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A Muscle-Splitting Approach to the Ulnar Collateral Ligament of the Elbow

Neuroanatomy and Operative Technique

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ABSTRACT

The standard surgical approach for repair or reconstruction of the ulnar collateral ligament of the elbow involves lifting off of the tendon of the common flexor bundle at its origin on the medial epicondyle. However, a more limited muscle-splitting approach may be feasible. A muscle-splitting approach is less traumatic to the flexor-pronator muscle mass, and it could decrease operative time and lessen immediate morbidity after surgery. A proposed muscle-split through the common flexor bundle extends from the medial humeral epicondyle to a point distal to the tubercle of the ulna such that repair or reconstruction can be performed on the ulnar collateral ligament. To examine the feasibility of this approach, we performed a study combining anatomic dissections with clinical observations. We dissected 15 fresh-frozen adult cadaveric elbows to examine the neuroanatomy of the medial side of the elbow. All pertinent nerves were identified and mapped. From these data, we defined a "safe zone" for a muscle-splitting approach to the ulnar collateral ligament that allows adequate room for repair or reconstruction of the ligament without risking denervation of the surrounding musculature. The safe zone extends from the medial humeral epicondyle to approximately 1 cm distal to the insertion of the ulnar collateral ligament on the tubercle of the ulna. Twenty-two patients with ulnar collateral ligament tears underwent either a direct repair or a reconstruction of the ligament using the proposed muscle-splitting approach. With a minimum followup of 1 year, there was no clinical evidence of muscle denervation. From the combined anatomic study and clinical data, we believe that a less traumatic muscle-splitting approach to the ulnar collateral ligament affords a safe and simple surgical approach for repair or reconstruction of the ligament.

As originally described by Jobe et al.,[8] the standard surgical approach for repair or reconstruction of the anterior band of the ulnar collateral ligament (UCL) of the elbow involves transection and lifting off of the tendon of the common flexor bundle and a part of the pronator teres muscle at its origin on the medial humeral epicondyle. This approach has provided a safe and reliable method for exposing the UCL and its surrounding bony anatomy to perform ligament reconstructive procedures. However, our clinical experience has led us to believe that a more limited, less traumatic muscle-splitting approach to the UCL can be used, thus preventing the need to take down—and subsequently repair—a portion of the origin of the common flexor bundle. In the initial description of the surgical technique for ligament reconstruction by Jobe and coworkers,[8] a fascial split was made over the UCL's anterior band to assess the ligament's integrity. Subsequently, Jobe and El Attrache[7] have demonstrated that it may not always be necessary to take down the common flexor bundle and that ligament repair or reconstruction may be possible solely through the muscle-split. We wish to better define both the anatomic guidelines for positioning the muscle-split, as well as the distal extent to which the split can be carried, to determine its potential use as the primary means of exposure for either ligament repair or reconstruction.

A muscle-splitting approach is less traumatic to the flexor-pronator muscle mass and could potentially decrease operative time and lessen immediate morbidity after surgery. To show the efficacy of an intramuscular-splitting approach to the UCL, a study must demonstrate that the surgical approach is safe and technically feasible

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and that adequate exposure for repair or reconstruction of the ligament has been obtained.

To determine the safe limits of proximal and distal extension (thus preventing muscular denervation), it must be demonstrated that the muscle-split is either sufficiently distant from the actual sites of muscular innervation or that it is essentially within an "internervous" plane. In reviewing the literature, there have been studies defining the course of the median and ulnar nerves, their branching patterns, and their internal anatomies.[1,4,6,9-11,13] Furthermore, some studies have measured the site of muscular innervation in relation to generalized bony landmarks (e.g., the medial epicondyle),[1,4,9,13] but to our knowledge no study has looked specifically at the muscular innervation in relation to the UCL and its associated bony landmarks.

This study examines the neuroanatomy of the medial side of the elbow using cadaveric dissections and, from these examinations, the study defines a safe zone for a proposed muscle-splitting approach to the UCL. Twenty-two patients who had UCL tears subsequently underwent either repair or reconstruction of the ligament using the muscle-splitting approach. The intraoperative and postoperative clinical findings were examined to better define the role of the proposed surgical approach.

