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Clinical outcomes of a unique ulnar collateral ligament reconstruction hybrid technique with ulnar-sided suspensory fixation

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Background: Ulnar collateral ligament reconstruction (UCLR) is the gold standard for treating ulnar collateral ligament injuries in throwing athletes who have failed conservative treatment. There are several described techniques that produce successful and reproducible outcomes. In addition, there is biomechanical evidence that supports hybrid fixation of the graft with a docking technique on the humeral side and suspensory fixation on the ulnar side. However, as of this writing there are no clinical studies that have reported results. This retrospective case series is the first of its kind to report on clinical outcomes following UCLR with hybrid suspensory fixation.
Methods: Fifty throwing athletes who underwent ULCR with hybrid suspensory fixation from 2010-2017 by one of 5 surgeons at a single institution were available at a median follow-up of 7 years. Return to sport, level of sport, and postoperative complications were recorded at final follow-up.
Results: A total of 50 patients were included in final analysis. Nearly all were able to return to sport at the same level or higher (48/50, 96%). One of these 50 athletes (2%) played professionally, 27 (54%) played collegiately, and 21 (42%) played at the high school level. Seven patients (14%) underwent reoperation following the index procedure. The median (interquartile range) Quick Disabilities of the Arm, Shoulder, and Hand questionnaire score was 0.098 (0-4.5) at final follow-up.
Conclusion: Hybrid suspensory fixation is a safe and effective technique for UCLR in the throwing athlete. Throwers can expect to return to sport at a very high rate with low risks for postoperative complications.
Level of evidence: Level IV; Case Series; Treatment Study

Keywords: Ulnar collateral ligament; reconstruction; hybrid; suspensory fixation; elbow

Injuries to the ulnar collateral ligament (UCL) are becoming more prevalent in competitive throwers because of a growing epidemic and media interest in professional overhead athletes.[1] Although nonsurgical treatments, including rest, physical therapy, and a supervised return to

Institutional review board approval from Carolina HealthCare System (File no. 10-19-16E) was received prior to the enrollment of any subject into this study.

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throwing program, are effective in many cases, these injuries are definitively managed with surgery in throwers who fail conservative treatment.[1-3,14,19] The frequency of reconstruction is also increasing with time in order to address the increase in injuries and increased attention on UCL injuries in throwing athletes.[5]

Although there is a renewed interest in techniques to repair the ligament, the historical standard has been to reconstruct the ligament with an autogenous graft.[2,9] Several techniques have proven efficacious with a relatively low incidence of complications. The most commonly used techniques include the modified Jobe and docking technique.[1,6,12] In the modified Jobe technique, originally described by Jobe in 1974 and modified by Thompson in 2001, a muscle-splitting approach is used to access the UCL.[3] An autogenous graft is passed through tunnels in the ulna and humerus in a figure-of-8 fashion, tensioned, and ultimately sutured to itself. In the modification, the common humeral tunnel is drilled with smaller exiting tunnels directed anteriorly to protect the ulnar nerve. Critics of the modified Jobe technique have noted that it is technically demanding, requiring exact placement of drill tunnels and proper tensioning of the graft prior to fixation.[1,11]

In contrast, the docking technique was introduced in 2002 to address some of the concerns of the modified Jobe technique, including the number of tunnels, tensioning, and graft passage.[20] In the docking technique, the humeral tunnel is drilled to allow docking of the graft on the humeral side with even smaller exiting tunnels posteriorly. The graft is passed through the ulna first and then the humeral side with sutures tied over the bony bridge after appropriate tensioning. Stress fracture of the bony bridge and suture-related ulnar neuropathy have been described as potential complications.[13,16,20]

Each of these techniques requires a steep learning curve and precision when placing the bone tunnels in order to achieve isometry of the graft. Although alternative techniques have since been proposed, including the David Altchek and Neal ElAttrache for Tommy John (DANE TJ),[8] interference screw fixation, and various hybrid techniques using suture anchors, no single technique has been shown to have superior outcomes.

