Distal Biceps Tendon Repair and Reconstruction

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Learning Objectives

Upon completion of this CME activity, the learner should achieve an understanding of:

- The demographics of and how to diagnose distal biceps tendon rupture
- Surgical indications and optimal techniques for distal biceps tendon repair and reconstruction
- Postoperative rehabilitation and outcomes of surgical intervention for distal biceps tendon rupture

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Distal biceps tendon ruptures can result in functionally significant loss of supination and flexion strength, as well as decreased resistance to fatigue. Although the diagnosis of distal biceps tendon ruptures remains straightforward, substantial debate continues with regards to surgical indications, pertinent surgical anatomy, single- versus double-incision surgical technique, and fixation options. This review discusses the latest evidence-based literature

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regarding distal biceps tendon repair/reconstruction including types of tears, demographics, clues for diagnosis, surgical indications, anatomy with special attention to how the distal tendon inserts distally and the relevant tuberosity anatomy (height and cam effect), common reconstruction techniques (single- vs double-incision and single-incision power optimizing cost-effective technique), fixation techniques (bone tunnels, distal biceps button, interference screw, button plus screw), surgical technique pearls, postoperative rehabilitation, postoperative outcomes, as well as the treatment of chronic tears with special reconstruction techniques including Achilles allograft, pedicled latissimus transfer, and the use of a free innervated gracilis. *(J Hand Surg Am. 2020;45(1):48–56.*

Key words Biceps, distal biceps, gracilis, latissimus.

Additional Material at jhandsurg.org

DEMOGRAPHICS

Distal biceps tendon ruptures may be more common than once thought, occurring at a rate of 2.5 per 100,000 patient-years. Risk factors include smoking as well as increased body mass index. The average age of patients is 47 years old (two-thirds of patients are between 25 and 54 years). Greater than 90% of patients are male.[1] Female patients are typically older (average >60 years), and partial tears are more common than in their male counterparts.

TYPES

Biceps tendon tears can theoretically occur at any point between the insertion and the origin. Nonpenetrating injuries occur most commonly at the insertion. Partial ruptures can occur; typically, the short head distally.[2] Tendon ruptures can also occur at the musculotendinous junction. The described mechanism for this injury includes glenohumeral elevation, elbow extension, and forearm supination.[3]

DIAGNOSIS

The diagnosis of a distal biceps tendon rupture can be missed or delayed. Typically, patients report a history of a popping sensation in the setting of an eccentric load with a flexed elbow. It is important to perform a careful physical examination confirming common findings such as a retracted biceps muscle belly (reverse Popeye), ecchymosis at the elbow, weak supination strength against resistance, and positive hook test, which can be both sensitive and specific for complete distal tears.[4]

Musculotendinous junction tears are rare, presenting with antecubital pain, bruising, swelling, and weakness with elbow flexion-supination. It may be possible to hook the tendon on physical examination.

DIAGNOSTIC IMAGING

Diagnostic imaging, such as magnetic resonance imaging (MRI) is usually not necessary for making the diagnosis of a distal biceps tendon rupture. However, MRI may be helpful to characterize the amount of tendon remaining attached in the setting of a partial biceps tendon tear or to elucidate the amount of retraction present in the setting of a full tear. The flexed, abducted, supinated view is ideal for MRI studies.[5]

SURGICAL INDICATIONS/CONTRAINDICATIONS

Surgical repair results in improvement in supination and flexion strength, as well as resistance to fatigue for both motions, normal posture during end supination, and correction of the reverse Popeye deformity. Supination strength is necessary for activities such as loosening a tight bolt, swinging a bat or golf club, and stabilizing tools. Contraindications to surgical repair-reconstruction include low functional demands, severe restrictions in passive elbow/forearm motion, active infection, significant medical comorbidities, and a compromised soft tissue envelope.

