

Original Article

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Ulnar collateral ligament repair in professional baseball players

Ajith Malige, Carlos Uquillas

Kerlan-Jobe Orthopaedic Clinic, Los Angeles, CA, USA

Background: While initial reports of surgical repair are promising, literature detailing post-repair outcomes is lacking. This study explores the effectiveness of ulnar collateral ligament (UCL) repair in returning professional baseball players to their pre-injury level of play. Professional baseball players undergoing UCL repair will have successful outcomes and high return to sport rates after surgery.

Methods: From 2016 to 2021, publicly available databases were utilized to search for professional baseball players who underwent UCL repair. Players were included if they underwent primary UCL repair with an internal brace. Players were excluded if they underwent revision UCL repair, UCL reconstruction, or were amateur baseball players.

Results: Of the 11 pitchers that underwent UCL repair, MiLB pitchers returned to sport at an average of 17.5 months. MiLB pitchers had similar ERA, games played, innings pitched, and walks plus hits per inning pitched (WHIP) before and after surgery. Four MLB pitchers (80%) returned to sport at 9.55 months. MLB pitchers had fewer games played and innings pitched but similar ERA and WHIP in after versus before surgery. Pitch velocity and spin rates after surgery varied based on pitch type. The 7 positional players who underwent UCL repair showed no differences in batting or fielding performances before versus after surgery.

Conclusions: UCL repair can successfully return both pitchers and positional players at both the MiLB and MLB level back to play at pre-injury levels. Repair can be considered as an option in the right type of injury for players hoping to maximize performance after surgery with minimal recovery time.

Level of evidence: IV.

Keywords: Ulnar; Collateral; Ligament; Repair; Elbow; Pitcher; Baseball

INTRODUCTION

Ulnar collateral ligament (UCL) injuries of the elbow can be career-altering for athletes at all levels. First described in javelin throwers by Willie Waris in 1946 [1], UCL tears have recently achieved more attention due to an increased incidence in baseball players. An increase in games played and an increase in throwing velocity, among other risk factors, have increased the rate of UCL injuries and the need for surgical intervention at all levels in recent years [2-7].

Initial UCL repair reports demonstrated poor results [8,9]. Therefore, UCL reconstruction became the first-line surgical

treatment for these injuries. First performed in 1974 and first described by Frank Jobe in 1986 [10], UCL repair has been modified on multiple occasions over time with the goals of decreasing ulnar nerve symptoms, decreasing graft re-rupture rates, maximizing positive outcomes, and returning the injured players to their sports [11]. While most modifications have achieved high return to sport rates [12-14], the main concern with UCL reconstruction is the long recovery period required before return to play. The average 12- to 16-month rehabilitation period after a UCL reconstruction results in considerable missed playing time that can extend up to two seasons.

To shorten the recovery process while still achieving high re-

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Correspondence to: Ajith Malige

Kerlan-Jobe Orthopaedic Clinic, 6801 Park Terrace, Los Angeles, CA 90045, USA

Tel: +1-408-406-6595, E-mail: Ajith.malige@gmail.com, ORCID: <https://orcid.org/0000-0002-3984-4804>

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turn to sport rates, UCL repair has been explored as a viable alternative surgical option. Indicated in patients with UCL avulsion tears and healthy ligament quality, recent advances in repair technique, specifically repair augmentation with an internal brace [15], have led to significantly better outcomes than those of initial repair reports [16-18]. Because of this, UCL repair is now considered to be a viable surgical treatment option for professional baseball players with UCL injuries. However, while recent reports of positive surgical repair outcomes are promising, the number of these reports is lacking. In this study, we sought to test the hypothesis that UCL repair is effective in returning professional baseball players to their pre-injury level of play. We tested the hypothesis by comparing advanced metrics before and after surgery with the goal of elucidating the effectiveness of UCL repair in returning professional baseball players to their pre-injury levels of play.