A hybrid suspensory technique (HST) is a unique technique described previously in a biomechanical study where results were equivalent to a modified Jobe technique. A cadaveric study by Morgan et al[17] first showed that HST was able to restore the biomechanical properties of the native ligament. The use of hybrid suspensory fixation, which consists of a ToggleLoc with ZipLoop suture button (Zimmer Biomet, Warsaw, IN, USA), for the ulna and a docking technique along the medial epicondyle of the humerus minimizes the risk of fracture through ulnar tunnels, maximizes isometry with graft placement and also allows the surgeon to adjust the tension on the graft after it has been fixed.

The goal of this study was to report the first clinical outcomes of patients undergoing UCL reconstruction (UCLR) with a unique HST. The primary outcomes were return to sport (RTS) and RTS at the same level. Secondary outcomes include patient-reported outcomes at final follow-up, complications, and reoperation rate.

Methods

We performed a retrospective review of all patients who underwent UCLR with the unique hybrid fixation technique at a single institution from 2010-2017. Institutional review board approval was required prior to the start of the study. All reconstructions were performed by one of 5 fellowship-trained surgeons. Indications for surgery were inability to participate in desired throwing activity without pain or instability and failure of a nonoperative treatment program. Inclusion criteria for this study were (1) UCL injury confirmed on magnetic resonance imaging, (2) UCLR within the study time period, (3) overhead athlete, and (4) 2-year follow-up. Exclusion criteria included (1) previous corticosteroid injection or platelet-rich plasma injection, (2) concomitant shoulder or wrist surgery to the ipsilateral arm at the time of UCLR, (3) revision UCLR, (4) skeletally immature throwers, and (5) previous surgery to the ipsilateral elbow. Patients who underwent concomitant procedures at the time of reconstruction were included.

All patients included had a preoperative examination with positive milking maneuver and/or positive moving valgus stress test.[3] Preoperative radiographs were obtained and evaluated in all patients; no radiographs demonstrated joint space narrowing at the ulnar trochlear joint. Initial management for all patients included rest, anti-inflammatory medications, and rehabilitation for a minimum of 6 weeks. All patients had a magnetic resonance imaging or arthrography demonstrating disruption of the UCL.

All patients had routine postoperative radiographs at the 2-week follow-up visit. Patients were contacted via telephone for final follow-up. A survey questionnaire was completed along with the patient-reported outcomes, consisting of the Quick Disabilities of the Arm, Shoulder, and Hand questionnaire score.

Surgical technique

A detailed surgical technique can be found in a previous publication.[17,21] Patients were positioned supine, and a hand table was used. A sterile tourniquet was used and inflated to 250 mm Hg. A palmaris, gracilis, or semitendinosus autograft was harvested in the standard fashion per the surgeon's preference. A 10-cm curvilinear incision was used over the anterior portion of the medial epicondyle. Sharp dissection was carried down to the flexor-pronator mass with branches of the medial antebrachial cutaneous nerve preserved. The flexor-pronator mass was split longitudinally at the posterior two-thirds of its thickness. The underlying UCL was identified and split longitudinally to identify the anatomic attachment sites on the ulna and humerus. The ulnar nerve was decompressed from the

