Elbow Ulnar Collateral Ligament Reconstruction Using a 4-Strand Docking Plus Technique

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Abstract: The "Docking Plus" technique for elbow ulnar collateral ligament (UCL) surgery is described in the following text and video. Depite the general success of UCL surgery, significant rates of retear and failure of return to competition persist. Hypothesized reasons for UCL surgery failure include insufficient graft strength (midsubstance tears), insufficient graft tensioning (functional UCL insufficiency, valgus extension overload), and insufficient healing of graft to bone (proximal avulsions). This technique is meant to incorporate the best aspects of the previously described techniques for UCL reconstruction to create a larger, stronger, better-tensioned graft with a larger healing surface area to bone, a lower retear rate, and a lower risk of complications. The Docking Plus technique has been used since 2012.

Since Dr Frank Jobe performed Tommy John's elbow ulnar collateral ligament (UCL) reconstruction in 1974,[1] there have been multiple modifications to Jobe's original technique. These have led to the widespread use of the "Modified Docking" techniques,[2-4] and now, the Docking Plus technique.[5]

The changes have included splitting the flexor pronator muscle,[6-8] subcutaneous (rather than submuscular) transposition of the ulnar nerve,[6,7,9] the Docking technique with its narrower epicondyle tunnels and alternate graft positioning,[9] discontinuation of obligatory ulnar transposition,[6] the advent and subsequent discontinuation of obligate elbow arthroscopy,[7,10,11] use of alternative fixation (e.g. interference screws, cortical buttons),[2,12,13] and Modified Docking techniques that allow for the use of additional strands of graft.[2-4]

The data on rates of postoperative return-to-pitch (as low as 67% in Major League Baseball)[14] and revision surgery rates (15% in Major League Baseball 1974-2004)[15] indicate that there is room for improvement in outcomes and in current UCL reconstruction techniques.

Recent studies of Major League Baseball (MLB) pitchers have shown return-to-pitch rates of 82%,[16] 83%,[17] and 87%[18] when the outcome is a single game pitched postoperatively at the MLB level. However, this measure drops to 67% return-to-pitch[14] when the outcome is 10 games in a single season at the MLB level postoperatively. The data are mixed on performance postoperative versus preoperative (e.g. by earned run average, innings pitched per season, and velocity).

There have been at least 20 surgeon-reported case series published 1986-2016. In these studies, patient reported return to pitch rates, for the same level of competition or one level below, are consistency reported from 80% to 90%. Recent high-volume case series demonstrated a return to play at the same level or higher in 90% of 228 pitchers and 83% of 256 baseball players[19] and 92% of 74 pitchers and 95% of 76 baseball players.[20]

Hypothesized reasons for UCL surgery failure include insufficient graft strength (midsubstance tears), insufficient graft tensioning (functional UCL insufficiency, valgus extension overload), and insufficient healing of graft to bone (proximal avulsions). The Docking Plus technique was developed to minimize these risks of failure. The Docking Plus offers (1) more autograft length, similar to the Modified Jobe technique of Paletta and Wright; (2) a higher amount of surface area for healing, akin to the Jobe technique; and (3) improved tensioning without the risk of graft bottoming out. Thus, the Docking Plus

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technique utilizes the best components of the Jobe and Docking techniques.

The incidence of UCL injury and resultant surgery continues to increase across all ages of throwing athletes,[21,22] making successful surgery increasingly important from a population health perspective.

The "Docking Plus" technique was developed to use more and longer strands of autograft in reconstruction. There are clear benefits and pitfalls to this technique (Table 1). It has been used since biomechanical[4] testing in 2012. The technique is detailed in the accompanying text and Video 1.

Technique

Positioning

The patient is positioned supine with the operative extremity on a hand table. A bump is placed under the operative-side scapula to externally rotate the shoulder. A nonsterile tourniquet is placed around the upper arm. The upper extremity is prepped and draped. The tourniquet pressure is elevated to 250 mmHg. The surgeon is positioned on the axilla-side of the operative extremity.

Graft Harvest

A 1-cm transverse skin incision is made in the distal wrist flexion crease overlying the palmaris longus. Gentle subcutaneous dissection with Metzenbaum scissors and an Adson forceps exposes and delivers the palmaris longus tendon from the incision. A small curved hemostat is placed deep to the tendon and pulls the tendon from the skin incision (Fig 1A). As this tension is applied, the tendon should be observed to elevate the skin throughout the distal third of the forearm in its correct anatomic position. If this anatomically correct prominence of the palmaris longus is not observed, dissect further to determine if the median nerve, flexor carpi radialis, or flexor carpi ulnaris has been mistakenly isolated.

