Should We Limit Innings Pitched After Ulnar Collateral Ligament Reconstruction in Major League Baseball Pitchers?

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Background: Ulnar collateral ligament reconstruction (UCLR) has become a common procedure among Major League Baseball (MLB) pitchers. It is unclear if a limit on innings pitched after UCLR should be instituted to prevent revision UCLR.

Hypothesis: Number of innings pitched and number of pitches thrown after UCLR will not affect whether a pitcher requires a revision UCLR.

Study Design: Descriptive laboratory study.

Methods: All MLB pitchers between 1974 and 2015 who pitched at least 1 full season after UCLR were included in this study. Pitch counts and innings pitched for the first full season after UCLR as well as total pitch count and total innings pitched were recorded. Pitch counts and innings pitched were compared among players who required revision UCLR and those who did not.

Results: Overall, 154 pitchers were included. Of these, 135 pitchers did not require revision UCLR while 19 underwent revision UCLR. No significant difference existed between pitchers who underwent revision UCLR and those who did not when comparing number of innings pitched in the season after UCLR (79.4 ± 46.7 vs 90.1 ± 58.6; $P = .9016$), number of pitches thrown in the season after UCLR (1233.2 ± 710.4 vs 1449.2 ± 904.1; $P = .7337$), number of innings pitched in the pitcher's career after UCLR (357.4 ± 312.0 vs 399.3 ± 446.4; $P = .6945$), and number of pitches thrown in the pitcher's career after UCLR (5632.7 ± 4583.9 vs 5674.7 ± 5755.4; $P = .4789$), respectively. Furthermore, no difference existed in revision rate between pitchers who pitched more or less than 180 innings in the first full season after UCLR ($P = .6678$).

Conclusion: The number of innings pitched and number of pitches thrown in the first full season as well as over a player's career after UCLR are not associated with an increased risk of a pitcher requiring revision UCLR.

Keywords: ulnar collateral ligament reconstruction (UCLR); Major League Baseball (MLB); revision; outcome; pitcher; Tommy John

Ulnar collateral ligament (UCL) tears have become common injuries among Major League Baseball (MLB) pitchers. The current treatment recommendation for elite-level pitchers with UCL tears who fail nonoperative treatment is a UCL reconstruction (UCLR).[9,13,15,21] This procedure has undergone several modifications since its initial description by Dr Frank Jobe but essentially involves reconstruction of the UCL with a tendon graft (allograft or autograft) fixed on both the medial epicondyle and sublime tubercle in one of a variety of ways.[6,12,14,22] Recent survey data from Conte et al[5] have shown that 25% of MLB pitchers surveyed had a history of a UCLR. Furthermore, with the recent increase in the number of primary UCLRs, the overall number of revision UCLRs has also increased (although the proportion of cases requiring revision each year has decreased).[8,18,24] Although the results after primary UCLR in MLB pitchers have been encouraging, with a greater than 80% return-to-sport (RTS) rate in MLB and a greater than 90% RTS rate in either the minor

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or major leagues, the results for revision UCLR are less predictable.[8,9,15,18]

Despite an increase in the overall number of revision UCLRs performed in MLB pitchers in recent years, risk factors for failure after primary UCLR have not been well elucidated.[15,18] There is speculation that limiting the number of innings pitched in a player's first full season back to MLB, as well as in his overall career, will decrease the player's risk for reinjury. Remarkably, postoperative protocols after UCLR differ among surgeons who care for professional baseball players, not only with regard to the early postoperative protection and mobilization of the surgical site but also in the pace and intensity of rehabilitation leading to return to sport. Some limit the number of innings pitched in a single season to 180 innings, while others have no limit on the number of innings pitched after UCLR.[4,8] No current data provide scientific support of one practice over the other.

The purpose of this study was to determine whether the number of innings pitched or number of pitches thrown in the first full season after UCLR as well as over the pitcher's MLB career affected the pitcher's need for a revision UCLR. We hypothesized that the number of innings pitched and number of pitches thrown in the first full season after UCLR as well as over the pitcher's career will have no significant effect on whether the pitcher developed elbow symptoms that led to revision UCLR.

