**Purpose of Review:**

The purpose of this literature review is to address a knowledge gap that I believe exists within our DPT curriculum. Throwing athletes, most commonly baseball players, are a population that is highly susceptible to injury due to the nature of the high-demand movements associated with overhand throwing. In my opinion, our program is lacking in specifics when it comes to diagnosing and treating injuries in athletes. While we have a good amount of course content focused on shoulder injuries – diagnostics, evaluation, and treatment, minimal clinical information is presented regarding UCL elbow injuries. For anyone who wants to work with athletes in future practice, I believe it is important to understand the current best practice approaches for UCL injuries. This is especially true since, as I will present in the following literature review, the instance of UCL tears have been increasing in recent years across all skill and competition levels.

**Please note:** UCLR = ulnar collateral ligament reconstruction (i.e. Tommy John Surgery). RTS = return to sport at prior level of competition. MLB = Major League Baseball. ERA = earned run average. WHIP = walks and hits per inning pitched. ASMI = American Sports Medicine Institute. PRP = platelet-rich plasma.

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| **Study:**  **Author:**  **Year:** | **Purpose:** | **Design &**  **Subjects:** | **Intervention:** | **Assessment:** | **Outcomes:** | **Comments:** |
| **1.**  Ulnar Collateral Ligament in the Overhead Athlete: A Current Review  Dugas et al. 2014 | To review functional anatomy and biomechanics of the UCL as it relates to overhead throwing, and to discuss clinical methods for diagnosis. Also, to provide a review of outcomes and complications of operative and nonoperative treatment. | Review by a panel of MD’s. | Anatomical and biomechanical reviews.  17 outcome studies were reviewed, containing 1953 patients. 2 studies were reviewed regarding surgical techniques, 138 patients. | Success was defined by a return to prior level of sport competition (RTS). | A comprehensive discussion was provided regarding the important role of the UCL in overhand throwing.  Multiple surgical techniques are effective, as well as multiple graft sites. Levels of RTS are high. | This study provides a very comprehensive review of numerous relevant areas. While it is not a direct intervention study, it incorporates many studies to assess the success rates of current intervention approaches. |
| **2.**  The Thrower’s Elbow  Patel et al. 2014 | To describe the biomechanics of the throwing motion, the examination of the elbow, the diagnostic evaluation, and diagnosis and treatment of the spectrum of elbow injuries common to a thrower. | Review by a panel of MD’s and a PT. | Discussion of: anatomy, biomechanics, developmental changes of the elbow, pathophysiology of elbow injuries, differential diagnosis, physical examination, imaging, treatment, and outcomes for numerous elbow pathologies in throwers. | The goal was to explain the mechanism by which elbow injuries occur in throwers, as well as to differentiate between common non-UCL injuries and describe proper treatment methods. | Outcomes are fair at best for nonoperative treatment of UCL injuries, and only appropriate for grade I and maybe grade II tears. Operative treatment is always advised for grade III tears, and has better ultimate success rates than nonoperative, but with a longer recovery time. | This is another great comprehensive review, and notably provides a PT perspective as well, not just MD. An important aspect of this review is their commitment to differential diagnoses and reviewing other relevant elbow pathologies. |
| 3.Ulnar Collateral Ligament Reconstruction in High School Baseball Players: Clinical Results and Injury Risk FactorsPetty et al. 2004 | The purpose of this study was to identify important risk factors for UCL injuries in high school baseball players. | Retrospective cohort study of 27 HS baseball players who underwent UCLR. | UCLR. | Identifying pertinent and common risk factors in this population, and quantifying RTS success rate. | 74% RTS. Average of 3 risk factors. 85% demonstrated at least one overuse category. Overuse and throwing breaking pitches at a younger age are important risk factors for UCL injury, as well as throwing at a higher velocity. | This article is one of the few that emphasizes the risk of overuse at a younger age as a risk factor for injury. Especially important in context of sport specialization. The authors also make recommendations to coaches and players for reducing injury risk. |
| **4.**  Incidence of Elbow Ulnar Collateral Ligament Surgery in Collegiate Baseball Players  Rothermich et al. 2018 | To evaluate, over a 1-year period, the incidence of UCL injuries requiring surgery in NCAA D1 baseball programs. | Descriptive epidemiology study including 155 baseball programs. 5295 total players, with 134 UCL surgeries. | Surgery for a UCL injury. | Quantifying the rate of UCL surgery per team and across NCAA D1 as a whole. | 2.5% of all baseball players in the study underwent UCL surgery. Over 1 year, an average of 0.86 UCL surgeries per program. 56.8% of the teams had at least one surgery. Over 6X greater rate for pitchers vs. non-pitchers. | This study was very helpful in quantifying the instance of UCL surgeries in a very relevant population. With nearly 1 surgery per program, and more than half of programs affected, we understand how common these injuries are. |
