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Ulnar Collateral injury: Review of current techniques

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Abstract

Overhead throwing athletes place substantial demands on the UCL, and repetitive overuse can result in chronic attenuation of the ligament. In the last 40 years a lot of techniques have evolved but still return to same level of play in major league players is highly variable. Through this article we are trying to elaborate major changes happened in UCL reconstruction along with current techniques which promises to be more consistent in returning the players to same level of play.

Keywords: UCL injury, UCL reconstruction, major league

Introduction

Elbow injuries in athletes have garnered a significant amount of attention over the last decade and while the overall rate of elbow injuries remained relatively low, the total number of injuries has likely increased because of record participation levels in organized athletic activities. Ulnar collateral ligament (UCL) injuries are a common problem in the throwing athlete and account for a large percentage of days lost because of elbow injury and by far, baseball exhibits the highest incidence of UCL injuries requiring surgical reconstruction [1]. 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 as well as growing media interest in professional overhead throwing athlete [2].

A prospective cohort study which 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 [3, 4] likewise, Conte *et al.* showed that pitchers have a high prevalence of UCL reconstruction in professional baseball, with 25% of major league pitchers and 15% of minor league pitchers having a history of the surgery [5] and even with the implementation of injury prevention programs, UCL reconstructions has increased approximately 10-fold in the first decade of the 21st century [6].

Elbow problems in throwing athletes were first documented in professional baseball players in 1941 by Bennett [7] while the Ulnar collateral ligament (UCL) injury to the elbow among throwing athletes were first described by Waris in 1946 , who reported a series of injuries among javelin throwers [8]. Although these injuries were once considered career-ending for athletes, a surgical technique pioneered by Jobe in 1974 facilitated successful return to competition. Jobe *et al.* first described reconstruction of the UCL with a palmaris longus tendon graft pulled through bone tunnels in the medial epicondyle of the humerus and the sublime tubercle of the proximal medial ulna [9]. While this procedure did allowed more than half of patients to return to their prior level of competition, the procedure is not without complications. Since then, several investigators have proposed alternative techniques of UCL reconstruction to ease technical demands and minimize the risk of injury to the ulnar nerve.

Anatomy: UCL is composed of three bundles: anterior, posterior, and oblique or transverse ligament. The anterior bundle originates from the anteroinferior surface of the medial epicondyle of the humerus (posterior to the axis of rotation) and it inserts on the medial aspect of the coronoid process of the ulna, the sublime tubercle. Recently, a second bony prominence has been described as a second bony attachment for the insertion of the UCL on the ulna. This prominence, termed the medial ulnar collateral ridge, originates near the sublime tubercle and travels distally to its end point near the brachialis muscle insertion. This ridge is the site of attachment for the UCL as it tapers out distally [10]. The oblique bundle (transverse ligament) is a thickening of the joint capsule extending from the medial olecranon to the inferior medial coronoid process and lies at the distal-medial aspect of the joint capsule. It does not actually cross the elbow joint and both originates and inserts on the ulna; consequently, it does not provide true stability to the elbow joint. The posterior bundle is thinner and weaker than the anterior bundle. It originates from the inferior portion of the medial epicondyle and inserts on the medial margin of the semilunar notch and provides secondary elbow stability at greater than 90 degree of flexion [11].

Histologically it has been shown that, anterior bundle consists of two separate layers: the deeper layer is composed of collagen bundles contained within the capsule, and the shallower layer is a distinct ligamentous structure superficial to the capsule [12].

Biomechanics of UCL injury: UCL injury most commonly occurs in overhead throwing athletes, particularly baseball pitchers, but it is also seen in other sports including javelin throwing, gymnastics, wrestling, football, and tennis [9]. The biomechanics of the UCL have been studied extensively in an effort to determine the role of each component in resisting valgus stresses and it has been shown that, anterior bundle is the primary stabilizing structure against valgus stresses. This bundle has been subdivided into 3 functional bands: the anterior, posterior, and central or isometric bands. The anterior and posterior bands have been shown to tighten in a reciprocal fashion throughout the normal range of motion of the elbow, whereas sequential sectioning of the 3 bands in cadaveric specimens has demonstrated that the central bundle is the most crucial for maintaining valgus stability [13-15].

