Return to Performance Following UCL Surgery in Major League Baseball Pitchers

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INTRODUCTION:

The recent development of advanced analytics and pitch-tracking analysis has been widely embraced throughout Major League Baseball (MLB), driving player development and personnel decisions over the past decade. While return to play is important for players and teams, return to performance following UCL surgery using several advanced metrics has not been studied in MLB pitchers.

METHODS:

We performed a retrospective return to play analysis on 119 MLB pitchers who underwent primary UCL reconstruction or repair from April 2018 to November 2023 and reported return to play and performance rates at one, two, and three seasons post-operatively. Advanced analytic and pitch-tracking metrics used commonly in MLB player evaluation were then collected for 54 total MLB pitchers from public web sources sponsored by MLB and used in previous studies. Return to performance analysis consisted of paired t-tests comparing pre- to post-operative metrics. The percentage of pitchers who returned to their pre-injury performance in each season after injury was also recorded. Return to full performance was defined as returning to all pre-operative metrics combined except for Stuff+, Location+, and Pitching+ given limited sample size of these metrics. Binary logistic regression evaluated for predictive factors associated with return to fWAR and full performance at 3-seasons.

RESULTS:

Mean age was 26.8 ± 3.6 seasons, 74% of included pitchers were right-handed, and 42.6% were starting pitchers. Only 4% returned to play at 1-year post-operatively, 79% at 2-seasons, and 99% at 3-seasons with a mean of 558 ± 159 days. There was a significant decrease in cumulative statistics such as innings pitched, pitch count, and fWAR in pre-injury season one (T1) compared to post-operative season one (M1) and two (M2) ($p < 0.001$), however rate-based ERA metrics such as xFIP and SIERA were similar. At 2-seasons post-operatively, pitchers maintained their Stuff+ but showed worse Location+ and Pitching+ ($p < 0.01$). At 3-seasons post-operatively, pitchers returned to performance comparable to their pre-injury form in pitch count (63% of players successfully returned), xFIP (61%), fWAR (53%), velocity (78%), fastball velocity (77%), horizontal movement (83%), vertical movement (72%), Stuff+ (73%), Location+ (89%), and Pitching+ (78%). Only 3%, 21%, and 32% of pitchers returned to full performance by 1-, 2- and 3-seasons post-operatively, respectively. Binary logistic regression did not identify any pre-operative factors associated with return to fWAR and full performance at 3-seasons.

DISCUSSION AND CONCLUSION:

Only 3%, 21%, and 32% of pitchers returned to full performance by 1-, 2- and 3-seasons post-operatively. While the majority of pitchers can regain their previous form in most important pitch-tracking metrics, the majority of pitchers did not return to performance in all metrics. During the first season after injury, no pitch-tracking metric had more than 39% of pitchers return to performance while at 3-seasons each metric had a majority of players return to performance, suggesting that despite returning to play pitchers still need time to recover performance. Only 53% of pitchers returned to their pre-injury fWAR 3-seasons after surgery, suggesting that only half of pitchers provide the same value to teams despite presumably being fully recovered. 4% returned to play at 1-year post-operatively, 79% at 2-years, and 99% at 3-years at a mean of 558 ± 159 days following UCL surgery from April 2018 to November 2023. Altogether, we believe this study better informs MLB players and teams about expectations regarding return to play and performance following UCL surgery.

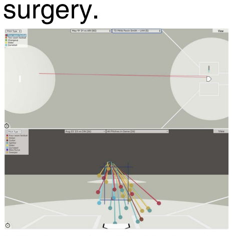

Figure 1: Release point, approach angle, and movement pitch-tracking data. These metrics are measured from the catcher's point of view. Horizontal and vertical release point are measured as the distance between the point in which a pitcher releases the ball relative to home plate. Horizontal and vertical movement are the amount a pitch moves from the time a pitcher releases the ball to the moment it crosses home plate. Vertical approach angle (VAA) describes the angle from which a pitcher releases the ball to when it crosses home plate vertically, while (HAA) captures the same horizontally. Release extension quantifies how close a pitcher's release point is to home plate. Image obtained from Baseball Savant at www.baseballsavant.mlb.com

Season		Innings pitched	fWAR	xFIP	SIERA	Stuff+	Pitching+	Location+
*Pre T1	Mean ± sd	86.13 ± 59.70	1.57 ± 1.68	4.29 ± 1.19	4.19 ± 1.12	103.73 ± 16.20	101.98 ± 5.54	100.86 ± 4.20
Post M1	Mean ± sd	26.11 ± 30.20	0.35 ± 0.59	4.27 ± 1.20	4.04 ± 1.21	101.78 ± 15.40	100.76 ± 6.65	99.62 ± 6.00
	p-value	**< .01**	**< .01**	.83	.85	.56	.34	.24
Post M2	Mean ± sd	58.00 ± 49.89	0.82 ± 1.13	4.22 ± 0.85	4.08 ± 0.84	103.34 ± 13.23	98.33 ± 6.30	97.82 ± 4.55
	p-value	**< .01**	**<.01**	.85	.77	.90	**<.01**	**<.01**

Table 1: Pre- and Postoperative Advanced Analytic Performance Data following UCL Injury. fWAR = Fangraphs Wins Above Replacement, M = post-operative year, SIERA = Skill-Interactive Earned Run Average, sd = standard deviation, T = pre-operative year, UCL = ulnar collateral ligament, xFIP = expected fielding-independent pitching. Stuff+, Pitching+, and Location+ are all scaled similarly to IQ — a score of "100" is graded out as league average. *Highlighted Season Pre T1 is the season to which all other time points were compared, establishing PreT1 as the "baseline" season. Significant p-values (i.e., <.05) in bold