| **5.**  Risk Stratification for Ulnar Collateral Ligament Injury in Major League Baseball Players  DeFroda et al. 2016 | To identify risk factors for UCL injury at the MLB level and to quantify epidemiology of such injuries. | Retrospective cohort study from 2007 to 2014, involving 170 UCL injuries at the MLB level. With a matched control group. | Epidemiologic analysis of UCL injuries to identify risk factors for injury. | Quantifying the rate of UCL injuries at the MLB level, as well as pre-injury risk factors, specifically pertaining to average fastball velocity. | Statistically significant higher mean fastball velocity of pitchers who injure their UCL than those who do not. Small increases in velocity are the main contributor to increased rate of UCL tear. | This study draws the direct link between increased pitching velocity and UCL injury. It also shows the dramatic recent increase in UCL injuries at the MLB level. |
| **6.**  Outcomes of Non-Operatively Treated Elbow Ulnar Collateral Ligament Injuries in Professional Baseball Players by Magnetic Resonance Imaging Tear Grade and Location  Chauhan et al. 2019 | To evaluate the relationship between MRI tear grade and location with outcomes for nonoperatively treated UCL injuries in professional baseball players. | 544 pro baseball players who were treated nonoperatively for UCL injury from 2011 – 2015. 237 had available MRI’s. 90% were minor league players. | Nonoperative treatment of UCL injury and available MRI. | Retrospective analysis of MRI findings to determine correlations with outcome. | While not statistically significant, objectively, worse grade of tear and distal location of tear were associated with worse outcomes and lower baseball survival rate with nonoperative treatment. | Interestingly, MLB players had higher instance of re-injury or requiring surgery than minor league players – likely due to higher demands. Survivorship (continued ability to play, not requiring surgery) was quite low for all grades and locations of tears. Overall, the success rate for nonoperatively managed UCL tears is fair at best, with 2-year survivorship around 40%. |
| **7.**  Magnetic Resonance Imaging Predictors of Failure in the Nonoperative Management of Ulnar Collateral Ligament Injuries in Professional Baseball Pitchers  Frangiamore et al. 2017 | To evaluate the efficacy of objective measures to predict failure of the nonoperative management of UCL injuries. | Case-control study. 32 pitchers from the Cleveland Indians organization. | An initial period of nonoperative treatment for a UCL injury. | Success defined as returning to the same level of play for one year without needing surgical intervention. | 66% RTS success. 82% of those who failed had distal tears, while 81% who succeeded had proximal tears. A 12.4X greater likelihood of failing nonoperative treatment with a distal tear compared to a proximal one. Tear location was the only clinically significant predictive variable in this study. | This study offers important insight that should be used when deciding if a course of nonoperative treatment makes sense for a player. Those with distal tears may be better advised to undergo immediate surgery due to poor success rate. Results can be taken with a grain of salt due to the high potential for bias in this sample. |
| **8.**  Platelet-Rich Plasma Can Be Used to Successfully Treat Elbow Ulnar Collateral Ligament Insufficiency in High-Level Throwers  Dines et al. 2016 | To evaluate the effectiveness of PRP injections for the treatment of partial UCL tears in high-level throwing athletes. | Retrospective review of 44 baseball players (6 pro, 14 college, 24 high school) with a partial thickness UCL tear. | A series of one, two, or three PRP injections directly into the UCL, followed by conservative rehabilitation and an interval throwing program. Mean follow-up was 11 months. | Physical examination and outcome classified according to a modified version of the Conway Scale. “Excellent” signifying RTS at same level. “Poor” unable to return at any level. | 15/44 had an “excellent” outcome, and only 10/44 had a “poor” outcome. All 7/7 with a distal tear had a poor outcome. Mean time from injection to RTS was 12 weeks. | This is an encouraging study that shows that PRP injections can be used to speed up recovery in the case of partial tears and help players avoid surgery. While the rates of RTS aren’t as high as with UCLR, they are high enough to warrant an attempt prior to surgery, especially with the vastly shorter time to RTS when successful. Also, another indicator that distal tears are much less amenable to conservative treatment. |
