

# The Effect of Ulnar Collateral Ligament Reconstruction on Pitch Velocity in Major League Baseball Pitchers

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**Background:** The medial ulnar collateral ligament (UCL) is the primary restraint to valgus load, and injury is commonly encountered as a result of overuse in throwing athletes. Reconstruction of this ligament has allowed for a high rate of return to sport for elite pitchers. Public perception of this procedure has resulted in a commonly held belief of increased throwing velocity following UCL reconstruction.

**Hypothesis:** Fastball velocity for Major League Baseball (MLB) pitchers is significantly decreased following UCL reconstruction.

**Study Design:** Case series; Level of evidence, 4.

**Methods:** A total of 129 pitchers were identified as undergoing UCL reconstruction from publicly available reports, and a final group of 80 MLB pitchers were included for analysis. Statistics were collected, including pitch velocity, pitch selection, and performance outcomes. Pre- and postoperative statistics were compared using paired *t* tests to allow for evaluation of each pitcher relative to his baseline velocity and performance.

**Results:** Mean fastball velocity was significantly decreased following UCL reconstruction, with a presurgical mean velocity of 91.3 mph and postoperative velocity of 90.6 mph ( $P = .003$ ). The greatest observed difference was in pitchers older than 35 years, with fastball velocity decreasing from 91.7 to 88.8 mph ( $P = .0048$ ). Pitchers threw fewer fastballs after reconstruction. Pitch velocity for curveballs, changeups, and sliders did not change significantly after UCL reconstruction. Additionally, pitchers threw fewer innings and pitches following reconstruction and produced fewer wins above replacement relative to their preinjury state.

**Conclusion:** Contrary to popular opinion, fastball velocity for MLB pitchers is significantly decreased following UCL reconstruction, which should reinforce the importance of preventing overuse injuries.

**Keywords:** medial ulnar collateral ligament; elbow; pitcher; overuse injuries

Injury to the medial ulnar collateral ligament (UCL) is frequently encountered by throwing athletes, especially baseball pitchers. The high valgus load and repetitive motion place this structure at risk. Prior to 1976, an incompetent UCL often meant the end of a throwing career. With the advent of successful UCL reconstruction, first described by Jobe et al<sup>7</sup> in 1986 and commonly referred to as Tommy John surgery, pitchers are able to return to a high level of play following surgical treatment and rehabilitation. Pitchers are now able to return to their previous level of activity at a high rate. Dodson et al<sup>4</sup> reported a return-to-sport rate of 90%, with only a 3% complication rate using the docking technique. Koh et al<sup>8</sup> found similarly high success rates at 95% using a modified docking technique. Previous studies

have demonstrated that pitchers resume playing at an effective and productive level, and pitchers frequently report a subjective increase in pitch velocity.

Recent studies have demonstrated that UCL reconstruction is being performed at an increasing rate and on younger throwing athletes.<sup>5,9</sup> Fleisig et al<sup>5</sup> reported a 6-fold increase in the number of elbow surgeries on high school pitchers between 1995-1999 and 2000-2004. Public perception of the effects of surgical reconstruction of the elbow can be heavily influenced by anecdotal reports of improved performance from the highest levels of competition. Ahmad et al reported on the general public's perception of UCL injuries and repairs.<sup>1</sup> A commonly held belief was that throwing performance would increase following surgical reconstruction of the UCL, with 28% of players and 20% of coaches believing this. These misperceptions are driven by reports of better performance and improved velocity after UCL reconstruction. According to "Tommy John surgery: Pitcher's best friend," a *USA Today* article from 2003, "these players typically perform as well, if not better, after the operation and have stronger arms, with radar gun readings to match."<sup>3</sup>

Advancements in data collection at the professional baseball level have allowed for a vast amount of information related to pitch type and velocity. The purpose of this study was to investigate the results of UCL reconstruction in

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TABLE 1  
Demographic Information  
of Pitchers in Study Group<sup>a</sup>

	Mean (SD) (n = 80)	Range
Age at injury, y	29.2 (4.51)	22-48
Seasons before injury	3.15 (1.94)	1-8
Seasons after injury	2.93 (2.02)	1-9
Height, inches	73.8 (2.16)	69-79
Weight, lbs	216.0 (22.3)	175-264
BMI, kg/m <sup>2</sup>	27.8 (2.34)	22.5-33.0
Number of left-handed pitchers <sup>b</sup>	21 (26.3)	
Starting pitchers <sup>b,c</sup>	36 (45)	

<sup>a</sup>SD, standard deviation; BMI, body mass index.