METHODS

Approval for this study was obtained from the Institutional Review Board of Cedars Sinai (No. STUDY00002458). This study utilized a database with all identified patients; therefore, written informed consent was not required. Publicly available websites and resources were utilized to search for data on professional minor league baseball (MiLB) and major league baseball (MLB) players who underwent UCL repair from 2016 to 2021. Active MiLB and MLB players undergoing primary UCL repair with an internal brace were included, regardless of position played. Amateur players or those undergoing revision UCL repair or UCL reconstruction were excluded. Access to Statcast's advanced metric outcomes, specifically those for spin rate, predicated our study time frame choice, 2016 to 2021. These data were not available before 2015.

Data were collected from Statcast (<https://baseballsavant.mlb.com/>), Fangraph (<https://www.fangraphs.com/>) and Baseball Reference (<https://www.baseball-reference.com/>). For each player, demographic information was acquired. This information included date of birth, level of play, handedness, position played, date of surgery, and return to sport (RTS) at any level of playing. For pitchers, data collected included win-loss percentage, games played, innings pitched, walks plus hits per inning pitched (WHIP), exit velocity, pitch type breakdown, pitch type velocity, and pitch type spin rate. For positional players, batting and fielding data were collected. The batting data included number of at-bats, batting average, on-base percentage, slugging percentage, barrel percentage, exit velocity, and "sweet spot" attainment. Fielding data accrued included errors, fielding percentage, outs

above average, arm strength, and catch percentage. Demographics were analyzed using descriptive statistics. Post-injury performance was compared to pre-injury combined performance using Mann-Whitney U-tests (IBM SPSS version 23 Statistics for Windows, IBM Corp.). For all analyses, statistical significance was set at $P < 0.05$.

RESULTS

Pitchers

Data from 11 pitchers, six MiLB (54.5%) and five MLB (45.5%) pitchers, who underwent primary UCL repair between 2016 and 2021 were included in this study. MiLB pitchers were younger at the time of surgical repair than MLB pitchers (23.9 years vs. 31.1 years, $P = 0.01$). Most of these pitchers were relief pitchers, and all 11 pitchers were right-handed (Table 1). The six MiLB players returned to baseball at an average of 17.5 months (Fig. 1). All six remained in MiLB after their surgery except for one who pitched in a few MLB games in the 3 years after his return. None of the pitchers have needed revision surgery thus far. We averaged the pitchers' statistics for the 2 years prior to the surgery and compared the results to their performance in their first year post-UCL surgery. MiLB pitchers had similar ERAs, numbers of games played and innings pitched, and WHIP ratios before and after surgery (Table 2).

Four of the five MLB pitchers (80%) returned to the sport. One pitcher returned to the majors, one spent his first season alternating between the major and minor leagues, and two returned to the minor leagues. Of the two who returned to the minor leagues,

Table 1. Demographic information of professional baseball pitchers undergoing primary UCL repair

Variable	Minor league pitcher (MiLB)	Major league pitcher (MLB)	P-value
Age (yr)	23.9 ± 4.6	31.1 ± 2.1	0.01 ^{a),*}
Role			0.54 ^{b)}
Starter	3 (50.0)	1 (20.0)	
Reliever	3 (50.0)	4 (80.0)	
Side of surgery			1.00 ^{b)}
Right	6 (100.0)	5 (100.0)	
Left	0	0	
Total	6 (54.5)	5 (45.5)	-

Values are presented as mean ± standard deviation or number (%). All percentages represented as proportion of total pitchers in their respective leagues.

UCL: ulnar collateral ligament, MiLB: minor league baseball, MLB: major league baseball.

^{a)}Mann-Whitney U-test; ^{b)}Fisher's exact testing.