| **9.**  Treatment of Partial Ulnar Collateral Ligament Tears in the Elbow With Platelet-Rich Plasma  Podesta et al. 2013 | To establish the efficacy of PRP injections to promote healing of partial UCL tears and allow a return to play. | Case series. 34 athletes with a partial thickness UCL tear who had failed at least 2 months of nonoperative treatment and a prior RTP. Both males and females, 4 different sports. | One ultrasound guided PRP injection into the UCL, followed by guided physical therapy. | RTS was measured, as well as medial elbow joint space opening with valgus stress. | 88% RTS at an average follow-up of 70 weeks. The average time to return to play was 12 weeks. Statistically significant decreases in valgus laxity as evidenced by less medial joint space opening. Only 1 athlete underwent eventual UCLR. | Another great study touting the role that a single PRP injection can play in RTS with partial UCL tears. This study demonstrates success for both males and females, and across multiple sports, making it more generalizable. Additionally, it provides hope that PRP is the key, since all players had failed a prior course of conservative treatment. The decrease in valgus laxity suggests PRP facilitated direct healing of the UCL. |
| **10.**  Ulnar Collateral Ligament Reconstruction of the Elbow: A Systematic Review of the Literature  Erickson et al. 2015 | To determine the effect of technique and level of play with UCLR on RTS. | Systematic review. 20 studies, including 2019 patients/ elbows. 97% male, and 94.5% baseball players. | UCLR performed with 7 different techniques and 7 different graft types. | RTS rate per technique, graft type, and level of play. | ASMI was the most common surgical technique, and palmaris longus autograft was the most common graft type. UCLR was most commonly performed in collegiate athletes. Collegiate athletes had the highest rate of RTS across levels. The Jobe technique showed inferior RTS rates. RTS between graft types couldn’t be compared, but all showed good results. | This systematic review gives insight as to the most common surgical techniques and graft types, as well as RTS rates between them and across levels. It is useful for broad perspective of UCLR. |
| **11.**  The Effects of Ulnar Collateral Reconstruction on Major League Pitching Performance  Keller et al. 2014 | To quantify the impact of UCLR on statistical pitching performance in MLB. | Statistical analysis of a cohort of 168 MLB pitchers who underwent UCLR. With 178 age matched control MLB pitchers. | UCLR. | Statistical analysis of pitching performance measures including: ERA, WHIP, innings pitched, etc. | Statistically significant declines in ERA, WHIP, and innings pitched compared to pre UCLR performance. There was a significant decline in performance in the season prior to UCLR. | Pitchers’ performance tended to decrease in the season prior to needing UCLR, potentially implicating declining performance as a risk factor for UCL injury. Following UCLR, pitchers tended to pitch less innings, but were more effective in those innings – signifying successful surgery, but the need for a slow RTS. |
| **12.**  Current Concepts in Rehabilitation Following Ulnar Collateral Ligament Reconstruction  Ellenbecker et al. 2009 | To provide a clinical template for rehabilitation for UCLR following a couple different surgical techniques. | Conceptual approach by a multidisciplinary team of 2 DPT’s and 2 MD’s. | N/A | Rehabilitation approaches for the Modified Jobe and Docking procedures of UCLR. | The proper approaches for protection, ROM, progressive resistance strengthening, functional activities, and return to throw are laid out. | This article provides a guide for what a rehabilitation approach may look like for a patient post UCLR. Ideas and progressions of exercises are useful, but the advised time frames may be the most clinically important aspect. |
| **13.**  Effect of a 6-Week Weighted Baseball Throwing Program on Pitch Velocity, Pitching Arm Biomechanics, Passive Range of Motion, and Injury Rates  Reinold et al. 2018 | To examine the effects of training with weighted baseballs on pitch velocity, PROM, muscle strength, elbow torque, and injury rates. | Level 1 randomized control trial. 38 healthy baseball pitchers, ages 13-18, randomized into an experimental and control group, both n=19. | 6-week weighed ball throwing program 3x per week, balls ranging from 2 to 32oz. Control group only used a standard 5oz baseball. Both groups performed a strength training program. | Pitch velocity, shoulder and elbow PROM, shoulder strength, elbow varus torque, and shoulder IR velocity were measured. Injuries were tracked in the subsequent baseball season. | Statistically significant increase (3.3%) in pitch velocity in the experimental group. Statistically significant increase (4.3o) in shoulder ER ROM in experimental group. 24% injury rate in experimental group, 0% in control group. Differences in arm strength or arm speed were not seen. The experimental group did not increase rotator cuff strength, but the control group did. | The 6-week weighted ball throwing program resulted in significant pitch velocity increases, but also significant increases in injury rate. The surmised method of velocity increase was via increases in shoulder ER PROM. Increases in shoulder ER PROM are correlated with increased pitch velocity, but also greater forces at the elbow, and thus, greater injury risk. These programs can be effective to increase velocity, but at a cost. |

