Four-Bundle Cortical-Button Ulnar Collateral Ligament Reconstruction

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Ulnar collateral ligament (UCL) injuries of the elbow can cause pain, dysfunction, and valgus instability in the overhead thrower. Once considered a career ending injury, UCL reconstruction now offers an athlete an 80-90% chance to return to full athletic activity. [1, 2, 3, 4]Multiple variations on Jobe's initial reconstruction technique have been described. We present two cases using a new technique for reconstruction of the UCL utilizing two cortical-buttons and a four-bundle autograft. This technique has an easy surgical setup, requires only two osseous tunnels, and provides a way for simple graft fixation and tensioning.

Keywords: UCL tear, UCL reconstruction, ulnar collateral ligament, valgus instability, elbow, cortical button.

Introduction

Waris, in 1946, first described injury to the UCL in a series of javelin throwers.[5, 6] This injury has also been identified in baseball, football, softball, tennis, volleyball players and gymnasts. [7, 8, 6, 9, 10] The UCL is the primary static contributor of valgus stability in the elbow and is thought be injured during the late cocking and early acceleration phases of overhead activity. Torque forces at the elbow while in a throwing position have been calculated to be greater than 60 N-m, well over the native UCL's ultimate tensile strength of 23-33 N-m found in cadaveric studies. [11, 12, 5, 13] Occasionally a complete acute rupture of the UCL may occur; however, it is often chronic tearing that leads to pain, instability, and functional limitations for overhead athletes.

Jobe first reported reconstruction of the UCL in 1986.[14] His technique consisted of a complete take down and repair of the flexor-pronator mass, transposition of the ulnar nerve, and multiple osseous tunnels for graft placement. Since that time there have been multiple modifications of Jobe's initial technique such as selective transposition of the ulnar nerve, flexor muscle-splitting dissection, docking of the humeral graft, and distal graft fixation with an interference screw.[15, 10, 13, 16, 17, 18]

We present a new surgical technique to reconstruct the ulnar collateral ligament using a four-bundle palmaris longus autograft, two bone tunnels and two cortical buttons for fixation. A cortical button only technique might offer several advantages including minimizing the risk of bone tunnel fracture, direct tendon-to-bone healing, ease of use, ease of tensioning, and possible biomechanical superiority in terms of ultimate load to failure.

Clinical outcomes were assessed using the disabilities of the arm, shoulder and hand (DASH) questionnaire. This is a validated outcome questionnaire that describes the disability experienced by people with upper-limb disorders and also monitors changes in symptoms and function over time. It is rated on a scale from 0-100 with 0 being an unaffected upper extremity.

Technique

Preoperatively we identify the palmaris longus. When not present, the ipsilateral gracilis may be used. We also routinely examine for ulnar nerve irritability, subluxation, neuropathy, or a positive EMG. Our indications for ulnar nerve transposition include a history of preoperative ulnar nerve symptoms, subluxation, neuropathy, or positive examination findings consistent with ulnar neuritis.

Prior to surgery the patient receives a supraclavicular nerve block and a third generation cephalosporin or, if penicillin allergic, vancomycin. The patient is maintained in a supine position and the arm is placed on a hand table with the elbow and wrist extended. A tourniquet is placed high on the arm and the arm is then sterilely prepped and draped.

The arm is exsanguinated and the tourniquet inflated. A small transverse incision is made over the palmaris longus tendon at the distal wrist crease. Loose areolar tissue is spread away and tendon identification is made. A second transverse incision approximately 8 cm proximal to the first is made and the tendon is once again identified. If needed, a third incision can be made to harvest the tendon at its musculotendinous junction. The tendon is dissected free from any adhesions and transected distally and proximally taking care not to injure the median nerve directly underneath. [19, 20] Sixteen percent of Caucasians have an absent palmaris longus tendon and 9% have bilateral absence of the tendon.[21, 22] In these instances, we prefer a gracilis autograft.