METHODS

All MLB pitchers who underwent UCLR between 1974 and 2015 were evaluated. These players were identified through prior studies, MLB team websites, and publicly available Internet-based injury reports.[9] Player profiles, biographies, and press releases were cross-referenced with the MLB database (HITS) to ensure accuracy over the available time period. Numerous prior publications have used this method of data collection.[9,17-19] Inclusion criteria were male MLB pitchers (defined as having pitched in at least 1 MLB game before undergoing UCLR) who had pitched at least 1 full season after UCLR. Exclusion criteria were collegiate (NCAA [National Collegiate Athletic Association]) pitchers, position players (nonpitchers), pitchers who never pitched in MLB, pitchers who never returned to MLB after UCLR, and pitchers who did not pitch at least 1 full season (defined as pitching for at least 4 months in a season). Number of innings pitched could be found for every player, while number of pitches thrown could not be found for 1 player. The pitch count information from this player was excluded, but the number of innings pitched was included (Figure 1). Pitchers who were less than 20 months out from their index UCLR were excluded.

Players who returned to MLB and played in at least 1 full season after their UCLR were included in the statistical analysis. The number of innings pitched in the first full season after UCLR as well as the number of innings pitched in the player's entire career after UCLR was recorded. The number of pitches thrown in the first full season after UCLR as well as the number of pitches thrown in the player's entire career after UCLR was also recorded. This information was obtained from the Baseball-Reference .com website. Pitchers were separated into 2 groups. One group did not require a revision UCLR, while the other group did require a revision UCLR.

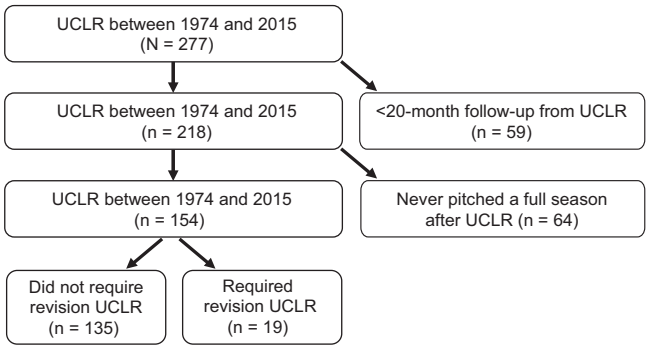

Figure 1. Flowchart of inclusion criteria for Major League Baseball (MLB) pitchers. UCLR, ulnar collateral ligament reconstruction.

Statistical Analysis

Descriptive statistics were determined and reported as mean ± SD for continuous variables and frequencies with percentages for categorical variables. Innings pitched the season after return from surgery, pitches the season after surgery, total innings pitched, and total pitches were evaluated with 1-sample Kolmogorov-Smirnov tests and found to be nonnormal in distribution ($P < .05$ in all cases). As a result, nonparametric Kruskal-Wallis tests were conducted for subsequent analyses involving these variables. For analysis of rate of UCLR revision surgery in starters versus nonstarters and those pitching more than 180 versus less than 180 innings in the season after surgery, Fisher exact test was used when at least one of the expected values of the contingency table was below 5, and chi-square test was used otherwise. $P < .05$ was considered significant in all analyses. Analyses were conducted using JMP Pro Version 11.0.0 (SAS Institute). A power analysis was not performed.

RESULTS

After implementation of the exclusion criteria, 154 pitchers were included. Of these, 135 pitchers did not require revision UCLR, while 19 underwent revision UCLR (12% of the UCLR group). Before UCLR and in the first season players participated in after UCLR, there was no change in the percentage of starters or relievers: 60 of the included pitchers were starters (39%), while 94 were either relievers or closers (61%).