**Overall Synthesis of Available Research:**

The elbow and forearm anatomy, as well as the biomechanics of overhand throwing, are well understood. The literature review demonstrated consistent agreement regarding the demands placed on the UCL during overhand throwing, as well as the most common problematic phases of the throwing motion. The rate of UCL injuries has been increasing dramatically in recent years, across all age groups of competition. The most frequently cited causative trends are increased pitch velocity and overuse. The concept of overuse is particularly troubling for youth athletes, as sport specialization becomes more common at younger ages. In baseball, pitchers are at a much higher risk of UCL injury than non-pitchers, and account for the vast majority of surgeries. This is an expected trend since pitchers are tasked to throw more often, harder, and various breaking pitches, while non-pitchers are not. Decreases in throwing-related performance are frequently noted in the season prior to UCLR, perhaps implicating decreased performance as an indicator of injury.

Ulnar collateral ligament reconstruction, also known as Tommy John surgery, has been in use for nearly 50 years. While there are numerous surgical techniques and graft types used today, the ASMI method and a palmaris longus autograft are overwhelmingly the most common. While some studies report differences in outcomes depending on the surgical technique utilized, most were in agreement that all techniques are similarly effective. Differences in outcomes between graft types are not well established.

There is a great deal of research regarding sport-specific outcomes following UCLR. As a whole, outcomes are quite good, with the rate of athletes returning to their pre-injury level of play reported as high. This trend holds true across most overhand throwing sports, and across competition levels (high school, collegiate, minor league, major league, etc.). In general, the timetable for RTS following UCLR is approximately 12 months. Most baseball pitchers exhibit improved success in the season following UCLR, albeit with a decrease in innings pitched, as workload is managed to mitigate risk of reinjury.

There is less research regarding nonoperative management of UCL tears. In general, nonoperative treatment is only viable for low grade (grade I) tears. A grade III (complete) tear will always warrant UCLR. Nonoperative treatment consisting of rest, targeted strengthening and stretching, along with a gradual return to throw program, has demonstrated modest success rates. While this approach is overall less successful in terms of RTS (compared to UCLR results), for those with low grade injuries, it may be worth attempting prior to considering surgery. This is primarily due to a potential for a quicker RTS following successful nonoperative treatment – usually around 12 weeks, compared to 12 months for surgery. Another nonoperative approach is PRP injections. These injections have thus far shown promise when used in conjunction with conservative therapy. PRP facilitates soft-tissue (ligamentous) healing via an increase in growth factors, and could be an important key in improving the success rate of nonoperative treatment.

The area of the research most lacking is high-level studies directly comparing UCLR with nonoperative treatment. These studies are difficult to implement in reality due to numerous factors. Unfortunately, most studies are retrospective case series or cohort studies. Drawing correlations from information in this manner is less than ideal, however, we were able to successfully extrapolate findings by comparing individual studies. Two of the more interesting findings from the literature review revealed:

* Distally located partial UCL tears typically have a worse outcome than proximal tears. The biomechanics behind this were not thoroughly explained, but this finding was consistent across the literature.
* A weighted ball throwing program is useful for increasing throwing velocity, however, these programs also carry significant increased injury risk. These programs may increase velocity, primarily through the mechanism of increasing shoulder ER ROM, but did not yield increases in arm strength or arm speed.

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