Sports Specific Outcomes for Ulnar Collateral Ligament Reconstruction

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Thomas O'Hagan, Charlton Stucken and Christopher C. Dodson

Introduction

Injury to the ulnar collateral ligament (UCL) most commonly occurs in overhead throwing athletes, particularly baseball pitchers, but is also seen in other specific subsets of athletes [1–10]. Prior to the first UCL reconstruction performed by Jobe in 1974, the UCL rupture was a catastrophic event in professional baseball pitchers [7]. Improvements in diagnosis, surgical technique, and rehabilitation programs have significantly improved outcomes for athletes.

The subsets of athletes most commonly associated with UCL injuries are baseball players, javelin throwers, softball players, tennis players, gymnasts, wrestlers, and football players [11–15]. Injury to the UCL in these athletes causes pain and valgus instability, which can adversely affect athletic performance in various ways depending on the sport. Therefore, surgical treatment is often necessitated in order to return both recreational and high level athletes back to their respective sports. In this chapter, we look to explore outcomes specific to various sports in order to guide treatment and set expectations for return to sport.

C. C. Dodson (✉) · C. Stucken · T. O'Hagan
Rothman Institute, 925 Chestnut St., 5th Floor, Philadelphia, PA 19107, USA
e-mail: ccdodson7@gmail.com

C. Stucken
e-mail: Charlton.Stucken@gmail.com

T. O'Hagan
e-mail: thomasohagan1@gmail.com

Baseball

The first description of injury to the UCL was in 1946 and involved a review of javelin throwers [10]. It was not until 1974 that Dr. Jobe performed the first successful UCL reconstruction on Los Angeles Dodger pitcher Tommy John, which eventually allowed him to return to professional baseball in 1976 [7]. Over the last half century, the injury has become well recognized in overhead throwing athletes with baseball pitchers at the highest risk [1].

Overhead throwing places high valgus stress and extension forces on the elbow, which place the UCL at risk. Baseball pitchers are at a unique risk due to the sheer number of pitches thrown over the course of a season. During late cocking and early acceleration of each pitch, enormous valgus loads are placed on the elbow, which have been estimated to approach the tensile strength of the UCL [16–18].

Initial management of UCL tears in the baseball player consists of a period of rest followed by return to sport with a structured throwing program. However, in the professional athlete as well as many college and even high school baseball players, prolonged attempts at rest or activity modification are often not well tolerated by the athlete. Furthermore, various studies have demonstrated poor results in symptomatic throwers with nonoperative treatment alone. Barnes and Tullos reported only 50 % of symptomatic throwing athletes returned to play out of 100 subjects, however, did not differentiate individual sports [19].

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Various surgical techniques have been utilized to address a ruptured UCL in baseball players, with the two major divisions being repairs versus reconstruction [6, 9, 12, 15, 20]. It has been shown that return to sport at the same previous level is less consistent with the repair when compared to reconstruction. Cain and Andrews reviewed the outcomes of 743 athletes and found 83% returned to the same level of sport after reconstruction while only 70% returned after repair [1]. Azar et al. demonstrated similar results with 81% of throwing athletes returning after reconstruction and only 63% returning after repair [12]. While neither study reported a return after treatment by individual sport, these studies and others have led to reconstruction as the mainstay for surgical treatment of a symptomatic torn UCL in the throwing athlete [1, 12, 13].

Numerous studies look at outcomes of operative reconstruction of the UCL; however, not all differentiate outcome by individual sport (Table 26.1). Conway et al. looked at throwing athletes undergoing UCL reconstruction between 1974 and 1987 with minimum 2-year follow-up [13]. Of the 56 patients who underwent reconstruction, 52 were baseball players. Of these 52 baseball players, 35 (67%) had an excellent result, defined as the ability to return to the same sport at the same or higher level for at least 12 months. Outcomes were worse for pitchers of which 62% had excellent results as compared to position players of which 85% had excellent

