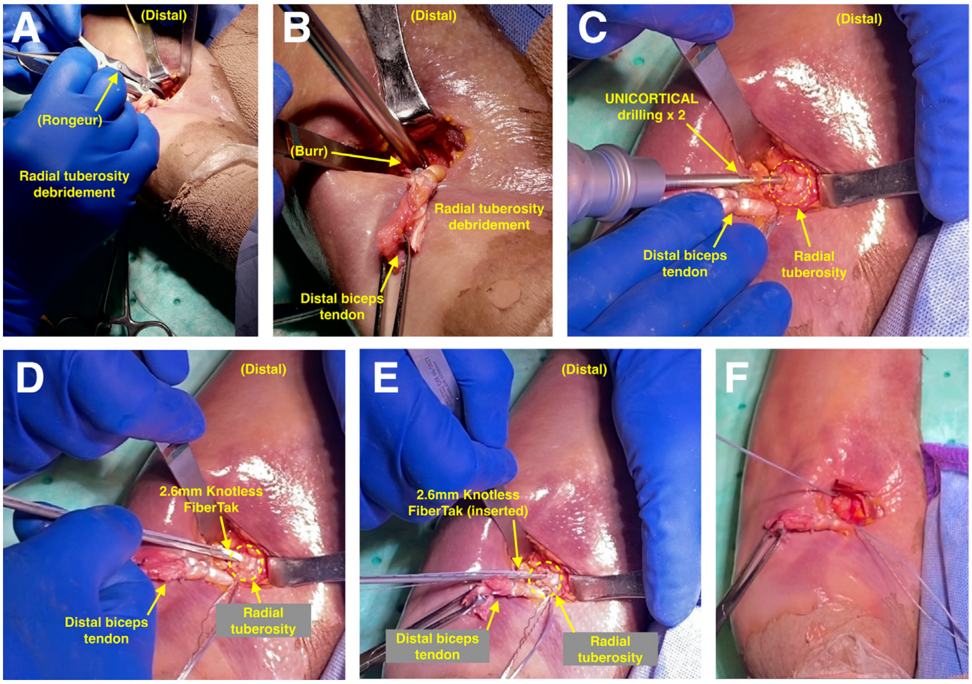

Fig 4. Right cadaver arm, volar surface facing up. View from the proximal aspect toward the distal aspect. (A) Radial tuberosity debridement with a rongeur. (B) Radial tuberosity debridement with a burr. (C) With the forearm maximally supinated and radial tuberosity exposed, drill in unicortical fashion the 2 tunnels for the 2.6-mm Knotless FiberTak all-suture anchors (Arthrex) at the proximal and the distal aspects of the radial tuberosity, spaced out by 1 to 1.2 cm, as low (posterior) on the radial tuberosity as possible yet still ending up within the medullary canal, and angle the drill distally by about 45° to increase the intramedullary excursion of the FiberTak anchors. (D, E) Place two 2.6-mm Knotless FiberTaks through the tunnels into the intramedullary canal, and pull back to set the all-suture anchors. (F) Appearance after placement of FiberTaks, with distal and proximal FiberTak suture bundles.

underside to the top surface (Fig 5A), then through the U-shaped FiberTag loop in the distal tendon, exiting on the posterior aspect of the tendon (Fig 5B). Pass the proximal FiberTak repair suture, in reverse fashion, through the FiberTag loop first, then through the distal flare from the top surface to the underside (Fig 5C).

Shuttle the repair suture from the distal FiberTak through the proximal FiberTak (Fig 5D) and the repair suture from the proximal FiberTak through the distal FiberTak, interlinking the 2 anchors (Fig 5E) and connecting the radial tuberosity to the distal biceps tendon.

Pull to tighten the repair sutures to reduce and compress the tendon and its distal flare longitudinally on the radial tuberosity, replicating the anatomic footprint (Fig 5 F and G).

Vigorously stress the repair, and retension the repair sutures as needed, to ensure maximal fixation security (Fig 5H).

The final repair construct is illustrated in a diagram (Fig 5I).

After incision closure and dressing application, the elbow is placed in a well-padded splint in 90° of flexion.

The technique is demonstrated in Video 1. Pearls/pitfalls are summarized in Table 1.

Rehabilitation

At the first postoperative visit 7 to 10 days later, remove the splint and place the elbow in a hinged brace with extension limited at 90°. Initiate a rehabilitation regimen consisting of serial extension advancement, progressive strengthening, and return to activities by 8 to 12 weeks postrepair.

Discussion

Although the single-incision, bicortical-drilling, extramedullary button, inlay technique has been the prevalent technique for distal biceps tendon repair since the mid-2000s, subsequent advances in implant technology and new insights into elbow biomechanics and tendon-bone healing continue to fuel a robust investigational effort for improvement.

