Technical Note

Ulnar Collateral Ligament Reconstruction Utilizing a 3-Strand Palmaris Tendon Autograft With a Hybrid Linear Construct

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Abstract: The integrity of the medial ulnar collateral ligament (UCL) of the elbow is vital for the throwing athlete. Although newer techniques exist, reconstruction remains the gold standard for full-thickness UCL tears. An increase in throwing velocity, inadequate recovery, and early sports specialization have contributed to increased rates of UCL injury. As increasing numbers of athletes undergo UCL reconstruction, we continue to search for the optimal technique to return athletes to the same level of competition. We present a UCL reconstruction utilizing a 3-stranded palmaris longus tendon autograft with an inlay linear construct.

Elbow injury is the most common reason for missed competition in elite baseball pitchers.[1-3] An increasing emphasis on high-velocity throwing with a concomitant decrease in recovery time has led to increasing rates of ulnar collateral ligament (UCL) injury.[1] Without the UCL, the medial elbow becomes unstable, and pitchers are unable to maintain velocity and accuracy. There has been a substantial increase in the incidence of Major and Minor League pitchers requiring UCL reconstructions.[4-7] Various techniques for UCL reconstructions have been developed that optimize graft preparation and fixation while mitigating complications.[8] We present a modification of previously described linear constructs using a 3-stranded palmaris longus tendon.[9]

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Surgical Technique

Patient Positioning and Anesthesia

A video presenting this technique is provided (Video 1). The patient is placed supine on an operative table with a hand table attached. Examination under anesthesia evaluates UCL stability and for ulnar nerve subluxation. A nonsterile tourniquet is applied to the upper arm. The arm is exsanguinated and a tourniquet insufflated.

Graft Harvest

Preoperatively, the palmaris longus tendon course is marked (Fig 1). A 1-cm transverse incision is centered over the palmaris tendon. The tendon is isolated (Fig 2) with a traction stitch placed, and the tendon is sharply released (Fig 3). A second transverse incision is made at the mid-forearm and the palmaris tendon identified. A right-angle forceps isolates the tendon at this juncture (Fig 4). After retrieval, a third incision is made at the myotendinous junction. The tendon is retrieved, and an elevator is used to remove residual muscle (Fig 5). The tendon is sharply transected. Incisions are closed using buried 3-0 Vicryl suture (Ethicon) (Fig 6).

Graft Preparation

The tendon is folded to create a 3-strand graft, which is then measured, with an ideal length of 50 to 60 mm (Fig 7). Three No. 2 OrthoCord sutures (DePuy Synthes) are used for graft preparation. The

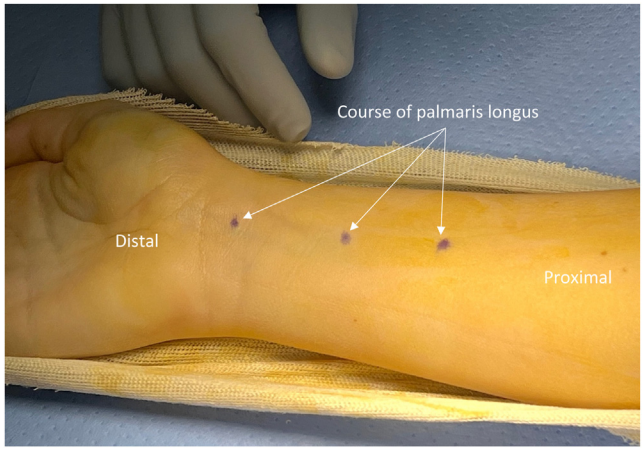

Fig 1. The patient is positioned supine with the right arm on a hand table in supination. The palmaris longus tendon course has been identified and marked preoperatively to assist with localization of the tendon during surgery.

ulnar end is first prepared. The first suture enters the distal looped end of the graft while securing the central and separate limb (Fig 8). Strands are then secured together using a locking stitch for 10 mm. Two limbs of the graft remain, one as a single strand of the graft and the other as a folded-over double strand. Each is prepared using a locking OrthoCord suture for 10 mm (Fig 9). The graft is sized with a typical diameter ranging from 5 to 6 mm (Fig 10). The triple-strand graft is then placed in gauze.

Fig 2. The patient is positioned supine with the right arm positioned on a hand table in supination. A 1-cm transverse incision is made over the wrist crease at the palmaris longus insertion, with tenotomy scissors utilized for dissection to identify the tendon's insertion.

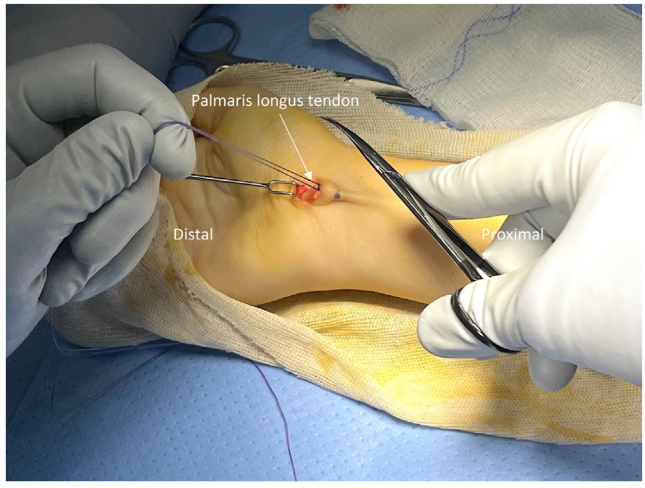

Fig 3. The patient is positioned supine with the right arm positioned on a hand table in supination. A skin hook is placed distally for visualization, and a 0 Vicryl suture (Ethicon) is placed through the distal aspect of the palmaris longus tendon to allow manipulation and control at its insertion.