No significant difference existed between pitchers who underwent revision UCLR and those who did not in the number of innings pitched ($P = .9016$) or pitches thrown ($P = .7337$) in the first full season after UCLR (Table 1). No significant difference existed in revision UCLR between

TABLE 1
Innings Pitched and Number of Pitches Thrown for MLB Pitchers Who Did and Did Not Require a Revision UCLR[a]

	Pitchers Who Did Not Require a Revision UCLR	Pitchers Who Underwent a Revision UCLR	*P* Value
First season after UCLR			
Innings pitched	90.15 ± 58.6	79.4 ± 46.7	.9016
Pitches thrown	1449.2 ± 904.1	1233.2 ± 710.4	.7337
Career after UCLR			
Innings pitched	399.3 ± 446.4	357.4 ± 312.0	.6945
Pitches thrown	5674.7 ± 5755.4	5632.7 ± 4583.9	.4789

[a]Data are reported as mean ± SD. No significant differences existed between groups. MLB, Major League Baseball; UCLR, ulnar collateral ligament reconstruction.

TABLE 2
Pitchers Who Pitched More/Less Than 180 Innings in Their First Season After UCLR Compared With Pitchers Who Did/Did Not Require Revision UCLR[a]

	Pitched >180 Innings in First Full Season	
Revision UCLR	Yes	No
Yes	0	19
No	16	119

[a]UCLR, ulnar collateral ligament reconstruction.

TABLE 3
Pitchers Who Pitched More/Less Than 150 Innings in Their First Season After UCLR Compared With Pitchers Who Did/Did Not Require Revision UCLR[a]

	Pitched >150 Innings in First Full Season	
Revision UCLR	Yes	No
Yes	0	19
No	17	118

[a]UCLR, ulnar collateral ligament reconstruction.

starters who pitched more than 180 innings in the first full season after UCLR and those who pitched fewer than 180 innings (P = .6955) (Table 2). Furthermore, no difference existed in revision rate between pitchers who pitched more or less than 180 innings in the first full season after UCLR (P = .6678). There was no difference in revision UCLR between starting pitchers and nonstarting pitchers (P = .839). Pitchers who underwent a revision UCLR pitched a mean of 5.2 ± 2.9 seasons after their index UCLR, while those who did not require a revision UCLR pitched a mean of 4.5 ± 2.9 seasons after their index UCLR. Contingency tables demonstrating the number of pitchers who required a revision based on having pitched more or less than 180 innings and 150 innings in their first season back after UCLR can be found in Tables 2 and 3.

DISCUSSION

No scientifically based guidelines currently exist regarding limitations on innings pitched and pitch counts after UCLR to prevent reinjury to the UCL. This study aimed to determine if a specific number of innings pitched after UCLR was associated with recurrent elbow symptoms that led to revision UCLR. A secondary aim was to provide recommendations to reduce the risk of revision UCLR if the data provided insight on a threshold of innings pitched or pitches thrown that was associated with revision UCLR. Our hypotheses were confirmed, as the number of innings pitched and number of pitches thrown both in the first full season after UCLR as well as the pitcher's overall career did not differ between MLB pitchers who underwent revision UCLR and those who did not require a revision.

Despite the increasing number of both primary and revision UCLR in MLB pitchers, the risk factors for recurrent elbow symptoms leading to revision UCLR are not well defined. Interestingly, although the overall number of UCLRs in MLB pitchers is increasing, the proportion of pitchers who undergo primary UCLR requiring a revision is decreasing.[24] Previous studies have concluded that risk factors for sustaining a UCL tear include glenohumeral internal rotation deficit, pitching for multiple teams, pitching while fatigued, pitching year round, pitching with higher velocity, overall pitch count, number of innings pitched, and others.[1-3,7,10,11,16,20] However, recent studies that have evaluated MLB pitchers who underwent revision UCLR have not defined risk factors for developing symptoms that lead to revision UCLR.[15,18,24] Wilson et al[24] found that pitching position (starter, reliever, closer), pitcher handedness, and age at the time of primary reconstruction did not play a role in whether the pitcher required a revision UCLR. Jones et al[15] evaluated 18 MLB pitchers who underwent revision UCLR and found the average time to RTS was 18.9 months and that relief pitchers returned earlier and performed better upon RTS than starting pitchers. Similarly, Marshall et al[18] evaluated a cohort of MLB pitchers who had undergone revision UCLR and compared these pitchers with a set of matched controls. These authors found that only 65.5% of pitchers who underwent revision UCLR were able to return to pitching in MLB, and pitchers who did return to MLB pitched significantly fewer seasons than control players.