*Statistically significant at $P < 0.05$.

one returned less than a year ago; the other retired after one season in the minors. The fifth pitcher underwent repair surgery in September 2021 and has not yet returned to pitching. This player's recovery period has been long enough for him to be included in this study. One of these pitchers (20%) required revision surgery, a Tommy John reconstructive surgery, after re-tearing his UCL in his first return season. MLB pitchers' recovery periods were similar to those of MiLB pitchers, 9.55 months and 17.5 months, respectively ($P=0.24$) (Fig. 1).

MLB pitchers had fewer games played and innings pitched in their first return season after UCL repair compared to their average over the 2 years before their injury. This was not consistent with the data from MiLB pitchers who returned fully to their pre-surgery activity levels. The MLB pitchers' ERAs and WHIPs were similar to pre-surgery data (Table 2). When comparing performance pre- and post-injury year, pitchers had higher four-seam and split finger fastball, changeup, curveball, sinker, and slider velocities the year of (or before) UCL injury and repair. Exit and cutter speeds were also lower compared to the prior year; and four-seam and split finger fastball, changeup, and sinker spin rates were higher during that period. Sinker velocity including lower cutter, curveball, and slider speeds in miles per

hour (MPH) were similarly higher.

Advanced metrics data before and after repair were available for two pitchers. After surgery, these two, both MLB pitchers, relied on their four-seam fastball more often than before surgery. Other changes in pitch breakdown varied between pitchers and are shown in Fig. 2. While both were able to regain their pre-injury exit velocity and slider MPH, only one was able to regain his curveball MPH. Neither regained their four-seam fastball, cutter, changeup, or sinker MPH (Fig. 3). Of the two players with spin rate (revolutions per minute) data available for review before and after UCL repair, both achieved their pre-injury curveball spin rates. One achieved pre-injury spin rate levels for the four-seam fastball, cutter, and slider; neither achieved pre-injury levels for their changeup or sinker (Fig. 4).

Positional Players

Overall, seven positional players underwent UCL repair from 2016 to 2021 (Table 3). Six players (83.3%) were in the major leagues; one (16.7%) was in the minor leagues. Three, two first basemen and one third baseman, were infielders and four were outfielders. Age at the time of surgery was not significantly different between the MiLB player (30.5 years old) and the six major leaguers (mean, 31.1 years). Three positional players (42.9%) underwent UCL repair on their right elbows; four (57.1%) underwent the procedure on their left elbows. These MLB players returned to play at 10.49 months, similar to the 9.55 months required for MLB pitchers to return to pitching at any level ($P=0.89$). The four MLB players (57.1%) that successfully returned to the major leagues returned at an average of 7.48 months. None have needed revision surgery.

Overall, there were no differences in pre-injury and post-UCL repair batting performances in our seven positional players (Table 4). Two players underwent UCL repair to their lead batting elbow, four underwent repair to their back elbow, and one was a switch-hitter. Batting performance difference before and after surgery was unaffected by lead versus back elbow surgery. These players also had no difference in their fielding metrics after sur-

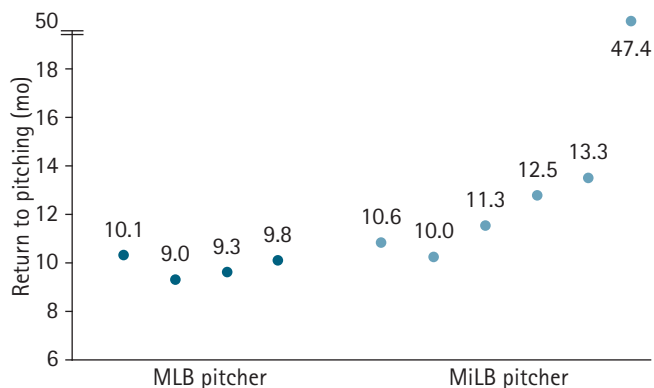


Fig. 1. Return to pitching time. Return to pitching (at any level) for major league baseball (MLB) and minor league baseball (MiLB) pitchers.