MATERIALS AND METHODS

First, 15 fresh-frozen cadaveric adult elbows were dissected to examine the neuroanatomy in the region of the flexor-pronator muscle mass and the anterior band of the UCL. The dissections were performed with the cadaveric elbows in slight flexion and through a standard longitudinal curvilinear skin incision centered over the medial epicondyle. The skin and subcutaneous tissue were carefully removed and branches of the medial antebrachial cutaneous nerve were identified. The positions of these branches were noted in relation to the medial epicondyle of the humerus and to the fascial line overlying the UCL (i.e., the site of the proposed muscle-split that is a fascial line in the posterior one third of the common flexor mass, extending from the medial epicondyle to the sublime tubercle of the ulna). A fascial raphe is generally identifiable between the ulnar-innervated flexor carpi ulnaris muscle and the median-innervated common flexor mass. The muscle-split is within this raphe or in the most anterior fibers of the flexor carpi ulnaris muscle when this raphe cannot be definitively identified.

Next, the ulnar nerve was identified proximal to the elbow, the cubital tunnel was unroofed, and the nerve was followed distally for approximately 6 cm. Using loupe magnification (original magnification, ×2.5), motor branches were identified and their positions from the medial humeral epicondyle and the sublime tubercle of the ulna were measured and mapped.

The median nerve was then identified proximal to the elbow and its course was traced distally. To follow the nerve and its branches sufficiently past the area of interest, the flexor pronator muscle mass was partially detached at its origin on the medial humeral epicondyle and supracondylar ridge, and distally the muscle mass was transected 12 cm beyond the elbow. The entire flexor-pronator muscle mass was then reflected toward the ulna (Fig. 1). This action exposed the undersurface of the muscles and, with this, the nerve branches were visualized as they entered the muscles. The sites of innervation were marked with spinal needles placed from deep to superficial, such that the needles exited the muscle roughly perpendicular to its surface (Fig. 2A). The muscle mass was then brought back to its native location and the origin of the common flexor bundle was sutured to its anatomic location on the medial epicondyle (Fig. 2B). The distances and positions of the needles were then measured and mapped in relation to three landmarks: 1) the medial humeral epicondyle, 2) the sublime tubercle of the ulna, and 3) the site of the muscle-split itself (Fig. 3).

The aforementioned data were then combined and a safe zone was created for performing a UCL-exposing muscle-split. This zone was such that exposure of the

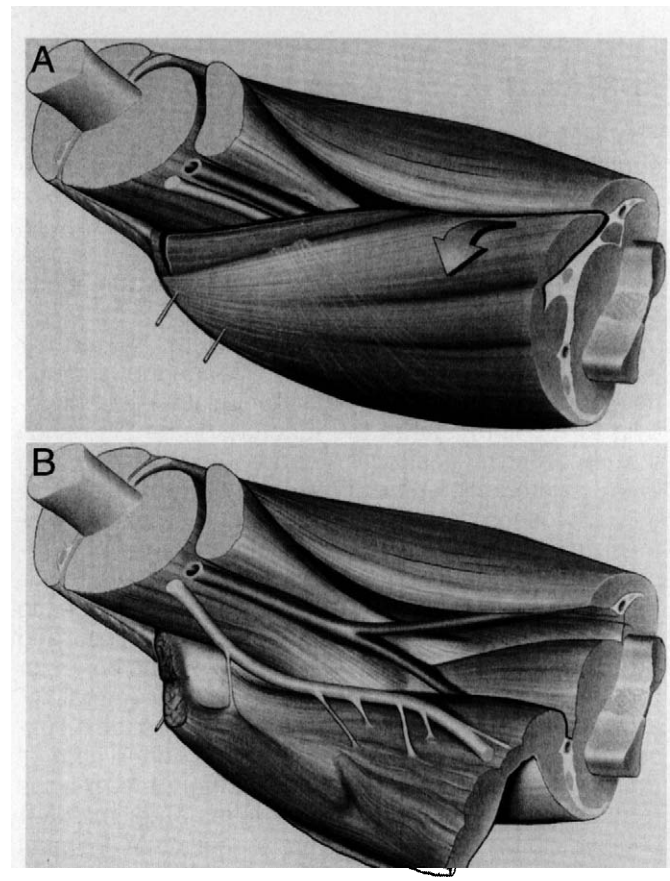

Figure 1. A, cadaveric dissection of the median nerve. The pronator teres muscle has been divided at its origin and the entire common flexor mass has been transected approximately 12 cm distal to the elbow. The medial epicondyle and the sublime tubercle of the ulna are marked with K-wires. B, the flexor mass has been reflected toward the ulna to expose the undersurface of the musculature for examining and marking the points of innervation of the median nerve branches.