A tagging horizontal mattress stitch is placed in the palmaris tendon using no. 0 Ethibond (Ethicon, Somerville, NJ) suture. Another 1-cm transverse skin incision is made overlying the palmaris tendon approximately 8 cm proximal to the first incision. The palmaris tendon is incised at its insertion and pulled from the more proximal skin incision (Fig 1B). A standard tendon stripper is used to harvest the

Table 1. Pearls and Pitfalls of the Docking Plus Technique of Elbow UCL Surgery

Pearls	Pitfalls
Palmaris harvest: Place upward tension on the tendon with a hemostat and look for the tendon to elevate the skin along the length of the forearm. This will confirm its identity.	Palmaris harvest: Avoid inadvertent harvest of the median nerve or the incorrect wrist flexor tendon.
Graft preparation: Narrow the graft as needed to 2.5 mm in width, although the docking limb can be wider. A length of 18 cm is sufficient for a 4-strand reconstruction.	Approach: Avoid the medial antebrachial cutaneous nerve. Don't worry about smaller cutaneous nerve branches, as mild peri-incisional sensation loss is well tolerated postoperatively.
Ulnar nerve management: Incise 1-2 cm of the Osborne ligament, enough to allow visualization, retraction, & protection of the ulnar nerve, but not so much to destabilize it. Use judicious indications for transposition.	Flexor mass split: Watch for an aberrantly anterior trajectory of the ulnar nerve. Pay attention to where the ulnar nerve dives between the heads of the FCU.
Flexor mass split: Make your incision in line with the tendinous raphe just anterior to the FCU.	Ulnar bone tunnels: Avoid making your bone bridge between the tunnels less than 1-1.5 cm, as this may cause a fracture. Have back-up fixation available.
Expose bony landmarks: Clear off the proximal ulna with a key elevator, make a full-thickness midline incision in the native UCL anterior bundle, and reflect the origin and insertion subperiosteally with a mini Beaver blade.	Humeral Bone Tunnels: Don't forget to protect the ulnar nerve. Use the handle of an Adson forceps to lightly retract and protect the nerve.
Ulnar bone tunnels: If the sublime tubercle is not clearly identifiable, mark the ulna 5-10 mm distal to the joint along the prominent medial ridge. Direct the drill angled 45° to the surface of the bone for these tunnels. Confirm the connection of tunnels by squirting saline through the tunnels with a bulb syringe.	
Humeral bone tunnels: Use a 4-mm burr to drill retrograde into deep, cancellous bone to avoid a fracture. The anterograde 2.7-mm tunnels should be positioned medial/superficial and lateral/deep on the proximal part of the epicondyle. Confirm the connection of tunnels by squirting saline through the tunnels with a bulb syringe.	
Graft Passage: Use passing sutures (aka "circles of trust") to ease the passage of graft.	
Graft Fixation: After the graft sutures are tied over the medial epicondyle, increase the strength of the construct by suturing together with a running stitch with no. 0 Ethibond the 4 strands of the reconstruction, plus any remaining native UCL ligament	

FCU, flexor carpi ulnaris; UCL, ulnar collateral ligament.

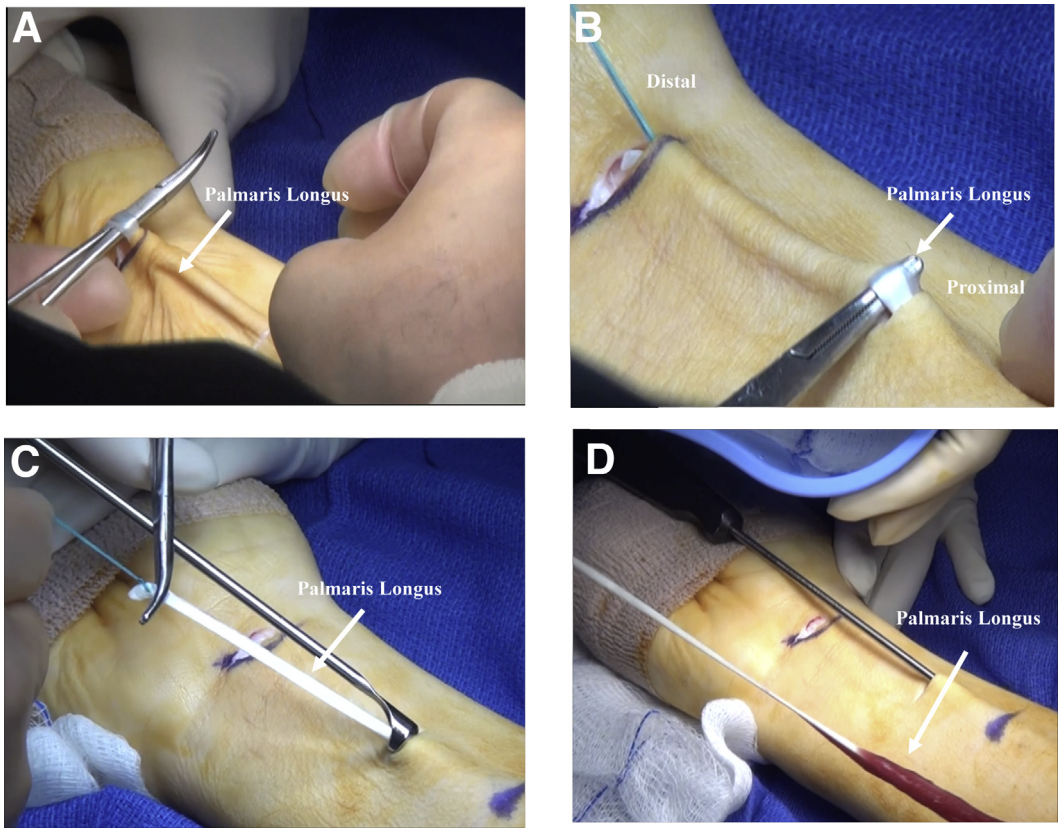

Fig 1. Patient is placed supine on an operative table with the right arm on a hand table, viewing the medial elbow. (A) A hemostat is placed deep to the palmaris longus tendon and used to pull the tendon from the skin incision. (B) Palmaris longus tendon is pulled from the proximal skin incision. (C) Tendon stripper is used to harvest the palmaris tendon. (D) Harvested palmaris tendon is assessed.

palmaris tendon through the proximal skin incision (Fig 1 C and D).

