

Ulnar Collateral Ligament Injuries in the Throwing Athlete

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Abstract

Repetitive valgus forces on the throwing elbow place significant stress on that joint. This stress can cause structural damage and injury to the ulnar collateral ligament. Many acute injuries of the throwing elbow are caused by repetitive chronic wear. Although much work has been done on injury prevention in youth who are pitchers, overuse injury in throwing sports constitutes an epidemic. Failing nonsurgical management, ulnar collateral ligament reconstruction is a viable option to return the throwing athlete to competition.

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Interest in ulnar collateral ligament (UCL) injuries and their treatment has increased due to both the growing epidemic of injury among youth involved in throwing sports and media interest in professional overhead throwing athletes. In 1974, Jobe performed the first surgical technique to reconstruct the UCL, but the technique and results were not published until 1986.¹ The first patient was Major League Baseball pitcher Tommy John, and the procedure became known as the Tommy John procedure.²

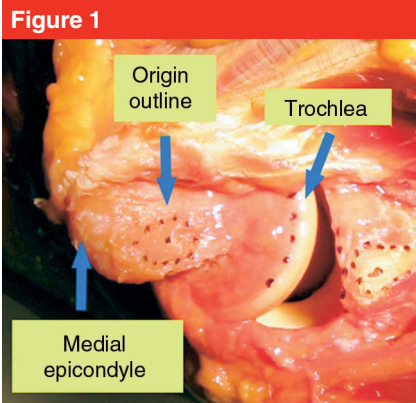
Optimal UCL reconstruction continues to be a topic of debate. To better understand, prevent, and manage UCL injury, we must fully comprehend the anatomy, biomechanics, pathomechanics, and current research available.

Anatomy

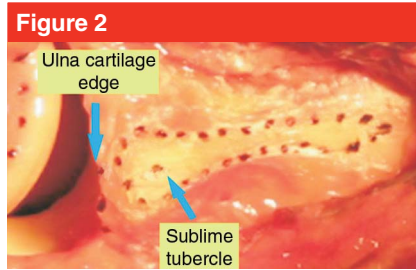
The UCL provides the primary restraint to valgus stress. Its three main components are the oblique, posterior, and anterior bundles.³⁻⁷ The oblique bundle, or transverse ligament, both originates and inserts on the ulna; consequently, it does not provide true stability to the elbow joint.^{3,4} The posterior bundle is

a fan-shaped thickening of the capsule that provides minimal, if any, stability to the elbow.⁴ The anterior bundle provides the main valgus restraint in the pitching motion and is the main restraint to valgus stress from 30° to 120° of elbow motion.⁵

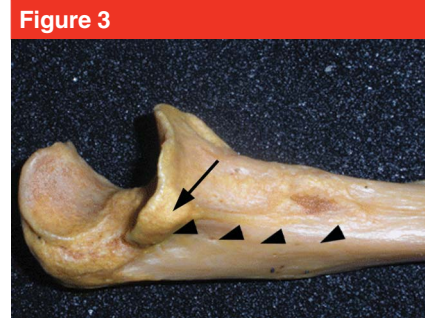
The anterior bundle originates on the anteroinferior edge of the medial humeral epicondyle, with a mean footprint of 45.5 mm² (Figure 1).^{3,5} The mean length of the UCL is 53.9 mm, with a mean width of 5.8 to 9.2 mm.^{4,6} The anterior bundle inserts an average of 2.8 mm distal to the ulna articular margin, with a mean footprint length of 29.2 mm on the sublime tubercle of the ulna.^{3,5,6} The anterior bundle has a mean footprint area of 127.8 mm², with a broad insertion proximally that tapers out distally on the ulna⁵ (Figure 2). Recently, a second bony prominence has been described as a second bony attachment for the insertion of the UCL on the ulna.⁶ This prominence, termed the medial ulnar collateral ridge, originates near the sublime tubercle and travels distally to its end point near the brachialis muscle insertion⁶ (Figure 3). This ridge is the site of attachment for the UCL as it tapers out distally.⁶



Photograph of a fresh-frozen cadaver elbow. The ulnar collateral ligament origin is outlined on the medial epicondyle. (Reproduced with permission from Dugas JR, Ostrander RV, Cain EL, Kingsley D, Andrews JR: Anatomy of the anterior bundle of the ulnar collateral ligament. *J Shoulder Elbow Surg* 2007;16[5]:657-660.)



Photograph of a fresh-frozen cadaver elbow demonstrating the insertion of the ulnar collateral ligament on the sublime tubercle of the ulna. (Reproduced with permission from Dugas JR, Ostrander RV, Cain EL, Kingsley D, Andrews JR: Anatomy of the anterior bundle of the ulnar collateral ligament. *J Shoulder Elbow Surg* 2007;16[5]:657-660.)



Photograph of the ulnar sublime tubercle (arrow) and the medial ulnar collateral ridge (arrowheads) in a cadaver specimen. The ulnar collateral ligament tapers out distally to attach to this ridge. (Reproduced with permission from Farrow LD, Mahoney AJ, Stefancin JJ, Taljanovic MS, Sheppard JE, Schickendantz MS: Quantitative analysis of the medial ulnar collateral ligament ulnar footprint and its relationship to the ulnar sublime tubercle. *Am J Sports Med* 2011;39 [9]:1936-1941.)

