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INJURIES IN OVERHEAD ATHLETES (J DINES AND C CAMP, SECTION EDITORS)

UCL Injury in the Non-throwing Athlete

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Abstract

Purpose of Review Primarily reported in the overhead throwing athlete, ulnar collateral ligament (UCL) injuries have been extensively studied since Dr. Frank Jobe first described his technique for ulnar collateral ligament reconstruction on professional baseball pitcher Tommy John. While the framework for our understanding of UCL injury was initially established studying the repetitive valgus loading of the throwers' elbow, other sport-related activities in non-throwing athletes can impart similar valgus stress on the medial elbow placing the UCL at risk for injury. The purpose of this review is to evaluate the current literature on UCL injury specifically in the non-throwing athlete.

Recent Findings In the four decades since Dr. Jobe's seminal description of UCL reconstruction, an abundance of literature has been published on UCL injury in the throwing athlete. The evidence evaluating the UCL specifically in the non-throwing athlete, however, is quite scarce. Several small retrospective studies have demonstrated good results with high rates of return to play with focused rehabilitation and non-operative management in non-throwing athletes. Recent evidence has also demonstrated that surgical repair and/or reconstruction of the UCL in this population can produce good outcomes.

Summary The level of evidence of these published studies is low and consists primarily of case series without control groups. Further investigation is warranted to determine the optimal treatment algorithm for UCL injury in the non-throwing athlete.

Keywords Ulnar collateral ligament injury · Non-throwing athlete · Non-operative treatment · Ulnar collateral ligament repair · Ulnar collateral ligament reconstruction

Introduction

In 1974, Dr. Frank Jobe reported on the use of free tendon graft for ulnar collateral ligament reconstruction on Los Angeles Dodgers pitcher Tommy John. His return to MLB pitching in 1976 and the subsequent case series of 16 reconstructions produced by Jobe in 1986 [1] transformed the treatment and prognosis for athletes with what was previously considered a career ending injury. Since that time, an abundance of UCL literature has been produced, characterizing injury mechanism [2] and epidemiology [3–5], various modifications of surgical technique [6], and outcomes of surgery with return to play metrics at various levels from high school to professional sports [7–9]. The overwhelming majority of these studies, however, were performed in the overhead throwing athlete—specifically baseball pitchers. And while our understanding of UCL pathology is most robust in the specific context of repetitive valgus loading of the ligament during the throwing motion, other sporting activities can impart stresses about the medial elbow that place the UCL at risk for injury. Combat sports (mixed martial arts, jiu-jitsu, wrestling), contact sports (football and hockey), and tumbling sports (gymnastics and cheerleading) all demand sport specific activities which place non-throwing valgus loads on the elbow. While there is a relative dearth of literature evaluating UCL injury in the non-throwing as compared with the throwing athlete, the purpose of this review is to summarize the available evidence to help guide management of UCL injury in this specific athletic cohort.

This article is part of the Topical Collection on *Injuries in Overhead Athletes*

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Epidemiology of Elbow Injuries in Non-throwing Sports

The epidemiology of UCL injury is well described in the throwing athlete [3, 5, 10–12]. Studies specifically evaluating non-throwing athletes are comparatively sparse. Kenter and colleagues retrospectively reviewed acute elbow injuries over 5 seasons in the National Football League (NFL) from 1991 to 1996 [13]. Of 91 injuries reviewed, 19 ulnar collateral ligament tears were identified and 17 of these occurred in non-throwing players (linemen, receivers, and defensive backs). All injuries were managed non-operatively, and 100% of players were able to return to the same level of sport with an average time loss of 0.64 games.

Two more recent studies evaluated the rate of UCL injury among combat sport participants. Frey and colleagues surveyed injury rates over 21 seasons of judo competitions in France evaluating over 400,000 matches involving 316,203 judokas [14]. The incidence of UCL sprains during this time period was found to be 17% of all injuries with a higher proportion involving more advanced practitioners competing in national competitions as compared with more amateur athletes. In a survey of injuries sustained during Brazilian jiu-jitsu (BJJ) competitions, Scoggins et al. found the elbow to be the most commonly injured joint with 6 UCL sprains sustained out of 5022 athlete exposures and the BJJ arm bar being the most commonly implicated mechanism for injury [15].

