Successful Performance After Ulnar Collateral Ligament Reconstruction

An Analysis of 88 Drafted Professional Baseball Pitchers With a Matched Comparison Cohort

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Background: Analysis of pitchers entering the Major League Baseball (MLB) draft after ulnar collateral ligament reconstruction (UCLR) is challenging for team physicians.

Purpose: (1) To define the characteristics of pitchers drafted after UCLR associated with placement in AAA and MLB professional levels and completion of a career of at least 3 years, (2) to define characteristics placing pitchers at risk for reinjury after surgery, (3) to compare the professional-level placement and career duration of the UCLR cohort with a matched control group, and (4) to evaluate the accuracy of team physician predraft risk assessments to predict elbow reinjury in pitchers with a history of UCLR.

Study Design: Cohort study; Level of evidence, 3.

Methods: We analyzed pitchers from a single professional baseball team database who were drafted after UCLR from 2010 to 2013. A matched control group based on position and draft year was selected with the MLB database. The following pitcher characteristics were analyzed: age at the time of UCLR, time from UCLR to the MLB draft, pitching role (starter vs reliever), highest level of play attained, body mass index (BMI), throwing-side dominance, and predraft physician risk assessment. Physician assessments to predict risk for elbow reinjury were derived from operative and clinical history and evaluated for accuracy during the follow-up period. Pitcher characteristics were evaluated for correlation with successful AAA or MLB placement with a career duration of at least 3 years and as risk factors for elbow reinjury. The professional-level achievement and career duration of the UCLR cohort were compared with the matched cohort.

Results: A total of 88 pitchers matched the selection criteria and had at least 5 years of follow-up (range, 5-8 years). Pitcher age at the time of UCLR ($P = .55$), throwing-side dominance ($P = .41$), and BMI ($P = .86$) did not correlate with AAA- or MLB-level placement. Relief pitchers ($P = .03$) and pitchers with a longer time from surgery to final follow-up ($P = .02$) were more likely to reach the AAA or MLB level. Similarly, pitcher age at the time of UCLR ($P = .56$), throwing-side dominance ($P = .27$), and BMI ($P = .69$) did not correlate with a duration of play of at least 3 years. Relief pitchers ($P = .03$) and pitchers with a longer time from UCLR to the final follow-up ($P = .005$) were more likely to achieve at least 3 years of play. There was no difference in AAA or MLB placement between the UCLR and matched cohorts ($P = .22$). The UCLR cohort achieved a higher duration of play than the matched cohort ($P = .002$). Pitchers with a BMI >25 kg/m^2 had a lower risk of elbow reinjury versus players with a BMI ≤ 25 kg/m^2 ($P = .012$). Patient age at time of UCLR ($P = .92$), time from UCLR to the MLB draft ($P = .18$), pitching role ($P = .74$), and throwing-side dominance ($P = .77$) did not correlate with elbow reinjury. Physician risk assessment did not accurately predict reinjury ($P = .27$). Of the 88 patients, 4 (4.5%) required revision UCLR.

Conclusion: Pitcher age at the time of UCLR, throwing-side dominance, and BMI did not correlate with performance. Relief pitchers and players with a longer time from surgery to final follow-up were more likely to reach AAA and MLB levels and achieve at least a 3-year duration of play. Pitchers with a greater BMI had a lower risk of reinjury. After UCLR, pitchers were able to perform at least as well as the matched nonsurgical cohort. Physician risk assessment at the time of the draft was not accurate at predicting reinjury.