The palmaris autograft is then prepared on a graft preparation table. A temporary horizontal mattress stitch using a no. 0 Ethibond suture is placed in the proximal end of the tendon, and the graft is tensioned through the provisional no. 0 Ethibond stitches. The tendon is debrided with a key elevator and curved mayo scissors. Biceps tenodesis sizers (Arthrex, Naples, FL) are used to size the graft. As needed, the graft is narrowed to 2.5 mm in width, with the exception of the docking (short) arm of the graft, which may be wider because it will not go through a bone tunnel. A "Roman sandal" stitch using no. 2 Orthocord (DePuy Mitek, Raynham, MA) or no. 2 FiberWire (Arthrex) suture is placed in the terminal 25 mm of either end of the graft. The Ethibond stitches are cut out. The graft length is measured; 18 cm is sufficient for our standard 4-loop docking-plus reconstruction. In the exceedingly rare event that the graft is shorter than this, a 3-loop reconstruction is done.

Exposure—Skin and Subcutaneous

With the elbow flexed 30°, a longitudinal, curved 6-cm skin incision is made, centered just posterior to the medial epicondyle. It runs from 3 cm proximal to 3 cm distal to the medial epicondyle (Fig 2A). As dissection with Metzenbaum scissors is carried through subcutaneous tissue, caution is taken to avoid injury to the medial antebrachial cutaneous nerve (Fig 2B). This nerve traverses the incision approximately 2 cm distal to the medial epicondyle. Two Gelpi self-retractors are inserted and the medial epicondyle and ulnar nerve are visualized.

Assessment of the Ulnar Nerve

The ulnar nerve is not routinely decompressed or transposed. Enough of Osborne's ligament is incised to allow direct visualization of the ulnar nerve posterior to the medial epicondyle (Fig 3). This will allow retraction and protection of the nerve when the humeral bone tunnels are prepared later in the procedure.

Split of the Flexor Mass

The flexor-pronator muscles and tendons are examined for any pathology (e.g. partial, full-thickness tears). Attention is paid to where the ulnar nerve dives deep between the 2 heads of the flexor carpi ulnaris. Care is taken to avoid working sufficiently posterior in the flexor mass to endanger the ulnar nerve. A longitudinal

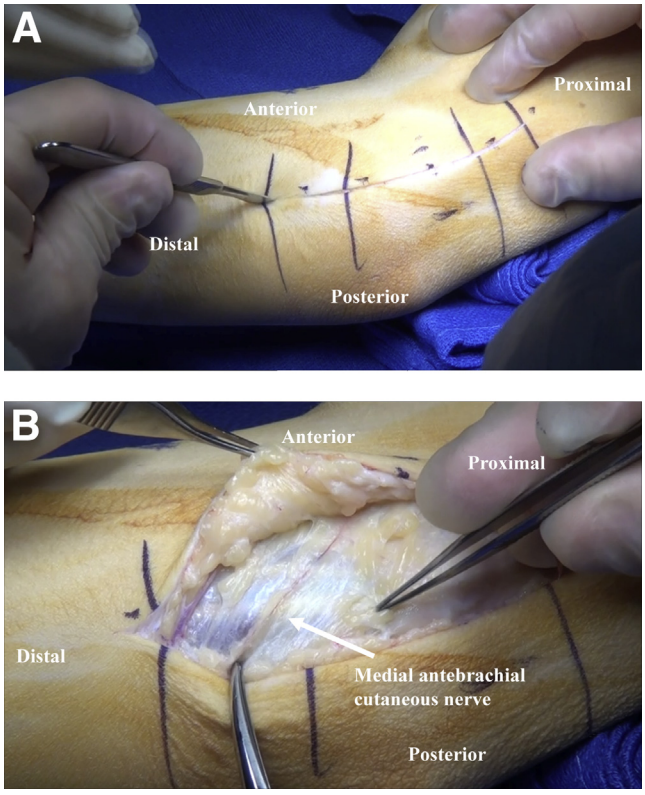

Fig 2. Patient is placed supine on an operative table with the right arm on the hand table, viewing the medial elbow. (A) An incision is made from 3 cm proximal to 3 cm distal of the medial epicondyle. (B) The medial antebrachial cutaneous nerve is located and retracted.

incision is made in the flexor/pronator fascia in line with the tendinous raphe anterior to the flexor carpi ulnaris (Fig 4A). Deep to the fascial incision, in an internervous plane (between the median and ulnar nerve distributions), the muscle fibers are split (Fig 4B). Care is taken to avoid the ulnar nerve deep and posterior to the flexor pronator mass. The proximal ulna is visualized and a key elevator is used to clear off its surface.