Approach

An approximately 7-cm incision is marked in line with the native UCL (Fig 11). Sharp and blunt dissection enables visualization of the underlying flexor pronator mass. A stripe within the flexor mass in line with the native UCL indicates the interval between the 2 heads of the flexor carpi ulnaris muscle (Fig 12). This is sharply incised. The flexor carpi ulnaris is then bluntly dissected, exposing the UCL, which is incised

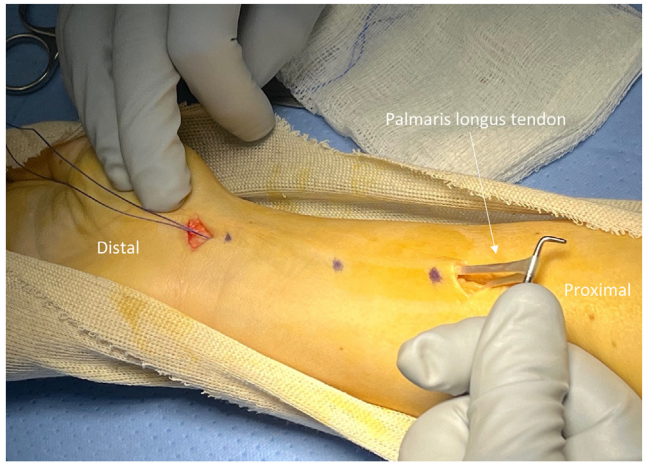

Fig 4. The patient is positioned supine with the right arm positioned on a hand table in supination. In this figure, the most distal incision has already been made, and following this, a second incision is made at the mid-forearm and the palmaris tendon identified. A right-angle forceps is used to retrieve the tendon through this second proximal wound once adhesions have been released.

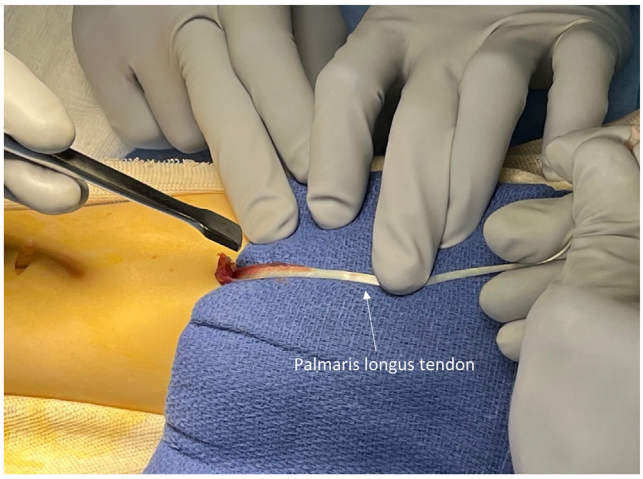

Fig 5. The patient is positioned supine with the right arm positioned on a hand table in supination. A third and final proximal incision is made after the distal and second incisions have been completed. This final incision is at the myotendinous junction of the palmaris longus and the tendon retrieved. A key elevator is used to remove any muscle along the proximal aspect of the tendon while under tension.

longitudinally to allow central placement of the graft and later imbrication of the native UCL. Gapping is assessed with valgus stress indicating UCL insufficiency (Fig 13).

Ulnar Tunnel Preparation

The sublime tubercle is identified as a landmark, and a 2.4-mm guide pin (Arthrex) is placed at the central aspect of the sublime tubercle (Fig 14). A tenodesis reamer typically 0.5 mm larger than the previously sized ulnar side of the graft (3-strand end) is selected and placed over the guide pin using a free-handed technique. The margins of the reamer are assessed to ensure it does not encroach on the articular surface or surrounding ulnar cortices (Fig 14). Once satisfied, the central pin is gently malleted, and a unicortical tunnel is then reamed to a depth of approximately 15 to 20 mm (Fig 15). A 15-mm Bio-Tenodesis Screw (Arthrex) of equal diameter or slightly smaller than the graft is utilized to tenodese the ulnar side of the graft (i.e., a 5.5-mm reamer, a 5.0-mm graft, and a 4.75-mm screw) (Fig 16). The integrity of the fixation is tested by pulling on the free end of the graft and ensuring the arm can be lifted from the hand table. If concern exists regarding fixation, the screw is upsized. A knot is tied for supplemental fixation.

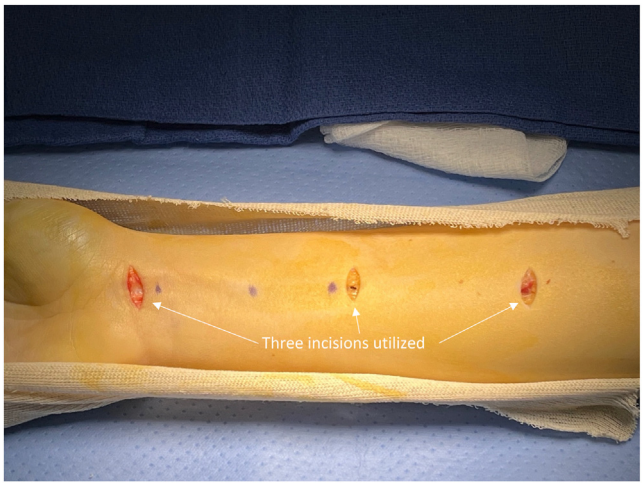

Fig 6. Three incisions have been created in a sequential fashion for our palmaris tendon autograft harvest. The most distal incision near the wrist crease at the palmaris longus insertion into the palmar fascia, the mid-forearm incision, and the most proximal incision at the musculotendinous junction. The 3 transverse incisions have been utilized to access and retrieve the palmaris longus tendon to ensure adequate length and mitigate iatrogenic injury during harvest.

Humeral Tunnel Preparation

The origin of the UCL on the medial epicondyle is identified. Scissors are used to enter the fascia adjacent to the bone on the posterior aspect of the medial epicondyle, with muscle elevated using a key elevator (Fig 17). The ulnar nerve is identified and protected with a retractor of choice. Replicating the ulnar tunnel preparation, a 2.4-mm guide pin (Arthrex) is placed at the native UCL origin. The corresponding tenodesis reamer is placed freehand over the guide pin, which is typically 0.5 mm larger than the humeral ends of the graft. The tunnel position is assessed and adjusted to avoid encroaching too medial, which may risk fracture. Once satisfied, the central pin is gently malleted, and the humeral tunnel is reamed to a depth of 15 mm, with a trajectory that would exit at the posterolateral aspect of the medial epicondyle (Fig 18). A 2.0-mm drill bit is then used to create 2 tunnels, drilling from distal to proximal through the previously reamed socket, with a bridge at least 5 mm apart at the posterolateral aspect of the medial epicondyle (Fig 19).