NONSURGICAL TREATMENT

Morrey et al[6] initially reported on average 40% loss of supination strength and 30% loss of flexion strength after nonoperative treatment. Of note, immediate reattachment resulted in normal flexion and supination strength, whereas late reinsertion improved strength in flexion and supination without return to normal.[6]

Subsequently, Freeman et al[7] retrospectively reviewed 18 patients (average age, 50 years; range, 35−74 years) treated nonsurgically after distal biceps tendon rupture. Six patients reported supination weakness when performing activities such as turning a screwdriver. Eight patients reported subjective weakness with heavy lifting. The median supination and elbow flexion strengths were decreased for the injured arms: 63% and 93%, respectively. However, Disabilities of the Arm, Shoulder, and Hand (DASH) scores were, on average, 14 (normative value, 10); and all 16 patients returned to preinjury level of work.[7]

SURGICAL ANATOMY

The long head of the biceps originates from the superior glenoid tubercle, and the short head originates from the coracoid. Distally, the tendon externally rotates such that the short head portion of the tendon inserts distal to the long head on the bicipital tuberosity (Fig. 1). The radial protuberance (apex of the tuberosity) functions as a mechanical cam maximizing supination torque throughout rotation (in particular, terminal supination) (Fig. 1).[8]

SURGICAL APPROACH

Distal biceps reconstruction can be performed through a single- (anterior) or double-incision (posterior) approach. It is critical to hypersupinate the arm for an anterior approach, whereas the posterior approach is performed in muscle-splitting fashion

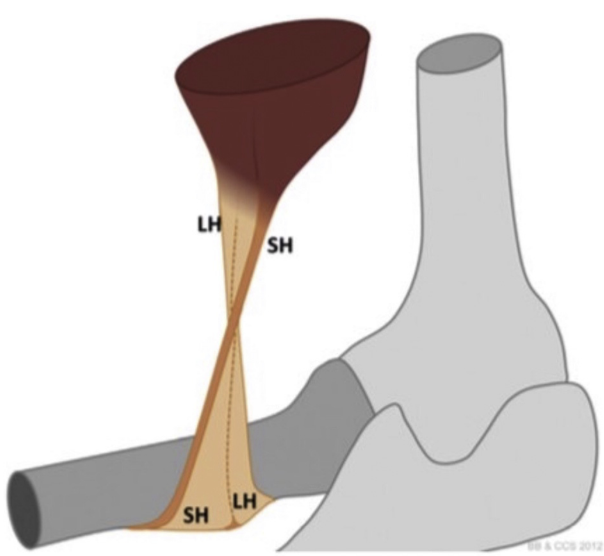

FIGURE 1: The schematic illustrates 90° of external rotation of the distal biceps tendon with the short head (SH) inserting distally. LH, long head.

(extensor carpi ulnaris [ECU]/supinator) with the forearm in pronation. Hypersupination of the arm for an anterior approach has 2 advantages: (1) it moves the posterior interosseous nerve (PIN) away from the site of surgery, (2) it avoids an anterior attachment site, which may limit terminal supination strength and resistance to fatigue.

Of note, the single-incision power-optimizing technique can be used to create an insertion point for the distal biceps tendon repair that is dorsal to the protuberance using bone tunnels during a single incision or anterior approach, maximizing terminal supination strength.[9]

Drawbacks of the posterior approach include damage to the supinator, which is partially split during this surgical exposure, which may result in loss of supination strength.

FIXATION BIOMECHANICS/COMPLICATIONS

Normal tension on the biceps tendon with the arm at 90° against gravity is about 50 N. Idler et al[10] reported mean failure strength as 204 N and maximum strength as 222 N. Mazzocca et al[11] compared bone tunnel versus suture anchors versus interference screws versus distal biceps buttons (EndoButton, Arthrex, Naples, FL) in 63 cadaveric elbows. Whereas bone tunnel and distal biceps button had the greatest tendon displacement at 3.55 and 3.42 mm, respectively, distal biceps buttons had a significantly higher load to failure (440 N) than suture anchors (381 N), bone tunnels (310 N) and the interference-interosseous screw (232 N).[11] Thus, most techniques/commercial systems appear to have sufficient strength to secure the biceps tendon to bone during the healing phase.

SURGICAL TECHNIQUE VARIATION

Classically, distal biceps tendon repair/reconstruction can be performed through an anterior (single-incision) or posterior (double-incision) approach. The single-incision approach should be performed with the forearm in hypersupination, starting the incision distal to the antecubital fossa between the pronator teres and the brachioradialis muscles. The basilic vein and lateral antebrachial cutaneous nerve (LABCN) are identified and protected. The torn tendon is located and dissected free from scar tissue. The tendon is secured with a Krakow stitch and reattached to the tuberosity as ulnarly as possible with the forearm hypersupinated (Video A; available on the *Journal*'s Web site at www.jhandsurg.org).