Keywords: ulnar collateral ligament reconstruction; Major League Baseball; Minor League Baseball; baseball draft; professional pitchers; Tommy John

The rate of medial ulnar collateral ligament (UCL) elbow injuries in young baseball pitchers is rising.[6] Accordingly, the rates of UCL reconstruction (UCLR) in amateur

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athletes have dramatically increased. Young pitchers aged 15 to 24 years have been forecasted as the demographic at highest risk for an escalating need for UCLR.[12] Despite reported rates of 79% to 91% for return to play to presurgical level of competition after UCLR, the analysis and risk assessment of an increasingly significant number of pitchers entering the Major League Baseball (MLB) draft after UCLR can be challenging for team physicians.[2,8,9]

Overall, there is a paucity of research evaluating pitchers entering the draft after UCLR with regard to the following: success in attaining the highest professional levels (AAA/MLB); pitcher characteristics, such as age at the time of index surgery, time from surgery to professional performance, pitching role (starter vs reliever), throwing-side dominance, and body mass index (BMI), and the relationship of these characteristics to successful performance and duration of play; and factors related to reinjury. Even less is known about the ability of team physicians to perform a risk assessment, or "grade" these players, and how their ratings correlate with their future performance. Two previous reports by Camp et al[4] and Wymore et al[15] comparing drafted players after UCLR with matched controls demonstrated conflicting results, with patients in the postsurgical group performing either similarly or even better than matched cohorts. These reports on drafted pitchers recommended longer follow-up, more pitchers in future studies, an evaluation of the accuracy of subjective team draft grades, and evaluation by pitching role.

Metrics associated with successful professional pitching performance have varied in studies. These have included analysis of performance outcomes, such as velocity, earned run average (ERA), walks and hits per inning pitched (WHIP), games started, and win/loss ratio, and outcome measures including the level of play attained and the duration of play.[4,15] Relevant studies have cited at least a 3-year mean career length and surgical survivorship after UCLR at the professional level.[3,10] In the present study, we evaluated a single team experience with the performance of a cohort of pitchers with a history of UCLR who were selected in the MLB draft; we compared them with a matched nonsurgical cohort with no known history of UCL injury as provided by the MLB. We sought to (1) define the characteristics in pitchers drafted after UCLR that were associated with success at obtaining the AAA and MLB professional levels with a career of at least 3 years, as well as risk for reinjury after surgery; (2) provide a comparison of the UCLR cohort with a matched nonsurgical control group; and (3) evaluate the ability of professional baseball team physicians to accurately assess pitchers drafted after UCLR for future risk. On the basis of our prior experience, we hypothesized that pitchers undergoing UCLR at a younger age, starting pitchers, pitchers with higher BMIs, and pitchers flagged as moderate and high risk by team physicians would be less successful and have a higher risk for reinjury. We also hypothesized, as concluded by Camp et al,[4] that the surgical cohort would be similarly successful to the matched nonsurgical cohort.

METHODS

After institutional review board, MLB, and Atlanta Braves Professional Baseball team approval, we analyzed the records of all pitchers who had undergone UCLR, had completed postoperative rehabilitation, had returned to their presurgical levels of competition, and were successfully drafted from 2010 to 2013. All players were completely deidentified prior to initiating data analysis. A control group was selected using the MLB database, matched by position and draft year, and included 421 pitchers drafted from 2010 to 2013 with no history of throwing elbow surgery. The following patient demographics were analyzed: age at the time of surgery, time from surgery to professional performance, pitching role (starter vs reliever), highest level of play attained (rookie, full season A, high A, AA, AAA, MLB), BMI, and throwing-side dominance.

Preparticipation physician risk assessments, with the goal of determining the likelihood of elbow reinjury, are performed and scored for each pitcher with a history of UCLR prior to entering spring training. Physician risk assessment scores are subjectively labeled low, moderate, and high and are subjectively based on the patient's operative and clinical history from all records attained by the Atlanta Braves. The risk assessments from 3 team physician orthopaedic surgeons are combined for an aggregate score for each draftee; all assessments during the study period were from the same 3 physicians. The aforementioned characteristics were evaluated statistically for correlation with successful pitching performance, defined as obtaining AAA and MLB professional levels and achieving a career duration of at least 3 years. We also evaluated pitcher characteristics and their correlation with risk for reinjury. Successful pitching parameters and injury rates for the predraft UCLR cohort were compared with those of the matched nonsurgical cohort. Subsequent elbow injuries were defined as those injuries of the operative elbow that presented after the player initiated professional play and resulted in at least 1 day out of play. The incidence of revision UCLR was also evaluated.