UCL injury can occur secondary to either an acute traumatic rupture or repeated valgus stress to the elbow, resulting in gradual attenuation and eventual rupture of the ligament [16].

There are six phases of throwing: (a) wind up; (b) early cocking; (c) late cocking; (d) acceleration; (e) deceleration; (f) follow through. The initiation of valgus load on the elbow coincides with the initiation of the acceleration phase of the throwing motion. In the 30 to 40 milliseconds from the initiation of the acceleration phase to the time of ball release, the elbow rapidly extends and achieves a mean angular velocity of 2300 deg/s. The mean valgus stress per pitch in an adult is 64 N.m. Consequently, a 64 N.m varus counter torque is needed to resist this massive torque; The UCL provides 54% of this varus counter torque or roughly 34 N.m. Although a portion of the medial tensile forces is likely resisted by the medial flexor-pronator muscles and the osseous anatomy of the elbow joint, it is clear that the UCL is subjected to repetitive high tensile loads [17-19]. Repetitive overloading associated with the throwing motion causes microscopic tears in the UCL with subsequent ligament attenuation and failure.

Evaluation of the patient

History: A thorough history is critical to properly diagnose UCL injuries in the throwing athlete. Patient with UCL injury usually presents with pain, decreased motion, mechanical symptoms (clicking, locking), instability and paresthesias. Some patients may report an actual **"**pop**"** (acute injury) that occurred while throwing. Along with that, timing, onset, and frequency of pain are also very important to determine as, athletes with valgus instability experience mostly pain during the late cocking and early acceleration phases of throwing [20].

Detailed history on the athlete**'**s injury also includes 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. Along with that documentation on rehabilitation course including details such as length of time without pitching, the physical therapy or training regimen, and any other nonsurgical measures attempted should also be included in history.

Examination: Physical examination include a detailed evaluation of the entire upper extremity, along with determination of elbow range of motion for both extremities, valgus stress testing at 30° and 90°, flexor-pronator; extensor-supinator muscle groups examination and complete neurovascular examination with special attention to ulnar nerve function.

On inspection, athlete's arm position, muscle mass, any asymmetries compared with contralateral extremity should be detected. Elbow flexion to approximately 70 degree allows the greatest intracapsular volume and may be an indication of effusion. Flexion, at a lesser degree, may be secondary to an extension block from posteromedial olecronan osteophytes. With the elbow in extension and forearm in full supination, the carrying angle can be determined. The normal carrying angle is 11degree in men and 13 degree in women. Lastly, skin is looked for any ecchymosis or prior incisions.

On palpation, UCL is palpated proximally and distally to determine the location of the tear or injury while keeping in mind that chronic tears may not have associated UCL tenderness and in the case of acute tears, tenderness often abates with rest. Tenderness on palpation of other landmarks like olecranon, medial and lateral epicondyles, radial head, and soft spot may indicate acute fracture, stress fracture, or tendonitis. In skeletally immature athletes, tenderness may indicate injury to the apophysis or physis. Lateral olecranon tenderness to palpation may indicate a stress fracture whereas proximal medial tenderness may be related to impingement. Along with that thorough ulnar nerve examination including nerve irritation should be analyzed by provocative maneuvers with an attempt to elicit the Tinel sign at the ulnar groove.

Tenderness over the insertions of the various tendons around the elbow can indicate microtrauma or inflammation. Lastly, palpation of the radial head during an arc of passive supination and pronation can help identify osteochondral defects, joint incongruency, and injury to the annular ligament.