Graft Passage and Fixation

Using a Hewson suture passer, a passing stitch is introduced (Fig 20). The graft ends are laid over the medial epicondyle to ensure no graft-tunnel mismatch. If the surgeon does encounter a graft that appears longer than the tunnel, the graft ends can be trimmed and resutured. Each of the 2 limbs of the graft is brought through the tunnel using the passing sutures (Fig 21). The elbow is then placed into 30° of flexion and varus stress, and the sutures are tied. The knot is created lateral to the ulnar nerve, preventing irritation (Fig 22). The graft is inspected for restoration of tension (Fig 23). An examination of the UCL graft is then performed, and the elbow is ranged to ensure full motion. As this technique does not involve release of

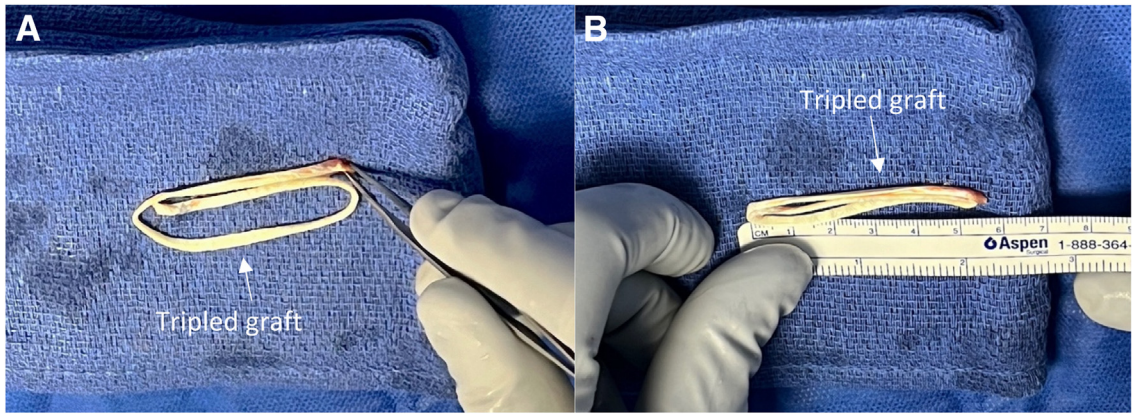

Fig 7. In this described technique, we are utilizing a palmaris tendon autograft from the ipsilateral forearm. After the palmaris tendon has been removed from the forearm, it is taken to the back table for graft preparation. The palmaris longus tendon is folded over to create a 3-strand graft (A). This is measured with a sterile ruler, with an ideal length of 50 to 60 mm (B).

the ulnar nerve, a transposition is not routinely performed. The native split UCL is imbricated over the graft using an interrupted 0 Vicryl suture (Fig 24).

Wound Closure

The wound is thoroughly irrigated, and the fascial interval of the flexor pronator split is closed utilizing 0 Vicryl suture (Fig 25). Subcutaneous tissue is closed with 3-0 Vicryl and the skin with 3-0 Monocryl in a subcuticular fashion (Ethicon). A sterile dressing is applied, and the elbow is placed in a well-padded posterior slab splint at 90° with a sling.

Postoperative Protocol

The splint is worn for 7 days while the patient begins finger and wrist active range of motion. The splint is transitioned to a hinged elbow brace set to 0° to 120° for 6 weeks, and isometric exercises are progressed for the wrist, shoulder, and elbow. A shoulder and scapular exercise program is initiated at week 4, with early eccentric loading allowed after week 8. Positional players may begin a hitting program at week 14 and a throwing program at week 16, with pitchers initiated at week 18. Typical return to sport ranges from 9 to 12 months.

Discussion

Stability of the medial elbow relies on both static and dynamic restraints. The medial UCL is the

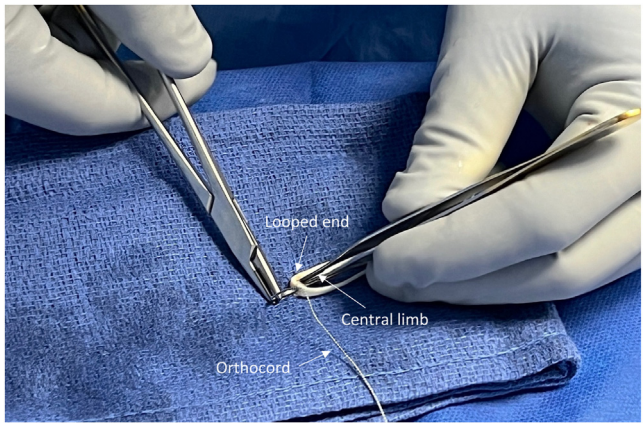

Fig 8. During ulnar collateral ligament graft preparation using an ipsilateral palmaris tendon autograft, the previously tripled palmaris tendon graft is sutured with a No. 2 OrthoCord (DePuy Synthes). The first suture is entered through the distal looped end of the graft while also securing the central and separate limb between the loop.

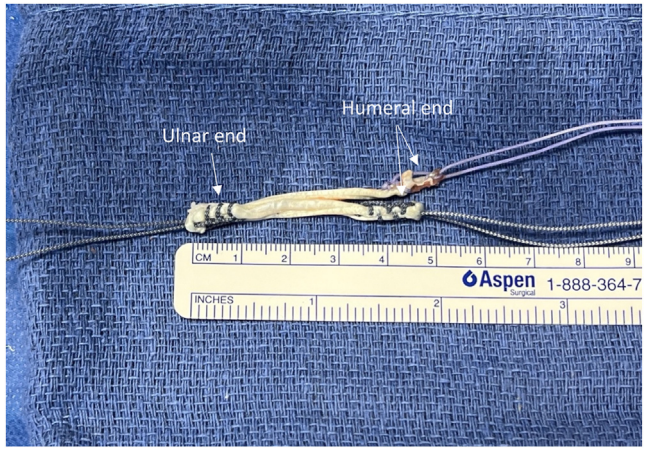

Fig 9. For ulnar collateral ligament reconstruction using a palmaris tendon autograft, we harvest the tendon from the ipsilateral forearm and take the graft to the back table for preparation. The graft is folded to create 3 strands and is prepared using No. 2 OrthoCord (DePuy Synthes). At the ulnar end, all 3 are sutured together. The humeral end consists of 2 separate limbs, 1 with 2 strands and 1 with a single strand. After preparation of the triple-strand graft, total length measures approximately 50 to 60 mm.