Our technique incorporates the following evidence-based features:

1. Onlay Fixation

In an in vivo study of biceps tenodesis,[3] healing occurs at the tendon-cortex interface, not in the medullary canal, in both onlay and inlay techniques, questioning the necessity of nonanatomic

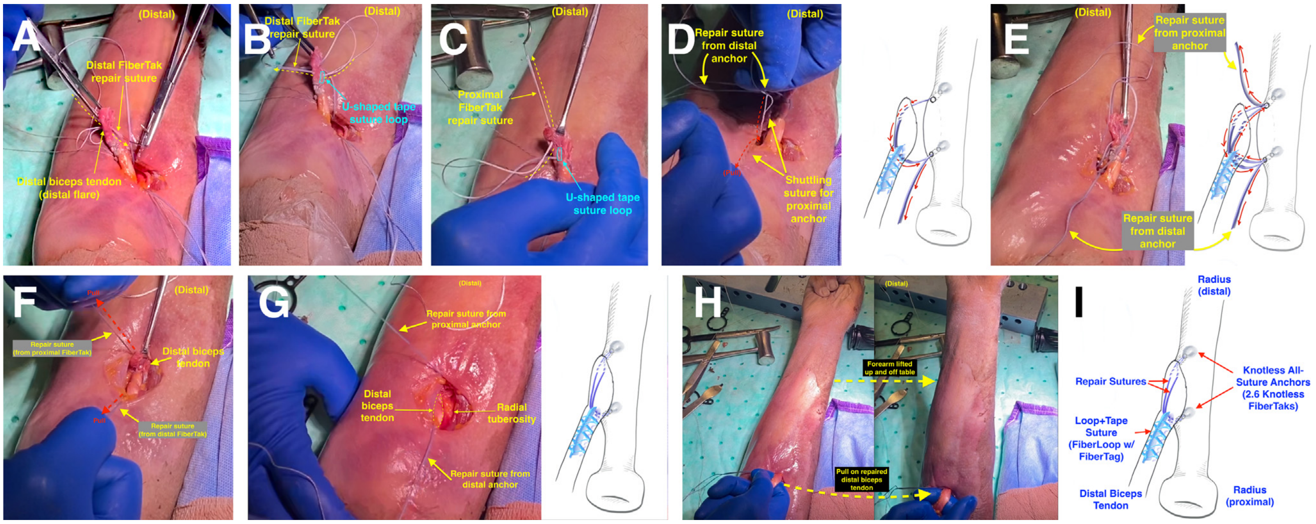

Fig 5. Right cadaver arm, volar surface facing up. View from the proximal aspect toward the distal aspect. Diagrams demonstrating repair details are also in the same orientation. (A) With a free needle, pass the distal FiberTak repair suture through the distal flare of the biceps tendon from the underside to the top surface. (B) Pass the distal FiberTak repair future next through the distal biceps tendon, making sure to also pass it through the U-shaped loop of the tape suture, and exit on the posterior aspect of the tendon. (C) The repair suture of the proximal FiberTak is passed, in reverse fashion, through the distal biceps tendon and the U-shaped tape suture loop first, then through the distal flare from the top surface to the underside. (D) Shuttle the distal FiberTak repair suture through the proximal anchor. (E) Shuttle the proximal FiberTak repair suture through the distal anchor, interlinking the 2 anchors. (F) Pull to tighten the repair sutures and compress the tendon down onto the radial tuberosity. (G) Appearance after distal biceps tendon fixation to radial tuberosity, with diagram of the repair. Note the biceps tendon is repaired to the medial/posterior aspect of the radial tuberosity with the forearm fully supinated, over a longitudinally oriented oval area, better reproducing the anatomic footprint. (H) Hook test to confirm repair integrity: hook the index finger behind the repaired distal biceps tendon and lift the forearm off the table only through pulling on the tendon. Further stressing can be done by pressing down on the distal forearm while pulling up on the distal biceps tendon. Retension the FiberTak repair sutures as needed after stress testing. (I) Diagram of the final repair construct, demonstrating a knotless, unicortical all-suture anchor repair of the distal biceps tendon, with passages of interlinked FiberTak repair sutures through the FiberLoop w/FiberTag suture construct in the distal tendon and with longitudinal compression of the distal flare tissue.

intramedullary tendon placement through a large single cortical opening when onlay fixation preserves radial tuberosity prominence without compromising healing.

2. Anatomic Footprint Replication and Radial Tuberosity Prominence Preservation

The distal biceps tendon anatomic footprint is oblong and runs along the posterior portion of the radial tuberosity when the forearm is maximally supinated.[4] The cam-like radial tuberosity prominence improves the biceps supination moment arm.[5]

Optimal footprint replication and radial tuberosity prominence contour preservation are important for maximal supination strength restoration.[5,6] However, inherent features of the bicortical drilling/inlay technique make those goals difficult if not impossible[7]: guide pin placement for the 8-mm reamer typically ends up more anterior and radial than the anatomic distal biceps footprint, to avoid eccentric reaming and cortical cutout. The larger hole necessary for intramedullary tendon insertion also reduces the radial tuberosity height.