The anterior bundle inserts onto the sublime tubercle with a ridge that separates the bundle into anterior and posterior bands of equal size.³⁻⁵ The anterior band of the anterior bundle provides primary valgus restraint, and its repair is crucial to adequate reconstruction.^{4,6} The posterior band provides assistive restraint at 90° to 120° of elbow flexion.⁴

Patient History

A thorough history is critical to properly diagnose UCL injuries in the throwing athlete. Some patients report an actual “pop” (acute injury) that occurred while throwing, whereas others may report only vague pain (chronic attenuation) that affects pitching accuracy or velocity. Most athletes with UCL injuries report pain in the late cocking and acceleration phases. Detailed information on the athlete’s injury should include timing in the season; position played; level of competition; training regimen; number of pitches thrown

or innings played at the time of injury; symptoms at onset, including any ulnar nerve symptoms; and duration of symptoms. The rehabilitation course should be well documented and include details such as length of time without pitching, the physical therapy or training regimen, and any other nonsurgical measures attempted.

Physical Examination

Physical examination should include a detailed evaluation of the entire upper extremity, the core, and the kinetic chain. Range of motion and strength at the shoulder, elbow, and wrist should be compared with those of the contralateral side. It is not uncommon for elbow and shoulder pathology to coincide, and the patient should be evaluated for motion deficits in glenohumeral internal rotation and total rotation. Failure to address abnormal shoulder kinematics can be detrimental to the outcome of an injured UCL. Lack of full elbow extension is common after years of pitching; this finding may be asymptomatic. The throwing arc ranges from 20° to 120°, and less than full

terminal elbow extension may not adversely affect the throwing athlete.^{7,8} Multisport athletes may not report elbow pain when throwing a football or softball, which requires less terminal extension at release than does throwing a baseball.

The UCL is palpated proximally and distally to determine the location of the tear or injury. Tenderness is found more posterior to the flexor-pronator origin.⁷ Tenderness may be found over the flexor-pronator wad. Pain on resisted wrist flexion represents a flexor-pronator strain in isolation or in combination with UCL injury. Chronic tears may not have associated UCL tenderness. In the case of acute tears, tenderness often abates with rest.

The differential diagnosis includes medial epicondylitis, flexor-pronator injuries, ulnar neuropathy, and apophysitis; however, occasionally such diagnoses occur simultaneously. MRI often shows edema in the flexor-pronator origin after an acute UCL injury; this finding may be confused

with flexor-pronator strain. Specific muscle strength testing and knowledge of the site location for soreness of each area can help differentiate these injuries. A thorough ulnar nerve examination should include motor and sensory testing. Ulnar nerve irritation can be analyzed by provocative maneuvers in an attempt to elicit the Tinel sign at the ulnar groove. Ulnar nerve stability can be assessed by palpating the nerve and feeling for any subluxation on active elbow motion.

Stability Tests

Multiple tests have been described for assessing valgus stability of the elbow. The valgus stress test is performed with the elbow in 30° of flexion to unlock the bony congruity and allow for stress to be applied to the soft tissues, specifically the anterior band of the anterior bundle. An isolated anterior band injury can produce opening at 30° to 40° of elbow flexion, whereas an injury to the entire UCL may demonstrate gapping at 80° to 100° of elbow flexion.⁴ The valgus stress test can be performed with the patient sitting upright or lying supine or prone, as long as the examiner is able to stabilize the elbow. Prone positioning allows the patient to relax and helps prevent the shoulder from externally rotating, as happens in the supine and sitting positions. The test is positive when laxity is 2 mm greater than that of the contralateral elbow or in the presence of a significantly softer end-feel.² Even in complete or partial tears of the UCL, the amount of laxity at the elbow may be too small to detect on examination. In these cases, medial-sided pain may be the more useful sign.

The milking maneuver is used to assess elbow stability at a flexion angle $\geq 90^\circ$ to assess the posterior band of the anterior bundle.⁷ The shoulder is abducted to 90°, the elbow is flexed to

Figure 4



Clinical photograph of the milking maneuver, which is used to evaluate elbow stability.

90°, and the forearm is supinated, with the examiner pulling posteriorly on the patient's thumb to apply valgus stress to the elbow (Figure 4). A positive test elicits pain, instability, and apprehension.

The moving valgus stress test is performed with the patient seated and the shoulder abducted to 90°.⁹ The elbow is placed in full flexion, and valgus stress is applied to the elbow, placing the shoulder in maximal external rotation. The elbow is then quickly extended to 30°. The test is positive when medial elbow pain is most severe between 120° and 70°, which represent the late cocking and early acceleration phases, respectively, as the elbow is extended. The shear angle is the angle at which maximal pain is encountered, and the shear range is the range of pain.