This study indicates there is no association between the number of innings pitched and the number of pitches thrown during the first full year after UCLR and the future need for revision UCLR. Furthermore, the data do not show an association between limiting the number of innings pitched or pitches thrown during the first full year after UCLR and the subsequent length of the pitcher's career. The ability of a player to return to pitching is a combined decision between the player, surgeon, trainer, and coach and not based on clear scientific parameters. There are some surgeons who impose an inning limit, commonly between 150 and 180 innings, on MLB players after UCLR, while others have no such limit.[23] This study has found that the cause of revision UCLR does not appear to be related to the number of innings pitched or pitches thrown.

Limitations

Despite our attempts to locate every MLB pitcher who underwent UCLR and revision UCLR, as there is no central database of all the MLB pitchers who have undergone UCLR, it is possible that some pitchers were missed. No power analysis was performed as no study has looked at number of innings pitched or number of pitches thrown as a risk factor for revision UCLR, so an accurate power analysis was not possible. This may have introduced type II (β) error. As pitchers who were unable to return for a full season were excluded, this could have introduced an element of selection bias, although this was necessary to answer the clinical question that was posed. Furthermore, information regarding surgical technique and concomitant injuries/procedures was not reliably available, and these factors may have some effect on the results.

CONCLUSION

The number of innings pitched and number of pitches thrown in the first full season as well as over a player's career after UCLR do not lead to increased risk of revision UCLR.