Table 2. Outcomes before and after UCL repair in MiLB and MLB pitchers

Time period	ERA		Games played		Innings pitched		WHIP	
	MiLB	MLB	MiLB	MLB	MiLB	MLB	MiLB	MLB
Pre-injury	4.45	3.55	23.33	33.63	49.05	34.74	1.39	1.23
Post-injury	7.78	6.65	27.17	7.00	39.08	8.10	1.91	1.50
P-value	0.38	0.06	0.47	0.04*	0.58	0.01*	0.38	0.40

UCL: ulnar collateral ligament, MiLB: minor league baseball, MLB: major league baseball, ERA: earned run average, WHIP: walks plus hits per inning pitched.

*Statistically significant at $P < 0.05$.

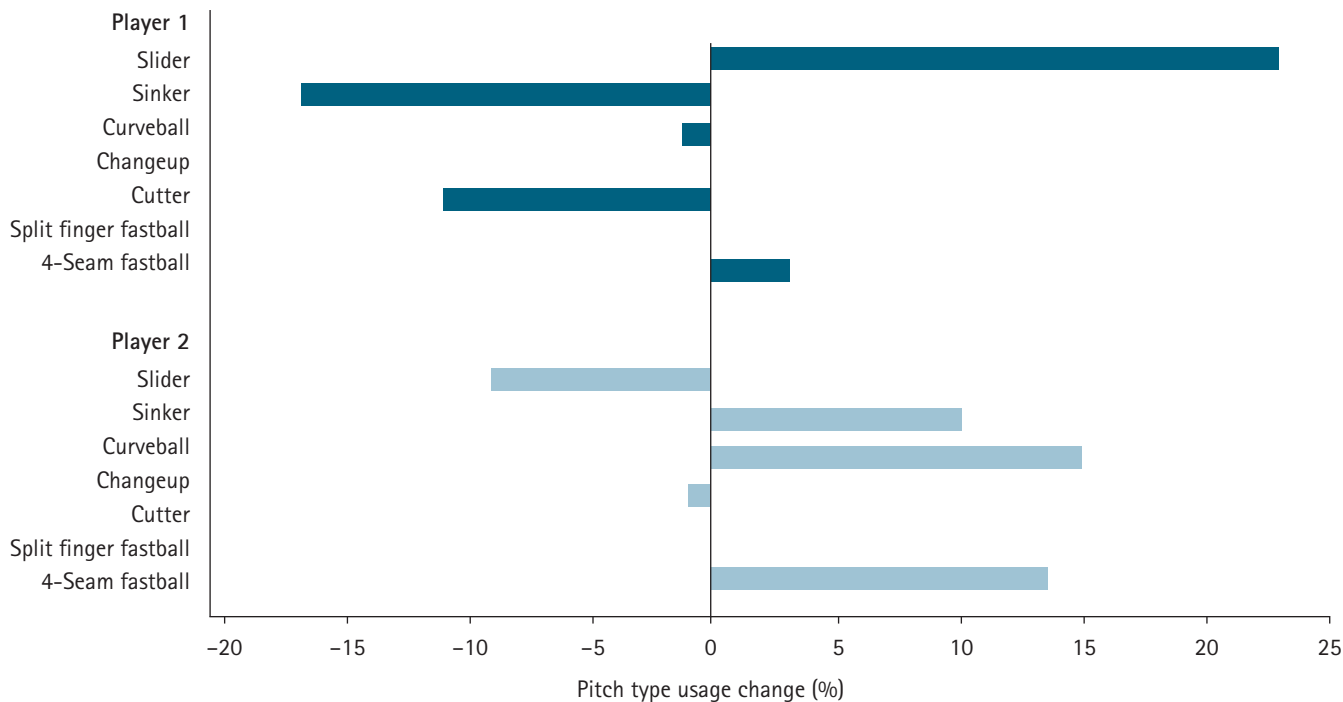


Fig. 2. Pitch type frequency change after ulnar collateral ligament (UCL) repair. Positive changes denote higher usage of a pitch type after UCL repair compared to before surgery. Negative changes denote lower usage of a pitch type after UCL repair compared to before surgery. All breakdowns were obtained from StatCast.

