



Functional outcomes following revision ulnar collateral ligament reconstruction in Major League Baseball pitchers

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Background: There is a paucity of data regarding outcomes following revision ulnar collateral ligament (UCL) reconstruction in Major League Baseball (MLB) pitchers. A single case series comprised of 4 MLB pitchers has reviewed outcomes in this cohort and reported a 75% rate of return to pitching. We hypothesize that MLB pitchers demonstrate a low rate of return to their pre-injury pitch workload following revision surgery.

Methods: Clinical outcomes were reviewed with an emphasis on return to pre-injury pitch workload. Utilizing MLB player performance statistics, the postoperative pitch workload (appearances for relief pitchers and games started/innings pitched for starting pitchers) was calculated to determine if players were able to resume pre-injury throwing activity. Position-specific analyses for pitchers (starter vs relief) were also performed utilizing objective pitching statistics.

Results: Overall, 78% (14/18) of pitchers were able to return to MLB play within 2 full seasons. Relief pitchers were able to resume 50% of their pre-injury pitch workload, while starting pitchers only reached 35% of their prior workload ($P = .52$). Relievers demonstrated better pitching statistics (ERA [earned run average], K/9 [strikeouts per 9 innings], and BB/9 [walks per 9 innings]) when compared to starters. Two starting pitchers were reassigned to relief roles by their teams, resulting in improvement in their postoperative pitch workload (mean 94%).

Conclusion: The overall rate of return to pre-injury pitch workload following revision UCL reconstruction is low among professional pitchers. Starting pitchers may be at higher risk for treatment failure in the revision setting, given the increased demands of the position, and may benefit from reassignment to a relief role.

Level of evidence: Level IV, Case Series, Treatment Study.

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Keywords: Ulnar collateral ligament; revision UCL reconstruction; Major League Baseball; throwing elbow; pitching injuries; elbow ligament

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Repetitive valgus stress generated at the elbow during the overhead throwing motion can result in ulnar collateral ligament (UCL) attenuation with subsequent development of degenerative changes and chronic, disabling elbow pain.^{1,3,6,13} This devastating injury was once considered

career-ending; however, numerous studies demonstrate up to 90% of overhead athletes are able to successfully return to competitive throwing activities with the use of modern UCL reconstruction techniques.^{5,7,11,12,14}

Ultimately, the recent evolution of surgical techniques could not be more timely, as studies reveal a substantial increase in overhead athletes requiring primary UCL reconstruction.⁹ Given the increased awareness and recognition of UCL injury in throwing athletes, there has been a commensurate rise in operative intervention, as some studies suggest that 1 in 9 Major League Baseball (MLB) pitchers have required the procedure.^{2,14} Despite the higher physical demands of this unique cohort, recent literature demonstrates a 75% rate of return to professional baseball following primary UCL reconstruction.² While these rates for return to play are promising, there is little data available to fully characterize the long-term durability of UCL reconstruction in this elite population.

Previous studies demonstrate revision UCL reconstruction is an uncommon procedure; however, as primary procedures continue to increase, there will likely be a proportionate rise in revision reconstruction. In the largest series to date, Cain et al reported the rate of recurrent UCL injury with subsequent revision reconstruction was approximately 1%.² Given the paucity of data highlighting functional outcomes following revision UCL reconstruction, particularly in professional baseball pitchers, treatment guidelines and recommendations for return to competition remain unclear. In a small case series by Dines et al, the authors revealed a 75% (3/4) rate of return to pre-injury competition for professional baseball pitchers; a rate significantly higher than the overall rate of return for minor league (14%) players.⁴

While the athletes in the study by Dines et al were able to return to MLB competition at a high rate, it is unclear if any of these players returned to their pre-injury pitching workload. In this study, we investigated the rate of return to pre-injury play with an emphasis on prior pitching workload (ie, games started/innings pitched for starting pitchers and relief appearances for relief pitchers) in MLB pitchers who underwent revision UCL reconstruction. Utilizing return to pre-injury workload as a primary outcome measure, we hypothesized that the overall rate of return for professional pitchers to pre-injury pitching responsibilities is low. Additionally, we examined potential differences in outcomes amongst starting and relief pitchers to better define the prognostic implications for each position type in the revision setting.