Table 26.1 UCL reconstruction outcomes in baseball players

Authors	Data collection period	Number of UCL reconstructions in baseball players	Number of pitchers	Level of play	Percentage returning to previous level or higher
Conway et al. [13]	1974–1987	52	45	20 majors 18 minors 10 college 4 high school	35/56 (67%)
Andrews and Timmerman [11]	1986–1990	14	Not reported	14 professional	12/14 (86%)[a]
Azar et al. [12]	1988–1994	37	Not reported	15 majors 6 triple-A 5 double-A 11 single-A	27/37 (73%)
Petty et al. [21]	1992–1996	27	24	27 high school	20/27 (74%)
Paletta and Wright [8]	1995–2000	25	25	1 majors 3 triple-A 6 double-A 7 single-A 3 independent minors 5 college	23/25 (92%)
Dodson et al. [14]	2000–2003	96	91	17 professional 63 college 16 high school	90/100 (90%)[b]
Cain and Andrews [1]	1998–2006	710	Not reported	45 majors 188 minors 346 college 131 high school	584/710(82%)[c]

UCL ulnar collateral ligament

[a] Authors do not specify at what level players returned

[b] Authors' results include four nonbaseball athletes

[c] The study included ten athletes who underwent direct repair and some of these may be included in the overall baseball player results

results although these differences were not statistically different in this study.

Andrews and Timmerman reviewed 72 professional baseball players undergoing elbow surgery between 1986 and 1990, 14 of whom underwent UCL reconstruction [11]. Twelve of the 14 (86%) were able to return to play at the same level. Later, Azar and Andrews reported on 59 throwing athletes undergoing UCL reconstruction between 1988 and 1994 [12]. While the authors do not differentiate results by sport, they do specify results on 37 professional baseball players in the group with 73% returning to their previous level of play or higher. This includes 11 of 15 (73%) major league players, 4 of 6 (67%) triple-A players, 4 of 5 (80%) double-A players, and 8 of 11 (73%) single-A players returning to their previous level of play or higher. The average time to return to competitive throwing in the baseball players in this study averaged approximately 1 year.

Petty and Andrews reported on 27 high school baseball players who underwent UCL reconstruction between 1995 and 2000 [21]. They found that 20 out of 27 (74%) baseball players returned to competition at or above their previous level. The average time to return was 11 months. Eleven percent (3/27) were catchers, while the remaining 24/27 athletes were pitchers, however, no distinction amongst outcomes were reported between the pitchers and catchers with respect to return to previous level of play.

Paletta and Wright retrospectively reviewed 25 professional and scholarship collegiate baseball pitchers undergoing UCL reconstruction [8]. This study was unique in that all subjects were not only high level baseball players, but specifically pitchers. Twenty-three of the 25 pitchers (92%) returned to the same level or higher with a mean time to return to competitive throwing of 11.5 months. There was no difference between professional and collegiate players.

More recently Dodson et al. reported on 100 consecutive overhead-throwing athletes treated with UCL reconstruction between 2000 and 2003 [14]. They found that 90% of 100 throwing athletes were able to return to the same level or higher after reconstruction. While the investigators did not stratify outcome by individual sport, the results are relevant in a discussion of sports specific outcomes of baseball players due to the high percentage of baseball players in their study. Ninety-six of the 100 athletes were baseball players, with 91 being pitchers and five positions players. Amongst the baseball players, 16 played professionally, 60 played at the collegiate level, and 15 were high school pitchers.

The largest study of UCL reconstruction was performed recently by Cain and Andrews in which they reported on 743 patients undergoing surgical intervention for UCL tears [1]. Of these, 733 underwent reconstruction and 10 underwent repair of the ligament between 1998 and 2006. Overall results demonstrated 610 of 733 (83%) athletes undergoing reconstruction and 7 of 10 (70%) athletes undergoing repair returned to their previous level of play or higher. Amongst these athletes, 710 were baseball players: 45 major league players, 188 minor league players, 346 collegiate players, and 131 high school and recreational baseball players.

In that same study, Cain and Andrews looked closely at results of baseball players stratifying outcomes by level of play [1]. In their review, 34 of 45 (75.5%) major league players returned to same level with 7 returning to the minor leagues and 4 not returning to sport. Looking at minor league players, 138 of 188 (73%) returned to the same level or higher. An additional 24 of the 188 minor league players (13%) returned to the minor leagues, however, at a lower level (i.e., triple-A to double-A). Amongst college players, 304 of 346 (88%) returned to the same level or higher. This included 5 college players eventually advancing to major league baseball, and 66 eventually advancing to minor league baseball. Amongst the high school athletes, 108 of 131 (83%) returned to the same level of play or higher. Overall, the average time to initiation of throwing was 4.4 months and average time to full competition was 11.6 months after reconstruction.