All soft tissue is then removed from the tendon and the tendon folded equally into

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fourths, creating a quadruple-bundle construct. Once folded, our ideal graft length is approximately 4 cm, although this varies slightly with patient height. A fiberwire suture is then placed in a luggage type fashion around the closed looped end of the graft. Next, a second fiberwire suture, utilizing a Krakow stitch, is used to secure the four free ends of the graft together. [23] The length of the suture ends are left equal. (Figure 1). One cortical button is placed in a sliding type fashion around the single proximal fiberwire while another cortical button is placed in a similar fashion through the distal fiberwire (Figure 2). We have used both the Arthrex (Arthrex Inc., Naples, FL) distal biceps button and the Smith and Nephew Endobutton (Smith & Nephew Inc., UK) for this technique. The graft diameter is then measured proximally and distally so that appropriate sized reaming can be performed. The graft is then wrapped in saline moistened gauze and set aside for implantation.

An incision is created from the distal third of the intramuscular septum across the medial epicondyle to a point 2 cm beyond the sublime tubercle. The fascia of the flexor pronator group is exposed. Careful dissection is made distally to preserve the branches of the medial antebrachial cutaneous nerve and the branches are maintained with the anterior skin flap.

The fascia of the flexor pronator mass is incised using a muscle-splitting approach. Blunt dissection through the posterior third of the flexor pronator mass is performed proximally to the humeral origin of the UCL and distally to the sublime tubercle. [18] The ulnar nerve is not routinely identified or dissected. Retractors are placed to better visualize the UCL. The torn anterior bundle of the UCL is incised in line with its fibers for incorporation into the final graft construct. Any diseased tissue is debrided, leaving as much native ligament as possible for subsequent imbrication with the graft.

Figure 1. Four-bundle graft with a luggage suture around the looped end of the graft and fiberwire securing the distal free ends of the graft.

Figure 2. Four-bundle graft with cortical button.

A guide pin is placed at the sublime tubercle. Using fluoroscopic guidance an AP of the ulna is obtained and the guide pin is directed to exit the radial cortex of the ulna distal to the proximal radial ulnar articulation (Figure 3). Similarly, the humeral origin of the ulnar collateral ligament at its isometric point is determined using a suture loop fixed at the ulnar guide pin. The elbow is taken through a flexion extension arc to most closely identify the isometric point. The humeral guide pin is drilled bicortically under fluoroscopic guidance to the lateral cortex of the humerus and isometry is again assessed using a fixed suture loop. Care is taken to keep the guide pin and subsequent tunnels distal to the olecranon fossa. The medial cortex of the ulna and humerus are reamed to accommodate the size of the quadrupled graft to a minimum depth of 15mm while leaving the respective guide pins in place. The reamer size has ranged from 5 – 5.5mm. The far cortices are subsequently drilled over the guidewires using a 4.0mm cannulated reamer to allow for insertion and engagement of the cortical button. When using the Arthrex button the guide pin is of sufficient size for passage of the cortical button.

The quadruple-bundled graft and cortical button construct is then placed through the ulna and the button is flipped (Figure 4). The ulnar construct is tensioned until the graft is advanced 7-10mm into the osseous socket at the sublime tubercle (Figure 5). Next, the cortical button from the humeral side of the graft is introduced through the humeral tunnel and the button is flipped on the far cortex. After fluoroscopic confirmation of the ulnar and humeral buttons, the humeral portion of the graft is pulled into the humeral tunnel by tensioning the humeral sutures until 10mm of the graft is positioned within the tunnel (Figure 6). Once 10mm of graft is within the proximal and distal tunnels and proper button positions are confirmed, pulling on the Fiberwire suture strands of the construct tensions the grafts. (Figure 7) During tensioning, each graft is tensioned sequentially. Elbow range

Figure 3. Placement of a guidewire from the sublime tubercle exiting distally at the lateral cortex of the ulna.

Figure 4. The quadruple-bundled graft and cortical button passing through the ulna.