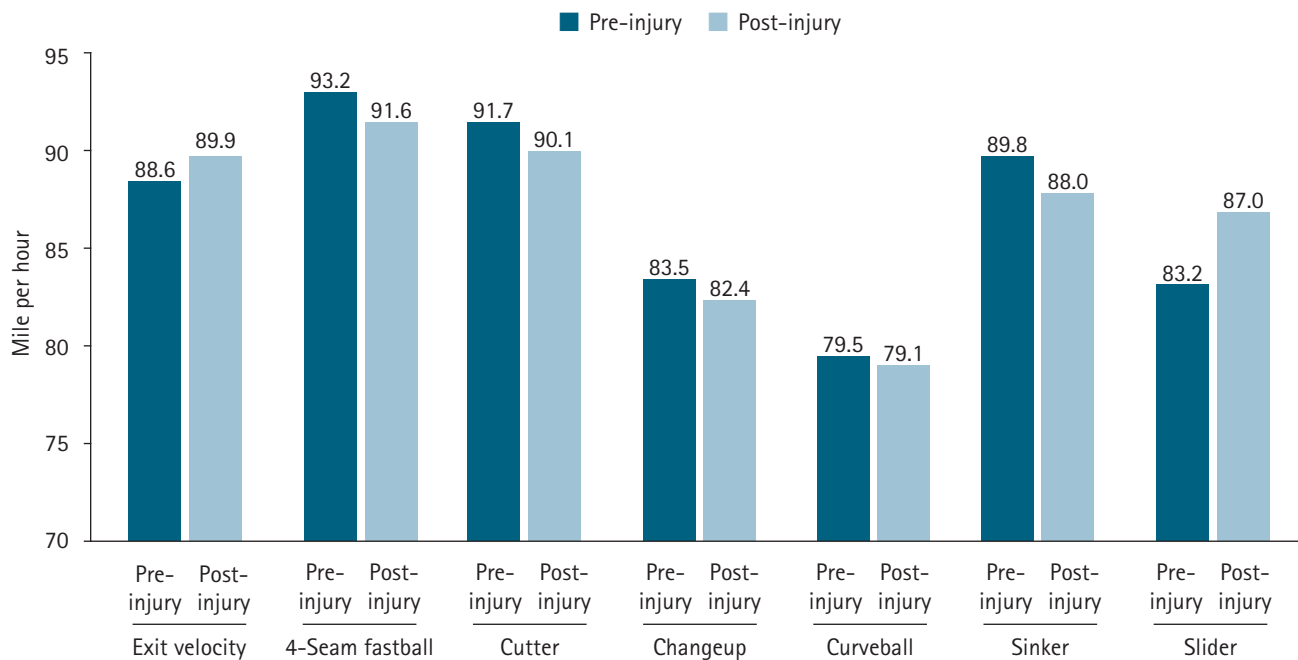


Fig. 3. Pitch speed before and after ulnar collateral ligament repair. All speeds were obtained from StatCast.

gery compared to the 2 years before surgery (Table 4). Three of these players underwent repair to the UCLs of their catching arms, and the other four had their throwing arms repaired. Fur-

ther sub-group comparison of these two cohorts did not find a difference in any fielding performance metrics compared to baseline levels. Arm strength and catch percentage were the most in-

