Technical Note

Minimally Invasive Distal Biceps Tendon Reconstruction With Semitendinosus Allograft and Dual Unicortical Button Fixation

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Abstract: Complete rupture of the distal biceps tendon is routinely treated with direct repair; however, chronic, mid-substance, or musculotendinous tears are challenging clinical scenarios for surgeons. Although attempts at direct repair should be considered, in cases of severe retraction or tendon deficiency, a reconstruction may be warranted. Herein the authors describe a technique for distal biceps reconstruction using allograft with a Pulvertaft weave via a standard anterior incision, similar to primary repair, with a small catchment incision more proximally for tendon retrieval. Use of this technique with dual unicortical buttons allows for early range of motion, restoration of the distal footprint, and improved biomechanical construct strength, which has proven invaluable in a population of elite and highly active military servicemembers.

Distal biceps ruptures occur after an eccentric load applied to the flexed elbow. Although surgical repair is most often advocated for restoration of flexion and supination strength,[1] in chronic cases or high energy mid-substance tears or in patients with substantial tendon degeneration, repair is not always possible. In these cases, reconstruction with either autograft or allograft tendon can be performed. However, optimal techniques remain relatively limited and require substantial dissection. The purpose of this article is to highlight a minimally invasive distal biceps

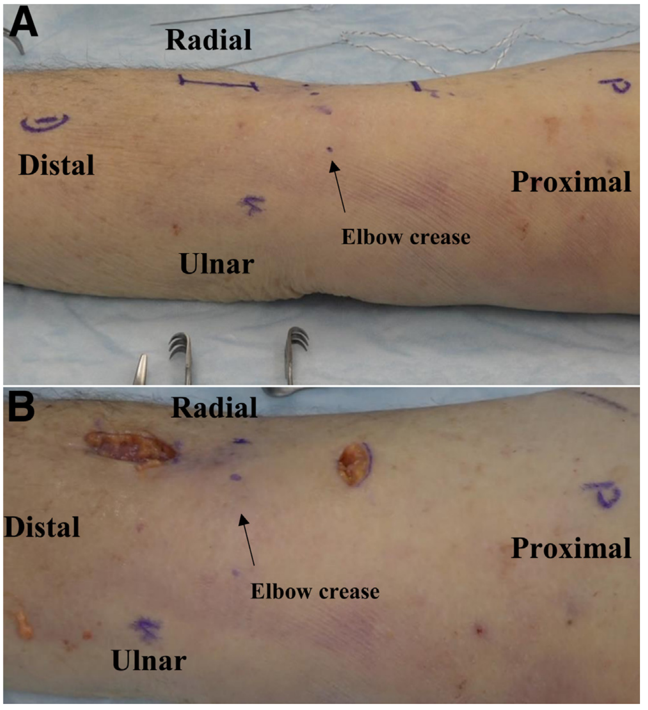

Fig 1. The right arm of the patient is seen in the supine position with a 2 to 3 cm distal longitudinal incision 3 cm distal to the antecubital crease directed over the radius between brachioradialis and pronator teres. A second, proximal incision in either transverse or vertical orientation of approximately the same dimension is made proximal to the antecubital fossa at the musculotendinous junction of the biceps muscle. (A) Planned incision. (B) Completed incisions.

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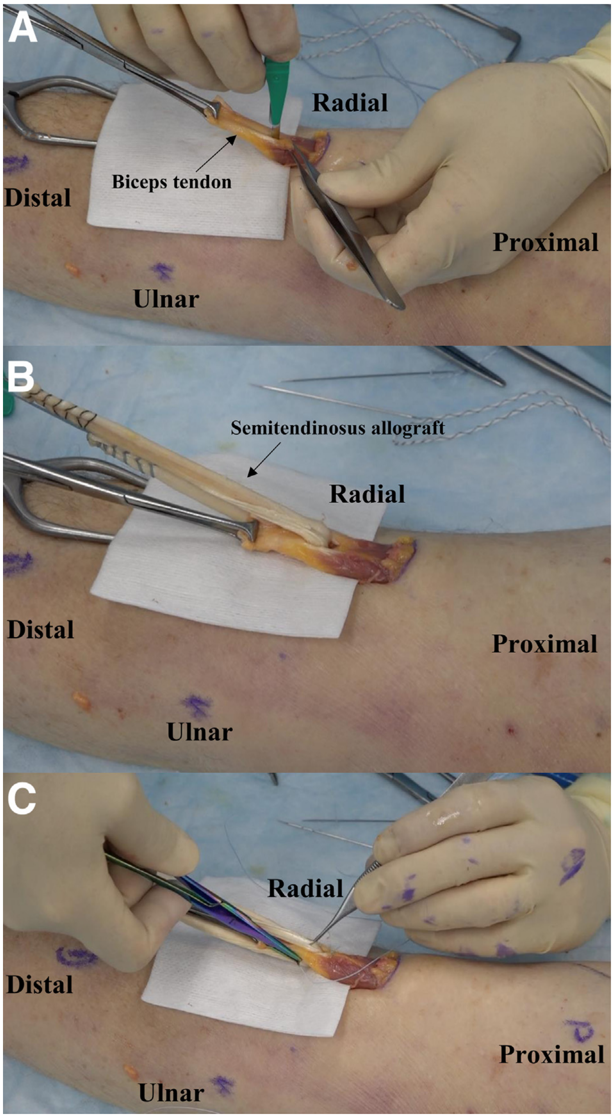