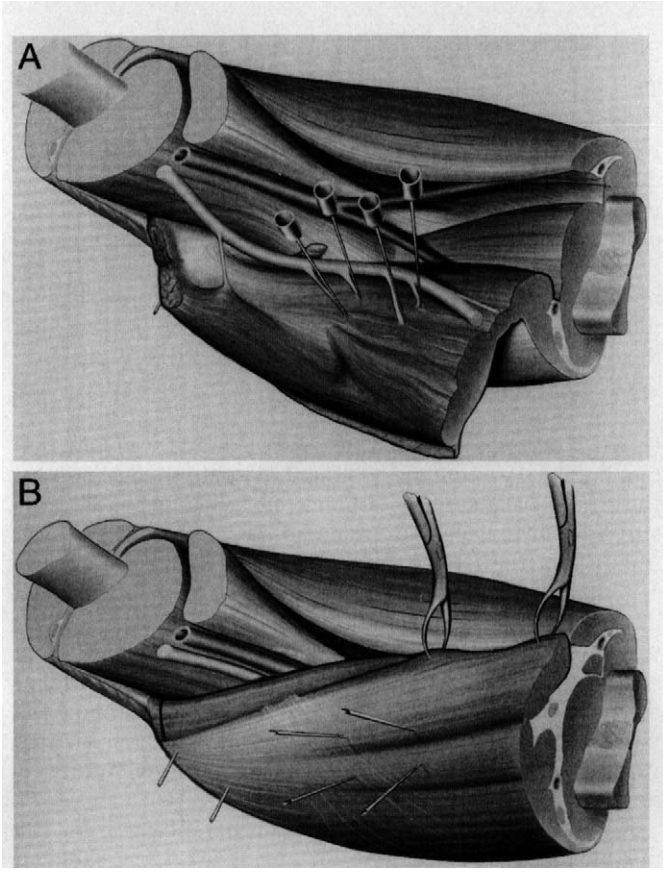

Figure 2. A, the median nerve's sites of innervation are marked with spinal needles from deep to superficial. B, the common flexor mass has been returned to its anatomic location, and distances are measured from the sites of innervation (as marked with needles) to the medial epicondyle and sublime tubercle (as marked with K-wires).

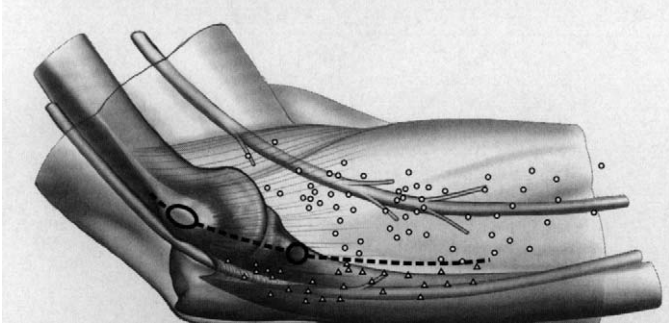

Figure 3. The plotted points of innervation of the branches of the median nerve (circles) and ulnar nerve (triangles). The site of the muscle-split extends primarily within the area of watershed innervation.

medial epicondyle, the anterior band of the UCL, and the sublime tubercle would allow sufficient room for either repair or reconstruction of the UCL without risking denervation of the surrounding muscle groups.