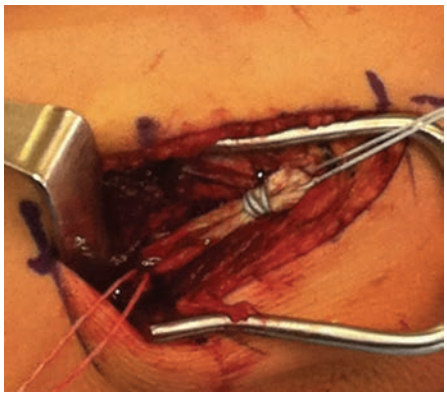

Figure 5. Autograft advancing into the osseous socket at the sublime tubercle.

of motion is rechecked to ensure graft isometry, maximize tension, and eliminate creep. The graft is then secured into place by passing the Fiberwire suture back through the graft at the ulnar and humeral tunnel apertures with a free taper needle and tying the suture in place. The native UCL tissue is then imbricated into the graft using absorbable, braided suture passed with a fine taper needle.

If symptomatic, the ulnar nerve is released proximal to the arcade of Struthers. The intramuscular septum is excised and the nerve is released distally through the FCU to the first motor branch. We prefer to utilize a subcutaneous transposition with the nerve secured in a sling of subcutaneous fat; however, in

Figure 6. Fluoroscopic verification of humeral tunnel and ulnar tunnel with flipped cortical buttons.

situ release and sub-muscular transposition have also been reported to achieve adequate symptomatic relief. [24]

The wound is then copiously irrigated and the tourniquet is deflated. All bleeding is stopped using bipolar electrocautery. The UCL incision is closed with absorbable subcutaneous sutures. Simple sutures close the graft harvest site.

Postoperative Rehabilitation

The elbow is immobilized at 90° of flexion with neutral forearm rotation for 5-10 days. The dressing and sutures are then removed and the patient is started with gentle wrist, elbow, and shoulder range of motion exercises. Strengthening without valgus stress is started at 4 weeks and at 4 months a ball toss program is initiated. Initially patients are allowed to toss up to 45 feet and then, over the next 6 months, progress to 180 feet. Athletes are allowed to return to competition around 12 months after surgery.

Case 1

A 19 year-old male collegiate pitcher presented with a two-month history of pain, decreased pitching velocity, and numbness in the ulnar nerve distribution. He had ceased pitching for one month; however, when resuming activity he could only pitch 10 throws before symptoms recurred.

A B C

Figure 7. (A) AP, (B), oblique, and (C) lateral radiograph of the elbow after MUCL reconstruction with two cortical buttons.

On evaluation he had symmetric elbow flexion-extension arcs of motion, full pronation, and full supination. A moving valgus stress test as well as palpation along the ulnar nerve caused medial sided elbow pain. There was focal tenderness to palpation at the sublime tubercle. He had a negative Tinels about the cubital tunnel. T2 weighted MRI revealed increased signal within the substance of the UCL and around the ulnar nerve. (Figures 8 and 9).

He underwent UCL reconstruction as well as ulnar nerve transposition. He is currently nine-months from surgery throwing >90 feet pain free. He has no pain with moving valgus stress test, denies any ulnar nerve symptoms, has no instability, and continues to have full elbow motion. His current DASH score is 5.8.

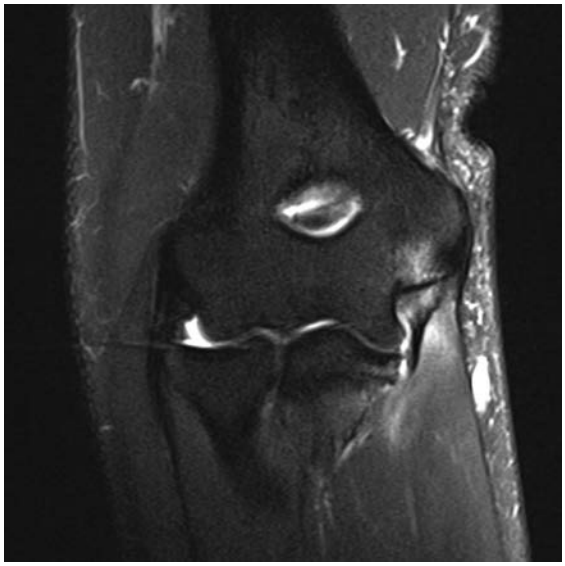

Figure 8. T2 MRI with increased signal in the UCL with detachment at the sublime tubercle