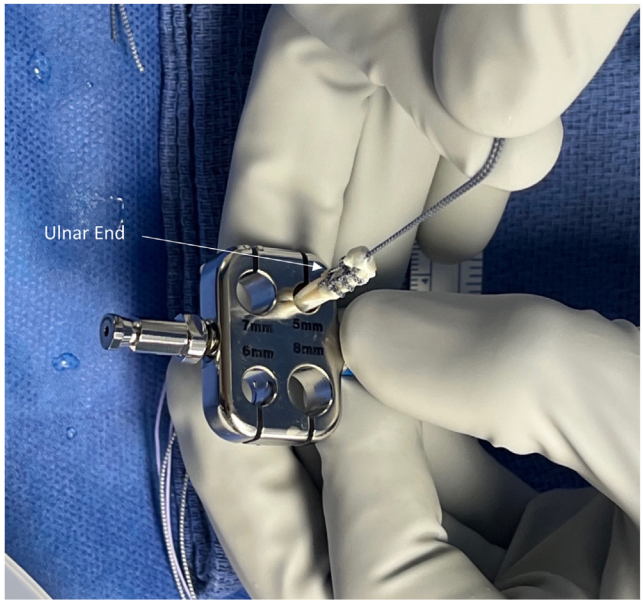

Fig 10. For ulnar collateral ligament reconstruction using a palmaris tendon autograft, we harvest the tendon from the ipsilateral forearm and prepare the graft on the back table. We prepare a 3-stranded graft, and each end of the prepared palmaris longus graft is sized using the paddle of the Bio-Tenodesis screwdriver (Arthrex). The typical diameter ranges from 5 to 6 mm.

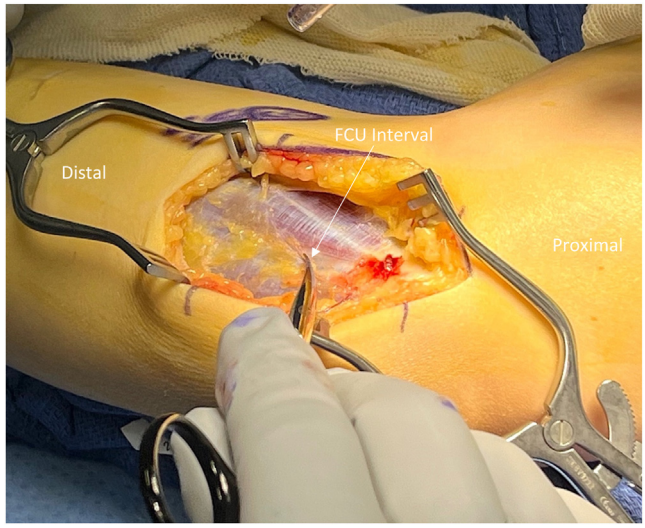

Fig 12. A right medial elbow is presented for our technique of ulnar collateral ligament reconstruction using a palmaris tendon autograft. Using a previously created 7-cm incision, dissection is performed through subcutaneous tissue, with retractors placed at the proximal and distal aspects of the wound for visualization. A white stripe within the flexor pronator mass in line with the ulnar collateral ligament can typically be identified, indicating the appropriate interval between the 2 heads of the flexor carpi ulnaris (FCU) muscle fibers. This interval is gently incised with a scalpel.

Fig 11. For our ulnar collateral ligament reconstruction, we place the patient supine on the operative table with the arm positioned on a hand table with a stack of sterile blue towels placed beneath the elbow. The right operative extremity is positioned with the arm in abduction and external rotation, the elbow slightly flexed, and the forearm supinated for best access to the medial elbow. An approximately 7-cm incision is marked from the medial epicondyle (ME) distally, in line with the native ulnar collateral ligament.

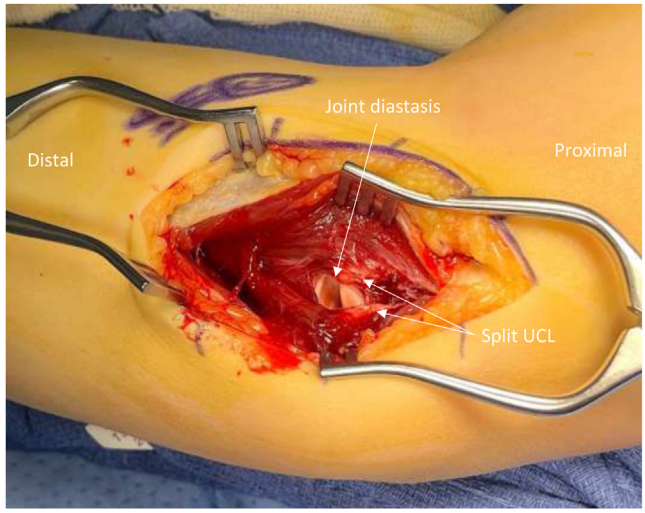

Fig 13. A right medial elbow is presented for our technique of ulnar collateral ligament (UCL) reconstruction using a palmaris tendon autograft. After we have approached the medial elbow and dissected through the flexor carpi ulnaris fascia, the flexor carpi ulnaris is bluntly split and dissected using scissors and a key elevator. The UCL is then incised longitudinally along the central portion to allow placement of the graft and later imbrication of the native UCL. In this patient, the UCL was found avulsed from the sublime tubercle. Upon splitting the UCL, excessive gapping of the joint can be visualized.

