Pitch-Specific Return to Performance Following Ulnar Collateral Ligament 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. Pitch-specific return to performance following UCL surgery using several advanced metrics has been minimally studied.
METHODS:
We performed a retrospective analysis on 119 MLB pitchers who underwent primary UCL reconstruction or repair from November 2017 to June 2023,. Exclusion criteria included pitchers without two qualifying seasons (i.e. >100 pitches in a calendar year) of post-operative pitch-tracking data except for analysis of Stuff+, Location+, and Pitching+ secondary to power limitations. Pitch-specific data was collected for fastballs, sliders, curveballs, cutters, changeups, and splitters for each injured pitcher. Pitch-specific pre- and post-operative pitch-tracking data evaluating mean velocity, release extension, spin rate, vertical and horizontal movement, angle, and release point were collected for 54 MLB pitchers. Advanced analytic metrics evaluating the physical qualities of a pitch (Stuff+), strike-zone command (Location+), and overall pitching ability (Pitching+) were also examined. Data was obtained from public web sources. Statistical analysis included paired and unpaired t-tests comparing pre-injury (T1) to post-operative (M1 and M2) season statistics, along with binary logistic regression to identify predictors of returning to performance for each metric. Return to full performance was also evaluated.
RESULTS:
Mean age was 26.5 $\pm$ 3.4 years, 70.6% of included pitchers were right-handed, and 43.1% were starting pitchers. Initially, there was a significant decrease in fastball velocity and spin rate at 1-year post-operatively, but by 2-years post-op all pitches had recovered to their pre-operative levels. Fastballs also had a significantly less horizontal approach angle above average (HAA AA) and a more vertical approach angle above average (VAA AA) two seasons after surgery. Sinkers and changeups were also thrown at a significantly less HAA AA, with changeups also being thrown at a lower release point and more vertical VAA AA. Sliders and curveballs were thrown at a more horizontal and vertical approach angle above average, and curveballs at a lower release point at 2-years post-operatively. All pitches were thrown with significantly longer release extensions. Sinker and changeup spin rates decreased at 2-years post-op, while splitters had significantly decreased vertical movement. Importantly, there were no significant pitch-specific differences in Stuff+, Location+, and overall pitching ability (Pitching+). However, for each pitch less than 40% of pitchers returned to full performance. Fastballs were the fastest to return to performance. Binary logistic regression did not identify any significant predictors for returning to performance in any pitch.
DISCUSSION AND CONCLUSION:
Pitch-specific differences in return to performance exist following UCL surgery, with less than 40% return to full performance at 2-years post-operatively for each pitch. Despite this, there were no differences in physical pitch quality, strike-zone command, and overall effectiveness, suggesting that each pitch remains similarly effective upon return. Fastballs appear to recover the fastest. There was no predictors for return to performance found for any pitch. Future research focusing on entire pitching arsenals is warranted to determine injury risk and return to performance.

Pitch-specific variable	Coefficient	p-value
Fastball		
Age	0.07	0.55
SP vs RP	-1.01	0.22
Velocity	0	0.95
Spin rate	0	0.82
Horizontal movement	-0.16	0.20
Vertical movement	0.02	0.91
Slider		
Age	0.12	0.60
SP vs RP	0.46	0.69
Velocity	0	0.75
Spin rate	0	0.67
Horizontal movement	0.09	0.52
Vertical movement	-0.25	0.15
Curveball		
Age	0.07	0.55
SP vs RP	-1.01	0.22
Velocity	0	0.95
Spin rate	0	0.82
Horizontal movement	-0.16	0.20
Vertical movement	0.02	0.91
Cutter		
Age	0.14	0.49
SP vs RP	0.25	0.84
Velocity	0	0.57
Spin rate	0	0.73
Horizontal movement	-0.09	0.62
Vertical movement	-0.08	0.61
Sinker		
Age	0.09	0.33
SP vs RP	0.62	0.16
Velocity	0	0.96
Spin rate	0	0.89
Horizontal movement	0.11	0.58
Vertical movement	0.07	0.67
Changeup		
Age	0.23	0.43
SP vs RP	1.21	0.44
Velocity	0	0.92
Spin rate	0	0.65
Horizontal movement	0.11	0.39
Vertical movement	-0.02	0.76

Table 3: Pitch-Specific Binary Logistic Regression to Identify Predictors of Return to Performance

Table 2: Pitch-specific approach angles, release points, and release extension following UCL surgery