Statistical Analysis

Quantitative variables are expressed as means and standard deviations and compared with a 2-sample pooled *t* test.

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Ethical approval for this study was waived by Piedmont Healthcare Institutional Review Board.

Proportions for categorical variables were compared by a Pearson chi-square test. Accuracy of physician risk assessments was performed with a Mantel-Haenszel chi-square test. Two-sided *P* values are reported and flagged as statistically significant if ≤.05. Statistical analyses were carried out with SAS for Windows software (v 9.2; SAS Institute).

RESULTS

A total of 88 professional baseball players with a history of UCLR were drafted by the Atlanta Braves from 2010 through 2013. All players had at least 5 years of follow-up (range, 5-8 years). The mean age at the time of final follow-up was 24.5 ± 2.0 years, and the mean age at the time of UCLR prior to the MLB draft was 18.8 ± 1.6 years. The mean time from surgical treatment to final follow-up was 8.2 ± 1.2 years; 43% (38 of 88) of the players underwent surgery prior to the age of 18 years and 57% (50 of 88) at the age of 18 years or older. Mean BMI was 25.5 ± 2.0 kg/m^2, and 75% (66 of 88) of the players were right-handed and 25% (22 of 88) left-handed. Overall, 55% (48 of 88) of the players were starters, while 45% (40 of 88) were relief pitchers. The team physicians considered 42% (37 of 88) of the pitchers as having a low risk of reinjury, 49% (43 of 88) as moderate risk, and 9% (8 of 88) as high risk. In sum, 17% (15 of 88) attained AAA or MLB status, while 83% (73 of 88) attained a rookie, full season A, high A, or AA level of performance. Of the players in the surgical cohort, 73% (64 of 88) achieved a duration of play of at least 3 years, while 27% (24 of 88) did not. Finally, 26.1% (23 of 88) of pitchers in the surgical cohort sustained a subsequent elbow injury (Table 1).

Among pitchers in the surgical cohort, age at the time of surgery ($P = .55$), throwing-side dominance ($P = .41$), and BMI ($P = .86$) did not correlate with the level of performance reached at the professional level. Players with a longer time from surgery to final follow-up ($P = .02$) and relief pitchers ($P = .03$) were more likely to reach the AAA or MLB level. Similarly, patient age at the time of surgery ($P = .56$), throwing-side dominance ($P = .27$), and BMI ($P = .69$) did not correlate with a duration of play ≥3 years. Players with a longer time from surgery to final follow-up ($P < .005$) and relief pitchers ($P = .03$) were more likely to achieve a ≥3-year duration as a professional pitcher.

Across the total sample, 17% (15 of 88) of the professional pitchers drafted with a history of UCLR and 23% (97 of 421) of the matched nonsurgical cohort had reached the AAA or MLB level at final follow-up. There was no difference in achievement of performance at the AAA or MLB level between those players drafted with a history of UCLR and the matched nonsurgical cohort ($P = .22$). Overall, 73% (64 of 88) of the UCLR cohort and 56% (236 of 421) of the matched nonsurgical cohort achieved a minimum 3-year professional career at final follow-up. The surgical cohort achieved a significantly higher likelihood of 3-year duration of play than the matched nonsurgical cohort ($P = .002$). A total of 26.1% (23 of 88) of pitchers in the surgical cohort sustained a subsequent elbow injury, as compared with a 33.7% (142 of 421) elbow injury rate in the matched cohort, which was not statistically significant ($P = .15$) (Table 2).