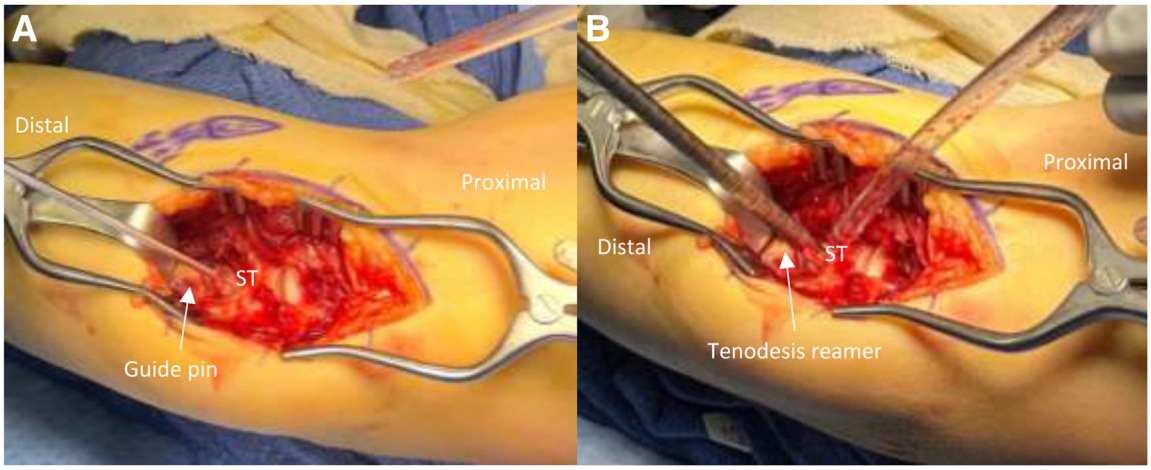

Fig 14. A right medial elbow is presented for our technique of ulnar collateral ligament (UCL) reconstruction using a palmaris tendon autograft. After we have performed dissection to the level of the native UCL and cleared soft tissue from the ulnar UCL footprint, a 2.4-mm guide pin for the tenodesis reaming system (Arthrex) is placed at the central aspect of the sublime tubercle (ST) (A). The corresponding tenodesis reamer is slid free over the guide pin, and the margins of the reamer are assessed to ensure it does not encroach on the articular surface or surrounding anterior and posterior cortices (B).

primary static stabilizer against valgus force.[2,3,10] Since the original description in 1986 by Dr. Frank Jobe, numerous modifications have been made.[8,11] These modifications hinge on improving biomechanical stability and returning players to competition. Recent studies have investigated anatomic reconstruction of the UCL footprint as compared to the traditional docking technique. Results have shown no significant differences in gapping with valgus loads.[12,13] The current return to sport ranges from 80% to 97%, although less when attempting to return to the same level of competition.[2,4,14] The revision rate of UCL reconstruction has also increased, and it is discouraging that return to the same level of sport after revision has been found to range from 50% to 55%, with higher complication rates and inferior outcomes compared to primary procedures.[5,6,15] Thus, there has been an initiative to develop an optimal technique to restore stability and return these athletes to the same level of competition.

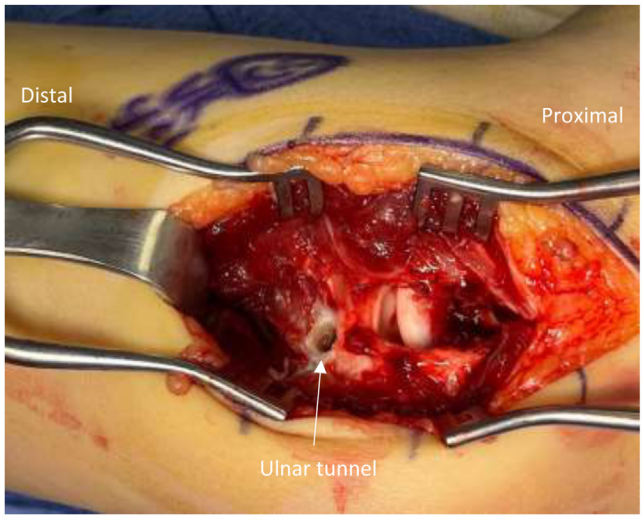

Fig 15. A right medial elbow is presented for our technique of ulnar collateral ligament reconstruction using a palmaris tendon autograft. We have previously placed a 2.4-mm guide pin for the tenodesis reaming system (Arthrex) at the central aspect of the sublime tubercle. We then utilize a cannulated reamer to achieve a tunnel centered on the sublime tubercle to a depth of 18 mm, careful to obtain a trajectory parallel and not toward the articular surface.

The technique presented in this article offers multiple advantages. The 3-stranded graft increases collagen across the reconstruction. The additional strand mitigates the size concerns of the palmaris tendon autograft. Furthermore, the native thickness of the UCL has been found to average greater than that of a double-strand palmaris autograft.[2,10,16] Although there is no set minimum for graft thickness when performing UCL reconstruction, a strong consensus by an expert panel concluded the graft should be no less than 3.5 mm in diameter.[17] The technique presented here approaches native UCL thickness, frequently 5.0 to 6.5 mm after preparation. No significant difference in valgus instability between the native elbow and constructs with the central fibers reconstructed through isometric points on the medial epicondyle and the sublime tubercle has been found.[18] This has been the premise of the linear construct. Creating a subcortical tunnel below the sublime tubercle can certainly be anxiety-provoking, and while the risk of fracture is low, it remains a devastating complication