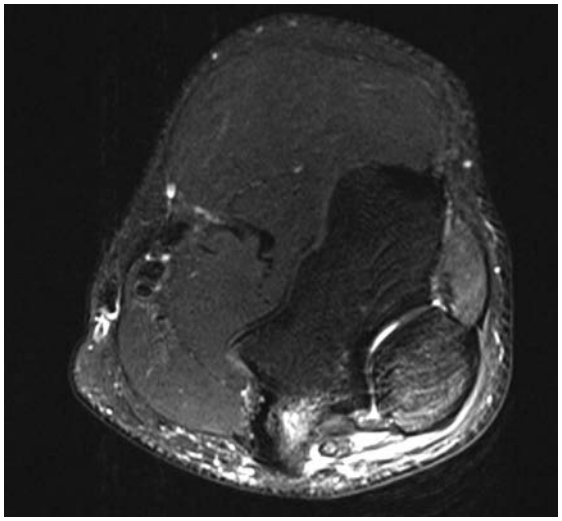

Figure 9. T2 MRI with increased signal surrounding the ulnar nerve at the cubital tunnel.

Case 2

A 16 year-old male pitcher presented with medial sided elbow pain and was diagnosed with a UCL strain. He underwent 3 months of rehabilitation; however, he continued to have medial sided elbow pain with pitching. He denied any cubital tunnel symptoms.

On initial exam he had full flexion, extension, pronation and supination. He had pain with moving valgus stress test, tenderness at the sublime tubercle, and a negative Tinels at the elbow. His MRI had increased signal within the ulnar collateral ligament with partial detachment from the sublime tubercle.

He underwent UCL reconstruction and is currently seven-months from surgery throwing without symptoms at 120 feet. On physical exam he has no pain with moving valgus stress test. He has full flexion, extension, pronation and supination. His current DASH score is 1.6.

Discussion

Dr. Jobe's UCL reconstruction technique included reflecting the flexor-pronator mass to visualize the UCL as well as transposing the ulnar nerve. His graft was also placed in a figure-of-eight pattern through three drill holes in the humerus and two in the ulna. The flexor-pronator mass was then repaired back to the medial epicondyle with the ulnar nerve transposed submuscularly.[14]

Smith et al modified Jobe's technique by performing a muscle-splitting approach through the flexor carpi ulnaris and not routinely transposing the ulnar nerve. [25] Thompson also endorsed this approach. [18] Further modification by Rohrbough included docking the free ends of the graft into a single medial epicondyle tunnel. [26].

As another variation, the DANE TJ technique utilizes a single bone tunnel in the ulna, securing the graft distally with a biotenodesis screw, and proximally docking the remaining graft.[15] It was hypothesized that the use of an interference screw with suture prevented graft pullout and a single bone tunnel might decrease ulnar nerve complications as well as minimizing the risk for fracture between the two ulnar bone tunnels. Another proposed advantage of the DANE TJ method was that it could be used after failed UCL reconstruction, sublime tubercle fracture, or in the presence of a prominent ulna enthesopathy. They, however, reported a 9% ulnar nerve complication rate as well as graft trauma due to graft-screw tunnel mismatch. [15] Jobe's technique had an 8% rate of ulnar neuropathy while the docking procedure had a 3% rate.[15]

A cadaveric study measuring peak load to failure and cyclical valgus loading with the elbow at 90 degrees of flexion of four reconstructive techniques (Jobe's original technique, the docking procedure, the DANE TJ procedure, and the docking procedure with cortical button distal fixation) demonstrated that none of the reconstructions reached native UCL peak load to failure. The docking technique, with and without cortical button fixation, had the highest peak load to failure and number of cycles prior to failure. [16]

We present a new UCL reconstruction technique utilizing a quadrupled Palmaris tendon reconstruction fixed with two

cortical-buttons. With using only two osseous tunnels we are able to accurately achieve graft isometry as well as proper humeral and sublime tubercle graft placement as described by Ochi et al. [27] Although rarely reported, multiple drill holes through the medial epicondyle and sublime tubercle have the potential for iatrogenic fracture. The use of a single osseous tunnel in the distal humerus and ulna theoretically decreases the risk of fracture.