Stability of the elbow can be assessed with patients in either the supine or seated position. Specific tests to evaluate the integrity of the UCL include: the valgus stress test; the milking test; the moving valgus stress test. In valgus stress test humerus is stabilized in maximal external rotation and 30 degree of flexion. With the forearm fully pronated and the elbow flexed 20 to 30 degree to unlock the olecranon from the olecranon fossa, valgus stress is gradually applied to the elbow and opening is assessed. Less than 1 mm of opening and a firm endpoint should normally be appreciated during the manual valgus stress test [21]. However, Physiologic laxity may be present and it is more appropriate to compare the stability with the contralateral extremity. Increased opening of the joint space or reproduction of a patient's pain should raise suspicion of injury to the anterior band of the anterior bundle of the UCL.

The moving valgus stress test is performed with the patient seated and the shoulder abducted to 90 degree. 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 30degree. The test is positive when medial elbow pain is most severe between 120 and 70 degree, which represent the late cocking and early acceleration phases, respectively, as the elbow is extended [22].

The milking maneuver tests the posterior band of the anterior bundle of the UCL. In this maneuver, the forearm is supinated fully and the elbow is flexed beyond 90 degree (approximately 120 degree). Athlete's thumb is then pulled laterally by the examiner or the athlete's contralateral extremity, creating a valgus force on the elbow. Pain, instability, or apprehension is indicative of injury to the UCL [23].

Lastly athlete should be evaluated for symptoms of Valgus extension overload syndrome by valgus extension overload test as Medial elbow pathology is often linked to the posteromedial Compartment. In this test with the patient in the seated position and the forearm supinated, the elbow is slightly flexed. With one hand on the posterior aspect of the distal humerus and the other hand on the volar forearm, the elbow is rapidly extended while applying a valgus stress. Pain with this valgus extension overload test indicates impingement of the posteromedial tip of the olecranon on the medial wall of the olecranon fossa [21].

Imaging: Standard anteroposterior, lateral, oblique and bilateral valgus stress radiographs are obtained of the elbow. Radiographs may demonstrate calcification of the UCL, osteophytes adjacent to the UCL, olecranon fossa osteophytes, sclerotic OCD lesions, and/or loose bodies. Fluoroscopy is useful in assessing for medial instability by stressing the elbow and comparing with the contralateral extremity. Asymmetry alone, may not be enough to diagnose acute injury to the UCL because asymptomatic pitchers have been found to have some laxity in pitching elbow compared with the contralateral extremity. However Rijke *et al.* 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 [24]. Musculoskeletal ultrasound is noninvasive, 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. However, results are dependent on clinician experience and expertise with ultrasound.

Currently, MRI is considered to be the modality of choice for detecting UCL tears. MRI can detect early stress changes as well as muscle and tendon changes, loose bodies, osteochondral injuries, olecranon osteophytes, and neurologic changes to thrower's elbow. MRI is useful in evaluating UCL avulsions, partial ligamentous injuries, midsubstance tears, and the status of the surrounding soft tissues. MRI has been found 57% sensitive and 100% specific in detecting UCL injuries [25]. MRI arthrography seems to improve the sensitivity of detection of UCL tears, with saline injection improving sensitivity of UCL detection to 92% [26]. However Kooima *et al.* has showed these MRI findings can be present in asymptomatic baseball players also, which undermines the importance of correlating history and examination with imaging studies to come at diagnosis of UCL tear [27].

Management of UCL injury: UCL injury can be managed in either of the three ways i.e. nonoperative, direct ligament repair, or free-tendon graft reconstruction depending on patient preinjury activity status and willingness to return as professional player.

Nonoperative management: Nonsurgical treatment measures are indicated for the initial treatment of UCL injury in nonthrowing athletes and lower demand population. The early focus in nonoperative management is in regaining or maintaining elbow and shoulder ROM in conjunction with shoulder-strengthening exercises. Along with that, cryotherapy, pain modulating electrotherapy modalities, anti-inflammatory medication, and a hinged elbow brace restricting full extension can be used [28].

Once a patient has regained full pain-free elbow ROM, focus on strengthening the medial dynamic stabilizers with emphasis on the pronator teres, FCU, and flexor digitorum superficialis should be done.

Hamilton and colleagues has found that when UCL stabilizing capabilities are compromised, activity of these medially based muscles is decreased, so a criteria-based return-to-throw program is initiated when functional patterns, consistent for pitching are pain-free and valgus stress testing is negative [29].