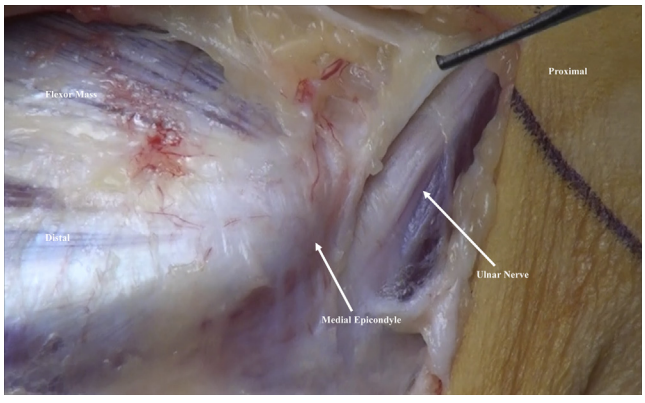

Fig 3. With the patient supine and his right arm on the hand table, looking inferiorly from medial to lateral. Osborne's ligament is partially released, allowing excellent visualization of the ulnar nerve in the cubital tunnel.

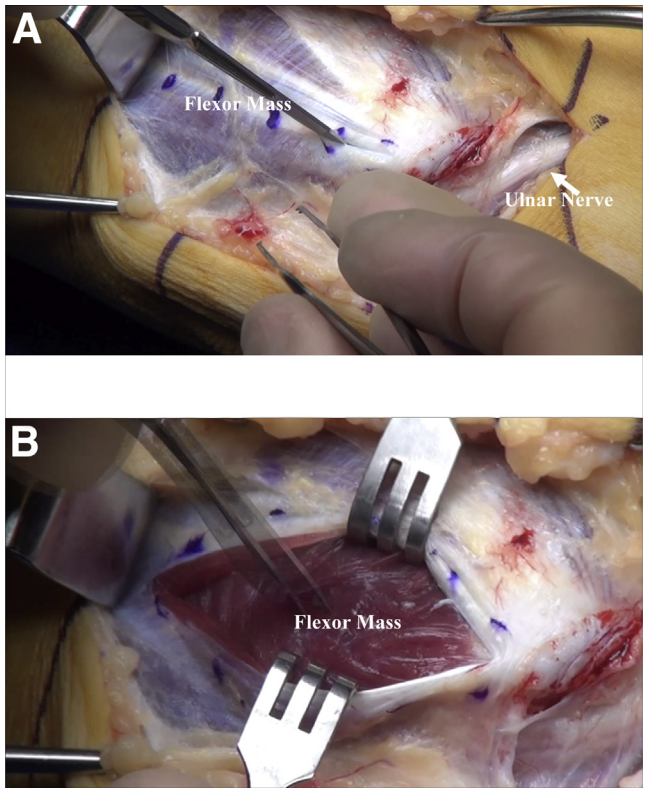

Fig 4. Patient is supine with right arm on the hand table, viewing the medial elbow. (A) The flexor/pronator fascia is split in line with the tendinous raphe anterior to the flexor carpi ulnaris. (B) The muscle fibers of the flexor mass are split.

Split of the Native Ulnar Collateral Ligament

The UCL is inspected. The ligament may be torn proximally, distally, or midsubstance. With chronic injuries, only a remnant may be in place or no ligament at all may be visible superficial to the ulnohumeral joint capsule. Valgus stress on the elbow is performed and often shows gapping greater than 2 mm at the ulnohumeral joint.

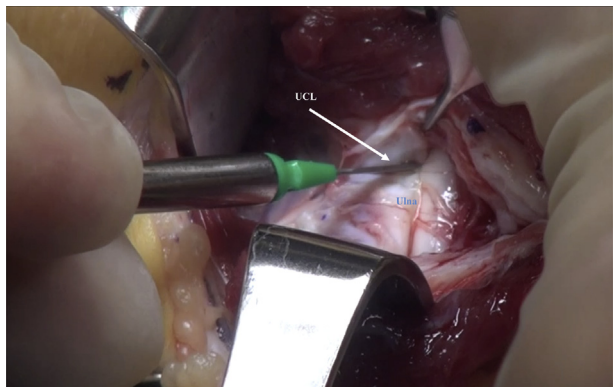

Fig 5. Patient is supine with right hand on the hand table, viewing the medial elbow. The ulnar collateral ligament is split with a longitudinal midline incision.