The double-incision approach requires a second incision posteriorly exposing the radial tuberosity with the forearm in pronation through an ECU/supinator-splitting approach, staying away from the ulna to minimize the risk of synostosis (Video A; available on the *Journal*'s Web site at www.jhandsurg.org).

RECENT ADVANCES IN FIXATION TECHNIQUES

Tanner et al[9] described the single-incision power-optimizing technique for distal biceps tendon repair. A right-angle clamp and spinal needle are used to complete the repair posterior to the apex of the radial tuberosity through a single anterior incision. Supination strength was, on average, 91% of the contralateral side. The use of bone tunnels avoids the cost of buttons, anchors, or screws.

Although multiple fixation techniques and hardware options have been described, it is important to note that any procedure that uses hardware for fixation may be more expensive than techniques that do not.

POSTOPERATIVE REHABILITATION

The reattachment site is at greatest risk for failure during the first 1 to 2 weeks after surgery. For standard repairs with minimal tension at the time of the repair, the arm is placed in a posterior elbow orthosis at 80° of flexion to take tension off the wound, with the arm in neutral rotation for 2 weeks. For repairs that require the elbow to be flexed more than 60° for the tendon to be reattached to bone, the previously-described orthosis is transferred to a hinged elbow brace at 2 weeks. The hinged elbow brace is initially locked to block elbow motion at 40° less than full extension and then is advanced 10° per week until full extension is gained by 6 weeks after surgery. Additional restrictions include no lifting more than 5 pounds and no forceful supination. At 6 weeks, gradual strengthening and conditioning can be started for standard repairs. Strengthening is delayed to 10 weeks for high-flexion repairs or allograft reconstructions. Return to heavy lifting and labor is allowed at 3 to 6 months after surgery depending on the quality of the repair at the time of surgery.

LIMITING ADVERSE EVENTS

Avoiding complications is critical for a successful outcome. Palsy/injury to the PIN, LABCN, and superficial radial nerve have been reported.[12,13] Tips to avoid PIN injury include hypersupination during an anterior approach and pronation during a posterior approach, both of which move the PIN away from the bicipital tuberosity. If bone tunnels or distal biceps buttons are used, it is best to angle the drill ulnarly and proximally, away from the distal posteroradial aspect of the bicipital tuberosity where the PIN is located.[12] Self-retaining retractors or extended retraction should be avoided laterally to mitigate the risk of paresthesias following a single-incision repair. Alternatively, a double-incision repair can be employed, which has a lower rate of postoperative neurapraxia for these cutaneous nerves.

Heterotopic ossification (7.2% vs 3.2%)[13] and synostosis (2.8% vs 1.0%)[14] have been reported to occur more commonly with a double-incision approach. Performing a muscle-splitting approach through the ECU, rather than the supinator, and staying away from the ulna during a posterior approach, likely lowers this risk. In addition, any bone debris created during drilling should be evacuated completely with irrigation and suction.

Rerupture can occur after surgery. It is critical to use an orthosis during surgery prior to extubation.

When performing an anterior or single-incision approach, it is important to hypersupinate the arm and reattach the distal biceps tendon as ulnarly as possible to avoid an anterior attachment site, which may result in loss of terminal supination strength and fatigue resistance.

CLINICAL OUTCOMES

In general, both techniques (single- and double-incision) restore function, strength, and motion to the elbow with an acceptable rate of complications. Grewal et al[15] performed a level 1 study comparing single- versus double-incision. They reported no difference in the following patient outcomes at 12- and 24-month follow-up: American Shoulder and Elbow Surgeons Elbow Score, DASH, Patient-Rated Elbow Evaluaton, isometric strength-supination and pronation, and range of motion. The double-incision group had slightly better isometric flexion at final follow-up: 104% versus 94%. Single incision had a higher rate of transient LABCN neurapraxias compared with double incision: 19 of 43 (44%) versus 3 of 43 (7%). Four tendon reruptures occurred; 3 for single incision and 1 for double incision, owing to patient noncompliance as described by the authors of this study. They concluded that the technique used was up to the individual operating surgeon and patient.[15]