Fig 2. The right arm of the patient is seen in the supine position. (A) A stab incision at the myotendinous junction is made in the remaining biceps tendon that has been identified and exposed through the proximal accessory incision. (B) The semitendinosus graft that has been whipstitched on both ends for ease of passage is passed through the stab incision. A suture is placed in the proximal biceps tissue to limit the propagation of the stab incision. (C) Gentle tension is placed on both ends of the graft, and a suture is passed through all limbs of the allograft and both sides of the native tissue to fix the graft in place.

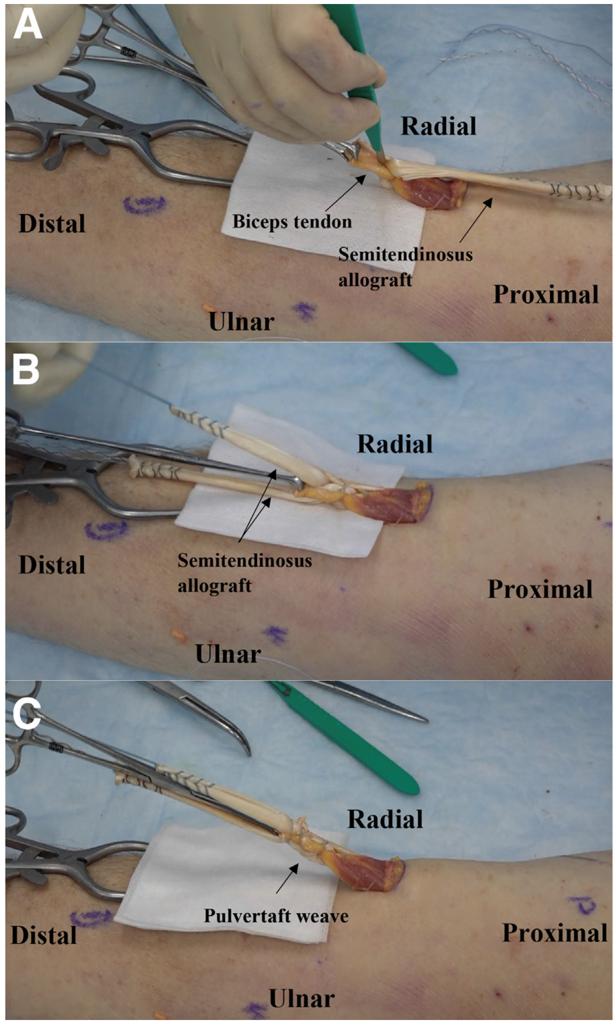

Fig 3. The right arm of the patient is seen in the supine position. (A) An additional longitudinal stab incision is made distal to the previous one in the remaining biceps tissue. A snap is passed through this incision from a bottom to top trajectory to retrieve and pass one limb of graft. The snap is then again passed through the same incision, from top to bottom, to retrieve the other end of the graft so that (B) both graft ends are woven through the native tissue. Gentle tension is applied to the construct, and a suture is passed through all limbs and then passed circumferentially around the construct to tubulurize it. (C) The suture is then tied, the free end is cut, and the knot is buried, completing the Pulvertaft weave.

reconstruction procedure using allograft, applied via Pulvertaft weave and secured with dual unicortical buttons.