Evaluating UCL epidemiology from a wider sporting perspective, Zaremski et al. reviewed a consecutive series of 136 UCL injuries sustained during sport at a single institution over a 16-year period [16]. While throwing athletes sustained the bulk of injuries within the cohort, 35/136 patients (26.7%) sustained injuries participating in non-throwing sporting activities including gymnastics, cheerleading, MMA, and football.

Lastly, Li et al. queried the National Collegiate Athletic Association (NCAA) Injury Surveillance Program for UCL injuries occurring between 2009 and 2013 across 25 varsity sports and sought specifically to compare the incidence, severity, and outcome of injury between throwing and non-throwing athletes [17•]. One hundred nine UCL injuries were recorded over the 5 seasons producing an injury rate of 0.29 per 10,000 athletic exposures. Interestingly, 83 (76.1%) of these injuries occurred with a contact, non-throwing mechanism compared to 26 (23.9%) sustained while throwing. Baseball, softball, and track (javelin) comprised the bulk of throwing injuries. Wrestling and football were implicated in the majority of contact non-throwing injuries. The authors found that the severity of throwing injuries appeared higher than contact injury mechanisms with a greater proportion of throwing injuries resulting in > 3 weeks' time lost from sport (36.4% throwing injuries vs 9.1% contact injuries, $p < 0.01$). Additionally, the percentage of throwing injuries requiring surgical intervention was higher than non-throwing contact injuries (11.1% throwing injuries vs 1.3% contact injuries, $p < 0.01$), although the absolute numbers for this comparison was small ($n = 2$ throwing injuries vs $n = 1$ contact injuries). These findings highlight that while the risk for UCL injury is the highest in the throwing athlete, a significant proportion of UCL injuries may occur in via a non-throwing contact mechanism.

Mechanism of Injury in Non-throwing Sports

The UCL complex is the primary soft tissue restraint to valgus loads on the elbow and its anatomy been extensively studied in various cadaver and biomechanical studies [18–21]. Of the three components of the UCL complex (anterior band, posterior band, transverse ligament), the anterior band has been shown to be the principal stabilizer of the elbow in response to valgus stress, and its recreation is the target of reconstruction in the majority of surgical techniques [22–24].

In cadaver studies, the anterior band has been shown to have the most inherent strength and stiffness of the UCL complex ligaments with an average load to failure of 260.9° N [25]. Studies evaluating the overhead throwing motion have demonstrated that the valgus load applied to the elbow in the late cocking/early acceleration phase approaches or exceeds the maximal tensile strength of the native UCL complex [2, 26]. The repetitive loads applied to the elbow over the course of a throwers' career can lead to chronic microtrauma, ligament attenuation, and eventual ligament insufficiency which may affect performance.

In the non-throwing athlete, valgus loads are applied to the elbow in a variety of ways. In gymnastics, the back handspring is a routinely performed transition maneuver. During this movement, the gymnast performs a 360 degree rotation of the body in the sagittal plane with a period of body weight support on bilateral upper extremities prior to completing full rotation. This axial loading of the upper extremities was studied by Koh et al., who used video and force plate analysis to determine loads applied across the elbow during the gymnastics back handspring [27]. The authors determined that the ground reactive forces at the hand during upper extremity loading produced a large (on average 2.37 times bodyweight) compression force and sizeable valgus moments (on average 0.03 × body weight × body height) on the gymnast's elbow.

In BJJ and MMA, the arm bar is a commonly used submission technique. During this maneuver, the competitor grasps an opponent's arm by the wrist with both hands and secures their legs around the proximal arm. The opponent's elbow is then torqued against the competitor's pelvic region by applying pressure to the wrist resulting in a powerful applied force to the elbow. If the opponent attempts to externally rotate the

arm in an attempt to escape or resist, a large valgus force is applied to the elbow which can result in UCL injury [15].