Twenty-two patients with UCL tears subsequently underwent either surgical repair or reconstruction of the ligament using the muscle-splitting approach. Care was taken to avoid any sharp exposure deep to the fascial split, and blunt dissection was routinely performed approximately 1 cm beyond the sublime tubercle. Fifteen patients had chronic UCL tears and 7 patients had acute traumatic episodes that accounted for their UCL injuries. The patients included 21 men and 1 woman (range, 17 to 24 years). Each injury involved the dominant upper extremity. Six patients underwent traditional reconstructions, 5 had augmented repairs, and 11 underwent primary repairs using suture-anchors. The ulnar nerve was not routinely transposed. Follow-up examinations averaged 2 years, 2 months (range, 13 months to 4 years). Each patient observed the standard rehabilitation protocol for UCL reconstruction after surgery.

RESULTS

In the superficial dissection, sensory branches of the medial antebrachial cutaneous nerve variably crossed the site of the muscle-split at points from 3 to 60 mm distal to the medial epicondyle. These sensory branches were preserved with identification and retraction.

The ulnar nerve is located just posterior to the site of the proposed approach and, thus, it is imperative to identify the nerve before proceeding with the split. There were no motor branches that directly crossed the site of the muscle-split, but in three specimens there were innervating branches approximately 1 cm distal to the sublime tubercle, which were roughly in line with the split. These motor branches were easily preserved with blunt dissection through the muscle mass and by taking care to remain subperiosteal when exposing the bone distal to the sublime tubercle. Furthermore, seven specimens had a branch innervating the flexor carpi ulnaris muscle proximal to the sublime tubercle. However, these branches were all more than 5 mm posterior to the line of the split and they were directed toward the olecranon head of the flexor carpi ulnaris muscle and, thus, they were preserved with posterior muscle retraction. In all of our specimens, the first motor branch went to the flexor carpi ulnaris muscle, and its point of innervation averaged 3.2 cm distal to the medial epicondyle (range, 1.5 to 5.6 cm). In general, the olecranon head of the flexor carpi ulnaris muscle was innervated before the condylar head, with the branches to the olecranon head directed more posteriorly. We also noted that in 5 of 15 specimens there were small branches innervating the elbow joint capsules. The small branches were routinely sacrificed to fully explore the nerves more distally.

The median nerve sends a variable number of innervating branches to the proximal portion of the flexor pronator muscle mass. All branches were anterior to the site of the muscle-split and, therefore, no branch was in danger during the split. Of the branches to the common flexor mass (we excluded those to the pronator teres muscle because they were consistently anterior and proximal to the area of interest), the most proximal branch innervated the

muscle mass at an average of 3.1 cm (range, 1.9 to 4.3) distal to the medial epicondyle. In relation to the muscle-split, the closest branch at the level of the medial epicondyle was 1.8 cm anterior to the site of the fascial split, and at the level of the sublime tubercle, the closest branch was 0.9 cm anterior to the split. More distally, three specimens had a branch that approached the distal extent of the split. These branches were 1.1, 1.3, and 1.3 cm distal to the sublime tubercle, but they were anterior to an extension of the split by 0.4, 0.6, and 0.4 cm.

From the aforementioned data, we defined a safe zone for a muscle-splitting approach to the UCL (Fig. 4). This zone is wider in the radioulnar dimension proximally and it narrows distally. The zone runs from the medial epicondyle to approximately 1 cm distal to the sublime tubercle of the ulna. If dissection extends beyond this safe zone, there is a risk of injury to the most proximal branches of the ulnar or median nerves or both. (This branch would generally be to the flexor carpi ulnaris muscle because the UCL insertion on the sublime tubercle of the ulna lies under the anterior most fibers of this muscle; however, if extended farther distally, branches to the flexor digitorum profundus muscle would be encountered in the region of its ulnar and median nerve "watershed" innervation.)

Five of the cadaveric specimens were examined to test the feasibility of performing ligament reconstruction using bone tunnels. A muscle-split was made and carried 1 cm distal to the ulnar tubercle. Bone tunnels were made using the technique described by Jobe et al.[8] Adequate exposure was obtained in all specimens.

Twenty-two patients with UCL tears underwent surgical repair or ligament reconstruction using the proposed muscle-splitting approach. With a minimum followup of 1 year, no patient had any clinical evidence of neuropathy during manual motor testing or two-point sensory examination.