Materials and methods

Following approval by the Institutional Review Board, we performed a retrospective review of the MLB disabled list over a 14-year period (1996-2009). In order to be placed on the disabled list, MLB guidelines state that the athlete must be designated as unable

to play, with a specific clinical diagnosis assigned by the medical staff. For the purposes of this study, any player diagnosed with an elbow injury that resulted in time on the disabled list was initially reviewed, and all cases of UCL injuries requiring surgical intervention were subsequently identified. Any pitcher on an active MLB roster who underwent revision UCL reconstruction during the aforementioned time period was included in the study.

Our database consisted of the athlete's name, team, position type (starter vs reliever), injury information, dates on the disabled list, date of surgery, and date of return to major league play. The total number of game appearances for relief pitchers and games started/innings pitched for starting pitchers both before and after revision UCL reconstruction was calculated using available team records to determine the overall percentage of postoperative pitch workload relative to pre-injury productivity. Return to play data were based upon the duration of time between revision UCL reconstruction and full, unrestricted participation in major league games. Objective pitching statistics including total innings pitched (IP), earned run average (ERA), strikeouts per 9 innings (K/9), and walks per 9 innings (BB/9) were also determined using available team records.

Time to return to pitching, innings pitched, objective pitching statistics (ERA, K/9, BB/9), and the postoperative workload percentage were compared between relievers and starters. Statistical analysis was performed utilizing a non-parametric Mann-Whitney *U* test with 2-sided hypothesis testing. Statistical significance was set to alpha equal to 0.05.

Results

We identified 18 MLB pitchers who underwent revision UCL reconstruction between the 1996 and 2009 seasons. Interestingly, 14 revision procedures were performed during the latter half (2003-2009) of this 14-year period, while only 4 operations were performed during the first half (1996-2002) of the study period. This observation may reflect the heightened awareness and recognition of UCL injury in throwing athletes over the last decade. Overall, there were 15 right-hand dominant pitchers and 3 left-hand dominant pitchers. The majority of players pitched in a relief role (11), while the remainder was classified as starting pitchers (7). The mean age for all pitchers at the time of revision surgery was 29.5 years (range, 22-35). The average age for starting pitchers was 29.6 years (range, 26-32) and the mean age for relief pitchers was 29.5 years (range, 22-35). According to available team records, recurrent UCL injury occurred in the acute setting in three (17%) patients, as they reported significant medial elbow pain following a single throw.

Following revision UCL reconstruction, 78% (14/18) of pitchers were able to return to the MLB level within 2 full seasons. Relief pitchers were able to resume approximately 50% of their pre-injury pitch workload. In comparison, starting pitchers were only able to resume 35% of their prior workload ($P = .52$). When analyzing pitchers that were able to return to play, only 1 starting pitcher (1/6, 17%) approached his pre-injury workload (94%) compared

to 38% (3/8) of relief pitchers. In fact, 2 relievers surpassed pre-injury productivity (103% and 117%). The mean time for return to pitching at this level was 18.9 months (range, 12-27). Relievers were able to return to MLB pitching approximately 2 months earlier compared to starters ($P = .32$). The average number of game appearances for relief pitchers was 45 and the mean number of innings pitched was 42.5 innings. The average number of games started for starting pitchers was 11.3 and the mean number of innings pitched was 61.1 innings. Relief pitchers demonstrated better pitching statistics in each category (ERA, K/9, and BB/9). Demographic information and pitching statistics are highlighted in [Table I](#).

Discussion

Recent studies have demonstrated a significant increase in MLB injuries over the past several years. A study by Posner et al reviewed the epidemiology of MLB injuries over a 7-year period (2002-2008).¹⁰ Overall, the incidence rate for injury was 34% higher for pitchers compared to field position players and the incidence rate for upper extremity injuries was 2.79 times higher for pitchers. In the largest review of UCL reconstruction in overhead athletes, Cain et al observed a 50% increase in the number of primary UCL reconstruction procedures performed between 1996 and 2001 at a single institution, thus highlighting an increased understanding and awareness for this debilitating injury.² Ultimately, as these overuse injuries continue to increase, one can speculate that a commensurate increase in the number of athletes that will require revision UCL reconstruction will occur.