The valgus extension overload test is performed by passively snapping the elbow into extension while maintaining valgus stress. Posterior elbow pain indicates a positive test. A positive test may be indicative of a symptomatic posteromedial olecranon osteophyte,

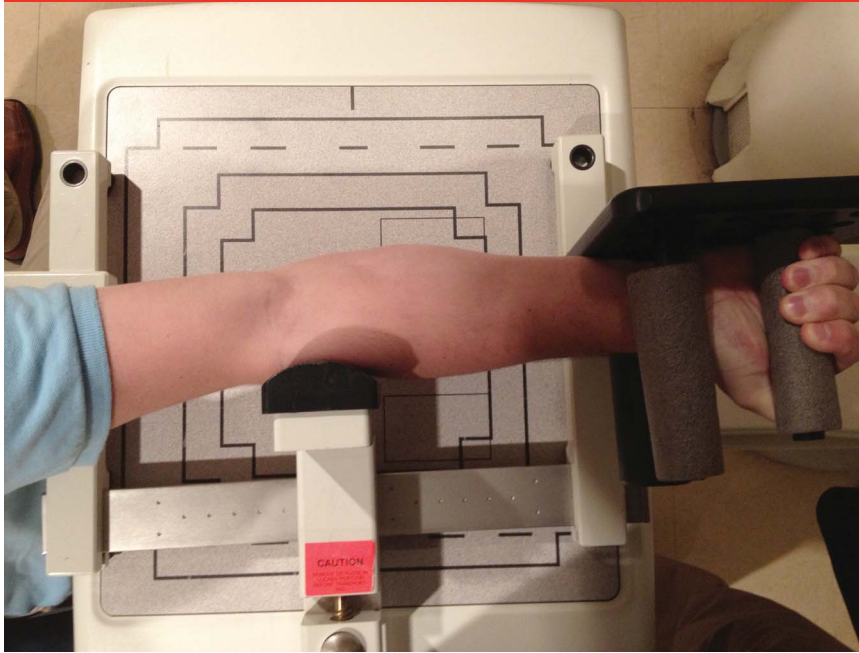
which may need to be excised at the time of UCL reconstruction.

Imaging

Standard AP, lateral, oblique, reverse axial (ie, cubital tunnel), and bilateral valgus stress radiographs of the elbow are obtained. These are evaluated for arthritic changes, bony UCL avulsions, traction spurs and calcifications in the ligament, and/or posteromedial olecranon osteophytes. In the large case series on UCL injuries published by Cain et al,² abnormalities were found in more than half of the patients evaluated; olecranon osteophyte formations and calcifications within the UCL were the most common abnormal findings.

Valgus stress radiographs are taken of both elbows for comparison. The patient is seated on a stool with the arm resting on the table in abduction and external rotation, and the elbow is positioned in 20° to 30° of flexion to unlock the bony conformity of the elbow. The forearm is placed in full

Figure 5



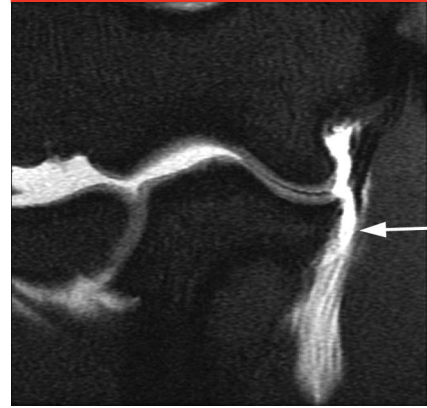
Photograph of patient positioning for the AP valgus stress view of the elbow using the Telos stress device SE 2000 (Telos Medical).

supination. A static AP radiograph is taken first, followed by the stress view. A Telos stress device (Telos Medical) is used to achieve 15 daN of valgus stress (Figure 5). Valgus stress views can be useful to demonstrate valgus laxity. Rijke et al¹⁰ found joint space widening >0.5 mm compared with the unaffected side to be diagnostic for complete or high-grade partial tears of the UCL. In pitchers, a small amount of opening may be considered adaptive and normal. In their study of 40 asymptomatic professional pitchers, Ellenbecker et al¹¹ found that in the dominant elbow, the medial joint space opens an average of 0.32 mm more on stress view compared with the nondominant elbow (1.20 and 0.88 mm, respectively). These studies demonstrate that only a small amount of opening may be present in laxity and instability, which points to the difficulty in diagnosing this condition with the valgus stress physical examination alone.

MRI can help better define the soft-tissue anatomy, including edema in the flexor-pronator origin. Currently, MRI is considered to be the modality of choice for detecting UCL tears. We prefer magnetic resonance arthrography at our institution (Figure 6). The T-sign is seen when a pathologic amount of dye leaks down along the sublime tubercle but is contained under the superficial fibers of a partially torn UCL.¹² Caution is required when reading a T-sign because the UCL has been found to attach, on average, 2.8 mm from the articular surface of the ulna; thus, some T-sign may be normal.⁵

Musculoskeletal ultrasound is non-invasive, involves no radiation exposure, and is convenient when used in the clinician's office. It can be used to help identify the integrity of the UCL and assess it for bony fragmentation at its origin and insertion. Ultrasound imaging can be used in conjunction with valgus stress maneuvers to identify medial joint laxity in real

Figure 6



Coronal magnetic resonance image demonstrating complete tear of the ulnar collateral ligament off the ulnar insertion (arrow).

time. Although this is a valuable noninvasive tool for assessing the anatomy of the medial elbow, results are dependent on clinician experience and expertise with ultrasound.