Clinical Evaluation

Patients typically present following a popping or tearing sensation after an eccentric load is applied to the arm with the elbow in a flexed position. Patients often experience a reverse popeye deformity in combination with forearm ecchymosis and supination weakness. Although a variety of physical examination tests have been proposed, Devereaux and El Margahy[2] showed that the combination of the following 3 physical examination findings yielded a 100% sensitivity and specificity for identifying a biceps tendon tear: the hook test, passive forearm pronation test, and biceps crease interval test. Relative strength testing of elbow flexion and supination can also be useful. Diagnosis is further confirmed using magnetic resonance imaging or ultrasound, which also provide details regarding the length

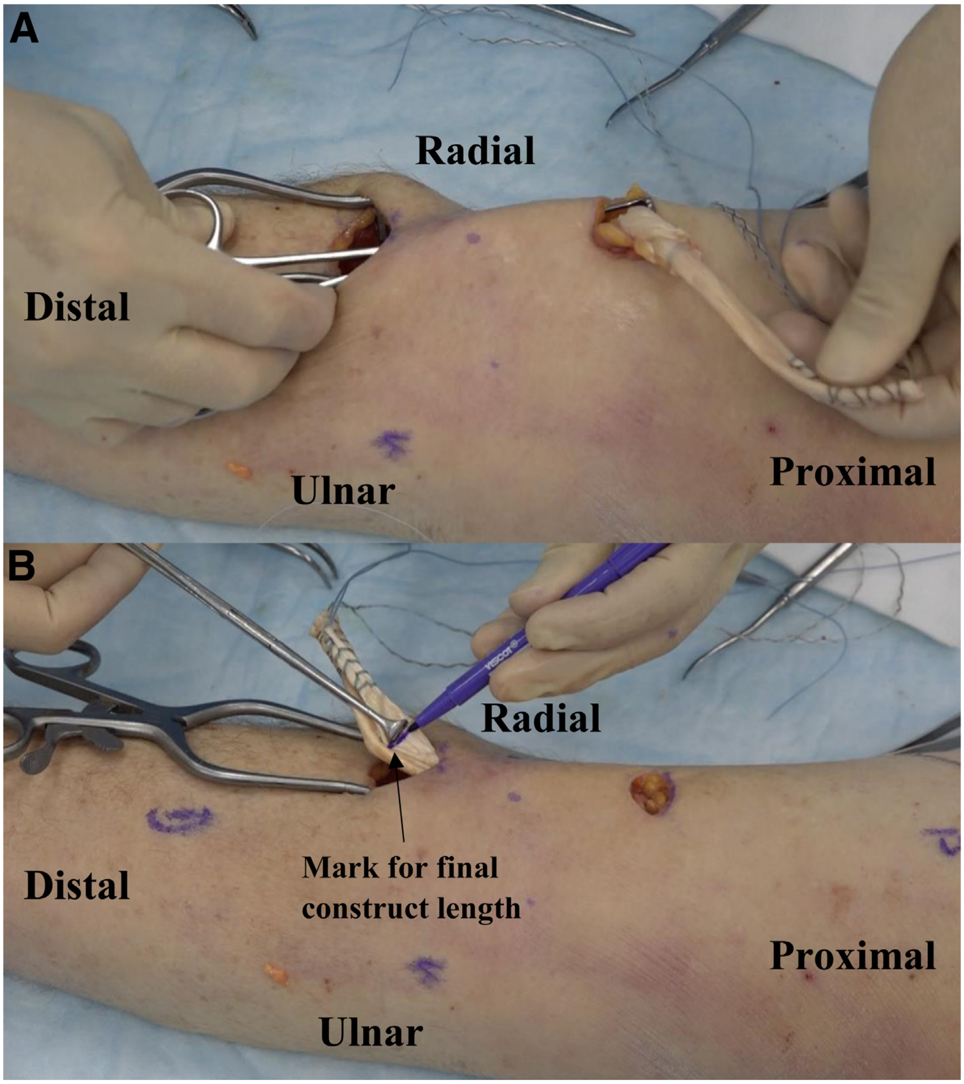

Fig 4. The right arm of the patient is seen in the supine position. (A) After completing the Pulvertaft weave, the entire construct is passed subcutaneously through the antecubital fossa following the normal course of the biceps tendon to the radial tuberosity. (B) The length to the radial tubersosity is measured and marked with a marking pen. Care is taken to ensure that appropriate length-tension relationships are optimized to allow for early motion while ensuring proper postoperative strength and appearance.

of remnant tendon, location of the injury, and muscular atrophy. These factors are important because they may impact subsequent surgical technique and expected prognosis.