cubital tunnel if determined to be symptomatic preoperatively and was later transposed in a subcutaneous fashion. The sublime tubercle was then drilled approximately 5 mm distal to the joint line with a 2.4-mm guide pin. The guide pin was angled at 45° with respect to the long axis of the ulna from anterior to posterior and slightly medial to lateral. The pin was also angled distally to avoid a transverse tunnel and to increase tunnel length. An acorn reamer sized appropriately to the graft diameter was then used to drill to, but not through, the far cortex. A 4.5-mm reamer was used to complete the tunnel and the length of the tunnel was measured, usually between 25-35 mm depending on the patient size and angle of the ulnar tunnel. On the humerus, a docking technique as described by Rohrbough et al[20] was used, aiming for a 15-mm socket depth. The graft was doubled when the gracilis or semitendinosus tendon was chosen, and either tripled or quadrupled when the palmaris was chosen depending on the total length of the graft. It was then prepared using a ToggleLoc-ZipLoop device (Zimmer Biomet). The length of the prepared graft was 55-60 mm. Using a Beath pin, the graft and ZipLoop were passed through the ulnar tunnel and tensioned until 15 mm of the graft was pulled into the ulnar tunnel. The ZipLoop was deployed on the far cortex and verified indirectly with a firm engagement of the cortex as the graft enters the socket or directly with fluoroscopy before passing the proximal sutures through the humeral bone tunnels and securing the graft in the humeral socket. The sutures were then tied over a 10-mm bone bridge. The elbow was cycled several times and then placed in 45°-70° of flexion, depending on surgeon preference, with a mild varus stress. Final tensioning of the ZipLoop was done by further cinching the tension sutures until there was no slack in the graft. The split in the native ligament was repaired. At this point, the ulnar nerve was transposed if indicated and the skin was closed in the standard fashion. Postoperatively, the elbow was placed into a posterior splint with the arm at 90° in all patients.

Postoperative rehabilitation was similar but not standardized for all patients. At the first postoperative visit, patients were transitioned into a hinged elbow brace with focus on improving the range of motion. The brace was discontinued around 6 weeks postoperatively, and patients were encouraged to work toward normal range of motion. Shoulder exercises, full body conditioning, and core strengthening were highlighted for the next phase of rehabilitation. A supervised throwing program was started once pain-free range of motion was achieved, usually around 4 months postoperatively. A full return to throwing was achieved anywhere from 9-12 months after surgery.

Statistical analysis

All data underwent standard descriptive statistical analysis using SAS, version 9.4 (SAS Institute, Cary, NC, USA). Mean and standard deviation were reported for normally distributed continuous variables; for nonparametric continuous data, median and interquartile range were reported. For categorical variables, frequencies and proportions were reported.

Results

In the initial query of our electronic medical record using the *Current Procedural Terminology* code 24346 (Reconstruction medial collateral ligament, elbow, with tendon graft [includes harvesting of graft]), a total of 157 patients were identified. Thirty-five patients were excluded (9 with previous elbow surgery to the ipsilateral elbow, 8 with no confirmed UCL injury on magnetic resonance imaging, 7 with concomitant surgeries to the wrist or shoulder of the ipsilateral arm, 5 with a previous platelet-rich plasma injection, 4 with a previous corticosteroid injection, 1 traumatic work injury, and 1 revision UCLR). Of the remaining 122 patients, 28 underwent UCLR using a traditional docking technique and 94 underwent UCLR using HST. Among the 94 patients who underwent UCLR using HST, 50 (53%) were available for final follow-up (Fig. 1).

Our final cohort consisted of 46 baseball players, 2 javelin throwers, 1 wrestler, and 1 softball player. Of those that participated in baseball, 36 (78.2%) were pitchers. All but 1 of our cohort were male, and the right arm was the injured arm in 39 (78%) of our patients. The mean age at the time of surgery was 18.7 years (range, 15.1-35.0 years). The preoperative level of competition was high school for 21 (42%) of the athletes, collegiate for 27 (54%) of the athletes, and professional for 1 athlete (2%) (Table I).

Fifty patients were available for follow-up at a minimum of 2 years. The median follow-up was 7.0 years. Forty-eight (96%) athletes were able to return to sport. Twenty-six athletes (96%) returned at the collegiate level, 13 returned at the high school level (93%), and 1 professional athlete (100%) returned at the professional level. The 2 athletes who did not return were high school seniors who did not go on to continue baseball at the collegiate level. Forty-four (84%) participated in a throwing program postoperatively at an average of 4 months. The mean time until RTS was 10 months.

Seventeen patients (34%) had ulnar nerve symptoms preoperatively. Twenty patients (40%) had a concomitant ulnar nerve procedure at the time of reconstruction. Eighteen nerve transpositions were performed, and 2 in situ decompressions were performed. All but one underwent ulnar nerve transposition; the other had an in situ decompression. Forty-three patients (86%) had a gracilis autograft, 5 patients (10%) had a palmaris autograft, and 2 (4%) had a semitendinosus autograft.