The result of non-operative treatment in the lower demand patient cohort and non-throwing athlete has shown that such treatment arrests the progression of instability and functional impairment. Dodson *et al.* recently performed a retrospective review of ten National Football League (NFL) quarterbacks with UCL pathology, which was secondary to contact injury in seven of the ten. Nine of the ten players were successfully managed nonoperatively and returned to play in the NFL [30].

However similar success rates, has not been seen in the non-operative treatment of higher demand overhead throwing athletes. Barnes and Tullos reported that only 50% of 100 symptomatic throwing athletes returned to play [31]. Similarly Retting and colleagues evaluated 31 throwing athletes treated nonoperatively for a UCL injury with a minimum of 3 months of rest with rehabilitation. They reported a only42% return to competitive throwing at the same level or higher at an average of 24.5 weeks [32].

Regarding the use of PRP in partial UCL tear, Podesta and colleagues evaluated their outcomes in 34 athletes with partial UCL tears. In their study athletes received 1 PRP injection to the elbow after failing 2 months of typical nonoperative management; 30 of the 34 returned to play at preinjury level at an average of 12 weeks. From this, they suggested patients in whom UCL reconstruction may not be indicated, such as younger aged athletes and older recreational athletes or in-season professional athletes with partial tears who do not want to undergo UCL reconstruction, PRP is a viable and safe option.

Although this study shows promise, the type of tear seen in a significant majority of their patients was a proximal injury; in addition, these patients were not compared with a control group. Also, there is a paucity of the literature on PRP as a treatment modality, so author suggest further studies need to be undertaken before definitive recommendations can be given [33].

Operative Management: Operative treatment of the UCL is indicated for the overhead athlete with a complete tear of the anterior bundle of the UCL if the athlete wishes to return to throwing sports, or in the case of a throwing athlete with a partial tear who has failed a comprehensive rehabilitation program. Surgery should also be considered for the nonthrowing athlete who remains symptomatic with nonoperative treatment [34].

UCL Repair: Historically, the torn UCL was treated with primary repair, but less-than-optimal results led to the contemporary belief that a damaged UCL must be reconstructed to restore valgus stability at the elbow and so permit a return to previous level of activity for repetitive throwing athletes [20, 35, 36]. However recent studies have shown that primary UCL repair can be successful in younger athletes who have avulsion injuries, which are repaired in a timely manner. According to them UCL repair remains a viable option for young athletes with acute bony avulsion injuries of the UCL with no chronic mid substance attritional injuries [37].

UCL Reconstruction: Jobe was the first to perform (in 1974) and to describe (in 1986) a standard technique for UCL reconstruction. The original Jobe technique involved detachment of the flexor-pronator mass, extensive routing of a long tendon graft in a figure-of-8 fashion through ulnar and humeral bone tunnels, and submuscular ulnar nerve transposition. It resulted in a 62.5% success rate as defined by return to preinjury level of sports participation but had a 31.25% complication rate related primarily to the ulnar nerve. Conway *et al.* performed an extended clinical follow-up study on the same population using the original Jobe technique. They reported that 38 (68%) of 56 athletes who
Underwent reconstruction were able to return to their previous level of play; however, 15 (21%) patients developed postoperative ulnar nerve dysfunction, with 8 requiring revision decompression [35]. Although the Jobe reconstruction technique defined a new approach toward treatment of UCL injury, several technical concerns with high complication rate persisted.