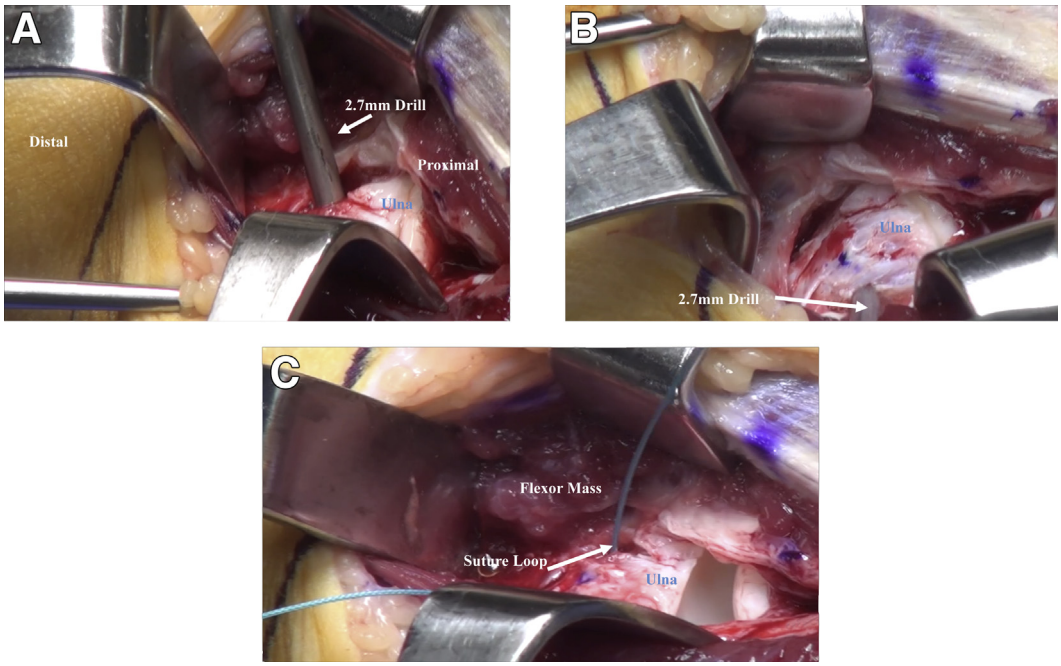

Fig 6. Patient is supine with arm on the hand table, viewing the medial elbow. Tunnels are made with a 2.7-mm drill bit in the (A) anterior and (B) posterior aspect of the sublime tubercle. (C) Hewson suture passer, bent acutely, is used to place a passing suture loop of no. 0 Ethibond through the 2 holes in the ulna.

A longitudinal midline incision is made in the UCL (Fig 5). Inspection of the ligamentous tissue usually shows signs of intrasubstance degradation. This midline incision is carried full-thickness in depth and through the ligament's origin and insertion. Any intact origin or insertion is peeled back via subperiosteal dissection (using a long-handled Beaver 4.0-mm blade; Smith & Nephew, London, UK). This allows for appropriate

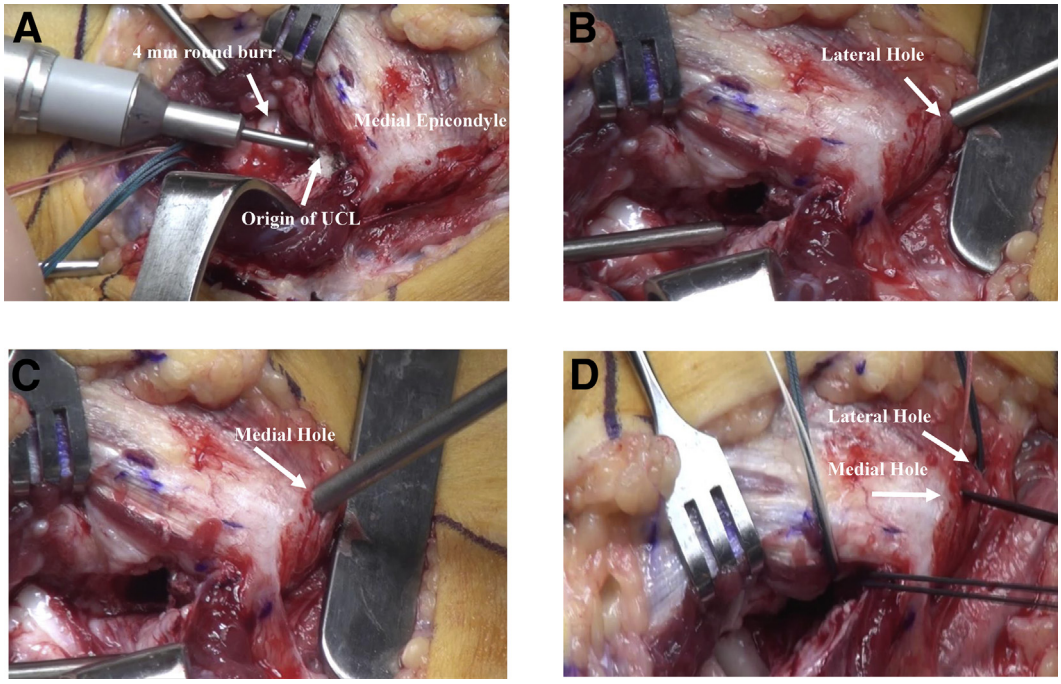

Fig 7. Patient is supine with right arm on the hand table, viewing the medial elbow. (A) A 4-mm round burr, 1.5 cm long, is advanced retrograde 1.5 cm to create a unicortical socket at the anatomic origin of the ulnar collateral ligament in the medial epicondyle. A 2.7-mm drill is used to create unicortical holes (B) more medial/superficial and (C) more deep/lateral. (D) A Hewson suture passer is used to place 2 separate suture loops of no. 0 Ethibond through the distal socket in the medial epicondyle and out either the medial or the lateral proximal tunnels.

exposure of surgical landmarks in the proximal ulna and medial epicondyle of the humerus.