Season		Velocity (mph)	Spin Rate (RPM)	Active Spin	Spin Axis (degrees)	Horizontal Movement (inches)	Vertical Movement (inches)	Horizontal Release Point (feet)	Vertical Release Point (feet)	HAA (degrees)	HAA above average	VAA (degrees)	VAA above average	Release Extension (feet)
*Pre T1	Mean ± sd	90.06 ± 3.19	2261.26 ± 207.86	78 ± 3%	174.55 ± 29.63	9.55 ± 3.16	8.09 ± 3.02	1.87 ± 0.76	5.97 ± 0.45	-1.50 ± 0.93	0.13 ± 0.97	-6.60- ± 0.57	-0.02 ± 0.55	6.10 ± 0.43
Post M1	Mean ± sd	89.85 ± 2.60	2250.33 ± 230.48	79 ± 9%	177.03 ± 24.95	9.68 ± 3.15	8.44 ± 3.36	1.88 ± 0.65	5.92 ± 0.45	-1.02 ± 1.55	-0.07 ± 0.72	-6.53 ± 0.59	0.03 ± 0.56	6.28 ± 0.43
	p-value	.25	**.03**	.57	.80	.49	.88	.65	.77	**.02**	0.10	.77	.86	**<.01**
Post M2	Mean ± sd	89.85 ± 2.78	2271.64 ± 216.19	74 ± 11%	173.48 ± 25.90	9.64 ± 3.45	7.72 ± 2.97	1.86 ± 0.65	5.87 ± 0.43	0.16 ± 1.87	-0.11 ± 0.52	- 6.49 ± 0.58	-0.04 ± 0.56	6.38 ± 0.39
	p-value	.39	.41	.27	.47	.36	.09	.89	**<.01**	**<.01**	0.11	.43	.34	**<.01**

Table 2: Pre- and Post-Operative Pitch-tracking Data following UCL Injury. HAA = horizontal approach angle, M = post-operative year, mph = miles per hour, T = pre-operative year, RPM = revolutions per minute, sd = standard deviation, UCL = ulnar collateral ligament, VAA = vertical approach angle. *Highlighted Season PreT1 is the season to which all other time points were compared, establishing PreT1 as the "baseline" season. Significant p-values (i.e., <.05) in bold. Horizontal release point and approach angles were normalized to right-handers, yielding negative values.

Pitch-Tracking Metric	Return to Performance M1 (%)	Return to Performance M2 (%)	Return to Performance M3 (%)
Pitch count	3.9	29.4	62.8
xFIP	13.2	54.3	60.5
fWAR	5.9	46.4	52.8
Velocity	23.8	57.1	78.1
Fastball velocity	27.5	56.4	76.9
Horizontal movement	21.6	70.6	83.0
Vertical movement	19.6	66.7	72.3
Spin rate	0	N/A	N/A
Stuff+	23.1	61.5	72.7
Location+	38.5	84.6	88.9
Pitching+	30.8	69.2	77.8
Full Performance	2.9	21.2	32.4

Table 3: Return to Performance of Advanced Analytic and Pitch-Tracking Metrics at 1-, 2-, and 3-Years Following UCL Surgery. Returning to pitch count was defined as returning to within 90% of the player's pitch count in the season before injury. Returning to velocity was defined as within 1 mile per hour in the season before injury. Returning to xFIP and fWAR was defined as within 10% in the season before injury; returning to Stuff+, Location+, Pitching+ was defined as being within given these values have an average of about 100. Overall return to full performance was defined as returning to all pre-operative metrics combined except for Stuff+, Location+, and Pitching+ given limited sample size of these metrics that were developed in 2020. Data on spin rate was also limited during M2 and M3 seasons for the same reason. fWAR = Fangraphs wins above replacement, M = post-operative season with ≥100 pitches thrown, UCL = Ulnar collateral ligament, xFIP = expected fielding-independent pitching.

Return to fWAR at 3-years	Coefficient	P value	95% CI
Starting versus relief pitcher	-0.57	0.61	0.15 to 0.44
Reconstruction versus repair	-2.79	0.19	0.01 to 0.67
Lifetime innings pitched	0	0.36	-0.34 to 3.73
Velocity	-0.30	0.21	-2.75 to 2.14
Spin	0.01	0.08	0.25 to 3.49
HAA AA	2.07	0.12	-0.02 to 0.22
VAA AA	-0.05	0.98	-4.86 to 0.04
Vertical release point	0.05	0.98	-4.42 to 0.04
Horizontal release point	0.60	0.67	0.002 to 0.01

Return to Full Performance at 3-years	Coefficient	P value	95% CI
Starting versus relief pitcher	-2.594	0.11	-6.6 to 0.1
Reconstruction versus repair	N/A	N/A	N/A
Lifetime innings pitched	0	0.36	-0.001 to 0.005
Velocity	-0.462	0.11	-0.46 to -1.19
Spin	0.001	0.84	-0.007 to 0.009
HAA AA	0.741	0.54	-1.60 to 3.32
VAA AA	2.340	0.42	2.87 to 9.04
Vertical release point	2.73	0.40	-2.96 to 10.48
Horizontal release point	-0.59	0.71	-3.88 to 2.55

Table 4: No Pitch-Tracking Metric was Associated with Return to Wins Above Replacement and Full Performance at 3-years after UCL Surgery. Binary logistic regression of various pre-operative pitching metrics from the season before injury was performed for return to fWAR and full performance at 3-years after surgery. CI = confidence interval, fWAR = Fangraphs Wins Above Replacement, HAA AA = horizontal approach angle above average, UCL = Ulnar collateral ligament, VAA AA = vertical approach angle above average, Δ = change in the three seasons prior to injury. Significant p values (< 0.10) in bold