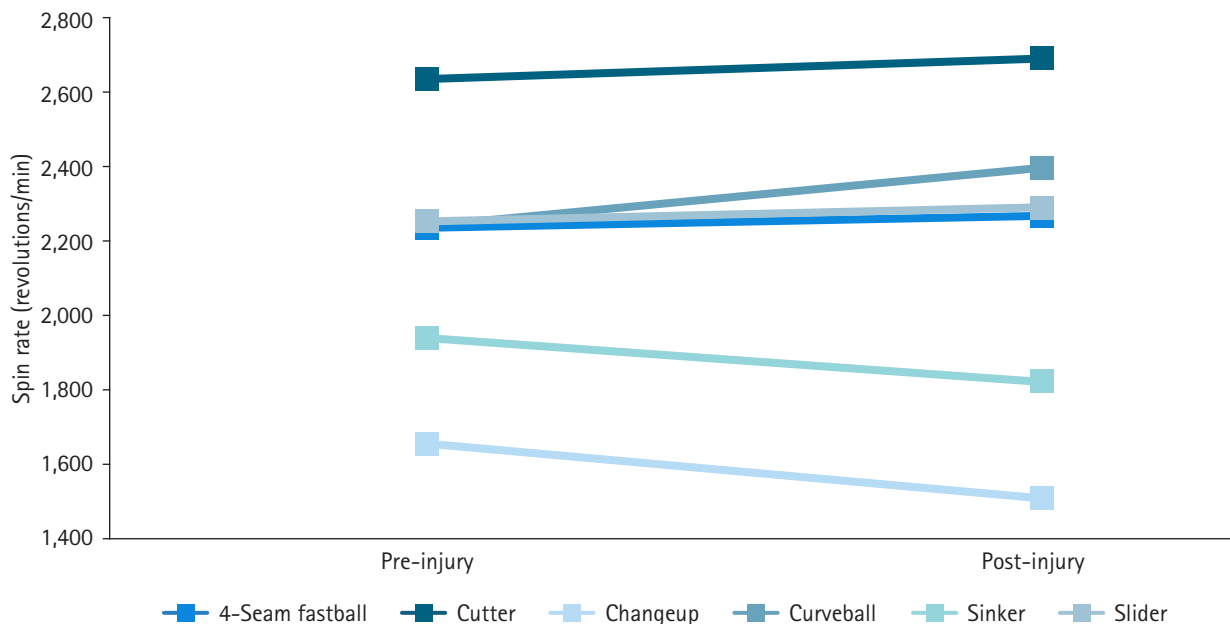


Fig. 4. Spin rate before and after ulnar collateral ligament (UCL) repair. All rates were obtained from StatCast.

Table 3. Demographic information of professional baseball positional players undergoing primary UCL repair

Variable	MiLB	MLB	P-value
Average age (yr)	30.5 ± 3.29	31.1 ± 2.14	NA
Position			1.00 ^{a)}
Infield	0	3 (50.0)	
Outfield	1 (100)	3 (50.0)	
Side of surgery			1.00 ^{a)}
Right	0	3 (50.0)	
Left	1 (100)	3 (50.0)	
Total	1 (16.7)	6 (83.3)	7 (100)

Values are presented as mean ± standard deviation or number (%). All percentages represented as proportion of total players in their respective league.

UCL: ulnar collateral ligament, MiLB: minor league baseball, MLB: major league baseball.

^{a)}Fisher’s exact testing (for role and handedness) was used to calculate statistical differences. No testing was done to compare age since there was only one MiLB positional player.

interesting variables to consider based on injury laterality.

DISCUSSION

Treatment regimens for UCL injuries are an area of heightened recent interest, not only due to the increased incidence of these injuries but also because of the surgical treatment improvements made and the effect of these surgical treatments on players’ careers. UCL repair has garnered particular attention due to the

potential for a shorter recovery period with high RTS rates [19]. Since 2015, Statcast has allowed for more precise analysis of advanced MLB player metrics. While not available for minor league players at this time, these statistics allow us to test new hypotheses related to UCL repair and post-surgical quality of play of MLB players. The main finding of our study is that professional pitchers undergoing UCL repair can RTS more quickly than those undergoing UCL reconstruction.