Recurrent UCL tears in baseball pitchers following primary UCL reconstruction is not a common injury, and there is a paucity of literature to guide realistic expectations for return to high-level throwing in these athletes. To date, only 1 study has attempted to define clinical outcomes following revision UCL reconstruction in overhead athletes.⁴ Dines et al performed a retrospective review of 15 baseball players who underwent revision UCL reconstruction and found that only 33% (5/15) were able to return to their pre-injury level of competition. As with any revision surgical procedure, the authors also noted an increased prevalence of postoperative complications (40%). Interestingly, they observed excellent results in 75% (3/4) of patients who were Major League Pitchers at the time of revision surgery, compared to minor league players (14% rate of return). While the authors did not specifically address potential reasons for such a high rate of success for MLB players in the setting of a revision procedure, one could attribute these findings to several factors. First, MLB organizations invest substantial amounts of money in players at the MLB level and guaranteed contracts represent a significant reason for the team to ensure a player who has reached this elite level can return to pitching.

Furthermore, a minor league player who has undergone revision UCL reconstruction may be less likely to get an opportunity to return to play, as organizations identify a pitching prospect with no significant injury history as a better investment.

One limitation of the aforementioned study by Dines et al is the fact that the authors did not record the level of productivity (ie, games started/relief appearances or innings pitched) for these professional pitchers and it is unclear if they were able to resume their pre-injury pitching responsibilities.⁴ Given these findings, we attempted to better define the success of MLB pitchers to resume their pre-injury pitch workload after revision UCL reconstruction. We found that 78% (14/18) of pitchers were able to return to the MLB level within 2 full seasons. These findings are similar to those reported by Dines et al, thus highlighting a high rate of return to professional pitching.⁴ The overall return to pre-injury pitch workload was diminished for both relievers (50%) and starters (35%), but more relievers approached or surpassed their previous workload (3/8, 38%). Furthermore, relief pitchers displayed better overall objective pitching statistics, thereby demonstrating more success upon return to play. While limited conclusions about potential for successful return to pre-injury workload can be ascertained from these observations, these findings may support the concept of overuse as a risk factor for poor clinical outcomes. In general, starting pitchers average more innings pitched per season and per game than relief pitchers, thus placing larger demands on the reconstructed elbow. In our study, starters averaged approximately 20 more innings pitched per season compared to relievers. Given the limitations of available data, it is unclear how much rest was given to each pitcher in between game appearances; but our data do suggest that starting pitchers that undergo revision UCL reconstruction may perform better if they are reassigned to a relief pitching role. In fact, 2 starting pitchers were assigned to relief roles by their teams and demonstrated improved return to pre-injury workload (63% and 125%) when innings pitched were used as a comparative measure both before and after surgery.

In the study by Dines et al, the mean age of professional players at the time of revision reconstruction was 22.2 years (range, 19-30).⁴ The mean age of our cohort was 29.5 years. This observation raises several interesting questions regarding the effect of age on clinical outcome. To our knowledge, no study has provided a clear causative association between older age and advanced elbow pathology in throwing athletes; however, some authors do suggest a possible relationship. A recent study by Osbahr et al demonstrated older age (>30 years) is a risk factor for the development of combined UCL and flexor-pronator injuries and portends a worse prognosis for return to play.⁸ When analyzing outcomes in patients older than 30 years in our study, we found older patients resumed approximately 53% of their pre-injury workload, compared to patients less than

Table I Summary of demographic information and pitching statistics for each player