The use of a cortical button in the ulna for distal fixation has higher peak load to failure than the DANE TJ and Jobe's technique. [16] Similar to the benefits suggested with the DANE TJ procedure, the current procedure may also be utilized after failed previous UCL surgery, sublime tubercle fracture, and prominent ulna enthesopathy.

In agreement with Paletta and Wright, we have found that the use of a quadruple-stranded palmaris graft offers the advantage of incorporation of increased collagen tissue into the reconstruction. [17] Also, obtaining correct tension is easy; by design the surgeon can appropriately tension the graft through the cortical buttons and suture construct after the graft is already positioned within the respective tunnel.

Conclusion

Once considered career ending, UCL reconstruction offers an athlete a greater than 80-90% chance to return to full athletic activity. [1, 2, 3, 4] Multiple reconstructive techniques have been described. This new technique allows for easy surgical setup, utilizes only two osseous tunnels, eliminates bone bridge fracture, creates a more anatomic UCL origin and insertion point, allows for direct tendon-to-bone healing, provides a simple method for proper graft tensioning, and has encouraging initial results based on our patients' DASH scores. Biomechanical as well as a longitudinal prospective studies are necessary to confirm this technique's efficacy. Given the increased load to failure with cortical button devices and our initial results, we find this technique promising.

References

1. **Gibson BW, Webner D, Huffman GR, Sennett BJ.** Ulnar collateral ligament reconstruction in major league baseball pitchers. *Am J Sports Med.* 2007;35 (4):575-581.
2. **Hechtman KS, Zvijac JE, Wells ME, Botto-van Bemden A.** Long-term results of ulnar collateral ligament reconstruction in throwing athletes based on a hybrid technique. *Am J Sports Med.* 2011;39 (2):342-347.
3. **Cain ELJ, Andrews JR, Dugas JR et al.** Outcome of ulnar collateral ligament reconstruction of the elbow in 1281 athletes: Results in 743 athletes with minimum 2-year follow-up. *Am J Sports Med.* 2010;38 (12):2426-2434.
4. **Bowers AL, Dines JS, Dines DM, Altchek DW.** Elbow medial ulnar collateral ligament reconstruction: clinical relevance and the docking technique. *J Shoulder Elbow Surg.* 2010;19 (2 Suppl):110-117.
5. **MD BFM.** Morrey's The Elbow and Its Disorders: Expert Consult - Online and Print. 4*Saunders;* 2008.
6. **WARIS W.** Elbow injuries of javelin-throwers. *Acta Chir Scand.* 1946;93 (6):563-575.
7. **Creighton RA, Bach BRJ, Bush-Joseph CA.** Evaluation of the medial elbow in the throwing athlete. *Am J Orthop (Belle Mead NJ).* 2006;35 (6):266-269.
8. **Dodson CC, Slenker N, Cohen SB, Ciccotti MG, DeLuca P.** Ulnar collateral ligament injuries of the elbow in professional football quarterbacks. *J Shoulder Elbow Surg.* 2010;19 (8):1276-1280.
9. **Domb BG, Davis JT, Alberta FG et al.** Clinical follow-up of professional baseball players undergoing ulnar collateral ligament reconstruction using the new Kerlan-Jobe Orthopaedic Clinic overhead athlete shoulder and elbow score (KJOC Score). *Am J Sports Med.* 2010;38 (8):1558-1563.