Evolution of UCL reconstruction techniques

Jobe Modification: In 1996, Smith and Altchek introduced a muscle splitting approach that had several inherent advantages, most notably eliminating takedown of the common flexor origin to achieve direct visualization of the UCL [38]. It involves a muscle split through the posterior third of the common flexor bundle—that is, the most anterior fibres of the FCU. Jobe modified his original surgical approach to make use of the inherent advantages of the muscle-splitting technique and made no ulnar nerve transposition, but continued to use the figure-of-eight graft configuration. Clinical results of this modified technique in eighty-three athletes were reported in 2001 [39]. After modifying their technique, they reported 82% of all throwing athletes and 93% of throwers without prior elbow surgery returned to play at a mean of thirteen months with very few complications, which included four reoperations and a 5% prevalence of transient ulnar nerve symptoms

ASMI Modification: The technique described by Andrews in 1995 utilized a posterior approach between the two heads of the flexor carpi ulnaris, with elevation of the flexor-pronator mass without takedown. Subcutaneous ulnar nerve transposition using facial slings was performed in all cases [20]. Azar *et al.* published the results of Andrews *et al.* in a retrospective review comparing UCL reconstruction with repair in 91 throwing athletes performed by a single surgeon over a six year period. They showed 79% athletes returning to their preinjury level of play, and having approximately 10% minor complication rate [36]. In the most comprehensive study to date, Cain and colleagues evaluated the clinical outcome of the ASMI modification in 1281 throwing athletes [1]. In their study overall, 83% of the athletes returned to their pre-injury level of competition or higher at a mean of thirty-eight months. Among the baseball players, return to the same or a higher level of play occurred in 75.5% of Major League, 73% of Minor League, 87.5% of collegiate, and 83% of high school players. Complication occurred in 20% of the patients; however, only 4% were classified as major and the remainder were classified as minor. Early in their study, 2 fascial slings were used to stabilize the ulnar nerve; however, this was changed to one intramuscular septum sling that was released proximally and remained attached to the medial epicondyle.
This modification was made in response to a high rate of postoperative ulnar nerve symptoms. After this modification, the rate of ulnar nerve symptoms decreased and they also showed that postoperative ulnar nerve dysfunction did not significantly affect clinical outcome, as 85% with and 83% without ulnar nerve complications returned to previous level of play. In this study most common reason for reoperation was posteromedial osteophytes and the UCL revision rate is 1%.

Docking Technique: In 1996 Altchek *et al.* first used a muscle splitting approach to modify UCL reconstruction in a technique called the ‘‘docking procedure’’. Rohrbough and Altchek *et al.* reported their experience with a significant modification of the classic reconstruction method in 2002. In this method, the muscle splitting approach adopted by Jobe was used but more widely space ulnar tunnels were created. The docking technique utilizes the muscle splitting approach but reconstructs the UCL by placing sutures into the end of each limb of the graft and after shuttling the graft through the traditional ulnar bone tunnels, each limb is “docked” into the medial epicondyle by pulling and securing the suture limbs through small exiting holes in the proximal epicondyle with no obligatory ulnar nerve transposition. This technique was developed over the concern for the risk of medial epicondyle fracture with traditional figure-of-8 bone tunnels. The longitudinal distal portion of this tunnel is created with use of a 4-mm burr, and the two small proximal exit holes are created with use of a 1.5-mm. Using this modified technique, called the docking technique, the authors reported that 33 of 36 throwing athletes were able to return to preinjury levels of sports participation by 2 years after surgery[40]. Dodson *et al.* using the same technique showed similar results, with 90/100 athletes returning to preinjury levels and only 3 minor complications, 2 of which were ulnar neuropathies requiring reoperation [41]. Numerous modifications of the docking technique have been proposed and shown to have favorable results. These modifications focus largely on three and four-strand graft reconstructions, and 90% to 95% of athletes were able to return to the same or a higher level of play [42-44].

Interference Screw Technique: The first introduction of using interference screw technology to reconstruct the UCL was described by Ahmad *et al.* in 2003 [45]. With a single tunnel in both the epicondyle and the sublime tubercle, they attempted to isometrically reconstruct the anterior bundle of the UCL. Kodde *et al.* reported on 20 European athletes using screw fixation and triceps fascia autograft [46]. They had 18 of 20 athletes return to preinjury level of play for at least 1 year and only 1 transient ulnar neuropathy was found. At a minimum of 3 years of follow-up no bone fracture was seen but 2 patients had signs of mild heterotopic ossification. However, 65% of the patients were female, with only 2 were baseball players, and 60% of the injuries were acute UCL rupture, making it difficult to translate this results to high-level throwing athlete.