Surgical Technique (Video 1)

In general, a regional block is used with this technique because the risk of iatrogenic posterior interosseous nerve palsy is minimized using intramedullary buttons. This allows for less anesthetic and improves postoperative pain control. The patient is positioned supine with the operative extremity on a hand table with a sterile tourniquet. A 2 to 3 cm anterior longitudinal incision distal to the antecubital crease is directed over the radius between brachioradialis and pronator teres (Fig 1). Although the lateral antebrachial cutaneous nerve is not often seen, careful dissection and retraction are performed to minimize injury to this nerve. The radial tuberosity is identified, and any adhesions are released. An attempt is made to retrieve the tendon end through this incision to perform a primary repair. If this is not feasible, a second catchment incision of approximately the same dimension is made proximally at the musculotendinous junction of the biceps muscle. This can often be localized through direct palpation of the retracted tendon. Through the catchment incision, blunt dissection is performed to identify and free the tendon, which maintains a superficial position within the arm. Once the tendon end is identified, it is delivered through the wound after any adhesions are removed. All degenerative tissue is removed, and excursion is checked. In cases requiring

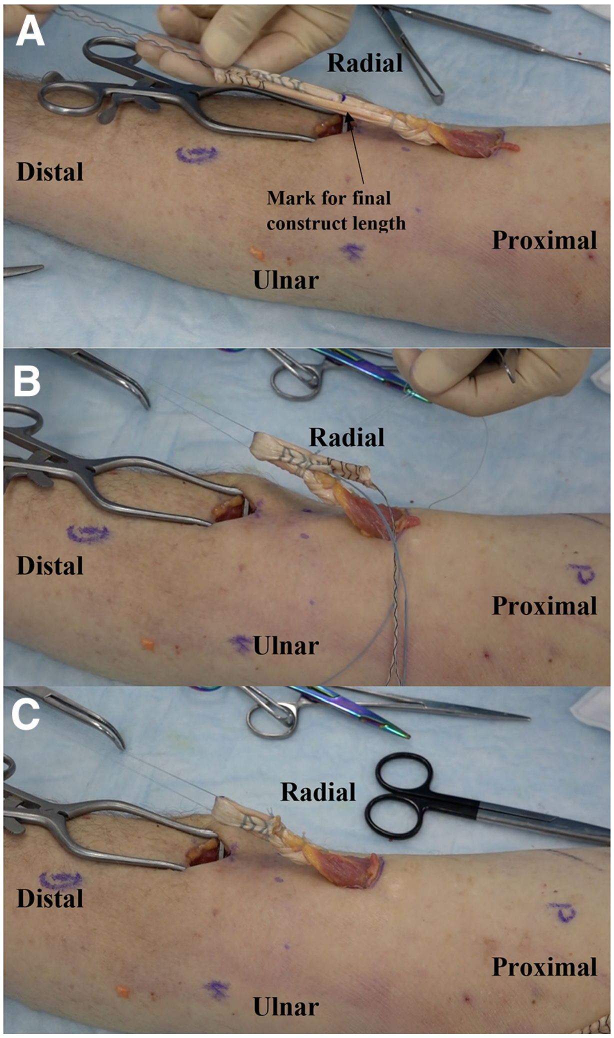

Fig 5. The right arm of the patient is seen in the supine position. (A) The marked graft is passed back through the proximal incision. (B) The graft is folded over a suture at the marked length to provide tension at the appropriate length for the remainder of the construct preparation. (C) A single stitch is used to secure the graft to itself at the desired length, and the excess graft is removed.

high degrees of elbow flexion or in which tendon quality precludes an adequate repair, a reconstruction or augmentation is performed.

Reconstruction Technique

A semitendinosus graft is used for this portion of the procedure. Each end of the graft is initially whip stitched to allow for easy passage throughout the remainder of the case. In general, a graft length of 175 mm with a diameter of 4 mm is sufficient to adequately reconstruct the biceps tendon. This size allows for modification of the final length-tension relationship without creating a final diameter graft that is too large.