Surgical Technique

The proposed approach uses either a standard medial incision centered over the UCL or a posterior incision raising an anterior flap to avoid branches of the medial antebrachial cutaneous nerve. The site of the proposed muscle-split is through the posterior one third of the common flexor bundle, within the most anterior fibers of the flexor carpi ulnaris muscle. This is essentially at the raphe between the flexor carpi ulnaris and palmaris longus muscles superficially and the flexor carpi ulnaris and flexor digitorum superficialis muscles slightly deeper. This raphe is more easily identified in the distal portion of the incision because proximally the muscles have a coalesced tendinous origin. The origin extends from the medial humeral epicondyle to a point distal to the insertion of the UCL on the sublime tubercle of the ulna (Fig. 5). This site for the muscle-split was chosen for two simple reasons. First, the UCL lies directly under this region of the common flexor mass (as Davidson and coworkers[3] have demonstrated in various degrees of elbow flexion). Second, the anterior portion of the flexor bundle (the flexor carpi radialis, palmaris longus, and flexor digitorum superficialis muscles) is innervated by the median nerve, and the posterior portion (the flexor carpi ulnaris muscle) is innervated by the ulnar nerve, thus making use of the internervous plane.

After making the fascial incision extending from the medial humeral epicondyle to a point overlying the suspected sublime tubercle (approximately 3 to 4 cm distally), the muscle is bluntly split down to the level of the UCL. The muscle-split can safely be extended 1 cm distal to the UCL's insertion on the sublime tubercle of the ulna. Subperiosteal dissection is performed to fully expose the ulna for placement of bone tunnels, and the retractors can be

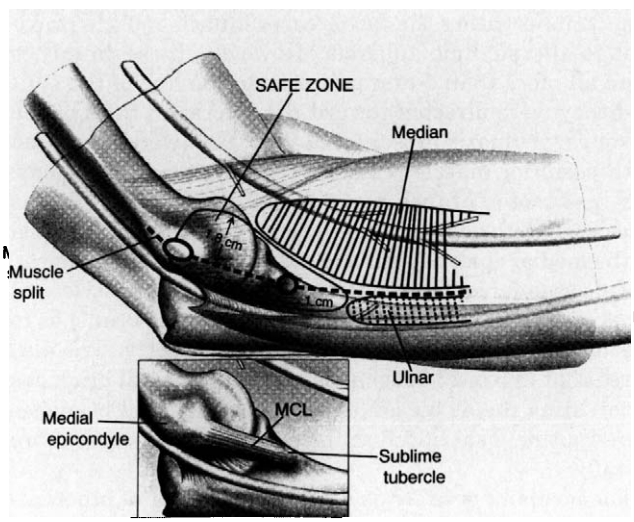

Figure 4. The "safe zone" for a muscle-splitting approach to the UCL. The shaded areas represent the primary regions of innervation for the median and ulnar nerves. The inset shows the UCL, the related bony landmarks, and their proximity to the ulnar nerve lying immediately posterior.

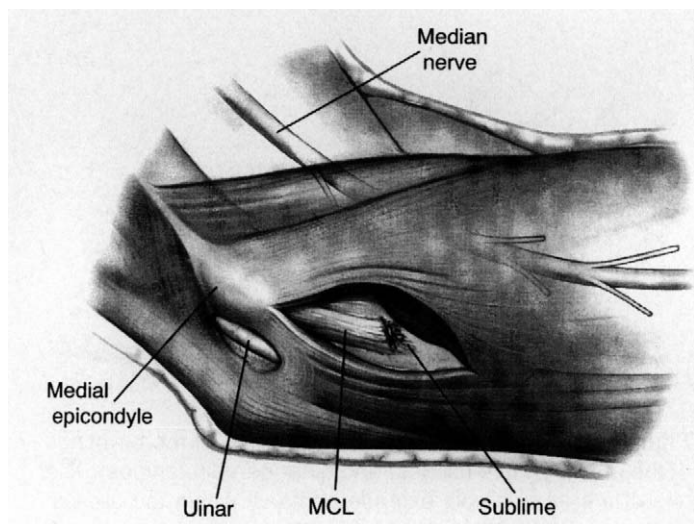

Figure 5. The site of the muscle-split. It extends from the medial epicondyle of the humerus to approximately 1 cm distal to the UCL's insertion on the tubercle of the ulna. The site is through the posterior one third of the common flexor mass.

left in place to protect the underlying ulnar nerve while the tunnels are created. Full exposure of the ligament and its bony attachments is thereby obtained such that either an augmented repair or a formal reconstruction of the UCL can be performed. After this, the fascia is repaired with a running 2.0 Vicryl suture (Ethicon Inc., Somerville, New Jersey).