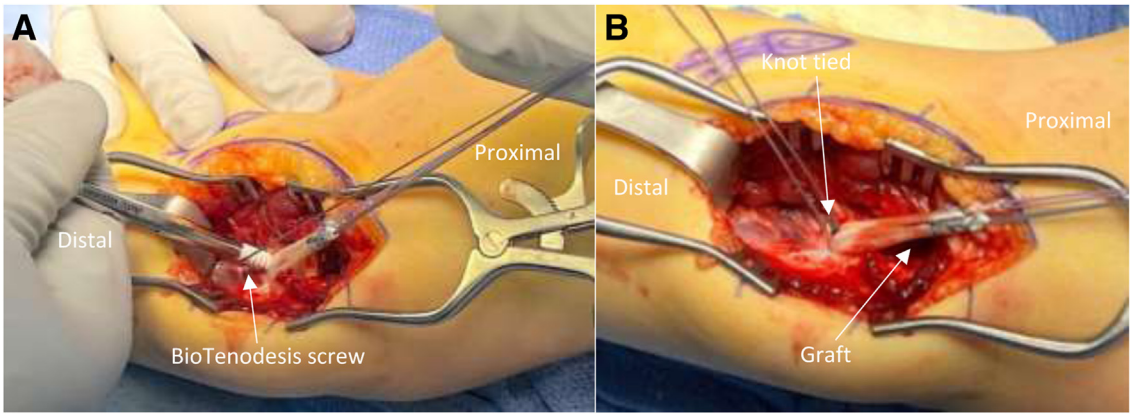

Fig 16. A right medial elbow is presented for our ulnar collateral ligament reconstruction using a palmaris tendon autograft. In this figure, we have already reamed a tunnel of approximately 18 mm in the ulna centered on the sublime tubercle, and in this image, we depict a 15-mm-long Bio-Tenodesis Screw (Arthrex), the same diameter or slightly smaller than the graft being secured to the ulnar end of the graft and inserted within the tunnel (A). A knot is tied with the suture ends (B).

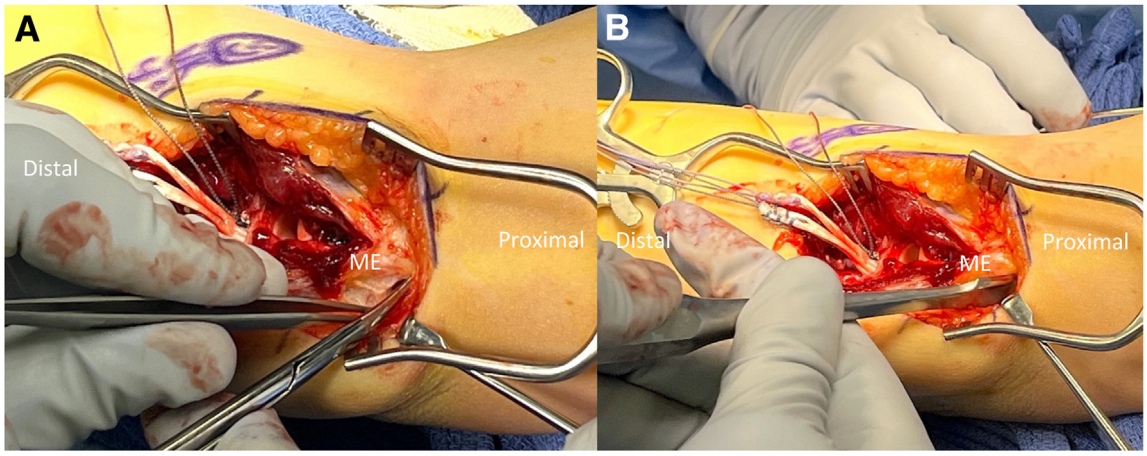

Fig 17. A right medial elbow is presented for our ulnar collateral ligament reconstruction using a palmaris tendon autograft. In this figure, the ulnar tunnel has already been created, and the ulnar end of the graft has already undergone interference fixation using a 15-mm Bio-Tenodesis Screw (Arthrex). This image depicts dissection being performed posterior to the medial epicondyle (ME) for visualization of intended drill tunnels and later knot tying. Scissors are used to enter the fascia adjacent to the bone on the posterior aspect of the medial epicondyle (A), with muscle elevated utilizing a key elevator (B). The ulnar nerve is identified just posterior to this site and protected with a retractor.

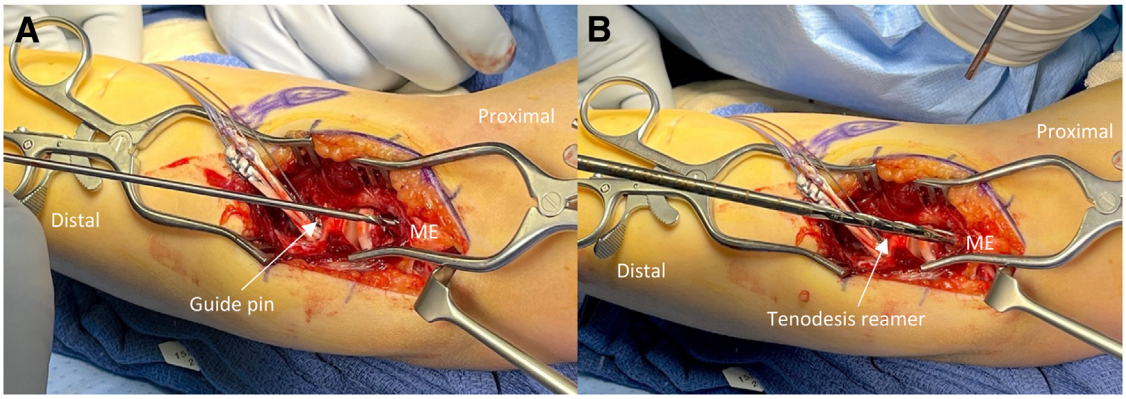

Fig 18. A right medial elbow is presented for our ulnar collateral ligament reconstruction using a palmaris tendon autograft. Ulnar fixation has already been achieved, and dissection has additionally been performed posterior to the medial epicondyle (ME). This image depicts a 2.4-mm guide pin (Arthrex) for the tenodesis reaming system being placed at the central aspect of the native ulnar collateral ligament origin (A). The corresponding tenodesis cannulated reamer is slid free over the guide pin, typically the same size or 0.5 mm larger than the humeral end of the graft, and the tunnel position is assessed. Once satisfied, the tunnel is reamed to a depth of 15 mm, with a trajectory that would exit at the posterolateral aspect of the ME (B).