Creation of Ulna Bone Tunnels

The bony prominence of the sublime tubercle is usually clearly identifiable. If it is not, the ulna is marked 5 to 10 mm distal to the ulnohumeral joint along the prominent medial ridge of bone. A 2.7-mm drill is used to make 2 unicortical holes 1 to 1.5 cm apart, one anterior and one posterior to the sublime tubercle (Fig 6 A and B). Attention is paid to directing the drill sufficiently deep (i.e. avoidance of skiving). The holes are deepened and widened with a no. 2-0 curette and then a no. 0 curette, ensuring convergence of the tunnels. A Hewson suture passer is bent acutely and used to place a passing suture loop of no. 0 Ethibond through the 2 holes in the ulna (Fig 6C).

Creation of Humerus Bone Tunnels

The ulnar nerve is gently retracted posterior and protected with the backside of an Adson forceps or with an Army-Navy retractor. A 4-mm round burr (Stryker, Kalamazoo, MI) with a 1.5-cm long drill tip is advanced retrograde 1.5 cm to create a unicortical socket at the anatomic origin of the UCL (Fig 7A).

Then a 2.7-mm drill is used anterograde to create 2 unicortical holes on the posterior aspect of the medial epicondyle, 1 to 1.5 cm apart, one more lateral and the other more medial (Fig 7 B and C). A no. 2-0 curette and then no. 0 curette are used to deepen these tunnels so that they each connect to the socket created from the origin of the UCL. Connection of the bone tunnels is confirmed and debris is removed by squirting saline into the socket distally with a bulb syringe. A Hewson suture passer (Smith & Nephew) is used to place 2 separate passing suture loops of no. 0 Ethibond in through the socket in the medial epicondyle and out either through the more medial or more lateral hole (Fig 7D).

Graft Passage and Fixation

The passing suture loop is used to pass the Orthocord-sutured graft through the 2 holes in the proximal ulna (Fig 8A). A shorter arm of graft, the "docking end," is aligned side-to-side with the longer

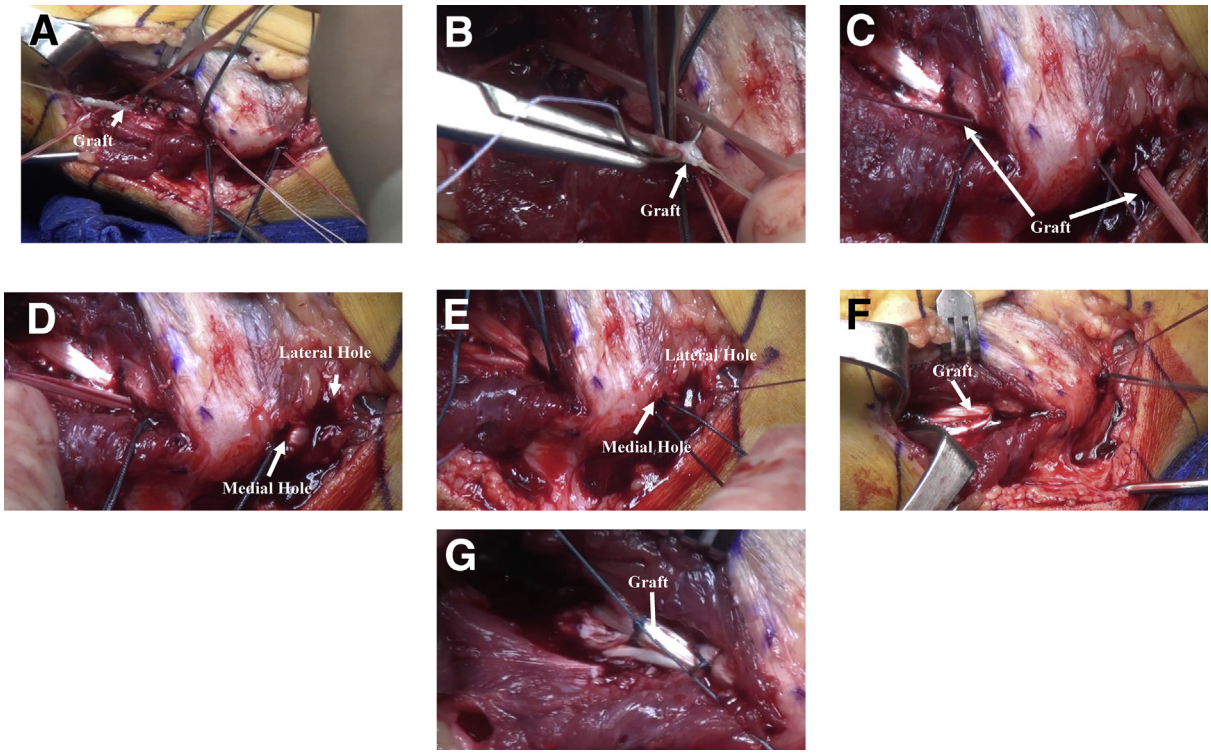

Fig 8. Patient is supine with right arm on the hand table, viewing the medial elbow. (A) A passing suture loop is used to pass the Orthocord-sutured graft through the 2 tunnels in the proximal ulna. (B) The shorter arm of the graft, the "docking end," is aligned side-to-side with the longer arm, and the 2 arms are sutured together side-to-side with a running stitch using no. 0 Ethibond. (C) Using passing suture loops, the long arm of the graft is passed through the lateral tunnel. (D) The docking arm is passed through the medial tunnel. (E) The long arm is passed distally through the medial hole, then across the ulnohumeral joint, and then through the 2 holes in the ulna, then again across the ulnohumeral joint and then out the lateral tunnel. (F) Suture ends of the graft are tied. (G) Four graft strands are sutured together with a side-to-side running stitch using no. 0 Ethibond.

arm and the 2 arms are sutured together with a running stitch using no. 0 Ethibond suture (Fig 8B).