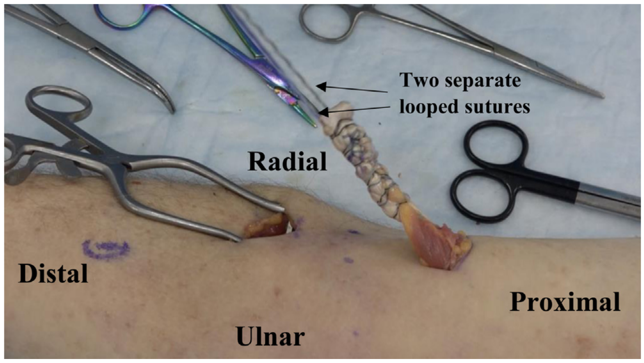

Fig 6. The right arm of the patient is seen in the supine position. A high-tensile, looped suture is passed from proximal to distal through the entire construct ending at the most distal portion of the construct. A second looped suture is then passed from proximal to distal, exiting approximately 1 cm proximal to the end of the construct, which helps create a broad footprint for repair.

Starting at the musculotendinous junction, a stab incision is made, and the prepared graft is passed through the biceps tendon with an equal tissue length on each side (Fig 2). A high-tensile suture is used in the proximal tissue to limit the propagation of the stab incision. Gentle tension is then placed on both ends of the graft, and a high-tensile suture is passed through all limbs of the allograft and the native tissue to fix the graft in place. Once complete, an additional longitudinal stab incision is made distal to this in the remaining biceps tissue. A snap is passed through this incision from a bottom to top trajectory to retrieve and pass one limb of graft (Fig 3). The snap is then again passed through the same incision, this time from top to bottom, to retrieve the other end of the graft so that both graft ends are woven through the native tissue. Gentle tension is again applied, a high-tensile suture is passed through all limbs and then circumferentially around the construct to tubularize it. The suture is tied, the free end is cut, and the knot is buried. This is repeated as often as desired or as the soft tissue allows.

Once completed, the construct is passed subcutaneously through the antecubital fossa following the normal course of the biceps tendon to the radial tuberosity (Fig 4). Length is then checked through a range of motion, and a decision is made on the desired construct length. Care is taken to ensure that appropriate length-tension relationships are established to allow for early motion while ensuring proper postoperative strength and appearance. Once this has been determined, the graft is marked and retrieved through the proximal incision (Fig 5). The graft is folded over a suture at the designated mark to provide tension at the appropriate length for the remainder of the construct preparation. A stitch is used to secure the graft to itself at the desired length, and the excess graft is removed. A