	Player position	Dominant arm	Age at revision surgery	Time to RTP (mos) at MLB level	MLB relief appearances	IP	ERA	K/9	BB/9	% workload reliever		
1	Reliever	RHP	35	18	61	60.2	4.9	10.38	3.12	94%		
2	Reliever	RHP	35	19	72	52.1	4.13	7.39	3.44	103%		
3	Reliever	LHP	22	22	60	59.2	4.22	10.71	4.98	No prior MLB experience		
4	Reliever	RHP	29	12	42	39.3	6.22	9.17	5.03	64%		
5	Reliever	RHP	31	21	64	70.1	4.48	7.29	3.07	117%		
6	Reliever	RHP	29	13	54	51.3	4.45	9.22	3.75	70%		
7	Reliever	RHP	33	16	3	3.1	5.4	2.7	8.1	5%		
8	Reliever	RHP	26	DNRTP	NA	NA	NA	NA	NA	0%		
9	Reliever	RHP	22	25	4	5	3.28	9	5.4	44%		
10	Reliever	RHP	32	DNRTP	NA	NA	NA	NA	NA	0%		
11	Reliever	RHP	30	DNRTP	NA	NA	NA	NA	NA	0%		
Mean			29.5 years	18.3 months	45 games	42.5	4.64	8.23	4.61	50%		
	Player position	Dominant arm	Age at revision surgery	Time to RTP (mos) at MLB level	MLB game appearances	IP	ERA	K/9	BB/9	% workload starter	Position switch	% workload reliever
1	Starter	LHP	30	13	33	186	4.55	8.13	2.56	94%	No	NA
2	Starter	RHP	31	27	9 (as starter)	77	5.14	4.44	2.34	47%	Yes	63%
3	Starter	LHP	26	DNRTP	NA	NA	NA	NA	NA	0%	DNRTP	NA
4	Starter	RHP	29	18	0 (as starter)	50.2	4.44	11.19	6.39	0%	Yes	125%
5	Starter	RHP	31	13	13	22.3	10.23	4.12	8.65	48%	No	NA
6	Starter	RHP	32	27	9	11	6.55	5.73	8.18	28%	No	NA
7	Starter	RHP	28	21	4	20.2	2.61	6.1	1.74	25%	No	NA
Mean			29.6 years	19.8 months	11.3 games	61.1	5.58	6.62	4.97	35%		
						<i>P</i> = .897	<i>P</i> = .439	<i>P</i> = .245	<i>P</i> = .897	<i>P</i> = .520		

RTP, return to pitch; *MLB*, Major League Baseball; *IP*, innings pitched; *ERA*, earned run average; *K/9*, strikeouts per 9 innings; *BB/9*, walks per 9 innings; *NA*, non-applicable; *DNRTP*, did not return to pitch in MLB; *NA*, not applicable; *RHP*, right-hand pitcher; *LHP*, left-hand pitcher.

30 years of age (29% of pre-injury workload). Clearly, several individual factors may play a role in this observation, including a patient's individual talent, maturity, work ethic, appropriate rehabilitation, concurrent procedures, and postoperative complications. It is possible that the maturity of older patients may play a role in return to play, as these players readily accept a diminished role or work diligently to expand their pitching armamentarium to compensate for certain loss of skill (eg, loss of fastball velocity).

We acknowledge that our study has some weaknesses. First, this retrospective series is based on the data available from team records of players placed on the disabled list during the 1996-2009 MLB seasons. Utilizing the disabled list as our primary source of injury data does introduce potential bias (information bias), as some elements of clinical data were not readily available. For example, it is unclear if any associated elbow pathology and additional procedures were performed at the time of revision reconstruction. While this information would provide a more comprehensive assessment of the spectrum of injury observed in the revision setting, the value of this data is of questionable significance, as some authors demonstrate additional procedures performed at the time of revision reconstruction have no significant effect on clinical outcome.⁴ Additionally, the method of revision reconstruction was not available for pitchers included in the study. Differences in surgical technique include the approach to the flexor-pronator mass, location of humeral tunnels, method of graft fixation, graft choice, and the management of the ulnar nerve. A recent systematic review of the literature suggests these variables could have an effect on surgical outcome.¹⁴ Last, this study did not use a validated outcome measure; but, as with most studies focusing on outcomes related to UCL reconstruction, we chose to focus on return to pre-injury level of play and pre-injury workload as our primary outcomes. Despite the aforementioned shortcomings, our study does have several strengths. First, this case series represents the largest review of patients who have undergone revision UCL reconstruction. Additionally, it provides clinical data on an elite group of professional athletes who are infrequently studied based on limited availability of their medical records.

Conclusion

The present study suggests that most MLB pitchers are unable to return to their pre-injury pitch workload, and that starting pitchers may be predisposed to poorer outcomes given the increased workload. In the age of informed consent, this study provides important outcomes data that can help guide treatment plans as well as expectations for both the surgeon and athlete.

Disclaimer

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