However, few studies have quantified repair location and measured isometric strength with the forearm in pronation, neutral, and supination. Hasan et al[16] demonstrated that a double-incision technique recapitulated 73% of the original biceps tendon insertion compared with 10% for a single-incision approach. Hansen et al[17] evaluated single-incision repair in 27 patients. The average anchor placement was 50° radial to the tuberosity apex. Flexion strength was approximately equal to that on the normal side (97%−106%), whereas supination strength was decreased (80%−86%) and work performed (66%−75%) was weaker on the repaired side.[17] Schmidt et al[8] evaluated the use of a trough versus no trough in a cadaver model. They demonstrated that preserving the radial tuberosity height (no trough) improved the supination moment arm at 60° by 27%. They concluded that the radial tuberosity functions as a cam, potentially maximizing end-supination strength and resistance to fatigue.[8] Thus, a double-incision technique may optimize the cam effect: by repairing the tendon beyond the apex of the bicipital tuberosity, supination torque may be maximized, which may be particularly important for terminal supination (when the forearm is positioned in ≥60° of supination) (Fig. 2).

CHRONIC DISTAL BICEPS RUPTURE

Injuries greater than 4 weeks old are frequently more challenging in that they may be complicated by adhesions, tendon shortening, and tunnel obliteration. Repair in high flexion angles (>60°) may be required to restore the normal anatomical footprint. Up to 100° has been reported to be safe. If the biceps tendon is adherent and wrapped upon itself, an Allis clamp can be applied, followed by a 360° adhesion release; frequently, the tendon may unravel like a ribbon, allowing for primary repair. The authors have repaired biceps tendons with the elbow flexed to 90° and 60° of supination with complete return of motion 6 weeks after surgery (Fig. 3).

If inadequate tendon is present (<2 cm), multiple tendon grafts have been reported including palmaris longus, flexor carpi radialis, and Achilles tendon allograft. The Achilles tendon allograft has the advantages of being anatomically similar to the distal biceps and it avoids donor site morbidity. If the biceps muscle itself is deficient, a bipolar pedicled latissimus transfer or free innervated gracilis may be considered.

ACHILLES TENDON RECONSTRUCTION

Chronic ruptures of the distal biceps tendon can be reconstructed with Achilles tendon allograft when native tissue is inadequate (Fig. 4). Sanchez-Sotelo et al[18] described the use of this technique in 4 patients. At an average follow-up of 2.8 years, all 4 patients had a satisfactory subjective result and full range of motion. The strength of flexion and supination was comparable with the contralateral side in 2 patients and slightly decreased in the other 2.[18]

BIPOLAR LATISSIMUS TENDON TRANSFER FOR BICEPS DEFICIENCY

The bipolar latissimus is raised while protecting its pedicle (the thoracodorsal artery and nerve). The latissimus tendinous insertion is secured with a Krakow