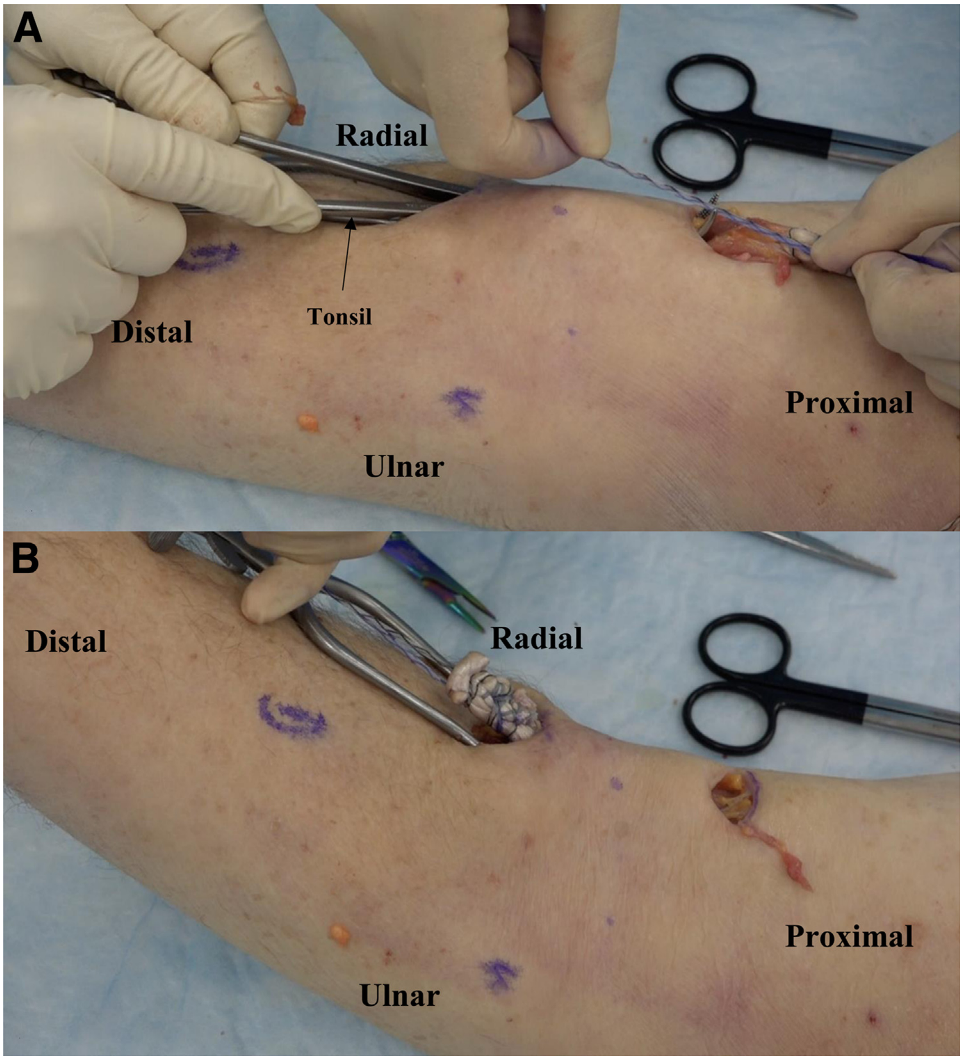

Fig 7. The right arm of the patient is seen in the supine position. (A) The 4 suture limbs from the looped sutures are retrieved through the distal incision, and (B) the reconstructed tendon is shuttled distally.

high-tensile, looped suture is subsequently passed from proximal to distal, ending at the most distal portion of the graft. A second looped suture is similarly passed, exiting approximately 1 cm proximal to the end (Fig 6).

Graft Fixation to Radial Tuberosity

The 4 suture limbs are shuttled through the antecubital fossa and retrieved from the distal incision (Fig 7). The limbs of each suture pair are passed through two separate 2.6 × 7 mm metallic buttons (Arthrex, Naples, FL). Using fluoroscopic guidance and direct visualization, two 3.2 mm unicortical holes are made centered in the radial tuberosity approximately 1 cm apart (Fig 8). The proximal suture button is inserted first, flipped, and provisionally tensioned. This is then repeated for the distal implant. A single limb of each suture pair is passed through the graft, the elbow flexed and final tensioning performed. Each suture pair is tied overtop to complete the reconstruction. The elbow is then taken through a range of motion, and the wounds are irrigated and closed (Fig 9).

Postoperative Protocol

The operative extremity is placed into a posterior slab splint in neutral rotation. At 2 weeks, the patient is transitioned to a hinged elbow brace, and they are allowed to work on immediate active range of motion with passive elbow flexion and active elbow extension. Strengthening is allowed to begin at 6 weeks after surgery. Patients are generally released from restrictions at 4 to 6 months after surgery, depending on their progress with therapy (Table 1).

Discussion

The current technique highlights use of a Pulvertaft weave with allograft tissue and dual intramedullary buttons. Compared to more traditional techniques that require dissection across the antecubital fossa, this technique allows for a more minimally invasive