Pitch-Tracking Variable	Fastball	Slider	Curveball	Cutter	Sinker	Changeup	Splitter
Horizontal release point (feet)							
Pre T1	1.80	1.99	1.86	1.76	1.91	1.96	1.65
Post M1 Δ	0	-0.12	0.06	0.11	0.04	-0.02	0.21
Post M2 Δ	-0.04	-0.07	-0.05	0.03	0	-0.02	0.11
Vertical release point (feet)							
Pre T1	5.90	5.91	**6.05***	5.83	5.89	**5.91***	6.22
Post M1 Δ	-0.01	-0.02	**-0.12***	0.06	-0.04	**-0.07***	-0.06
Post M2 Δ	-0.05	-0.07	**-0.10***	0.01	-0.05	**-0.15***	-0.06
Horizontal approach angle above average							
Pre T1	**0.46***	**-1.05***	**-1.18***	-0.29	**0.94***	**0.73***	1.05
Post M1 Δ	**-0.32***	0.16	0.10	-0.16	-0.32	-0.25	-1.10
Post M2 Δ	**-0.41***	**0.57***	**0.37***	0.19	**-0.64***	**-0.53***	-0.80
Vertical approach angle above average							
Pre T1	**-5.10***	**-0.90***	**-2.53***	-6.48	-5.88	**0***	-8.03
Post M1 Δ	**0.16***	0.19	**0.89***	-0.18	0	**0.06***	-0.05
Post M2 Δ	**0.24***	**0.51***	**1.33***	-0.27	0.06	**0.11***	0.12
Release extension (feet)							
Pre T1	**6.23***	**5.86***	**5.78***	**6.19***	**6.16***	**6.27***	**5.76***
Post M1 Δ	**0.10***	**0.33***	**0.34***	0.02	**0.11***	0.03	0.41
Post M2 Δ	**0.20***	**0.51***	**0.48***	**0.11***	**0.17***	**0.11***	**0.62***

Δ = change, mph = miles per hour, Post M = post-operative season, mph = miles per hour, Pre T1 = season prior to injury, RPM = revolutions per minute, SD = standard deviation. Pre T1 is the season to which Post M1 or Post M2 were compared. * indicates significant difference from Pre T1.

Table 1: Pitch-specific pitch count, velocity, spin rate, movement, and advanced analytic outcomes following UCL surgery

Variable	Fastball (n = 53)	Slider (n = 38)	Curveball (n = 32)	Cutter (n = 10)	Sinker (n = 28)	Changeup (n = 37)	Splitter (n = 6)
Velocity (mph)							
Pre T1, mean	**94.45***	84.52	79.49	88.95	93.91	86.32	86.76
Post M1 Δ, mean	**-0.32***	-0.50	0.21	0.09	-0.36	-0.14	-0.30
Post M2 Δ, mean	0.20	0.36	0.19	-0.53	-0.21	-0.06	0.30
Spin Rate (RPM)							
Pre T1, mean	**2284.50***	2424.38	2518.09	2393.53	**2217.10***	**1785.11***	1416.26
Post M1 Δ, mean	**-12.46***	34.25	29.96	41.99	-24.74	**-99.20***	39.94
Post M2 Δ, mean	-7.06	31.64	8.51	70.28	**-47.21***	**-88.82***	14.99
Horizontal movement (inches)							
Pre T1, mean	7.96	6.75	8.83	2.87	14.63	13.33	11.57
Post M1 Δ, mean	-0.57	0.41	1.27	0.41	0.47	0.53	-1.92
Post M2 Δ, mean	-0.06	0.39	0.67	0.64	0.37	0.91	2.28
Vertical movement (inches)							
Pre T1, mean	15.37	1.42	-9.10	8.94	10.54	8.52	**4.75***
Post M1 Δ, mean	0.38	-0.17	0.89	-1.47	-0.40	-1.10	**-0.34***
Post M2 Δ, mean	0.06	-0.08	0.37	-2.24	-0.29	-1.52	**-1.21***
Stuff+							
Index, mean	100.11	109.67	106.56	98.60	103.75	85.22	94.32
Post M1 Δ, mean	-0.92	-2.20	-3.5	-9.10	-9.34	2.69	N/A
Post M2 Δ, mean	-1.86	-0.27	-2.9	N/A	-6.18	-5.44	N/A
Location+							
Index, mean	102.33	99.00	97.64	97.80	100.88	100.11	93.2
Post M1 Δ, mean	-9.19	2.53	-5.6	-12.97	1.07	-0.11	N/A
Post M2 Δ, mean	-2.78	0.73	-3.8	N/A	-5.74	-3.86	N/A
Pitching+							
Index, mean	101.11	106.67	101.06	101.20	92.50	96.22	92.9
Post M1 Δ, mean	-8.19	-0.33	-5.8	-14.28	4.62	2.74	N/A
Post M2 Δ, mean	-5.94	-0.97	-4.6	N/A	-3.02	-4.90	N/A

Δ = change, Location+ = strike-zone command, mph = miles per hour, Pitching+ = overall pitching ability, Post M = post-operative season, mph = miles per hour, Pre T1 = season prior to injury, RPM = revolutions per minute, SD = standard deviation, Stuff+ = physical qualities of a pitch, Highlighted Season Pre T1 or the index season values are compared to Post M1 and Post M2 values.
* indicates significant difference from Pre T1 or index season. Stuff+, Location+, and Pitching+ analyses were all under-powered since the data has only been available since 2020. Splitters only had two pitchers with Post M1 and Post M2 data for Stuff+, Location+, and Pitching+ and thus no analysis was completed.