In other contact sports, UCL injuries typically occur via a traumatic mechanism. Kenter et al. found that the majority of UCL injuries occurring in the NFL were sustained with contact while blocking at the line of scrimmage with the arms extended in front of the body (50% of injuries) followed by application of valgus force at the elbow with the hand planted on the playing surface (29% of injuries) [13].

The described UCL injury mechanism in the non-throwing athlete commonly involves an acute traumatic incident. In contrast to the chronic, attritional stresses imparted to the UCL in the throwing athlete, non-throwing injuries may reflect a distinct subset of UCL pathology which may be amenable to different treatment options.

Outcomes of UCL Injury Managed Non-operatively in Non-throwers

Studies evaluating the outcome of UCL injuries managed non-operatively are limited and return to play rates in early studies were poor, specifically in the throwing athlete. Rettig et al. reported on a series of 31 patients who underwent a structured rehabilitation program for treatment of UCL insufficiency [28]. All patients were overhead throwers (29 baseball players and 2 javelin throwers). The treatment protocol entailed a cessation from throwing and bracing for 2–3 months with a progressive rehabilitation program and return to throwing at that time if patients were pain free. Out of the 31 patients included for study, only 13 (42%) were able to return to sport at average of 24.5 weeks. It should be noted that MRI was not routinely used for confirmatory diagnosis in this study.

UCL insufficiency exists as a spectrum of disease with different prognostic implications for various subtypes of UCL tears (i.e., partial tears or ligament avulsions vs mid substance ruptures with general ligament attenuation). This was highlighted in a study by Ford and colleagues who retrospectively evaluated UCL injuries in a cohort of 43 professional baseball players [29]. An MRI grading scheme was utilized to evaluate injuries (I, intact ligament with or without edema; IIA, partial tear; IIB, chronic healed injury; and III, complete tear), and treatment was based on the severity of injury. Of 31 players without complete ligament tears (I, IIA, or IIB), 26 (84%) were able to return to sport. The authors proposed that incomplete ligament injuries may be successfully managed non-operatively in the throwing athlete.

In the non-throwing athlete, UCL injury patterns differ from the chronic ligament attenuation seen in the throwing elbow. Nicolette et al. reviewed a cohort of 5 NCAA division I female gymnasts who sustained UCL injuries [30•]. All patients were injured via a traumatic mechanism with valgus load applied to the elbow either during a backhand spring or a "bail" from elevated surface (i.e., vault or uneven bars). All patients underwent MRI which revealed either high grade partial tearing or end ligament avulsion without significant ligament attenuation or edema. After undergoing a structured rehabilitation program, 4 out of 5 patients were able return to competitive gymnastics at an average of 3.98 weeks following injury.

UCL injuries in non-throwers were further studied by McCrum et al. who evaluated a series of 3 professional hockey players who sustained in game elbow injuries [31•]. All patients reported a distinct traumatic mechanism with a valgus load applied to the elbow either through collision with an opposing player or a fall onto the ice with an outstretched hand. MRI evaluation revealed 2 partial ligament tears and 1 complete proximal avulsion. All patients were treated with a structured rehabilitation program and bracing. Additionally, all patients underwent ultrasound-guided injection with a leukocyte poor platelet rich plasma formulation at 2 days after injury followed by a second injection 1 week later. Successful return to play was demonstrated in all three athletes at mean 36 days following injury.

Outcomes of UCL Reconstruction with Non-throwers Included in Study Cohort

A number of published studies on UCL reconstruction have included non-throwing athletes (Table 1). While significant improvement in patient reported outcomes and high return to play rates in the overall cohort of these studies suggests that UCL-R can be effective in the non-throwing athlete, the lack of outcome reporting specifically in the non-thrower subgroups limits the information to be gleaned from these results.