In contrast, the far smaller dimensions of the 2.6 Knotless FiberTak drill and inserter improve the ability to drill and reattach the tendon more posteriorly on the radial tuberosity, while preserving the tuberosity height. Repair suture interlinkage of 2 FiberTaks provides broad compression between the anchors and better replicates the oblong footprint.

3. Unicortical Drilling and Intramedullary Fixation

Unicortical drilling and intramedullary placement of fixation devices have demonstrated similar or better biomechanical properties in distal biceps repair pullout strength compared to bicortical drilling and extramedullary button placement,[8] and intramedullary all-suture anchors have demonstrated equal or superior fixation strength compared to intramedullary button.[9]

4. Posterior Interosseous Nerve Injury Avoidance

Iatrogenic posterior interosseous nerve injury from drilling and/or button placement through the far cortex occurs in 5% of single-incision distal biceps tendon fixation,[10] despite guidelines to help avoid nerve injury.[11,12] The risk can be substantially reduced with

Table 1. Pitfalls and Pearls

Pitfall: The FiberTak fails to set after full impaction.
Pearl: Drilling at a 45° or higher distal trajectory increases the intramedullary excursion of the FiberTak and inserter, which helps the FiberTak to set within the medullary canal. If the FiberTak still fails to set, consider switching to the self-punching version of the Knotless FiberTak so that insertion depth is not limited by the drill sleeve.
Pitfall: During impaction/insertion, the FiberTak is stuck in the cortex and fails to advance into the medullary canal.
Pearl: Increase the tunnel diameter to 2.8 or 3.0 mm to ease FiberTak passage through the cortex. In this technique, the FiberTak deployment occurs within the medullary canal and not in cancellous bone, and thus the exact tunnel diameter is not as critical as in settings where the anchor deploys secondary to friction against the tunnel. As long as it passes into the medullary canal, the FiberTak will still deploy even if the tunnel is slightly larger than 2.6 mm.
Pitfall: The FiberLoop w/FiberTag placement in the distal biceps tendon results in uneven suture tension, with some loose suture loops.
Pearl: Similar to the quadriceps tendon autograft preparation for anterior cruciate ligament reconstruction, it is important to tension the 2 strands of the FiberLoop individually after each needle passage to maximally tighten the suture construct and avoid loose suture loops.
Pitfall: During final fixation tensioning, the FiberTak repair sutures fail to maximally tighten, and laxity persists at the tendon/radial tuberosity interface.
Pearl: To maximally tighten the FiberTak repair suture, it is important to pull in line with the tunnel trajectory. In this case, it is the 45° distal angle when pulling on the repair sutures to tighten the repair construct. If there is significant tension on the distal biceps tendon secondary to postinjury tendon retraction, flex the elbow during repair suture tightening to lessen the tension on the distal biceps tendon.

unicortical drilling and intramedullary anchor placement, as the far cortex is unpenetrated.

5. Knotless Fixation

Knotless technology permits retensioning after vigorous stress testing of the repair to ensure final fixation tension is maximized and eliminates a potential weak link in fixation consistency.[13]

6. Reinforced Tendon Suturing

Not only is the Fiberloop w/FiberTag suturing method essential for connection with the knotless FiberTaks, but it also significantly increases the maximal load to failure and resistance to displacement during cyclic loading compared to the whipstitching/tension-slide technique.[14]

Drawbacks of the technique include initial learning curve of new suturing and all-suture anchor placement techniques if the surgeon is not familiar with these implants, potential of increased implant costs, and, as with any new technique, the need for validation through future clinical studies.

In summary, this distal biceps tendon repair method incorporates new techniques and technology to revamp multiple aspects of the prevalent repair technique. The method may improve treatment outcome by preserving anatomic features key to distal biceps tendon function, enhancing repair integrity, and improving patient safety.

Advantages and disadvantages of the technique are listed in Table 2.

Table 2. Advantages and Disadvantages

Advantages
1. Onlay technique preserves radial tuberosity prominence and its supination cam function to enhance forearm supination torque function of the distal biceps tendon
2. Unicortical drilling and intramedullary placement of all-suture anchors, avoiding the risk of posterior interosseous nerve injury inherent to bicortical drilling/button placement
3. Smaller footprint and dimension of implant and drill, facilitating an improved anatomic footprint replication
4. Distal tendon suturing with FiberLoop w/FiberTag, improving tendon capture security over standard whipstitching
5. Knotless fixation eliminates knots as a weak spot and permits retensioning after final stress testing
6. Interlinking the 2 anchors broadens the tissue compression area and better replicates the anatomic footprint
Disadvantages
1. Possible increased cost
2. Learning curve of suture construct placement in distal biceps tendon with FiberLoop w/FiberTag
3. Need for follow-up studies

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