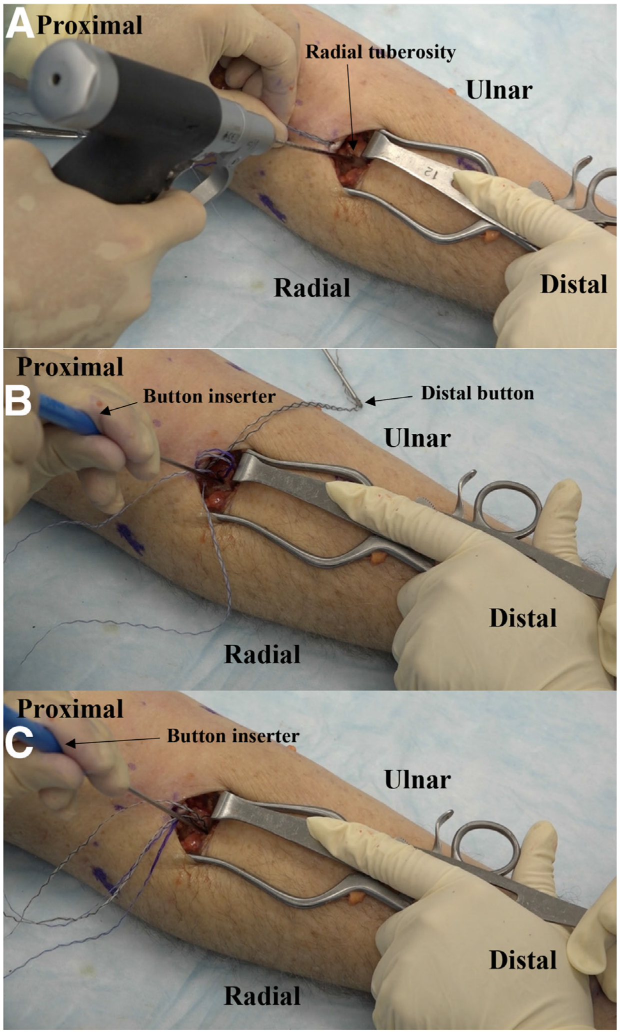

Fig 8. The right arm of the patient is seen in the supine position. (A) Two unicortical holes are drilled into the radial tuberosity, approximately 1 cm apart, with the arm in full supination. (B) The proximal button is placed first and tensioned. (C) This is followed by the distal button.

approach, with decreased risk of damage to posterior interosseous nerve, enhanced biomechanical strength, allowing for early range of motion, and a more anatomic approximation of the distal biceps footprint (Table 2).

Two recent meta-analyses of cadaveric studies investigating distal biceps fixation found that cortical buttons have superior biomechanical strength as compared to other fixation strategies,[3,4] with 2 separate studies from Siebenlist et al.[5,6] finding that dual intramedullary buttons have an increased mean load to failure compared to a single intramedullary button and may allow for more aggressive early postoperative rehabilitation.

Similarly, although distal biceps repairs can be performed in as much as 90° of flexion,[7] concern remains regarding early range of motion limitations. Despite

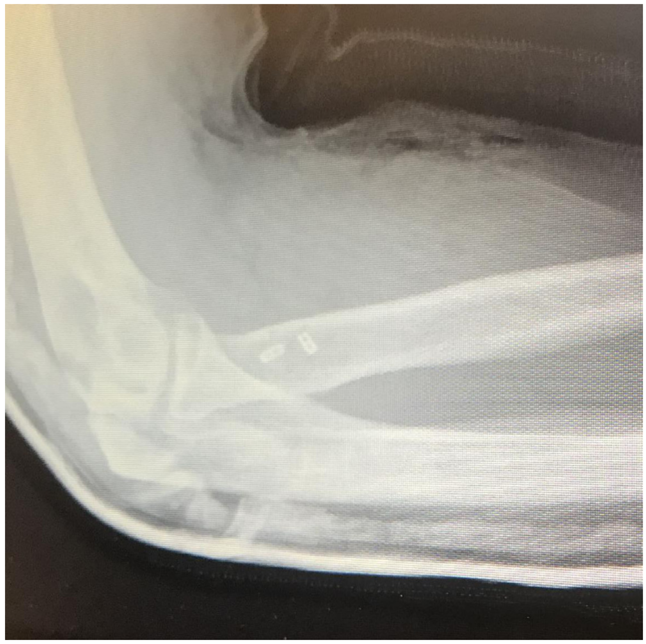

Fig 9. Final lateral radiographs of the right elbow demonstrating dual unicortical button fixation in the radial tuberosity

overall good results at high flexion angles noted by Morrey et al.,[7] 17% (4/23) had limitations in extension of 10° or more, with patients fixed at high flexion angles requiring more graduated rehabilitation protocols. Although this may be acceptable for most patients, in the high-demand military servicemember or athlete, this may limit their ability to return to pre-injury functional levels.

Table 1. Pearls and Pitfalls

Pearls
Use of intraoperative fluoroscopy allows for appropriate incision placement.
Careful retrieval of the biceps tendon through the proximal incision allows for easy tissue manipulation and preparation while minimizing the risk to surrounding structures.
Use of a small unicortical button allows for easy flipping of the button within the radial tuberosity without binding.
Use of an appropriately sized graft limits an oversized graft construct.
Pitfalls
Poor incision placement can lead to excessive retraction and poor visualization.
In chronic cases, careful dissection must be performed to limit damage to neuromuscular structures that are not fully visualized.
Placement of drill holes too vertically or not within the widest portion of the tuberosity can make it difficult to flip the buttons.
Failure to maintain graft and native tissue tension can lead to "bunched-up" construct.
Use of Hohmann's around the tuberosity can cause iatrogenic PIN injury.