As is evident from the above findings, outcomes for return of baseball players after UCL reconstruction has improved over the last 30–40 years. This trend is likely a result of improved clinical diagnosis, advancements in

surgical techniques, and more structured rehabilitation throwing programs [6, 9, 12, 15, 20]. Certainly, the overwhelming majority of athletes sustaining these injuries are baseball players as is evident by the high percentage of these athletes in the aforementioned studies.

Important to consider when reviewing the literature on sports specific outcomes after UCL reconstruction are the numerous variables with respect to each athlete's history and treatment method. Specific surgical technique can affect results and current published data includes flexor pronator mass detachment, retraction, as well as muscle-splitting techniques [9]. Also important is the presence of previous operations on the same elbow, as it has been shown that a history of prior procedures on the ipsilateral elbow yield poorer outcomes [13]. Another consideration is additional procedures performed at the time of reconstruction, which can also affect outcomes [9]. All of these factors must be taken into account when evaluating outcomes in baseball players or other athletes.

Baseball and specifically pitching represents a unique activity in sports that places a huge amount of force on the elbow in a repetitive manner placing the UCL at risk. It is for this reason that evaluating UCL reconstruction outcomes specifically for baseball players is important. The average starting major league pitcher throws over 3,000 live game pitches per year, and as youth baseball becomes a year round sport, younger baseball players throw more and more. Studies have shown the valgus force reaches 290 N, resulting in angular velocity in excess of 2400–3000°/s [17, 22]. Taking these factors into consideration, it is not difficult to see why sport-specific outcomes, specifically with respect to pitching is important to consider when looking at results of ulnar ligament reconstruction.

Author's preferred treatment: It is our experience that expectations for baseball players to return to the previous level are similar to the current literature, and thus we provide expectations that 85–90% of baseball players will return to their previous level of play after UCL reconstruction. Reconstruction involves a muscle-splitting technique utilizing a docking or figure-eight technique. Players may begin throwing at 4 months at which time a structured throwing program is implemented. Return to full competitive throwing takes place at approximately 1 year after UCL reconstruction.

Additional Sports

Most of the attention regarding injuries to the UCL has been placed on baseball players, specifically pitchers. However, it has also been reported in other overhead athletes, including javelin throwers, quarterbacks, softball pitchers, and tennis players. Each sport requires different throwing mechanics, and with each change in motion, there are different stresses imparted to the elbow. The common denominator in these sporting activities is a repetitive valgus stress to the elbow. The role of surgical reconstruction of the UCL in the elbow is sport specific and must be individualized to the patient (Table 26.2).

Javelin Throwers

Although baseball pitchers garner most of the attention regarding UCL injuries, the first reported diagnosis of a UCL tear was made in 1946 in a javelin thrower [10]. Numerous studies have analyzed the biomechanics of the javelin throw [23–25]. The javelin event involves throwing a 2.6 m spear weighing at least 800 g. The generation of a large release of speed is the major contributing factor in a long distance throw, and throwers lengthen the path of acceleration of the javelin by maintaining an extended elbow for as long as possible until foot strike [26]. The throwing motion is broken down into four phases: approach run, cross steps, delivery stride, and thrust phase. The time between final foot contact and release is called the thrust phase. During this thrust phase, the elbow flexes through a range of 40–60°, which is comparable to baseball pitchers [24]. As contrasted with baseball pitchers who undergo rapid *extension*, javelin throwers undergo rapid *flexion*. During this rapid flexion, the flexion angular velocity approaches 1900°/s

Table 26.2 Outcomes of nonbaseball UCL injuries

Study	Sport	Number of patients	Treatment	Outcomes
Dines et al. [3]	Javelin	10 (2 partial, 8 complete)	Reconstruction	9 excellent, 1 fair
Conway et al. [13]	Javelin	3 (of 71)	Reconstruction	3 excellent
Kodde et al. [28]	Javelin	6 (of 20)	Reconstruction	6 return to play
Cain et al. [1]	Javelin	15 (of 1281)	Reconstruction	Overall 83 % return to play
Dodson et al. [4]	Football	10 (4 grade I, 3 grade II, 3 grade III)	9 Non-OP, 1 repair	10 return to play
Kenter et al. [31]	Football	2 (both grade I)	2 Non-OP	2 return to play
Dodson et al. [14]	Football	2 (of 100)	Reconstruction	Overall 90 % return to play
Argo et al. [34]	Softball	8 (of 19)	Repair	Overall 94 % return to play

(compared with 2400°/s in baseball pitchers), imparting a large valgus force on the medial side of the elbow [3, 26]. For these throwers, as much as 70 % of the release speed of the javelin is developed in the last second [25].