Analysis of postdraft elbow injury after UCLR revealed that players with a BMI >25 kg/m^2 had a lower risk of

TABLE 1
Descriptive Characteristics of Pitchers With a History of UCLR Prior to the MLB Draft: 2010 to 2013[a]

Variable	n	%
Age at UCLR, y		
≤18	38	43.2
≥19	50	56.8
Risk score		
High	8	9.1
Moderate	43	48.8
Low	37	42.1
School		
HS/JC	16	18.2
4-year college	72	81.8
Position		
Relief	40	45.5
Starter	48	54.5
Handedness		
Right	66	75.0
Left	22	25.0
Duration of play ≥3 y		
Yes	64	72.7
No	24	27.3
Subsequent elbow injury		
Yes	23	26.1
No	65	73.9
Highest level		
MLB/AAA	15	17.0
A/AA/rookie	73	83.0
Draft year		
2010-2011	15	12.7
2011-2012	37	31.4
2012-2013	36	30.5

[a]HS, high school; JC, junior college; MLB, Major League Baseball; UCLR, ulnar collateral ligament reconstruction.

TABLE 2
Performance Metrics Between UCLR Cohort and Matched Nonsurgical Controls: 2010 to 2013[a]

Performance Metric	UCLR Cohort (n = 88)	Control Cohort (n = 421)	*P* Value
Highest level attained			
MLB/AAA	15 (17.0)	97 (23.0)	.22
Rookie, full season A, high A, AA	73 (83.0)	324 (77.0)	
Duration of play, y			
≥3	64 (72.7)	236 (56.1)	.002
<3	24 (27.3)	185 (43.9)	
Elbow injury during study period			
Yes	23 (26.1)	142 (33.7)	.15
No	65 (73.9)	279 (66.3)	

[a]Values are presented as n (%). MLB, Major League Baseball; UCLR, ulnar collateral ligament reconstruction.

sustaining a subsequent elbow injury versus players with a BMI $\leq$25 kg/m^2 (P = .012). Age at the time of surgery (P = .92), time from surgery to professional performance (P = .18), pitching role (P = .74), and throwing-side dominance (P = .77) did not correlate with the risk of a subsequent elbow injury. Physician risk assessment, when defining players as moderate or high risk, did not correlate with the risk of a subsequent elbow injury (P = .27). Of the 88 patients, 4 (4.5%) required revision UCLR.

DISCUSSION

As the rate of medial UCL injuries in young baseball pitchers increases, more players are entering the MLB draft after UCLR. There is a paucity of research evaluating pitchers entering the draft after UCLR with regard to the following: success in attaining the highest professional levels, pitcher characteristics and their relationship to successful performance and duration of play, and factors related to reinjury.

In our study, we found preliminary evidence that pitchers entering the draft after UCLR performed at least as well as a matched nonsurgical cohort. Specifically, the surgical cohort demonstrated no difference reaching the AAA or MLB level and actually achieved a significantly higher likelihood of playing as a professional pitcher for at least 3 years. These findings are similar to previously published data. In 2016, in a series of 38 pitchers evaluated after UCLR and compared with a control group, Wymore et al[15] demonstrated statistically similar performance metrics between the cohorts in terms of velocity, wins, ERA, WHIP, games started, innings pitched, wins, losses, strikeouts, and batters walked. In 2018, Camp et al[4] conducted a large matched cohort comparison of 345 pitchers after UCLR and demonstrated a statistically higher likelihood of advancement to the MLB level in the UCLR group. Camp et al[4] also found that the postsurgical cohort had a more rapid progression to successive levels of play (such as A, AA, AAA, or MLB). We believe that these data should be interpreted with caution, as there is already a public perception that UCLR may enhance performance.[1,7] The finding of similar or improved performance in the post-UCLR cohort can be explained by a superior level of talent and the benefits of an exhaustive rehabilitation program after surgery.

Physician risk assessments, as performed by our team orthopaedic surgeons at the time of spring training, were entirely subjective and based purely on our collective experience. Patients deemed high risk were more likely than those considered low or moderate risk to have sustained multiple prior injuries to the throwing elbow and/or shoulder or to have had pain or problems in the operative extremity after surgery, with no clear resolution in the provided clinical notes. Despite our hypothesis that high-risk pitchers would be less successful and have a higher risk for reinjury, our predictions were inaccurate. This highlights the need for further research directed at establishing an accurate, objective risk assessment tool to be used by MLB team physicians to evaluate postsurgical patients entering the draft.