DISCUSSION

When performing the standard surgical approach to the UCL as described by Jobe et al.,[8] the actual transection and lifting off of the common flexor mass is generally preceded by a muscle-split over the UCL to assess the ligament's integrity. The purpose of this study was to determine the extensile nature of the muscle-split and to provide intraoperative guidelines for defining the distal extent of the split. Based on the cadaveric specimens we examined, the defined safe zone easily allows complete exposure of the anterior band of the UCL and, thus, allows for direct repair. To perform ligament reconstruction, a small amount of muscle must be stripped subperiosteally in the region of the sublime tubercle to make the bone tunnels. This may require an additional 1 cm of split beyond the sublime tubercle to comfortably perform the reconstruction. Again, based on this study, adequate room was obtained.

The muscle-splitting approach offers several advantages over taking down part of the common flexor mass. First, the operative time may be lessened because takedown and repair of the flexor mass is unnecessary. Second, a muscle-split is less traumatic than taking down the tendon at its origin, and there may be less morbidity associated with pain and patient rehabilitation after surgery. (These outcomes were not specifically looked at in the present study; therefore, a randomized, controlled study will be needed to examine these areas.) Third, this approach is practical in that the UCL lies directly under the region of the anterior flexor carpi ulnaris muscle and not under the anterior portion of the common flexor bundle. Thus, transection and takedown of the common flexor bundle does not significantly increase exposure of the UCL itself. Fourth, it is unnecessary to routinely mobilize and transpose the ulnar nerve if either a direct or augmented repair of the ligament is performed. However, this point is controversial and perhaps depends more on a patient's symptoms before surgery, as well as the surgeon's impression that prophylactic transposition may benefit a patient who is in a population in which there is a high incidence of ulnar neuritis.[2,5]

This study does have limitations that make it impossible to provide absolute boundaries. First, there are anatomic variations both in the number of nerve branches as well as the absolute distances where they innervate the muscle mass.[6,9,12,13] However, based on our dissections, there was consistently an area of musculature where no innervating branches crossed, and this area should be safe for an intramuscular split provided care is taken when extending the split more than 1 cm beyond the sublime tubercle. Second, the pattern of nerve arborization was not specifically investigated in the specimens examined, but it would likely show variability. Given that the muscle-split is within a watershed area of innervation and that no actual branches were encountered during the split (neither in the cadaveric specimens nor the surgical patients), proceeding with careful blunt dissection will ensure safety in this proximal region of musculature. Third, the clinical ramifications of violating a single branch are unknown. Because the majority of the muscles within the flexor group receive innervation through multiple nerve branches, it is possible that there may be no clinical impairment noted even if the most proximal portion of the muscle mass is denervated. Our patient evaluation relied on the testing of manual motor strength and sensation, and it may have been helpful to have other clinical measurements (i.e., circumferential measurements of the forearms before and after surgery and at followup, or objective measurements of strength) or to have performed electrodiagnostic studies after surgery. However, given the complete lack of clinical neuropathy in our patients, further investigation was not routinely performed.

It is important to point out that this study was not designed to examine the efficacy of the various methods of surgically managing UCL tears (i.e., traditional reconstruction versus augmented reconstruction versus primary repair); instead, this study focused on showing the usefulness of the surgical approach.

CONCLUSIONS

We evaluated the use of a muscle-splitting approach through the posterior one third of the common flexor mass (i.e., the most anterior fibers of the flexor carpi ulnaris muscle) for providing complete exposure of the anterior band of the UCL and its related bony landmarks. Through a cadaveric study, we defined the safe zone and the anatomic landmarks for performing a muscle-split. In a cohort of 22 patients, the approach was used for reconstruction or repair of the UCL and proved to provide safe, simple, and complete access for either surgical procedure.

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