Biomechanics of Pitching

Biomechanical studies have shown the valgus forces to be as high as 64 Nm during the late cocking and acceleration phases of the throwing motion, which is the period in which most elbow injuries occur.¹³ Varus torque moments are needed to prevent valgus overload, which is produced by tension of the UCL and flexor-pronator muscles in accordance with compression of the radiocapitellar joint.^{13,14} When dynamic stabilizers (eg, flexor-pronator muscles) become fatigued, even more stress is placed on the UCL. The UCL approaches the maximum varus torque allowable with every pitch, which explains why UCL injuries are so common in competitive pitchers.^{13,14}

Prevention

Injury prevention in baseball is difficult due to increased play and

Table 1**USA Baseball Medical/Safety Advisory Committee Recommendations on Limits on Pitches by Youth Athletes^{16,17}**

Age (y)	Pitches per Game	Pitches per Week	Pitches per Season	Pitches per Year
9–10	50	75	1,000	2,000
11–12	75	100	1,000	3,000
13–14	75	125	1,000	3,000
15–16	90	2 games/wk	—	—
17–18	105	2 games/wk	—	—

Adapted with permission from Kerut EK, Kerut DG, Fleisig GS, Andrews JR: Prevention of arm injury in youth baseball pitchers. *J La State Med Soc* 2008;160(2):95-98.

competition at the youth level. Baseball, once considered a seasonal sport, has become a year-round event in some regions of the United States, with increased travel team play and sponsored tournaments. The USA Baseball Medical/Safety Advisory Committee was designed to provide scientifically based information to its youth baseball players to help reduce injury. The committee sponsored an epidemiologic study by the American Sports Medicine Institute that demonstrated that pitch counts correlated to both elbow and shoulder pain in youth pitchers.¹⁵ As a result of that study, the committee made position statements on recommendations for pitch counts in the youth thrower^{16,17} (Tables 1 through 3).

A prospective cohort study followed 481 youth pitchers for 10 years and found that players who pitched more than 100 innings in one calendar year had a 3.5 times greater chance of sustaining a serious injury.¹⁸ Young pitchers should be limited to 100 innings in any calendar year. Recommendations have also been given to discourage year-round baseball to ensure a period of so-called active rest from throwing in the off-season.¹⁶ Youth pitchers should be discouraged from pitching for multiple teams and showcases because doing so has been associated with elbow pain.^{16,18}

Debate persists regarding the effect of breaking balls (ie, curveballs) on injury in youth pitchers. The kinematics of the

curveball are different from those of the fastball. The curveball is associated with greater forearm supination, less wrist extension, and a shorter stride.¹⁹ Initially, a link was believed to exist between throwing curveballs at an early age and an increase in elbow injuries. In a prospective study of 476 young pitchers aged 9 to 14 years, the curveball was found to be associated with a 52% increased risk of shoulder pain, and the slider was found to be associated with an 86% increased risk of elbow pain.¹⁵ In contrast, in a follow-up study evaluating risk factors for shoulder or elbow injuries that required surgery, no correlation could be identified between injury and age at which breaking pitches were first thrown.²⁰ This study provided additional support for overuse as the main cause of injury, noting an increased risk of 500% for surgery for those pitching more than 8 months per year, 400% risk for pitching >80 pitches per game, and >250% increased risk in those who could throw a fastball >85 mph.^{17,20} Biomechanical testing has revealed that the curveball produces less elbow torque than does the fastball in youth pitchers.²¹ This has led many to return to the belief that limiting pitch counts rather than pitch types is the main goal in educating coaches, parents, and players with regard to preventing throwing injury in youth.²¹ However, we still caution against throwing curveballs at an early age because of the high level of

neuromuscular control needed to throw with proper mechanics.

Injury prevention in youth pitching is a public health concern, and any effective approach requires buy-in from athletes, parents, and coaches. Even with the implementation of injury prevention programs, UCL reconstructions increased approximately 10-fold in the first decade of the 21st century.²² No available data prove that injury rates are declining.²²

Public perception of the success with UCL reconstruction also could be a factor in failure to adhere to injury prevention guidelines and recommendations. A recent study on public perception of pitching showed that 31% of coaches, 28% of players, and 25% of parents did not believe that the number of pitches thrown was a risk factor for injury.²³ Additionally, 51% of high school athletes, 37% of parents, and 30% of coaches thought that UCL reconstruction should be performed on players without an elbow injury to enhance performance. There are no data to support the misperception that UCL reconstructive surgery will improve pitching beyond the preinjury state, and we do not recommend prophylactic reinforcement of the UCL in young aspiring pitchers. Continued efforts are needed to address public perception of the throwing athlete and to better educate players, coaches, and parents regarding the prevention of overuse throwing injuries.