Postoperative radiographs were obtained at the 2-week follow-up visit (Fig. 2). These did not reveal any hardware complications or bony abnormalities. The Quick

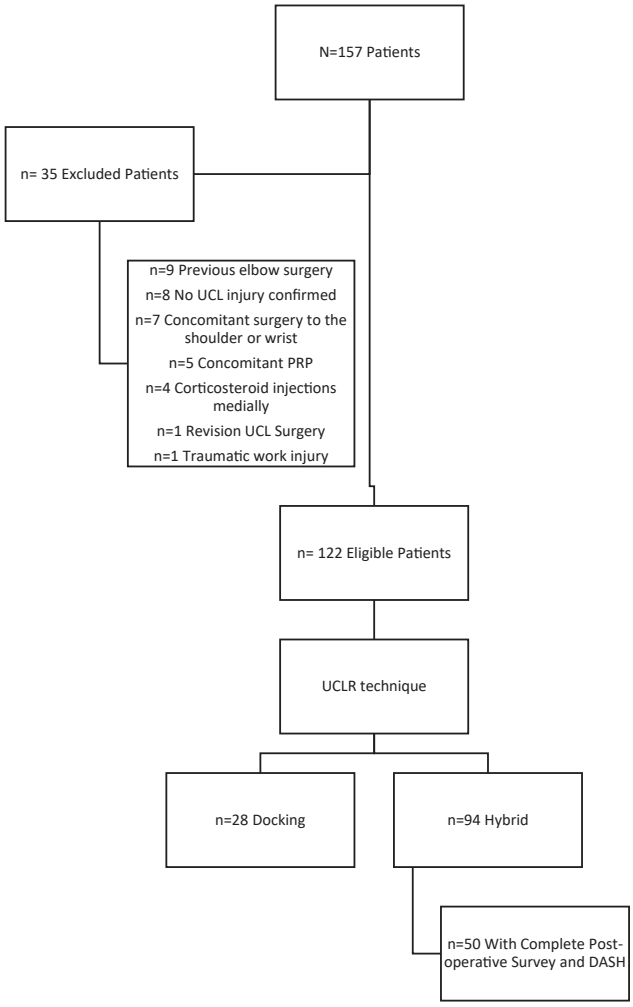

Figure 1 Consort diagram for patient eligibility.

Disabilities of the Arm, Shoulder, and Hand questionnaire patient-reported outcome tool was obtained at final follow-up for all patients. All but 1 patient registered a value of zero. The median score was 4.5.

There were 9 (18%) complications in our cohort. Three patients (6%) experienced postoperative ulnar neuropathy that persisted beyond 2 months and was not present preoperatively. Two patients (4%) had functionally limiting stiffness, 2 patients (4%) had a retear of the UCL, 1 patient (2%) had symptomatic hardware, and 1 patient (2%) fractured his olecranon after a fall during the immediate postoperative period. Seven of nine went on to reoperation: 2 (4%) underwent ulnar nerve transposition, 2 (4%) had arthroscopic capsular release, 1 (2%) had revision UCLR, 1 (2%) had symptomatic hardware removal, and 1 (2%) underwent open reduction internal fixation. The 2 patients who experienced retear of the UCL did so at 15 months and 68 months postoperatively.

Table I Patient information

	Hybrid technique (n = 50)
Age at surgery, yr, median (IQR)	18.7 (3.1)
BMI at surgery, median (IQR)	25.0 (3.0)
Sex, n (%)	
Male	49 (98.0)
Female	1 (2.0)
Laterality, n (%)	
Right	39 (78.0)
Left	11 (22.0)
Time to follow-up, yr, median (IQR)	7.0 (3.0)
Sport, n (%)	
Baseball	47 (94.0)
Javelin	2 (4.0)
Other	1 (2.0)
Level of sport, n (%)	
High school	21 (42.0)
Collegiate	25 (25.0)
Professional	1 (2.0)
Other	1 (2.0)

IQR, interquartile range; *BMI*, body mass index.