10. **Vitale MA, Ahmad CS.** The outcome of elbow ulnar collateral ligament reconstruction in overhead athletes: a systematic review. *Am J Sports Med.* 2008;36 (6):1193-1205.
11. **Fleisig G, Nicholls R, Elliott B, Escamilla R.** Kinematics used by world class tennis players to produce high-velocity serves. *Sports Biomech.* 2003;2 (1):51-64.
12. **Fleisig GS, Bolt B, Fortenbaugh D, Wilk KE, Andrews JR.** Biomechanical comparison of baseball pitching and long-toss: implications for training and rehabilitation. *J Orthop Sports Phys Ther.* 2011;41 (5):296-303.
13. **Ruland RT, Hogan CJ, Randall CJ, Richards A, Belkoff SM.** Biomechanical comparison of ulnar collateral ligament reconstruction techniques. *Am J Sports Med.* 2008;36 (8):1565-1570.
14. **Jobe FW, Stark H, Lombardo SJ.** Reconstruction of the ulnar collateral ligament in athletes. *J Bone Joint Surg Am.* 1986;68 (8):1158-1163.
15. **Dines JS, ElAttrache NS, Conway JE, Smith W, Ahmad CS.** Clinical outcomes of the DANE TJ technique to treat ulnar collateral ligament insufficiency of the elbow. *Am J Sports Med.* 2007;35 (12):2039-2044.
16. **Armstrong AD, Dunning CE, Ferreira LM, Faber KJ, Johnson JA, King GJ.** A biomechanical comparison of four reconstruction techniques for the medial collateral ligament-deficient elbow. *J Shoulder Elbow Surg.* 2005;14 (2):207-215.
17. **Paletta GAJ, Klepps SJ, Difelice GS et al.** Biomechanical evaluation of 2 techniques for ulnar collateral ligament reconstruction of the elbow. *Am J Sports Med.* 2006;34 (10):1599-1603.
18. **Thompson WH, Jobe FW, Yocum LA, Pink MM.** Ulnar collateral ligament reconstruction in athletes: muscle-splitting approach without transposition of the ulnar nerve. *J Shoulder Elbow Surg.* 2001;10 (2):152-157.
19. **Weber RV, Mackinnon SE.** Median nerve mistaken for palmaris longus tendon: restoration of function with sensory nerve transfers. *Hand (N Y).* 2007;2 (1):1-4.
20. **Kovacsy A.** [Removal of the median nerve instead of the palmaris longus tendon]. *Magy Traumatol Orthop Helyreallito Seb.* 1980;23 (2):156-158.
21. **Thompson NW, Mockford BJ, Cran GW.** Absence of the palmaris longus muscle: a population study. *Ulster Med J.* 2001;70 (1):22-24.
22. **Troha F, Baibak GJ, Kelleher JC.** Frequency of the palmaris longus tendon in North American Caucasians. *Ann Plast Surg.* 1990;25 (6):477-478.
23. **Krackow KA, Thomas SC, Jones LC.** Ligament-tendon fixation: analysis of a new stitch and comparison with standard techniques. *Orthopedics.* 1988;11 (6):909-917.
24. **Waugh RP, Zlotolow DA.** In situ decompression of the ulnar nerve at the cubital tunnel. *Hand Clin.* 2007;23 (3):319-27, vi.
25. **Smith GR, Altchek DW, Pagnani MJ, Keeley JR.** A muscle-splitting approach to the ulnar collateral ligament of the elbow. Neuroanatomy and operative technique. *Am J Sports Med.* 1996;24 (5):575-580.
26. **Rohrbough JT, Altchek DW, Hyman J, Williams RJr, Botts JD.** Medial collateral ligament reconstruction of the elbow using the docking technique. *Am J Sports Med.* 2002;30 (4):541-548.
27. **Ochi N, Ogura T, Hashizume H, Shigeyama Y, Senda M, Inoue H.** Anatomic relation between the medial collateral ligament of the elbow and the humero-ulnar joint axis. *J Shoulder Elbow Surg.* 1999;8 (1):6-10.