DANE TJ Technique: The DANE TJ technique for UCL reconstruction was first described by Conway in 2006[34]. This approach represents a hybrid of two fixation strategies described by David Altchek and Neal ElAttrache (DANE) for Tommy John (TJ) surgery. This technique was developed to improve fixation and avoid complications at the humeral and ulnar bone tunnel sites by taking advantage of the excellent results of the docking technique and the favorable biomechanical characteristics of interference screw fixation with screw fixation distally and the docking method proximally. Dines and colleagues are the only authors to conduct a clinical investigation using this technique. Nineteen of 22(86%) returned to their previous level of play. Four minor complications occurred with 3 requiring reoperation [47].

Hybrid Technique: Hechtman *et al.* described hybrid technique with an ulnar osseous tunnel and suture anchor fixation on the humerus, they also achieved an 85% excellent result in their cohort [48]. Humeral graft fixation with suture anchors has also been utilized to simplify UCL reconstruction and potentially reduce morbidity associated with humeral tunnel drilling. Their complication rate is also lower than that reported with the classic technique with ulnar and humeral tunnels, as well as that reported by Rohrbough *et al.* Through it is difficult to comment on technique from the result of single clinical study but definitely it's a one step forward in the direction of reducing complication and better outcome.

Revision UCL Reconstruction: There is little published in the orthopaedic literature on revision UCL reconstruction. However recent study by marshall *et al.* in which he compared 33 MLB pitchers who underwent revision UCL reconstruction surgery with 33 age- and position-matched controls found that only 65.5% of UCL-Revision pitchers returned to the MLB level. Through this he concluded MLB pitchers who undergo UCL-Revision have a low rate of return to MLB play and have shortened careers after return [49]. Other studies on revision UCL reconstruction by Dines *et al.* [50] found a 75% (3/4) return to MLB play and in a slightly larger study by Jones and colleagues who reviewed 18 MLB pitchers, found a return to MLB play of 78% (14/18) in revision pitchers [51]. On the basis of this three study at this time we cant conclude prognosis after revision UCL reconstruction, but definitely one can say it is less than primary UCL reconstruction and revision ulnar collateral ligament reconstruction remains a challenging problem, especially in the face of ulnar cortical bone loss at the sublime tubercle.

Lee *et al.* did suggested use of endobutton technique on ulnar side and showed reconstructed UCL strength similar to other techniques biomechanically [52] but till now we don't have any clinical study to support endobutton use in ulnar cortical boss loss.

Allograft: Some authors have raised concerns toward use of autograft and potential for donor site complications and morbidity. Savoie *et al.* reported first case series on the use of allograft for ulnar collateral ligament reconstruction that, at the time of the two-year follow-up, 110 of 116 patients had returned to competition, with 88% returning to their previous level of sport or better. In their study, the authors retrospectively reviewed outcomes in 116 patients who were treated with an ulnar collateral ligament reconstruction using either gracilis or semitendinosus allograft tissue. The average time for return to competition was 9.9 months and they reported an overall complication rate of 6%. [53]. Although result of allograft use in UCL reconstruction is encouraging, but donor site complication after autograft use in UCL reconstruction as reported by Cain *et al.* in a series of 942 patients is only 4%, with most complications being superficial infection only, similarly Vitale and Ahmad, in their systematic review of ulnar collateral ligament reconstruction, reported only a 1% rate of donor site complications [54]. From the above one can say that, although donor site complications do occur, they are rare and typically transient and allograft can be used depending on surgeon preference and patient profile.

Conclusion

Over the last 40 years the original UCL reconstruction has evolved. The literature shows that with advancement of UCL reconstruction techniques, including minimal dissection of the flexor-pronator mass and abandonment of submuscular ulnar nerve transposition, reported clinical outcomes have shown a rate of return to competition of 80% to 90% for throwing athletes. Similarly few studies on revision UCL reconstruction had shown good result but there is still a long way to go and future clinical studies on different modes of fixation is definitely required.

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