Table 2

USA Baseball Medical/Safety Advisory Committee Recommendations for Days of Rest After a Pitching Event^{16,17}

Age (y)	1 Day Rest	2 Days Rest	3 Days Rest	4 Days Rest
9–10	21–33 pitches	34–42 pitches	43–50 pitches	51+ pitches
11–12	27–34 pitches	35–54 pitches	55–57 pitches	58+ pitches
13–14	30–35 pitches	36–55 pitches	56–69 pitches	70+ pitches
15–16	30–39 pitches	40–59 pitches	60–79 pitches	80+ pitches
17–18	30–39 pitches	40–59 pitches	60–89 pitches	90+ pitches

Adapted with permission from Kerut EK, Kerut DG, Fleisig GS, Andrews JR: Prevention of arm injury in youth baseball pitchers. *J La State Med Soc* 2008;160(2):95-98.

Nonsurgical Management

A trial of nonsurgical measures is appropriate, especially in the young athlete with an acute injury. The young athlete with a partial tear should be advised to not throw for 6 weeks while therapy is initiated. Rehabilitation should address pitching mechanics, shoulder kinematics, and shoulder motion deficits, as well as strengthening of the core, lower extremities, and upper extremities.²⁴ Once the patient is pain-free and kinetic chain deficits have been addressed, an integrated gradual throwing program may be started. The return to throwing program must be gradual and guided by a therapist or trainer in order to keep the athlete pain-free until he or she is ready for competition. A platelet-rich plasma injection may be considered for some athletes, although data are limited for UCL tears. We do not recommend corticosteroid injections because of the possible attenuation and weakening of critical structures in this area.

Surgical Management

The following UCL reconstruction technique has been performed by the senior author (J.R.A) in more than 2,000 athletes.^{2,25} Although ipsilateral palmaris longus autograft is the

first choice for graft, the contralateral gracilis tendon is used in patients without a palmaris tendon. Lateral and oblique radiographs help to determine whether posteromedial osteophyte excision will be performed. Calcifications within the UCL that may need to be excised are visualized on an AP radiograph.

Palmaris Longus Graft Harvest

A regional block is not used for UCL reconstructions in order to allow assessment of ulnar nerve function postoperatively. The palmaris longus tendon is harvested first. Two small 8- to 10-mm transverse incisions are made, the first at the wrist crease and the second 4 cm proximal to it. Hemostats are placed under the palmaris tendon through both incisions to ensure safe harvest while protecting the other flexor tendons and the median nerve. The most proximal incision is made 15 cm proximal to the first two incisions. This third transverse incision is extended 15 to 20 mm, until the proximal end of the palmaris tendon is identified. Following proximal harvest of the tendon, the fasciae are closed to prevent muscle herniation. The tendon is prepared at the back table with a running 0 Vicryl whipstitch suture (Ethicon). A graft of ≥ 15 cm in length is preferred.

Table 3

USA Baseball Medical/Safety Advisory Committee Recommendations for Youth Pitchers^{16,17}

- No breaking pitches (curveball, sliders) until puberty (approximately age 13 y)
- Proper pitching mechanics in youth and year-round physical conditioning should be stressed.
- Discourage youth from pitching for more than one team in a season.
- Three-month rest period per year from overhead throwing activities
- No pitching in a game or practice after being removed from pitching in a game.

Incision and Ulnar Nerve Release

The incision for the UCL reconstruction is made directly over the medial epicondyle, extending 4 cm proximal and 6 cm distal from the point of entry. The two limbs make a 160° angle extending from the medial epicondyle. The medial antebrachial cutaneous nerve can often be found traversing the distal one third of the incision, running just medial to the medial antebrachial vein. Both the nerve and the vein are mobilized in order to protect them in the anterior skin flap. The ulnar nerve is released from the cubital tunnel proximally and distally, then protected with a vessel loop. To free the nerve distally, the flexor carpi ulnaris fascia that overlies the nerve is incised and the muscle fibers are carefully split so that the branches of the nerve can be protected. The first branch of the nerve innervates the joint capsule and may be sacrificed. The next two branches are the anterior and posterior motor branches; these must be protected at all times.

A small amount of the intermuscular septum is used later in the procedure for subcutaneous transposition of the ulnar nerve. Great care

is required in this step because the brachial artery and median nerve lie just lateral to the medial edge of the intermuscular septum. A strip of septum 1 cm wide and 4 to 5 cm long is taken down to its insertion on the humerus. Bipolar electrocautery is used throughout for hemostasis. Excessive bleeding, specifically in the area of the intermuscular septum and the cubital tunnel, can lead to heterotopic ossification.

Exposing the UCL

Exposure of the UCL ligament is begun by elevating the flexor mass off the deep fascia near the sublime tubercle. The flexor digitorum profundus muscle is elevated carefully with a knife and elevator, taking care not to cut into the UCL that lies just underneath. A longitudinal incision is made in the center of the ligament to inspect the undersurface of the ligament. If present, a symptomatic posteromedial olecranon osteophyte is resected at this time through a small vertical posteromedial arthrotomy located just posterior to the posterior band of the UCL.