We hypothesized that those pitchers who underwent surgery at a younger age would have a higher risk of dominant elbow injury than the age-matched cohort. Our work, with a minimum 5-year follow-up, revealed no effect of patient age at the time of surgery on performance outcomes or an increased risk of subsequent elbow injury. In fact, those pitchers with a longer time between surgery and final follow-up were more likely to reach MLB and achieve a 3-year duration of play. This finding conflicts with the work of Keller et al,[11] who, in a retrospective review of 29 professional pitchers in 2017, found a statistically higher likelihood of need for revision surgery when surgery was performed at an early age (mean, 22.96 years).

Although we did not find BMI to be associated with successful ability to reach the AAA or MLB level or a higher likelihood of playing for at least 3 years, analysis of post-draft elbow injury after UCLR revealed that players with a higher BMI (>25 kg/m^2) had a lower risk of subsequent elbow injury than players with a lower BMI ($\leq$25 kg/m^2). This is in contrast to previous findings in the literature. Chalmers et al,[5] in a retrospective study of 1327 professional pitchers, found that higher BMI significantly correlated with risk of need for UCLR. In 2018, Okoroha et al[14] found that increased BMI was a predictor of increased elbow torque, placing those pitchers at an increased risk for medial elbow injuries. In the same study however, the authors noted that an increasing size of a pitcher's arm protected against elbow torque. Similarly, in a wearable device study assessing pitcher characteristics leading to medial elbow torque, Makhni et al[13] found that smaller elbow circumference led to greater medial elbow torque while pitching. With the above results in mind, and given that our study noted BMI as a protective characteristic against elbow reinjury, we conclude that BMI is an overly simplistic measurement of weight distribution. Body mass would be more accurately described through extremity circumference measurements, as performed by Okoroha et al, to better characterize the quality of muscle mass and dynamic stabilizers of the elbow that provide increased surface area for load distribution while pitching. Our finding of a 4.5% revision rate after UCLR concurs well with the findings of Erickson et al[10] from 2014, in which those authors noted a 3.9% revision rate in a study of 179 professional pitchers after UCLR.

Our study has multiple limitations. This was a retrospective review of a single team experience with pitchers drafted after UCLR. The data collected are reliant on the accuracy of information placed in the database by medical professionals; however, we feel that the medical and recruiting personnel of the professional baseball team are leaders in their field and are well-trained and thorough. Draft grades admittedly rely on multiple subjective factors. There is inherent selection bias in that pitchers in this study were drafted after a successful return to sport and did not include those unable to return to play after surgery. We were further unable to include performance metrics used in other studies on surgical outcomes in pitchers, such as velocity, wins, ERA, WHIP, games started, innings

pitched, wins, losses, strikeouts, and batters walked, owing to the limitations of our database. However, our study also has several strengths. There is a paucity of data on this subject, and this is a relatively large review of 88 professional pitchers with use of a matched cohort. We present unique data, to our knowledge, not previously published on the effect of characteristics such as age at the time of surgery, time from surgery to MLB draft pitching role (starter vs reliever), and throwing-side dominance on UCLR outcomes after the MLB draft. We are also unaware of published data with results on the accuracy of preparticipation physician risk scores.

CONCLUSION

Pitcher age at the time of UCLR, throwing-side dominance, and BMI did not correlate with performance. Relief pitchers and players with a longer time from surgery to final follow-up were more likely to reach AAA and MLB levels and achieve at least a 3-year duration of play. Pitchers with a higher BMI had a lower risk of reinjury. Pitchers after UCLR were able to perform at least as well as the matched nonsurgical cohort. Physician risk assessment at the time of the draft was not accurate at predicting reinjury.

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