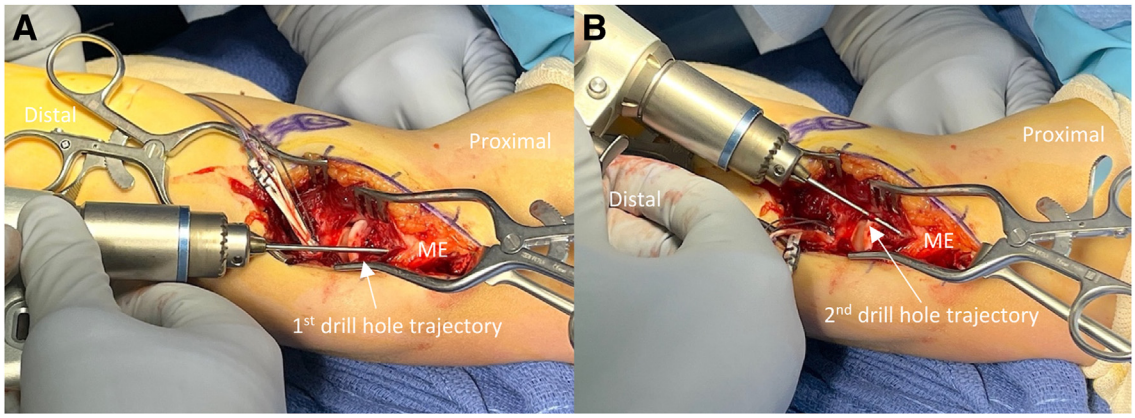

Fig 19. A right medial elbow is presented for our ulnar collateral ligament reconstruction using a palmaris tendon autograft. In this image, ulnar fixation has been completed and the humeral socket additionally already drilled. At this point, a 2.0-mm drill bit is used to create 2 tunnels, drilling from distal to proximal through the previously reamed socket, with a bridge at least 5 mm apart at the posterolateral aspect of the medial epicondyle (ME).

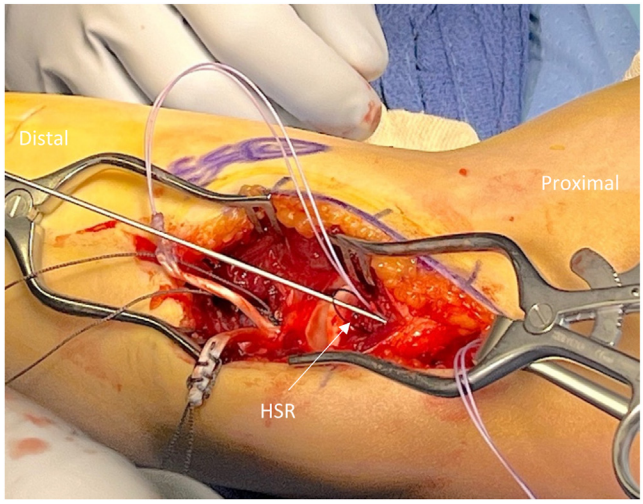

Fig 20. A right medial elbow is presented for our ulnar collateral ligament reconstruction using a palmaris tendon autograft. In this image, the ulnar interference fixation of our palmaris tendon autograft has been achieved and the humeral socket with two 2.0 mm tunnels has been created. This image depicts a Hewson suture retriever (HSR) being placed through each drill hole, anterior to posterior, with the looped end of a passing stitch retrieved from behind the medial epicondyle.

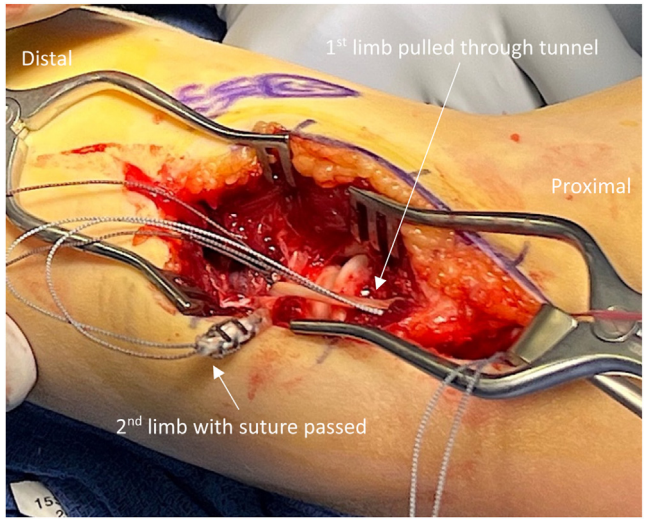

Fig 21. A right medial elbow is presented for our ulnar collateral ligament reconstruction using a palmaris tendon autograft. In this image, the ulnar interference fixation of our palmaris tendon autograft has been achieved and our humerus additionally prepped. Passing sutures have been placed past our graft limbs into the humerus for our docking portion. This image depicts each limb of the graft being introduced into the humeral tunnel using the passing sutures.

should it occur.[19] The ulnar interference inlay fixation avoids tunneling deep into the sublime tubercle and provides reliable and simplified fixation. Additionally, humeral docking with ulnar interference fixation allows simplified tensioning of the graft, which can be difficult with figure-of-8 constructs.

This technique is not without limitations. Depending on the bone quality and thickness of the graft, ulnar interference screw size may need adjustment during surgery. Iatrogenic disruption of the surrounding cortices during the ulnar preparation is also possible. This risk is mitigated by ensuring the cannulated reamer is well contained with cortical margins. Graft-tunnel mismatch is also possible, but the average length of the UCL from the center of the humeral footprint to the sublime tubercle has been found to range from 22 to 27 mm.[10] By drilling tunnel lengths and preparing graft lengths as

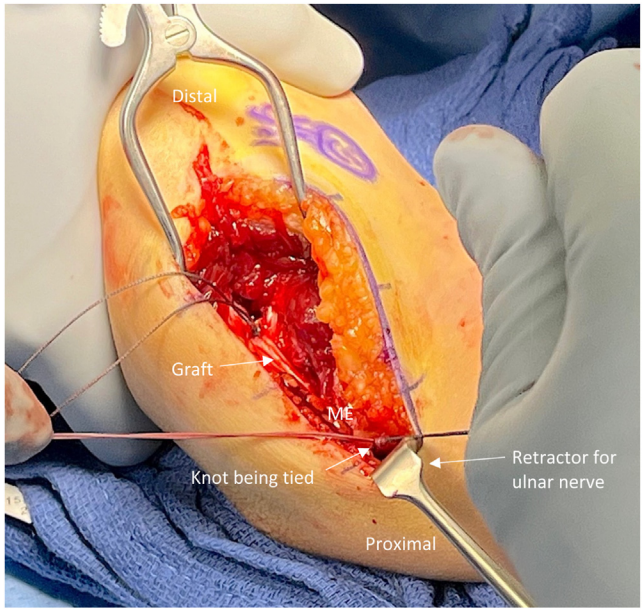

Fig 22. A right medial elbow is presented for our ulnar collateral ligament reconstruction using a palmaris tendon autograft. The ulnar end of the graft has undergone successful interference fixation with a Bio-Tenodesis Screw (Arthrex), and the humerus has been prepared using a biotenodesis reamer with additional 2.0-mm tunnels made for suture passage. The humeral end of the graft has been introduced into the humeral socket with each graft limb suture already having been passed through the smaller 2.0 mm tunnels. This image depicts the elbow being placed into 30° of flexion and varus stress. The sutures from each graft are tied together behind the medial epicondyle (ME). The knot created is deep (lateral) to the ulnar nerve, preventing any irritation.