PIN, posterior interosseous nerve.

Table 2. Advantages and Disadvantages

Advantages	
	Enhanced immediate biomechanical strength
	Wider footprint approximation
	Unicortical drilling minimizes the risk of PIN injury
	Avoids repair at a higher degree of elbow flexion, creating an opportunity for earlier range of motion
Disadvantages	
	Increased cost of 2 implants and allograft
	Volar-only incisions may limit access to anatomic footprint
	Creates bony bridge between 2 drill holes
	Requires allograft incorporation

PIN, posterior interosseous nerve.

Finally, prior anatomic studies have shown that the tendon ranges from 6.3 to 9.2 cm in length to 2.9 to 6 mm in diameter,[8,9] whereas Beeler et al.[10] found that various radiographic measurements can reliably predict native tendon length. As such, final reconstruction should aim to approximate the native tendon while maintaining an appreciation for the existing length-tension relationship. The current technique first reestablishes sufficient tendon length and then recreates the length-tension relationship, with the goal of approximation of the tendon to bone at 30° of flexion during fixation. Given that both repairs and reconstructions have been shown to lengthen over time, this moderate flexion angle allows the final result to more closely approximate the native myotendinous length while still allowing early postoperative range of motion.

This article describes a minimally invasive technique for distal biceps reconstruction with Pulvertaft weave using a semitendinosus allograft secured via 2 unicortical buttons. This has successfully been performed in high-level competitive athletes and special forces soldiers with early return to activity and good final functional results. Although not appropriate in all cases, this technique allows for an additional reconstruction option in difficult treatment scenarios.

References

1. Cuzzolin M, Secco D, Guerra E, Altamura SA, Filardo G, Candrian C. Operative versus nonoperative management for distal biceps brachii tendon lesions: A systematic review and meta-analysis. *Orthop J Sports Med* 2021;9, 232596712110373.
2. Devereaux MW, El Maraghy AW. Improving the rapid and reliable diagnosis of complete distal biceps tendon rupture: A nuanced approach to the clinical examination. *Am J Sports Med* 2013;41:1998-2004.
3. Taylor AL, Bansal A, Shi BY, Best MJ, Huish EG, Srikumaran U. Optimizing fixation for distal biceps tendon repairs: A systematic review and meta-regression of cadaveric biomechanical testing. *Am J Sports Med* 2021;49:3125-3131.
4. Forlenza EM, Lavoie-Gagne O, Parvaresh KC, Berlinberg EJ, Agarwalla A, Forsythe B. Two intramedullary and one extramedullary cortical button, with or without interference screw, show biomechanical properties superior to native tendon in repair of the distal biceps tendon: A systematic review and network meta-analysis of biomechanical performance. *Arthroscopy* 2023;39:390-401.
5. Siebenlist S, Lenich A, Buchholz A, et al. Biomechanical in vitro validation of intramedullary cortical button fixation for distal biceps tendon repair: A new technique. *Am J Sports Med* 2011;39:1762-1769.
6. Siebenlist S, Buchholz A, Zapf J, et al. Double intramedullary cortical button versus suture anchors for distal biceps tendon repair: A biomechanical comparison. *Knee Surg Sports Traumatol Arthrosc* 2015;23:926-933.
7. Morrey ME, Abdel MP, Sanchez-Sotelo J, Morrey BF. Primary repair of retracted distal biceps tendon ruptures in extreme flexion. *J Shoulder Elbow Surg* 2014;23:679-685.
8. Walton C, Li Z, Pennings A, Agur A, El Maraghy A. A 3-dimensional anatomic study of the distal biceps tendon: Implications for surgical repair and reconstruction. *Orthop J Sports Med* 2015;3, 232596711558511.
9. Bhatia DN, Kandhari V, DasGupta B. Cadaveric study of insertional anatomy of distal biceps tendon and its relationship to the dynamic proximal radioulnar space. *J Hand Surg* 2017;42:e15-e23.
10. Beeler S, Hecker A, Bouaicha S, Meyer DC, Wieser K. Indirect markers for length adjustment in distal biceps tendon allograft reconstruction. *PLoS One* 2021;16, e0257057.