Despite common belief, undergoing Tommy John UCL reconstruction surgery does not improve performance compared to pre-injury levels [20]. The myth may have found basis in the declining performance sometimes experienced prior to debilitating injury. This is the reason we chose to average pre-injury performance over 2 years. For our limited sample, the pitchers improved in some performance aspects and declined in others, suggesting similar overall performance in the pre-injury years. We also chose to average performance in the 2 years before surgical intervention to account for mid-season injuries in addition to accounting for decline in performance secondary to a failing, but functional, UCL. We chose the first postoperative year for post-operative performance analysis to highlight immediate surgical results. However, merit could also have been gained in assessing longer-term performance effects.

Our finding that MiLB pitchers undergo UCL repair at a younger age than MLB pitchers has at least two possible explanations [5]. First, pitchers are usually younger in the minor leagues; the minor leagues are generally a learning ground for future MLB

Table 4. Batting and fielding performance before and after UCL repair

Variable	Pre-injury performance	Post-UCL repair performance	P-value
Batting			
At-bats	173.79 ± 110.73	170.57 ± 162.32	0.96
Batting average	0.21 ± 0.06	0.18 ± 0.09	0.42
OBP	0.29 ± 0.09	0.24 ± 0.11	0.41
Slugging (%)	0.35 ± 0.12	0.30 ± 0.16	0.55
Barrel (%)	7.41 ± 4.95	9.83 ± 5.40	0.52
Exit velocity	87.64 ± 4.64	88.70 ± 2.13	0.67
Sweet spot (%)	34.03 ± 2.59	33.30 ± 5.59	0.82
Fielding			
Errors	4.07 ± 3.38	1.14 ± 1.57	0.07
Fielding (%)	0.99 ± 0.01	0.83 ± 0.40	0.37
OAA	-0.75 ± 2.60	1.00 ± 2.94	0.41
Arm strength	81.64 ± 9.72	83.20 ± 7.97	0.81
Catch (%)	90.67 ± 2.89	87.33 ± 4.73	0.37

Values are presented as mean ± standard deviation. Advanced metrics of positional players' batting and field performance before and after surgery. All breakdowns were obtained from StatCast.

UCL: ulnar collateral ligament, OBP: on-base percentage; OAA: outs above average.

players. The second explanation is that UCL injury in younger MiLB pitchers prevents their development into MLB pitchers. This second explanation suggests that MLB pitchers are generally major injury-free during their professional maturation process.

Comparing our RTS times to those after UCL reconstruction is challenging due to the heterogeneity of competition levels and surgeon rehabilitation protocols in the relevant studies [21]. Camp et al. [5] noted that positional players RTS faster, but not at a higher rate, than pitchers after UCL reconstruction. We observed similar RTS rates at any level for MLB pitchers and positional players, a deviation from Camp et al.'s results [5]. While MiLB players took more time to RTS in our study, our RTS times for MLB pitchers were shorter than those in Gibson et al.'s UCL reconstruction study [22], 18.5 months. In addition, our RTS times for MLB position players were consistent with those reported for Jack et al.'s MLB position players [23], 336.9 days. Finally, both pitchers and positional players in our report had high RTS rates at any level, pointing to the success of UCL repair in returning baseball athletes to the sport. Some factors that may influence the longer time for RTS of MiLB players are decreased rehabilitation resources, decreased return opportunities, and presence of more extensive elbow pathology that may have limited their potential for advancement to the major leagues.

In our study, all six MiLB pitchers (100%) and one (20.0%) MLB pitcher returned to the sport at their pre-surgical competitive level of play. We anticipate that the MLB RTS rate will improve over time. This highlights the need to counsel pitchers not only on the RTS time but also the time required for return to

pre-injury performance level. The lack of a statistically significant difference in RTS time between MiLB and MLB pitchers is consistent with Camp et al.'s study findings [5]. However, our data need to be interpreted with caution; the 8-month difference in RTS time we noted may have reached statistical significance with a larger sample size. Outcome differences between relief and starting pitchers would have been interesting to compare given the difference in pitch counts and elbow demands between the roles. Limited sample sizes of relief and starting pitchers precluded us from performing this assessment. In this study, 57.1% of MLB positional players returned to the sport at their pre-injury level of competition, a rate higher than the 20% of MLB pitchers. In Camp et al.'s study [5], positional players returned to the sport at a lower rate than pitchers.