Passing the Graft

The drill holes for the ulna are located just below the sublime tubercle, where the superficial flexor tendon mass arises (approximately 7 mm distal to the joint). Using a 3.5-mm drill bit for palmaris grafts (4.0-mm bit for gracilis grafts), the posterior ulna hole is drilled first. A hemostat is placed in the hole with the tips aimed anteriorly to aid in triangulation when drilling the connecting hole. The anterior hole is drilled just above the sublime tubercle, aiming for the hemostat tips. The drill holes should lie at least 8 to 10 mm apart. Straight and angled curets are used to open and connect the holes. A Hewson suture passer (Smith & Nephew) contoured with a C curve is used to pass the graft through the holes. The use of mineral oil on the

graft can aid in passage. A hemostat is placed on the distal suture strands once the graft has been passed, and the native UCL is repaired with side-to-side stitches (Figure 7, A).

The humerus is drilled next, starting with the most distal drill hole at the medial epicondyle, made in retrograde fashion (Figure 7, B). The two proximal holes are drilled again using a hemostat in the most distal hole as a guide for triangulation. Curets are used to connect the three humeral tunnels to create a Y, after which the holes are irrigated to clear any bony debris. Using a Hewson suture passer, the graft is passed one limb at a time through these holes. The two free limbs exit the proximal holes and are overlapped. The limbs are sutured together while an assistant holds them in tension with the elbow in 30° of flexion. Suturing the graft together on the ulnar side provides extra tension, as well (Figure 7, C and D).

The small strip of intermuscular septum is used to transpose the ulnar nerve anteriorly to protect it from scarring in the area of the cubital tunnel. A drain is placed before closure, and the patient is placed in a posterior splint.

Postoperative Management

For the first week, the patient is maintained in a posterior sling to allow soft-tissue healing, after which he or she is progressed to an elbow range-of-motion brace. A guided therapy program is undertaken, with the goal of returning motion and strength and engaging in sport-specific exercises as described by Ellenbecker et al.²⁶ An interval throwing program is begun at approximately 4 months postoperatively provided all motion, strength, and endurance parameters are met. Athletes are not allowed to throw from the mound until 6 to 8 weeks after commencement of the interval throwing program. Return to competitive throwing is expected 9 to 12 months postoperatively.

UCL Repair Outcomes

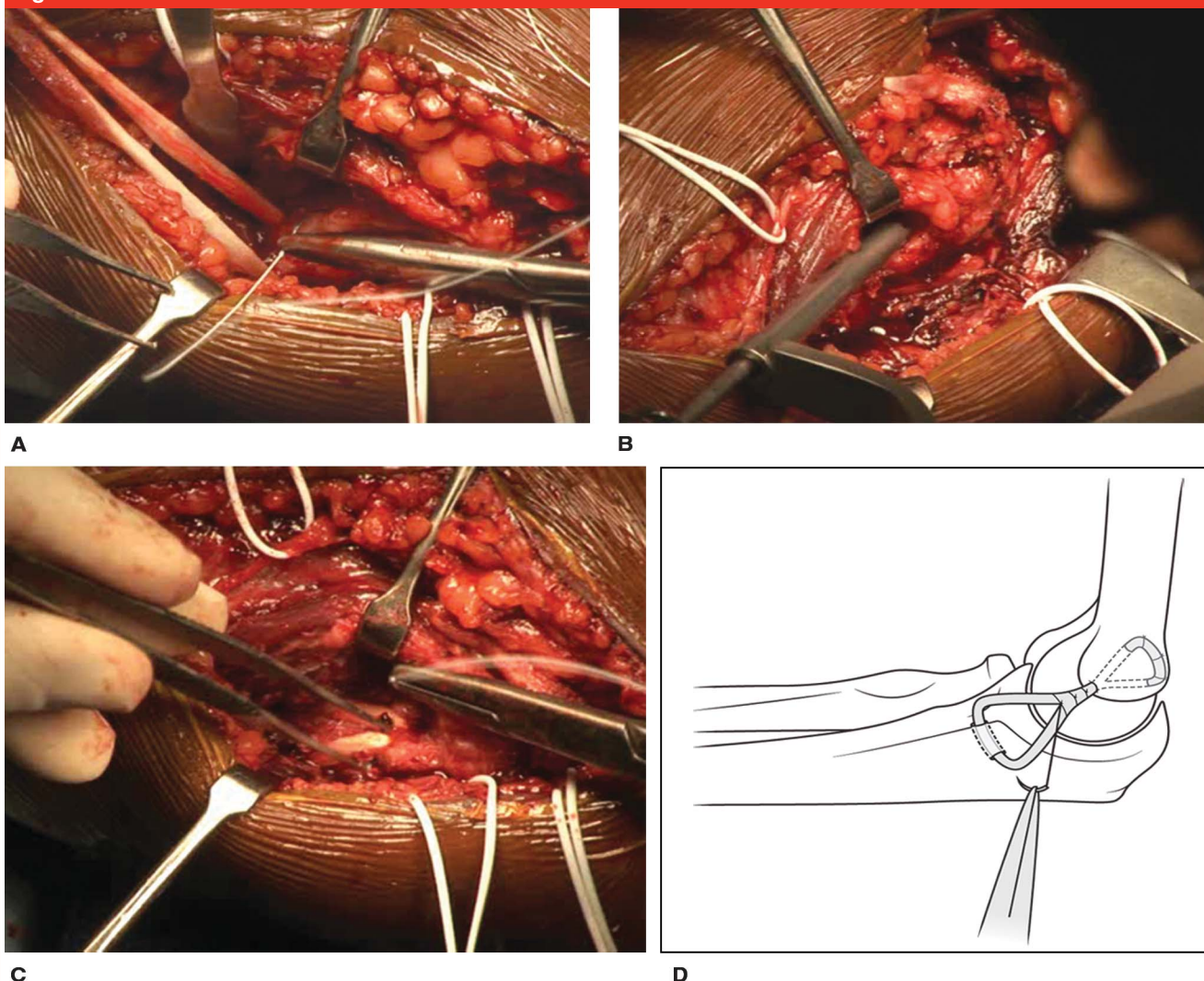
Most data on surgical treatment have been on UCL reconstruction; however, primary repair of the UCL has been described in athletes.^{2,8,27} Savoie et al²⁷ performed direct repair in 60 young athletes (mean age, 17.3 years) with UCL tears, and 93% of patients had good to excellent results. Fifty-eight of the 60 athletes were able to return to sport within 6 months of surgery. Other studies have found rates of return to previous level of play of 29% to 70% following UCL repair.^{2,8} We have abandoned this technique due to the high success rate with reconstructive procedures and the concern that these ligaments become attenuated during the tearing process. However, this technique may be an option for some patients, specifically in young athletes with acute tears off the bone or bony avulsion fractures.