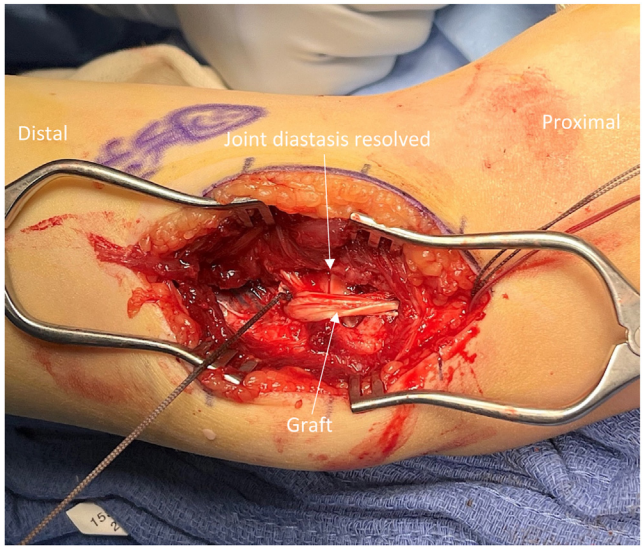

Fig 23. A right medial elbow is presented. This image depicts a palmaris tendon autograft that has successfully been fixated to both the ulna and the humerus using interference screw fixation and docking technique, respectively. This image demonstrates no additional ulno-humeral diastasis with excellent fixation of our palmaris tendon autograft as a hybrid-linear construct.

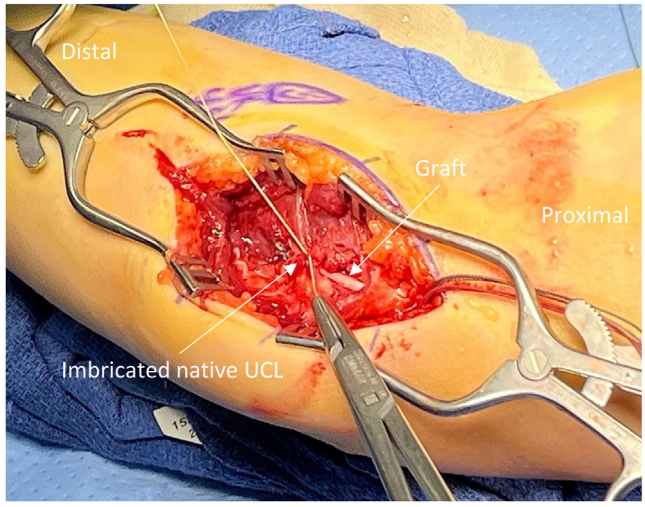

Fig 24. A right medial elbow is presented. This image depicts a palmaris tendon autograft in place for our ulnar collateral ligament (UCL) reconstruction and an overlying native UCL remnant being imbricated and incorporated into our graft using interrupted 0 Vicryl suture (Ethicon).

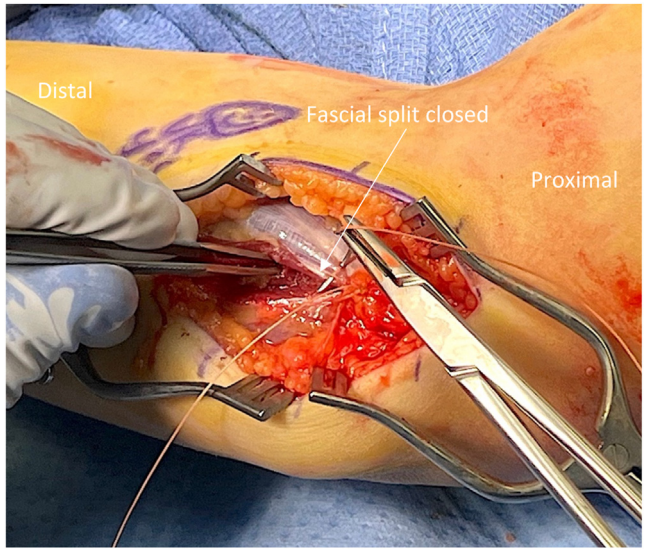

Fig 25. A right medial elbow is presented. This image depicts the final aspects of the ulnar collateral ligament reconstruction after successful fixation of a palmaris tendon autograft into the ulna via interference fixation and into the humerus via docking fixation. Here, the fascial interval of the flexor pronator split is closed utilizing 0 Vicryl suture (Ethicon).

previously described, this risk is mitigated. Various pearls and pitfalls of this technique are presented in Table 1.

This Technical Note describes a 3-strand palmaris longus autograft for UCL reconstruction. We believe our technique holds numerous advantages and has performed well in both low- and high-level throwers.

Table 1. Pearls and Pitfalls

Pearls	Pitfalls
Three-strand construct adds collagen and provides strength	Possible failure of interference fixation if not tested intraoperatively
Length of 50 to 60 mm allows for reproducible technique	Potential fracture if too close to surrounding cortices with ulnar drilling
Inlay-type fixation mitigates risk of sublime tubercle fracture	Graft-tunnel mismatch if preparation graft and tunnels not prepared per technique
Linear construct produces a more anatomic construct, reconstructing the central fibers	Knot not ensured tied lateral to ulnar nerve to mitigate risk of symptoms
A flexor split approach avoids the need for ulnar nerve transposition and mitigates muscle violation	

Disclosures

All authors (V.H.K., A.A.C., M.H.F.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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