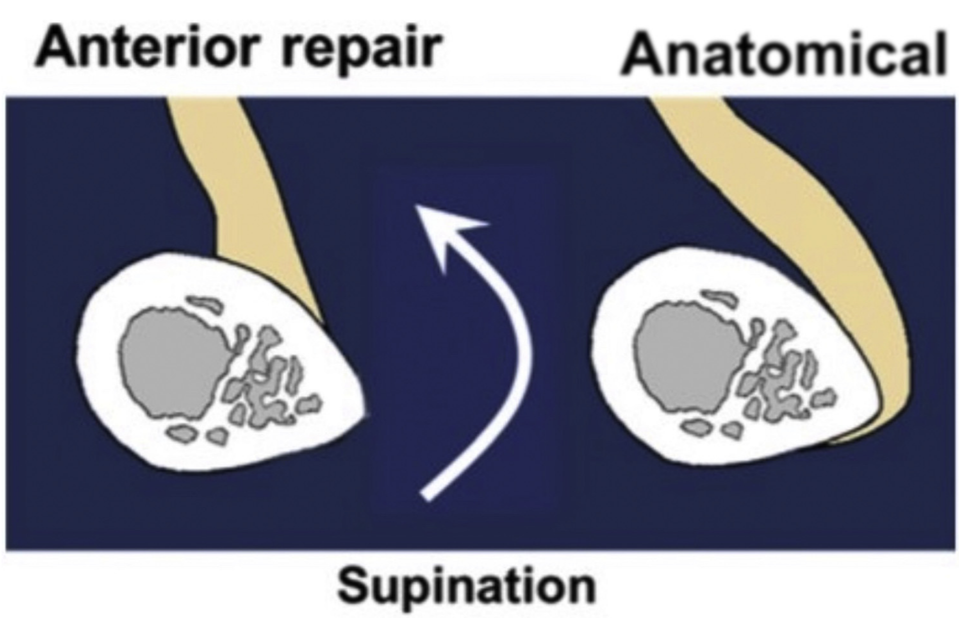

FIGURE 2: A schematic shows that an anterior repair can lead to supination weakness.

FIGURE 3: In the setting of chronic rupture with adequate tendon remaining, a high flexion angle repair may be necessary. (Courtesy of Ramesh C. Srinivasan MD)

stitch and attached to the coracoid process using bone tunnels or suture anchors (Fig. 5). The latissimus is tubularized with multiple figure-of-eight nonabsorbable sutures to create a distal biceps tendon insertion, which then can be secured to the bicipital tuberosity using a distal biceps button or other fixation technique. Tension is set with the elbow in 90° of flexion and 60° of supination. The patient is placed in an orthosis with the elbow flexed to 90° after surgery with the forearm supinated for 2 weeks. Immobilization continues for an additional 4 weeks; isometric contractions are started in the orthosis. At 8 weeks, resistive elbow flexion range of motion exercises are started. Recovery of 75% of contralateral elbow flexion strength has been reported. However, there may only be modest gains in supination and flexion contractures of 10° to 15° can occur (Video B; available on the *Journal*'s Web site at www.jhandsurg.org).[19]

FREE FUNCTIONING MUSCLE TRANSFER

In cases in which the biceps is severely damaged or denervated, transfer of a gracilis muscle from the medial thigh can give excellent results in terms of flexion and extension. Utilized primarily for reconstruction of Volkmann ischemic contracture and to manage brachial plexus and cervical spine injuries, this muscle also works well for reconstruction of an avulsed biceps muscle and tendon (Fig. 6). It has