UCL Reconstruction Outcomes

Although the first UCL reconstruction was performed in 1974, the first data on the technique were not published until 1986.^{1,3} Jobe et al¹ described a figure-of-8 autograft technique with submuscular ulnar nerve transposition in which the flexor-pronator origin had to be detached to achieve exposure. The procedure was successful in 10 of the first 16 patients who underwent the procedure. Success was defined as the ability to return to the previous level of participation in sports. Jobe went on to modify his own technique by using a muscle-splitting approach without subcutaneous ulnar nerve transposition.²⁸ Use of the modified technique resulted in improved outcomes.

The surgical technique used by the senior author (J.R.A) and described in this article has been referred to as the

Figure 7



A, Intraoperative photograph of graft passed through the ulnar drill holes. The native ulnar collateral ligament, which had been split longitudinally, is repaired before the humeral tunnels are drilled. **B**, The most distal humeral tunnel is drilled from distal to proximal for ulnar collateral ligament reconstruction. The medial antebrachial cutaneous nerve is protected anteriorly with a vessel loop, and the ulnar nerve is protected posteriorly. **C**, The graft is tensioned on the ulnar side after the humeral side has been sewn down and secured to itself. **D**, Illustration of the final appearance of the graft.

American Sports Medicine Institute technique.^{3,25} The largest case series to date on UCL reconstructions involved this technique.² A total of 1,281 patients were evaluated, 743 of whom were contacted for follow-up evaluation at a minimum of 2 years postoperatively. Of these, 83% returned to the same or higher level of competition. Thirty-four of 45 major league players returned to the same level, and 7 returned to the minor

league. At the collegiate level, only 10% of the 346 athletes did not return to sport or returned to a lower recreational level of play. One hundred forty-eight complications were reported, 82% of which consisted of minor transient ulnar neurapraxia that resolved within 6 weeks. The average time to begin throwing was 4.4 months, and the average time to return to full competition was 11.6 months.

The docking technique described by Rohrbough et al²⁹ uses a muscle-splitting approach without ulnar nerve transposition. A single Y-shaped humeral tunnel is made, and smaller proximal exit holes are made with a 1.5-mm drill bit.^{3,29} Rather than pass the graft out two proximal drill holes, the proximal ends are docked in the humerus, and the suture itself is tied over a humeral bone bridge^{29,30} (Figure 8). These modifications were