Discussion

This is the first study to report on RTS, patient-reported outcomes, and clinical outcomes following a unique HST for UCL reconstruction. Our results showed that 96% of athletes were able to return to sport at the same level of competition or higher. Although several techniques exist for reconstructing the ligament, and more recent techniques for repair have become popular, our HST is a unique one. The advantages of the HST are 3-fold. It allows for less bone tunnels in the ulna, theoretically limiting the risk for fracturing through convergent bone tunnels. Second, it allows for isometric placement of the graft with less difficulty. Third, it allows the surgeon to apply maximum tension to the graft after it has been fixed on both the ulnar and the humeral sides.

Historically, the RTS following UCLR has been very good, with more recent studies showing higher RTS than older studies.[1,3-5,10,16] Typically, throwing athletes have better return rates than nonthrowing athletes.[13] Marshall et al[16] demonstrated RTS at 96% in Major League Baseball players, with 84% RTS at the Major League Baseball level. Our athletes were all amateur throwers, with the exception of 1 minor league pitcher. However, they returned to their sports at a very high rate (96%). Jones et al[13] reported an 87% RTS in adolescent, skeletally mature athletes who included throwers and nonthrowers. All of the athletes returning to sport did so at the same level of competition or higher. In a recent study that used suspensory fixation on

Figure 2 Postoperative anteroposterior and lateral radiographs.

both the humeral and ulnar side of the joint, RTS was reported at 83%.[18]

Nine of our patients (18%) experienced a postoperative complication. Seven of these (14%) underwent a second trip to the operating room for reoperation. Watson et al[22] reported a complication rate of 18.6% in a 2014 systematic review. The most common complication was postoperative ulnar neuropraxia (12.9%). Cain et al[4] similarly demonstrated a complication rate of 20% in the largest single institution study. Reoperation rates in the literature are cited at 1%-15%.[4,7,10,23] In our cohort, stiffness and ulnar neuritis were the most common reasons to have a secondary procedure. UCL rerupture in our series occurred at 15 and 68 months. Only 1 of these went on to revision ULCR, using the same ulnar and docking tunnels and a semitendinosus allograft fixed with a ZipLoop on the ulna. The olecranon fracture requiring open reduction and internal fixation represents an extremely rare event with an acute traumatic fall. Traditionally, fractures have most commonly occurred at the medial epicondyle and less frequently through the converging ulnar tunnels.[3] It must not be discounted that an ulnar tunnel in a nearly transverse orientation produces a stress riser that is susceptible to fracture from a direct blow.

There are several limitations to our study. The retrospective nature of the study introduces the possibility of selection bias and recall bias that may influence the outcomes. However, it is important to study a unique technique retrospectively before initiating prospective studies. The level of athletics in our study was predominantly amateur in nature. For this reason, it is important to consider age, competition level, and other factors that may favor an RTS of a professional athlete. The age and social circumstances of our cohort also made contacting them for follow-up difficult. This heavily influenced the percentage of eligible patients at final follow-up in this study. The cost of this technique compared with the modified Jobe or docking technique was not evaluated in this study. Theoretically, introducing the ZipLoop implant could increase the cost of this technique. However, many surgeons use commercially available kits for the modified Jobe and docking techniques that may be cost drivers. Finally, the exact surgical technique and postoperative protocol varied from surgeon to surgeon, albeit slightly.

Conclusion

UCLR using HST is a safe and effective procedure. Overhead athletes with UCLR using HST can expect to return to sport at a high rate and at the same level of competition. The theoretical advantages of more isometric graft placement, minimizing ulnar tunnel fracture, and the ability to retension grafts after fixation make HST an attractive technique. This technique may also be useful in the revision setting as it preserves bone stock on the ulna.[3,15] Further prospective investigations are needed to provide direct clinical comparisons with other techniques.

Disclaimer

Patrick M. Connor reports he is a paid consultant for Zimmer Biomet and is a board member/past chairman for OrthoCarolina Research Institute. He reports no conflicts of interest directly related to the content of this study. All the other authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other

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