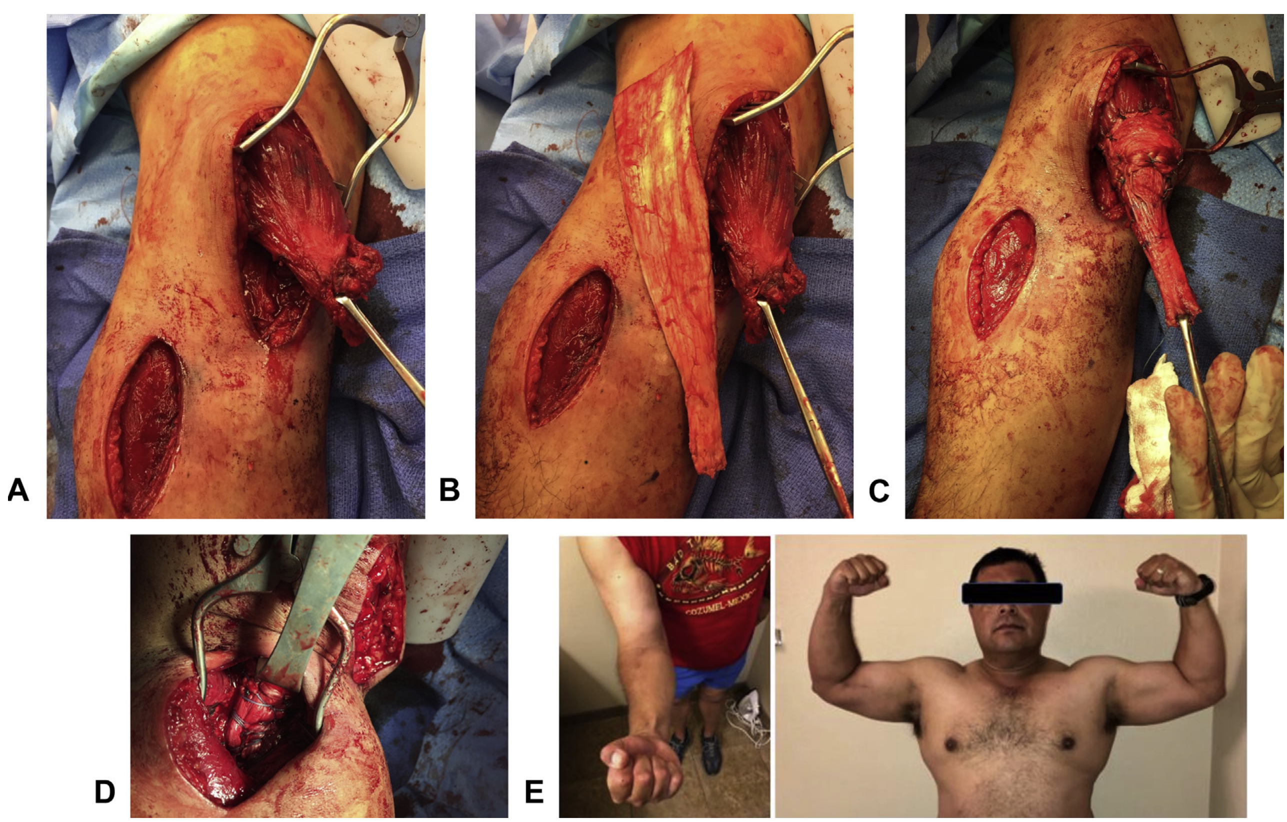

FIGURE 4: A 53-year-old man, right-handed police officer presents with a 3-month-old distal biceps tendon tear with proximal retraction on examination. **A** Intraoperative evaluation demonstrates minimal biceps tendon stump. **B** Achilles tendon allograft prior to inset. **C** Achilles tendon allograft after incorporation of the graft with the native biceps muscle. **D** Reinsertion. **E** Final clinical photographs.