Two studies have evaluated UCL reconstruction and reported outcomes specifically for non-throwers. Jones et al. reported on a series of 55 adolescent athletes (mean age 17.6) who underwent UCL reconstruction with the docking technique [39]. Three gymnasts were included in the study cohort. At final follow, 87% of patients had an excellent Conway score. Specific evaluation of the gymnasts, however, revealed only 1/3 had an excellent Conway score at final f/u and only 1/3 were able to return to gymnastics. The two failures in the subgroup had advanced osteochondral lesions of the capitellum which were drilled arthroscopically at the time of UCL reconstruction. The authors cautioned that the presence of intra articular lesions may confer a risk for poorer outcome.

Erickson et al. subsequently reported on a series of 187 UCL reconstructions performed at a single institution [8]. Similarly, the vast majority of patients were baseball players, but also included 2 gymnasts and 1 cheerleader. Overall 94.1% of patients were able to return to sport with a mean KJOC score of 90.4. The cheerleader was able to return to sport with a final KJOC score of 94.7. In the gymnast subgroup, only 1 (50%)

Table 1 Outcomes of UCL reconstruction with non-throwers in cohort

Year	Author	Surgical technique	Number of non-throwers in cohort	Overall cohort outcomes
2019	Donahue et al. [32]	Docking plus	39/324	88% good/excellent Conway scores, 98% RTP
2018	Myeroff et al. [33]	Cortical button suspension	7/23	Mean DASH at final f/u 3.8, 82.6 RTP
2012	Kodde et al. [34]	Interference screw with triceps autograft	9/20	90% excellent Conway scores, mean MEPI at final f/u 91
2010	Cain et al. [35]	Modified Jobe	18/1281	83% RTP
2007	Dines et al. [6]	Dane TJ	2/22	86% excellent Conway scores
2002	Rohrbough et al. [36]	Docking technique	3/36	92% RTP
2001	Thompson et al. [37]	Modified Jobe	1/78	94% good/excellent results
2000	Azar et al. [38]	Modified Jobe	2/91	79% RTP

patient was able to return to competitive gymnastics with an average subgroup KJOC score of 76.3.

Outcomes of UCL Reconstruction in Non-throwers

Only one study has evaluated the outcomes of UCL-R specifically in a non-throwing cohort. Fuller and colleagues reported on the result of ULC-R in a cohort of 66 US military members [40•]. At final follow-up, the authors found a mean DASH score of 10.8 ± 16.7 with 86.4% of patients reporting no significant disability due to their elbow. The average Mayo Elbow Performance Score (MEPS) at final follow-up was 87.6 ± 17.1 with 83.3% of patients reporting good or excellent outcomes. While the authors suggest that the military population is suitable proxy for the young athletic non-throwing patient population, 47% of the cohort reported a throwing history with 90.3% of this subset being baseball pitchers. Furthermore, throwing was the most commonly reported mechanism of injury comprising 36.4% of UCL injuries.

Despite this confounding factor, this study represents the largest cohort of ULC-R in a predominantly non baseball population. Interestingly, in their multivariate analysis, the authors demonstrated that a throwing history and a throwing mechanism of injury were correlated with improved DASH and MEPS scores ($p < 0.05$). Only 13.6% of patients in this study were no longer active duty specifically due to their elbow at final follow-up, suggesting that UCL-R can reliably return individuals to the intense upper extremity demands of the military member.

Outcomes of UCL Repair in Non-throwers

Historically, the outcomes of UCL repair in the overhead throwing athlete were inferior, as compared with those of reconstruction, with return to sport rates ranging from 50 to 63% [38, 41]. With the recent rise of UCL injury primarily in younger, adolescent patients [5, 10] and recognition of the spectrum of disease with UCL insufficiency (partial tears, proximal or distal avulsions, etc.), UCL repair has garnered renewed interest [42], and more recent studies have demonstrated improved outcomes with repair than what was previously reported.