Using the suture loops, the long arm of graft is passed out the more lateral tunnel in the medial epicondyle (Fig 8C), whereas the Ethibond suture attached to the docking arm is passed out the more medial tunnel (Fig 8D). The elbow is kept in 30° of flexion and an assistant holds constant tension on the docking arm suture. Next, the long arm of graft is passed through the more medial hole, across the ulnohumeral joint, through the 2 holes (radial to ulnar) in the ulna, back across the ulnohumeral joint and out the lateral hole in the epicondyle (Fig 8E).

As sutures from either end of the graft are tensioned, the elbow is gently passively flexed and extended. No change in suture tension nor block to range of motion confirms that graft has been placed in isometric points. With the elbow in 70° of flexion, the forearm in neutral rotation, and no valgus stress on the elbow, the suture from the 2 graft ends is tied over the posterior aspect of the medial epicondyle (Fig 8F).

The 4 graft strands that cross the ulnohumeral joint are then sutured together with a running stitch using Ethibond (Fig 8G). If the native UCL is present (and so split longitudinally), it is repaired and tenodesed to the (deeper) autograft UCL with a running stitch with Ethibond.

Wound Closure

The flexor-pronator fascia is closed with buried figure-8 stitches using no. 0 Ethibond (Fig 9). Range of motion of the elbow is checked and confirmed to be full. The wound is copiously irrigated. The subcutaneous layer is closed with buried simple stitches using no. 2-0 Vicryl suture (Ethicon). The skin is closed with a running stitch using no. 4-0 Nylon suture (Ethicon) (Fig 10A).

The palmaris incision sites are closed with buried, interrupted stitches in the subcutaneous layer with no. 2-0 Vicryl and horizontal mattress stitches in the skin with no. 4-0 Nylon.

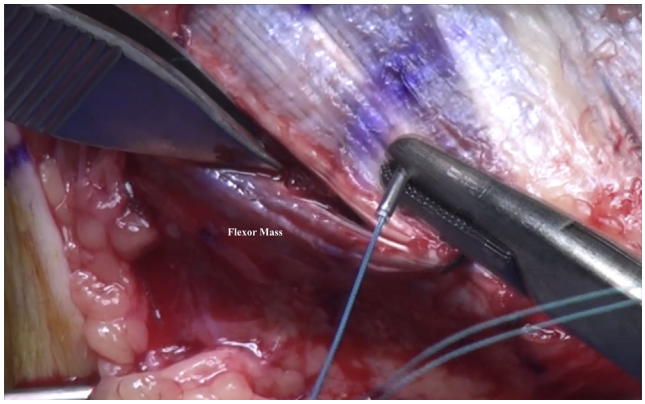

Fig 9. Patient is supine with right arm on the hand table, viewing the medial elbow. Subcutaneous layer is closed with buried figure-8 stitches.

Dressing and Postoperative

The tourniquet is deflated. A sterile, compressive dressing is placed. A Breg (Carlsbad, CA) T-Chek elbow brace locked to 60° of flexion is applied.

The patient is discharged home from the recovery room and follows up 7 to 10 days postoperatively for a wound check and removal of skin sutures. At 2 weeks postoperatively, the elbow brace will be adjusted to allow 20° to 90° of flexion. At 4 weeks, the elbow brace will be unlocked and at 6 weeks the elbow brace is typically removed.

Technique Variations

Alternative Graft Source

Absence of the palmaris longus is not uncommon. If the palmaris longus tendon is absent bilaterally, the contralateral or ipsilateral gracilis hamstring tendon is harvested. Apart from the harvest technique, this does not change our procedure.

Ulnar Nerve Treatment

Decompression or transposition of the ulnar nerve is rarely performed. The decision to do so is usually made preoperatively. Indications include (1) painful subluxation of the nerve over the medial epicondyle or (2) persistent or profound numbness, tingling, pain, or weakness in the ulnar nerve distribution.

Rarely, transposition of the ulnar nerve is required to safely perform the UCL reconstruction. In some patients, the ulnar nerve, after diving deep proximally between the heads of the flexor carpi ulnaris, will lie more anterior and superficial to the proximal ulna in the area of the sublime tubercle. This is appreciated when the fascia or the muscle of the flexor-pronator mass are split.

Elbow Arthroscopy

Diagnostic elbow arthroscopy is not a component of our UCL reconstructions. If surgical intra-articular pathology (e.g. loose body, chondral lesion) is identified preoperatively, elbow arthroscopy will be performed. It is done either at the start of the UCL reconstruction procedure or during a separate procedure done days or weeks prior to the UCL reconstruction to allow dissipation of resultant soft tissue edema that can make the reconstruction procedure more difficult.