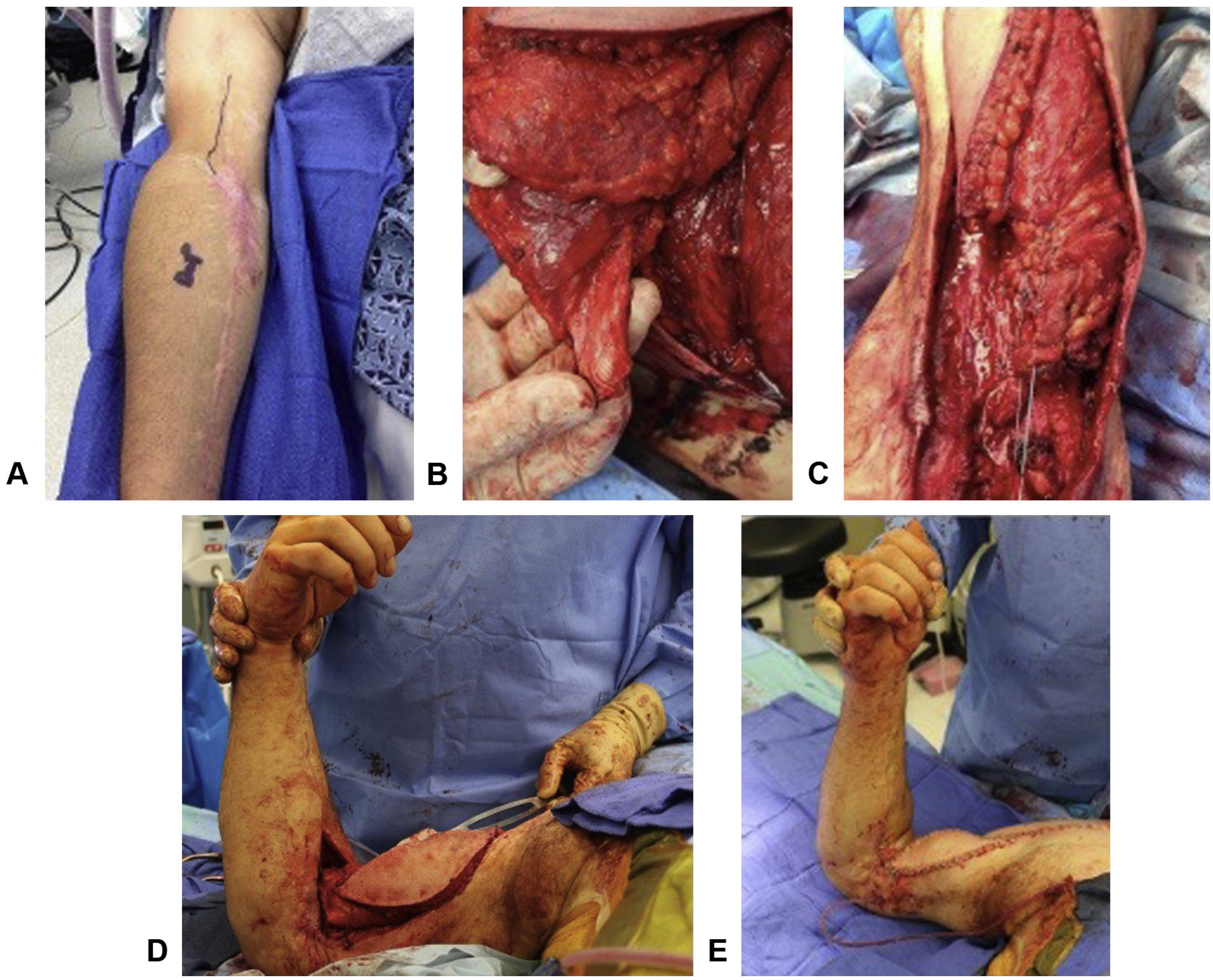

FIGURE 5: A 32-year-old right-handed man, status post severe crush injury, presents with loss of elbow flexion. Initial treatment included fasciotomies, brachial artery bypass, and biceps and brachialis debridement. He presented with grade M2 flexion of the elbow (he could flex the elbow with gravity eliminated). He elected for latissimus reconstruction for elbow flexion. **A** Preoperative incision. **B** The tendinous insertion was attached using a Krakow stitch to the coracoid process with bone anchors. **C** The elbow was approached through an S-shaped incision. The latissimus muscle was advanced into the defect and the distal portion of the latissimus muscle was tubed using Vicryl stitches. **D** The tension was set with the elbow flexed and forearm supinated. **E** Wound closure with skin graft. (Courtesy of Ramesh C Srinivasan, MD and David W Person, MD)

been widely utilized in the forearm[20] and the parameters for success are the same in reconstruction of the biceps. The muscle origin is attached to the acromion and the distal tendon is either woven into the biceps tendon stump or repaired to the bone as described previously.

The muscle should be placed in tension so that the muscle is tight with the elbow flexed 90°. There are numerous vessels available for anastomosis in the upper arm, and vascular access is generally not an issue. In terms of a donor nerve, the musculocutaneous is obviously ideal, but the flexor carpi ulnaris branch from the ulnar or the flexor carpi radialis branch from the median can be used as well with good results. After surgery, the elbow is kept flexed 90° for 6 weeks, and then gradually allowed to stretch over another month to a fully extended position. When not in therapy, the patient should be maintained in a 90° elbow-flexion orthosis.

Reinnervation of the muscle is usually accomplished within 6 months, and often the muscle will gain some tone prior to active motion. Usually by 8 months, there is active contraction of the muscle. In our experience, the muscle will often have grade 4 strength by 1 year. There may be small gains in strength over the course of the next year as well.