REFERENCES

1. Anz AW, Bushnell BD, Griffin LP, Noonan TJ, Torry MR, Hawkins RJ. Correlation of torque and elbow injury in professional baseball pitchers. *Am J Sports Med*. 2010;38(7):1368-1374.
2. Bushnell BD, Anz AW, Noonan TJ, Torry MR, Hawkins RJ. Association of maximum pitch velocity and elbow injury in professional baseball pitchers. *Am J Sports Med*. 2010;38(4):728-732.
3. Byram IR, Bushnell BD, Dugger K, Charron K, Harrell FE Jr, Noonan TJ. Preseason shoulder strength measurements in professional baseball pitchers: identifying players at risk for injury. *Am J Sports Med*. 2010;38(7):1375-1382.
4. Cain EL Jr, Andrews JR, Dugas JR, et al. Outcome of ulnar collateral ligament reconstruction of the elbow in 1281 athletes: results in 743 athletes with minimum 2-year follow-up. *Am J Sports Med*. 2010;38(12):2426-2434.
5. Conte SA, Fleisig GS, Dines JS, et al. Prevalence of ulnar collateral ligament surgery in professional baseball players. *Am J Sports Med*. 2015;43(7):1764-1769.
6. Dines JS, ElAttrache NS, Conway JE, Smith W, Ahmad CS. Clinical outcomes of the DANE TJ technique to treat ulnar collateral ligament insufficiency of the elbow. *Am J Sports Med*. 2007;35(12):2039-2044.
7. Dines JS, Frank JB, Akerman M, Yocum LA. Glenohumeral internal rotation deficits in baseball players with ulnar collateral ligament insufficiency. *Am J Sports Med*. 2009;37(3):566-570.
8. Dines JS, Yocum LA, Frank JB, ElAttrache NS, Gambardella RA, Jobe FW. Revision surgery for failed elbow medial collateral ligament reconstruction. *Am J Sports Med*. 2008;36(6):1061-1065.
9. Erickson BJ, Gupta AK, Harris JD, et al. Rate of return to pitching and performance after Tommy John surgery in Major League Baseball pitchers. *Am J Sports Med*. 2013;42(3):536-543.
10. Erickson BJ, Harris J, Tetreault M, Bush-Joseph C, Cohen MS, Romeo AA. Is Tommy John surgery performed more frequently in Major League Baseball pitchers from warm weather areas? *Orthop J Sports Med*. 2014;2(10):2325967114553916.
11. Fleisig GS, Andrews JR, Cutter GR, et al. Risk of serious injury for young baseball pitchers: a 10-year prospective study. *Am J Sports Med*. 2011;39(2):253-257.
12. Hechtman KS, Zvijac JE, Wells ME, Botto-van Bemden A. Long-term results of ulnar collateral ligament reconstruction in throwing athletes based on a hybrid technique. *Am J Sports Med*. 2011;39(2):342-347.
13. Jiang JJ, Leland JM. Analysis of pitching velocity in major league baseball players before and after ulnar collateral ligament reconstruction. *Am J Sports Med*. 2014;42(4):880-885.
14. Jobe FW, Stark H, Lombardo SJ. Reconstruction of the ulnar collateral ligament in athletes. *J Bone Joint Surg Am*. 1986;68(8):1158-1163.
15. Jones KJ, Conte S, Patterson N, ElAttrache NS, Dines JS. Functional outcomes following revision ulnar collateral ligament reconstruction in Major League Baseball pitchers. *J Shoulder Elbow Surg*. 2013;22(5):642-646.
16. Lyman S, Fleisig GS, Andrews JR, Osinski ED. Effect of pitch type, pitch count, and pitching mechanics on risk of elbow and shoulder pain in youth baseball pitchers. *Am J Sports Med*. 2002;30(4):463-468.
17. Makhni EC, Lee RW, Morrow ZS, Gualtieri AP, Gorroochurn P, Ahmad CS. Performance, return to competition, and reinjury after Tommy John surgery in Major League Baseball pitchers: a review of 147 cases. *Am J Sports Med*. 2014;42(6):1323-1332.
18. Marshall NE, Keller RA, Lynch JR, Bey MJ, Moutzouros V. Pitching performance and longevity after revision ulnar collateral ligament reconstruction in Major League Baseball pitchers. *Am J Sports Med*. 2015;43(5):1051-1056.
19. Namdari S, Baldwin K, Anakwenze O, Park MJ, Huffman GR, Sennett BJ. Results and performance after microfracture in National Basketball Association athletes. *Am J Sports Med*. 2009;37(5):943-948.
20. Petty DH, Andrews JR, Fleisig GS, Cain EL. Ulnar collateral ligament reconstruction in high school baseball players: clinical results and injury risk factors. *Am J Sports Med*. 2004;32(5):1158-1164.
21. Rettig AC, Sherrill C, Snead DS, Mendler JC, Mieling P. Nonoperative treatment of ulnar collateral ligament injuries in throwing athletes. *Am J Sports Med*. 2001;29(1):15-17.
22. Rohrbough JT, Altchek DW, Hyman J, Williams RJ III, Botts JD. Medial collateral ligament reconstruction of the elbow using the docking technique. *Am J Sports Med*. 2002;30(4):541-548.
23. Wagner J. Stephen Strasburg: medical experts weigh in on innings limit. https://www.washingtonpost.com/sports/nationals/stephen-strasburg-medical-experts-weigh-in-on-innings-limit/2012/08/15/f2c0684e-e6e4-11e1-936a-b801f1abab19_story.html. Accessed September 13, 2015.
24. Wilson AT, Pidgeon TS, Morrell NT, DaSilva MF. Trends in revision elbow ulnar collateral ligament reconstruction in professional baseball pitchers. *J Hand Surg Am*. 2015;40(11):2249-2254.