The MLB hurlers in this study pitched in significantly fewer games and innings after surgery compared to the 2 years before surgery, but their ERAs and WHIPs were comparable over the time frame. We believe that the differences in games and innings pitched would become insignificant in a larger case series and would, therefore, bring our findings in line with Gibson et al.'s UCL reconstructive surgery results [22]. Our data also show no major differences in pitch type breakdown, pitch speed, or spin rate before and after UCL repair. These data are consistent with those for UCL reconstruction [24]. This emphasizes the relevance of Fleisig et al.'s report on variations in throwing mechanics, e.g., elbow extension, elbow velocity, and shoulder internal rotation, after UCL repair [25]. A study involving more pitchers is required to draw more definitive conclusions, but our results

suggest that those pitchers undergoing UCL repair possess an ability to return to a pre-injury level of performance after UCL repair. This also suggests that these pitchers either overcome biomechanical changes and return to pre-injury biomechanics or that these differences do not correlate with changes in the performance metrics we measured. Similarities in post-surgery performance compared to pre-injury levels were demonstrated in both the batting and fielding metrics of our study's positional players. Future studies are required to compare performance outcomes after UCL repair to those after UCL reconstruction. These data may then compliment the many studies noting biomechanical result similarities between the two procedures [26-28].

The limitations of this study are important to note. The most significant limitation is that the indications for each player's requirement for UCL repair or reconstruction cannot be confirmed. Pre-operative symptoms and injury details, including chronicity, severity, and concomitant pathology, were not available for review. Therefore, the repair and subsequent postoperative performance might be more of a reflection of clinical decision-making than the effectiveness of UCL repair. The surgical technique used for each UCL repair was not available for review. The multiple available techniques for repair, including the use of anchors and internal braces or the exclusive use of sutures can introduce bias into the results. Limited numbers of cases in our cohort make many comparisons impossible, including those between MiLB and MLB players as well as between pitchers and positional players. Furthermore, the minor league 2020 season was cancelled due to the coronavirus pandemic, possibly affecting both return to play and possibly post-repair performance levels. Our outcome metrics analysis for players who participated in both the major and minor leagues may not have been completely satisfactory. The competition level differences suggest that metrics values should not just be averaged together in those cases. We attempted to minimize the confounding effects of these situations by only using the statistics from the league in which the player participated the most. Finally, the small sample size of players that have undergone UCL repair is a major limitation to the strength of our advanced metrics results. As more case results become available, future studies will experience improved statistical power; and stratification of results by demographic factors will be possible.

CONCLUSIONS

UCL repair can successfully restore performance of pitchers and positional players to pre-injury levels. Repair may be a feasible alternative to UCL reconstruction in a subset of UCL injuries

and may provide a mechanism for return to maximal performance with minimal post-surgical recovery time.

NOTES

ORCID

Ajith Malige <https://orcid.org/0000-0002-3984-4804>

Carlos Uquillas <https://orcid.org/0000-0002-3915-1282>

Author contributions

Conceptualization: AM, CU. Data curation: AM. Formal analysis: AM. Investigation: AM, CU. Methodology: AM. Project administration: AM, CU. Resources: AM. Software: AM. Supervision: CU. Validation: AM, CU. Visualization: AM, CU. Writing – original draft: AM. Writing – review & editing: AM, CU.

Conflict of interest

CU is part of the Arthrex Speakers Bureau. No other potential conflicts of interest relevant to this article were reported.

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Data availability

Contact the corresponding author for data availability.

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