Operative Evaluation of Ulnar Collateral Ligament

Despite no clear pathology on MRI or dynamic ultrasound imaging, open evaluation of the UCL is occasionally offered. Open evaluation can be considered if a patient has persistent medial elbow pain, exacerbated with palpation of the UCL and with valgus stress,

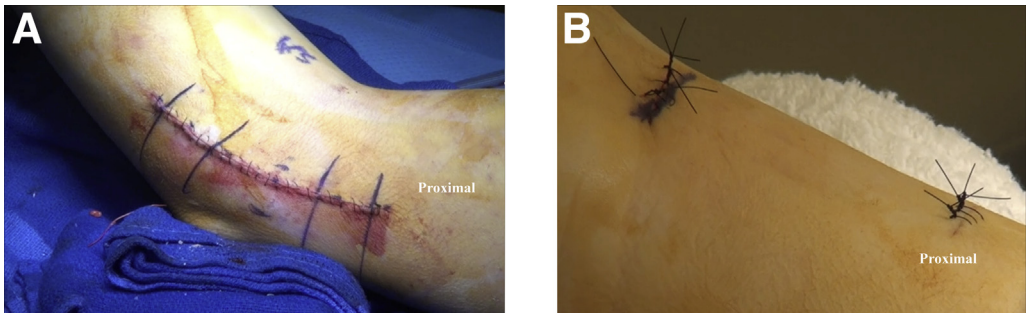

Fig 10. Patient is supine with right arm on the hand table, viewing the medial elbow. (A) The elbow skin incision is closed with a running stitch using no. 4.0 Nylon suture. (B) Palmaris harvest skin incisions are closed with simple stitches using no. 4.0 Nylon suture.

unexplained by core, shoulder, elbow, forearm, or psychiatric pathology, and refractory to (1) more than 3 to 6 months of high quality physical therapy with a dedicated throwing therapist and possibly (2) a platelet-rich plasma (PRP) injection. This involves identical exposure of the UCL and then a longitudinal midline splitting of the tendon with examination of its fibers. If there is intra-tendinous tearing, angiofibrodysplasia-like gross changes in tissue quality, or significant intra-tendinous fluid accumulation, a UCL reconstruction will be performed. If the tendon appears normal, the UCL reconstruction procedure will not be performed.

Discussion

Postoperative return-to-play rates in MLB case series are only 67% to 87%.[14,16-18,23] In a study by Conte et al.,[24] only 72% of professional baseball players surveyed postoperatively responded that they would have the surgery again, whereas 17% answered that they would not have the surgery.

Rates of return to play are higher in surgeon case series that encompass more levels of competition (e.g. high school, college, professional). A review of 16 such case series reveals a return to play (at the same level or a lower level of play) as ranging from 74% to 100%.

The Docking Plus technique employs the best features of its predecessor techniques (Table 2). The Docking Plus uses a 4-strand palmaris tendon repair, enabling more autograft, and thus more collagen, to be incorporated into the repair. Biomechanical testing shows that the Docking Plus technique leads to increased graft stiffness and load to failure compared with the Docking technique.[8] The only well-described technique with a quadrupled graft is the Modified Docking technique of Paletta and Wright.[3]

Another advantage, as with the original Jobe technique, is that the Docking Plus benefits from maximal graft contact surface area (for healing) with the humeral tunnels, as the graft is brought all the way through these tunnels and over the humeral bone bridge between the 2 proximal holes in the medial epicondyle.

The Docking Plus technique allows for tightening the graft with a knot over the medial epicondyle (as with most Docking and Modified Docking techniques),

Table 2. Advantages and Disadvantages of the Docking Plus Technique of Elbow UCL Surgery

Advantages of the Docking Plus Technique	Also Seen With the Following Techniques
Stronger because of a larger-volume graft (4 strands of palmaris tendon)	Modified Docking with doubled-up graft (Paletta and Wright[3])
Better healing because of graft contact with full length of medial epicondyle tunnel	Jobe
Well-tensioned graft	
Sutures tied over the proximal epicondyle bone bridge	Docking, Modified Docking
No risk of graft "bottoming out" in the epicondyle tunnel, fewer measurements	Jobe
Smaller bone tunnels (2.7 mm × 2 in ulna; 4.0 mm × 1, 2.7 mm × 2 in humerus)	Docking, Modified Docking
No obligatory ulnar nerve transposition	Most current
No hardware (screws, buttons) complications	Most other than DANE TJ, Kodde
Disadvantages of the Docking Plus Technique	
Risk of bone bridge fracture (ulna)	Most other than DANE TJ, Kodde
Postoperative ulnar neuritis	All

UCL, ulnar collateral ligament.

although it obviates the need for graft measurement to minimize the risk of graft bottoming out in the humeral tunnels (as with the Jobe technique). There is no obligatory ulnar nerve transposition and there is no risk of hardware complications.

Disadvantages to the Docking Plus technique are few. As with all techniques that use bone bridges, there is a risk of fracture. This complication has been exceedingly rare and is planned for by the availability of backup hardware fixation. Postoperative ulnar neuritis is occasionally seen with this as with all other techniques, including those that involve obligate ulnar nerve transposition.

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