Savoie and colleagues reported on a series of 60 patients with UCL insufficiency treated with primary repair [43]. Patients included had failed a 3-month trial of rehabilitation and bracing, were unable to return to their respective sport, and had UCL damage at a single site (either proximal or distal end) within the ligament. Fifty-one patients were overhead throwing athletes, but 9 participated in basketball [2], cheerleading [2], and gymnastics [5]. UCL repair was performed via suture plication of the ligament with reattachment to either the medial epicondyle or sublime tubercle using suture anchors or bone tunnels. The mean Andrews-Carson score for the cohort improved from 132 to 188 postoperatively ($p < 0.05$). Ninety-three percent of patients returned to the same level of sport at mean 6 months following surgery. Of the 4 failures, none competed in a non-throwing sport.

The results of primary UCL repair in athletes specifically following an acute traumatic injury were further studied by Richard et al. [44]. Direct primary UCL repair using non-absorbable sutures and bone tunnels was performed in 10 collegiate athletes with complete humeral UCL avulsions. Only 3 athletes in this study were overhead throwers. The remaining athletes played football, golf, swimming, wrestling, and volleyball. The mean DASH Score at final follow-up was 6 (range 2 to 12). Nine out of the 10 athletes were able to return to the same level of sport between 4 and 6 months. The one athlete who failed to return was a college senior football player who did not go on to play professionally.

Discussion

UCL injury in the non-throwing athlete is a distinctive pathology as compared with UCL injury in throwers. In contrast to

the repetitive valgus loading of the ligament seen with overhead throwing—leading to chronic attritional microtrauma, non-throwers typically sustain acute traumatic injuries to the medial elbow. The resultant injury pattern is typically damage (often times partial versus complete tearing) of the ligament at a single site [30•, 31•, 44] without compromise of tissue quality elsewhere within the ligament substance. This injury subtype in and of itself has improved prognostic implications in terms of success of UCL non-operative management [29, 45]. Furthermore, the demands of the medial elbow stabilizing structures in the non-throwing athlete differ from throwers in that they are not subjected to the same repetitive valgus forces of the throwing motion which approach the maximal tensile strength of the ligament. The unique nature of UCL injury and sport specific demands in the non-throwing athlete may allow for different treatment protocols as compared with overhead throwers.

Non-operative treatment with structured rehabilitation has demonstrated high rates of return to play following UCL injury in professional football [13], gymnastics [30•], and professional hockey [31•] when compared with baseball [28, 29]. The use of PRP has emerged as an adjunct treatment modality to accelerate and enhance the healing potential of UCL injuries; however, existing studies are limited to uncontrolled case series in homogenous cohorts of young adolescent patients [46–48]. While initial results appear promising, further controlled studies are warranted to clarify the role of adjunct PRP in the treatment of UCL insufficiency.

Surgical intervention is indicated for those patients who remain persistently symptomatic after a failed a trial of conservative treatment. The single site of ligament damage often seen in the non-throwing athlete UCL injury may be amenable to primary repair. While studies evaluating UCL repair are limited in comparison to reconstruction, excellent results have been demonstrated in throwing athletes with high rates of return to sport and shorter return to sport times [43, 44, 49] than typically observed with UCL reconstruction [35, 50, 51] (4–6 months with repair vs 11–20 months reconstruction). The sport specific demands of the non-throwing athlete's elbow, namely the lack of repetitive valgus stress with throwing, may further facilitate earlier return to play following repair. UCL reconstruction should be reserved for those patients with more extensive ligament damage and injury patterns more often seen in the throwing athlete. Only 1 study has specifically evaluated the outcomes of UCL reconstruction in a non-throwing population [40•], and while good outcomes were demonstrated, no control group was utilized. Further studies, specifically in non-throwers, would help define the indications and elucidate outcome of the procedure in this patient population.

Conclusion

While classically regarded as a pathology of the overhead thrower, UCL injury also occurs in non-throwing athletes. Non-operative management can successfully return the majority of these players to their respective sports. For those patients who fail conservative management, primary UCL repair may be an effective treatment strategy with reconstruction reserved for those with more diffuse ligament damage not amenable to repair.

Compliance with Ethical Standards

Conflict of Interest Nicholas Ramos and Orr Limpisvasti declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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