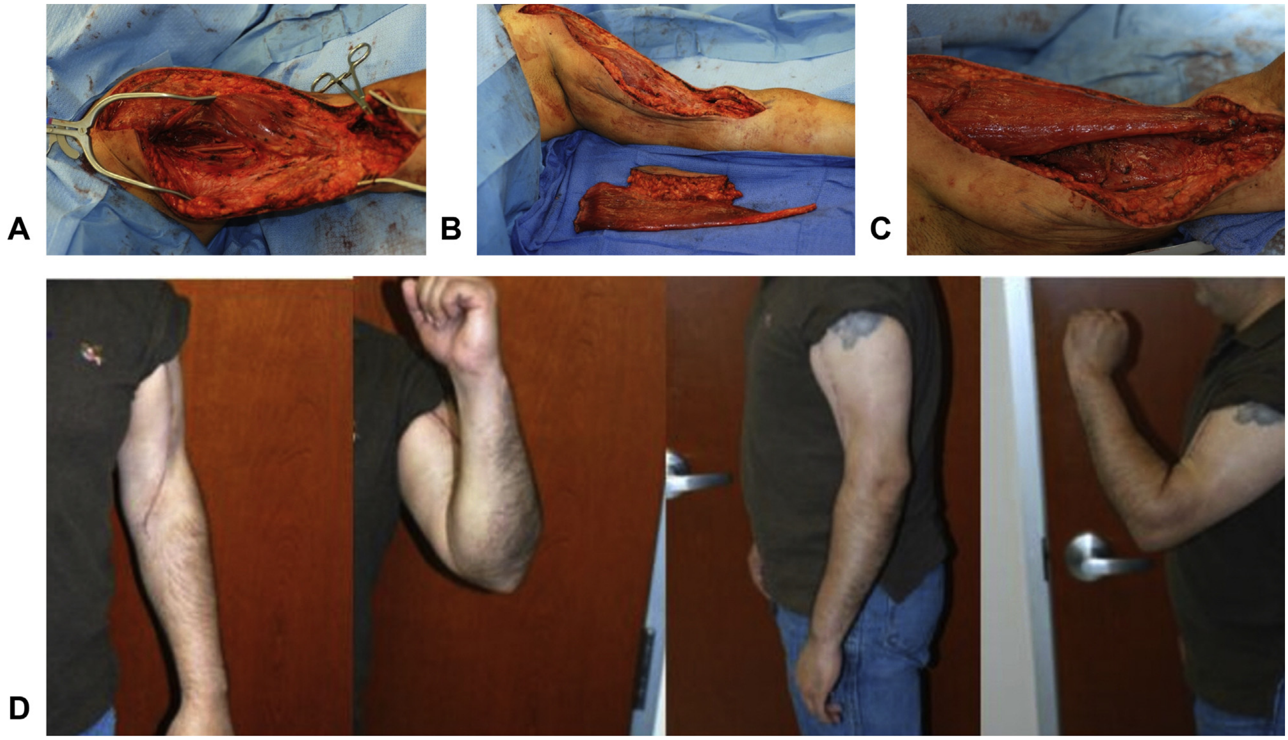

FIGURE 6: A 42-year-old man with a crush/avulsion injury of the biceps with subsequent gracilis reconstruction. **A** Wound bed preparation. **B** Gracilis harvest. **C** Gracilis inset. **D** Six months postoperative motion. (Courtesy of William C. Pederson, MD)

DISCUSSION

Distal biceps repair/reconstruction can restore near-normal flexion and supination strength. Clinical outcomes between single- and double-incision are comparable. Whereas the double-incision approach may result in a lower rate of cutaneous nerve neurapraxia and improve terminal supination strength and fatigue resistance, the single incision approach may have a lower risk of heterotopic ossification/synostosis formation. If adequate tendon is not present, Achilles tendon allograft, bipolar latissimus transfer, or free innervated gracilis are surgical reconstruction options that may be considered.

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JOURNAL CME QUESTIONS

Distal Biceps Tendon Repair and Reconstruction

1. What loss of supination strength can be expected with nonsurgical treatment of a distal biceps tendon tear?
   a. 10%
   b. 20%
   c. 30%
   d. 40%
   e. 50%

2. What nerve has NOT been reported to be injured after distal biceps tendon repair?
   a. Posterior interosseous nerve (PIN)
   b. Lateral antebrachial cutaneous nerve (LABCN)
   c. Superficial radial nerve (SRN)
   d. Ulnar nerve

3. Which complication is more common with a single-incision versus double-incision surgical approach for distal biceps tendon repair/reconstruction?
   a. Heterotopic ossification
   b. Synostosis
   c. Lateral antebrachial cutaneous nerve (LABCN) neurapraxia
   d. Wound dehiscence

4. Which reconstructive graft has been reported for distal biceps tendon reconstruction?
   a. Flexor carpi ulnaris
   b. Latissimus
   c. Groin flap
   d. Radial forearm flap

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