Figure 8

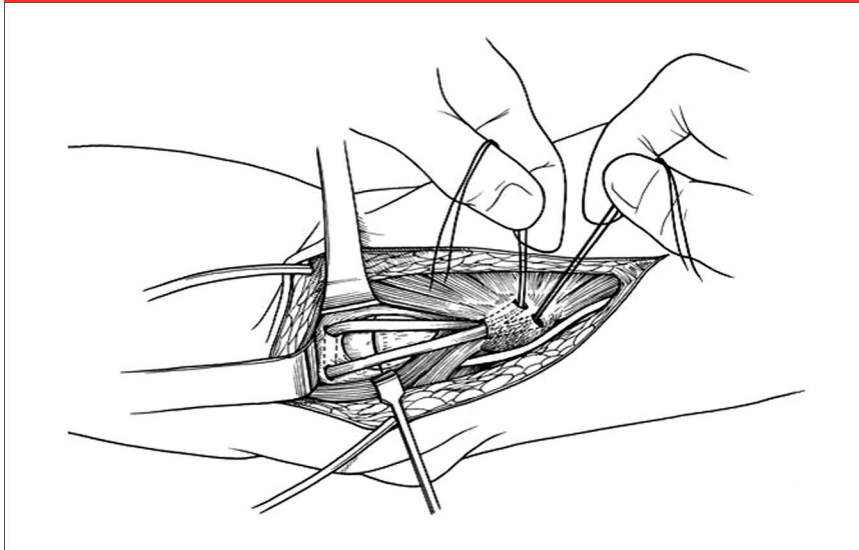
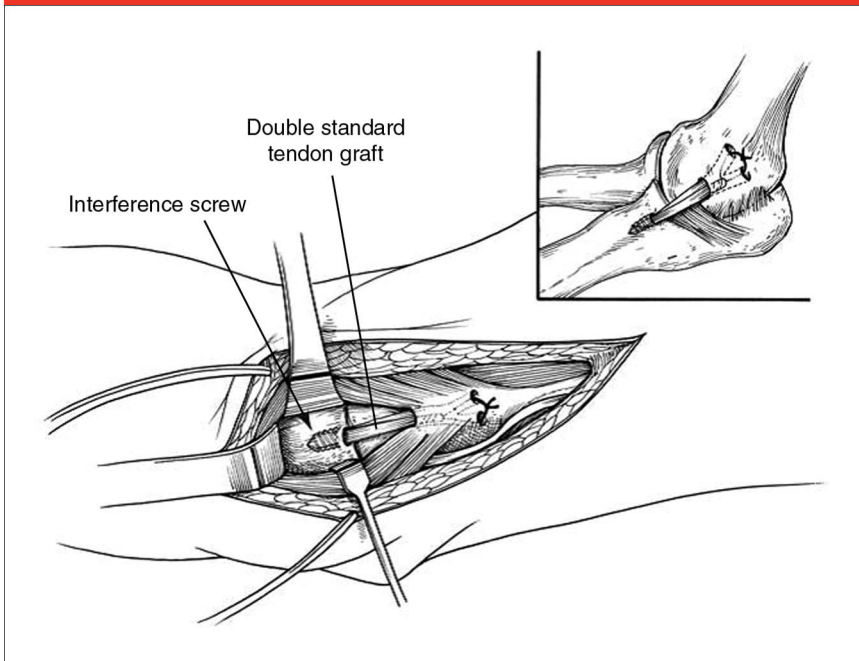


Illustration of the docking technique used in ulnar collateral ligament reconstruction. The two humeral ends of the graft are docked within the humerus and secured by tying down over a bony bridge. (Reproduced from Ahmad CS, ElAttrache NS: Elbow valgus instability in the throwing athlete. *J Am Acad Orthop Surg* 2006;14[12]:693-700.)

Figure 9



Illustrations of the David Altchek and Neal ElAttrache for Tommy John (DANE TJ) technique, with interference screw fixation in the ulna and use of the docking technique in the humerus. (Reproduced from Ahmad CS, ElAttrache NS: Elbow valgus instability in the throwing athlete. *J Am Acad Orthop Surg* 2006;14 [12]:693-700.)

made due to concerns regarding the ability to adequately tension the graft with the Jobe technique as well as the potential for complications due to detachment of the flexor origin, the creation of three large drill holes on the epicondyle, and excessive handling of the ulnar nerve.³¹ This technique has shown good outcomes, with 90% to 92% of patients returning to their previous level of competition and experiencing low complication rates due to minimal ulnar nerve handling.^{3,29-31}

In 2006, Conway³² described the David Altchek and Neal ElAttrache for Tommy John (DANE TJ) procedure.^{3,33} This technique utilizes a combination of fixation techniques. On the humeral side, docking fixation is used to take advantage of smaller proximal drill holes. On the ulnar side, interference screw fixation is performed, with a single drill hole made at the UCL insertion site. This interference screw fixation has shown favorable biomechanical characteristics³⁴ (Figure 9). In theory, use of the single ulnar tunnel decreases the risk of bony fracture and reduces the amount of surgical dissection required for exposure compared with the two-tunnel technique. Dines et al³³ reported that 86% of athletes returned to an equal or a higher level of play in their study of 22 athletes treated with the DANE TJ technique.

Complications

Transient neurapraxia of the ulnar nerve is the main complication noted in most studies; most cases resolve within a few months.^{8,35} Medial epicondyle avulsion fracture is a rare event that may require surgical fixation.^{8,36} In one case series, 7 fractures occurred out of approximately 1,100 procedures; all fractures occurred within 13 months postoperatively.³⁶ Stiffness is another concern due to

soft-tissue restrictions or, in rare cases, heterotopic ossification that blocks motion.³⁵ A few patients have presented to our practice with heterotopic ossification with reported loss of motion. Once the ossification is beyond the active phase, typically at approximately 6 months post-operatively, it can be resected arthroscopically, followed by radiation treatment, indomethacin, and physical therapy.

Summary

Repetitive valgus stress places great strain on the UCL in throwing athletes. Thorough examination and imaging is crucial for proper diagnosis and management of UCL injuries. When nonsurgical measures fail, UCL reconstruction can lead to good results and return to sport. Prevention of throwing injury requires a coordinated effort between the athlete, coach, and parents.

References

Evidence-based Medicine: Levels of evidence are described in the table of contents. In this article, reference 9 is a level II study. References 3, 7, 11, 18, 20, 22, 30, and 35 are level III studies. References 1, 2, 8, 10, 12, 14, 15, 23-29, 31-33, and 36 are level IV studies. Reference 17 is level V expert opinion.

References printed in **bold type** are those published within the past 5 years.

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