There is no literature describing nonoperative outcomes of UCL injuries in javelin throwers. The sole article in the English language on nonoperative treatment of UCL injuries in throwing athletes does include two javelin throwers [27]. However, the results of these two javelin throwers were not separated from the 29 baseball players; overall 42 % of athletes returned to previous level of competition at an average of 24.5 months after rest and rehabilitation exercises.

Besides several series of outcomes after UCL reconstruction that include a few javelin throwers, there is only one report that focuses specifically on reconstruction in this group of athletes [3]. Dines et al. evaluated ten javelin throwers who underwent UCL reconstruction after failing a course of nonoperative management that included rest, physical therapy, and a structured attempt to return to throwing [3]. All patients had positive physical examination findings and magnetic resonance imaging (MRI) showed partial tears in two and complete tears in eight. These patients all underwent UCL reconstruction with docking technique, and at the 2-year follow-up, nine had excellent outcomes, and one had a fair outcome. The average time to start throwing was 8 months, and the average time to return to the previous level of competition was 15 months. All ten patients were subjectively satisfied with their clinical outcome.

Other reports only include a few javelin throwers among their other reconstructions, which are mostly baseball players [1, 13, 28]. Conway et al. included three (of 71 patients) javelin throwers, and all three had excellent results; however, they do not describe changes to postoperative protocol nor specifically address these athletes' results [13]. Kodde et al. included six javelin throwers (of 20 patients) who underwent reconstruction; all six returned to play at their preinjury level of sports [28]. The largest series of UCL reconstruction included 15 javelin throwers (of 1281 patients), yet no sport-specific outcomes were included; 83 % of all patients included in the study returned to previous level of competition [1].

No consensus postoperative protocol and throwing program exists for javelin throwers in the literature. Dines et al. modified their baseball interval throwing program to account for the specialized movements of the javelin throwing motion [3]. As the javelin is much heavier than a baseball (1.76 versus 0.32 pounds), they waited 8 months from surgery (as compared to four in baseball players) to begin an interval throwing program. They also focused more on lower extremity and core strengthening to account for the increased weight of the javelin.

Author's preferred treatment: Javelin throwers, like other overhead athletes with UCL insufficiency, can expect to return to their previous level of play after surgical reconstruction. They should be counseled that due to their unique throwing motion and increased weight of the javelin, their return to play will be longer than in baseball players. A postoperative protocol

focusing on core and lower extremity strengthening then progressing to a throwing program at 8 months should allow them to return to play at around 15 months.

Football Quarterbacks

The motion of throwing a football is similar to throwing a baseball pitch; however, kinematic and biomechanic distinctions between the two result in a very different injury profile. The lower incidence of elbow injuries in football quarterbacks may be attributed to lower forces and torques throughout the throwing motion [26, 29, 30]. During arm acceleration, the elbow reaches a maximum elbow extension velocity of 1760°/s, as compared with 2400°/s in pitchers [17]. The increased weight of a football (0.9 pounds) as compared with a baseball (0.32 pounds) appears to affect shoulder position and stresses throughout the throwing motion. The follow-through phase used to decelerate the arm is abbreviated in football as the quarterback must be prepared for the impact from an opposing player, possibly lowering forces and torques produced during this phase. Quarterbacks are at risk of elbow injuries from both the chronic throwing motion as well as from acute contact injury.

The largest series of UCL injuries in football players includes ten quarterbacks [4]. Dodson et al. reported on ten national football league (NFL) quarterbacks with UCL injuries; seven occurred as a result of contact injury. Four of the UCL injuries were grade I ligamentous injuries, three were graded as grade II, and three were graded as grade III. Nine of the ten quarterbacks were treated without surgery, while the other one quarterback underwent surgery (grade II injury with return to play in 17 days, implying simple ligamentous repair). Nonoperative treatment consisted of rest, anti-inflammatories, and other forms of local modalities. The average time after nonoperative treatment was 27.4 days (7.8 days for grade I, 7 days for grade II, and 67.3 days for grade III). These results suggest that even a complete tear of the UCL in a quarterback can be managed nonoperatively.

Another study of acute elbow injuries in all NFL players from 1991 to 1996 included 19 acute UCL injuries, including 2 quarterbacks [31]. Both injuries were acute, grade I injuries and both players were able to return to the same level of play without surgical repair or reconstruction of the UCL. There are also previous reports that included quarterbacks under a broader heading of overhead athletes. In 2006, Dodson et al. reported on the results of 100 overhead athletes undergoing ligament reconstruction, of which two were quarterbacks [14]. The specifics of these two patients are unavailable; however, 90 % of these patients were able to compete at the same or higher level. Thompson et al. reported on reconstruction in 83 overhead athletes, including one quarterback, and all patients were able to return to their sport; no information regarding mechanism of injury or rehabilitation was described. Studies by Cain et al. and Dines et al. also reported on one and 13 football players, respectively, who underwent ligament reconstruction, but again, specifics are unavailable with overall outcomes of 83 and 86 % return to play, respectively [1, 32, 33].

Author's preferred treatment: While successful outcomes have been reported after surgical reconstruction in quarterbacks, the available literature suggests that these players can be successfully treated nonoperatively and return to competitive play.

Softball Pitchers

Softball pitchers present as a unique subset of throwers as their primary motion is underhand. Also, as compared to the overhead throwers in baseball and football, softball pitchers are primarily female. As with overhead throwers, underhand throwers are subject to high forces and torques on the upper extremities, but this force is less than that of baseball pitchers [26, 33]. The maximum stress is imparted upon the elbow just before the ball release when an elbow extension velocity of 570°/s is produced, and at this moment elbow extension is terminated and elbow flexion is terminated. So, while the overhead

thrower is extending at ball release, the underhand softball pitcher is flexing the elbow.

In 2006, Argo et al. reported the largest series of UCL insufficiency in female patients, including eight softball players (of 19 patients) [34]. Only one of these players was a pitcher. All patients underwent surgery, yet the majority (18 of 19) underwent repair instead of reconstruction. Of the 18 patients who participated in athletics, 17 (94%) were able to return to their sport at a mean of 2.5 months postoperatively. In terms of rehabilitation, patients were allowed to start throwing in a brace at 6 weeks postoperatively. They attribute this rapid return to activity to less invasive surgery combined with aggressive sport-specific rehabilitation in a brace and a lower functional demand population. Although reasons are unclear, the female athlete, especially the underhand softball pitcher, imparts less stress to the elbow, making injury more amenable to repair. Other reports have included softball players among their UCL reconstructions with favorable results, yet none of these studies include sport-specific outcomes [1].

Author's preferred treatment: The focus on the female thrower, with specific attention to softball players, lacks the data and support afforded to the elite, male, overhead thrower. While there is evidence to suggest positive outcomes in ligament reconstruction for these athletes, the only study with a specific focus on the female thrower has shown favorable results with ligament repair. Further research into female throwing injuries is necessary, but repair is currently a viable option.

Other Sports

UCL injuries have also been reported in tennis, gymnastics, and wrestling [1, 28]. Each of these sports places stresses across the medial elbow, but not to the degree of baseball pitcher, thus, the lower frequency of injury. During the tennis serve, the angular velocity of elbow extension was found to reach 982°/s, much less than the 2300°/s in baseball pitchers [35]. While several large series of UCL reconstructions include these athletes, there is no discrete data on treatment algorithms or rehabilitation protocols [1, 3, 34]. Further research is needed to investigate sport-specific protocols and treatment outcomes for athletes who play sports that place the UCL at risk.

Conclusion

Overhead throwing athletes place considerable stresses on the UCL. While our techniques have continued to evolve over time, we should not place our technical advances above the sport-specific needs and demands of our athletes. The role of ligamentous reconstruction in baseball players is well described and widely accepted, yet the treatment of other throwers still lacks conclusive data. The specific demands, chronicity of injury, and integrity of the ligament should all be taken into consideration when treating javelin throwers, quarterbacks, softball players, and other overhead athletes.

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