<sup>b</sup>Expressed as n (%).

<sup>c</sup>Starting pitcher defined as more than 5 games started prior to surgery.

Major League Baseball (MLB) pitchers as it pertained to velocity, pitch type, and pitching outcome metrics. We hypothesized that fastball velocity would significantly decrease following UCL reconstruction, and that the type of pitches thrown would change after UCL reconstruction.

## METHODS

Publicly available data were reviewed to determine pitchers on active rosters in MLB who underwent primary reconstruction of a UCL. Data were collected for 2003 through 2011. All cases were confirmed using national news media sources. Inclusion criteria consisted of all MLB pitchers for whom there were public reports of a UCL reconstruction. Pitchers who underwent multiple UCL reconstruction procedures were excluded from analysis. Players without Major League statistics at least 1 season prior to injury and 1 season after were also excluded from this study.

General demographic information for each player was recorded, including height, weight, age, and handedness. Common statistical measures (www.fangraphs.com) of performance were recorded, including earned run average (ERA), wins, innings pitched (IP), strikeouts per 9 innings, walks per 9 innings, fielding-independent pitching (FIP), and wins above replacement level (WAR). Pitch selection and mean velocity for each pitch were obtained from publicly available information provided by Baseball Info Solutions (Coplay, Pennsylvania, USA). Pitch type and velocity were available beginning in the 2002 season, so all data were limited to the 2002 through 2012 MLB seasons. The year of injury was noted, and data were divided into pre- and postinjury groups, which were averaged for each player.

Data were managed in Excel (Microsoft, Redmond, Washington, USA), and statistical analyses were performed in Stata 13 (StataCorp, College Station, Texas, USA). For all players, the season during the year of injury was excluded from analysis. Paired Student *t* tests were used for comparing pre- and postinjury variables. The

TABLE 2  
Pitch Velocity Before and After  
Ulnar Collateral Ligament Reconstruction

Pitch Type <sup>a</sup>	Presurgery Velocity <sup>b</sup>	Postoperative Velocity <sup>b</sup>	<i>P</i> Value <sup>c</sup>
Fastball (n = 80)	91.3 (2.61)	90.6 (2.55)	.0034
Curveball (n = 50)	76.9 (4.14)	76.3 (3.10)	.29
Changeup (n = 72)	82.3 (2.62)	82.5 (2.76)	.50
Slider (n = 70)	82.9 (2.49)	82.7 (2.54)	.68

<sup>a</sup>n denotes number of pitchers.

<sup>b</sup>Values are expressed in units of miles per hour as mean (standard deviation).

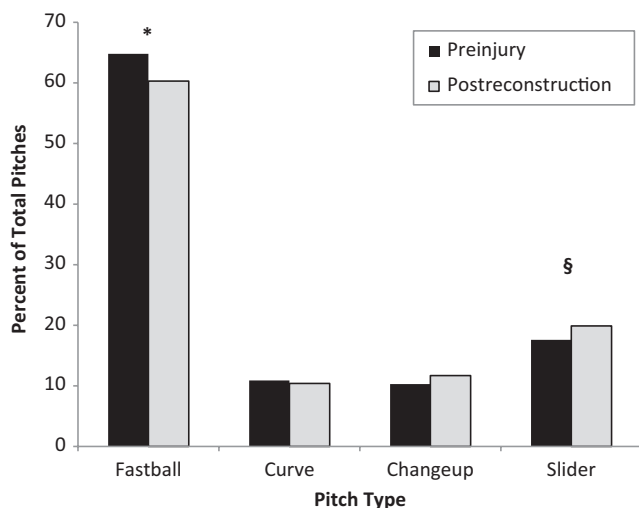
<sup>c</sup>*P* value from 2-tailed paired *t* test.

primary outcome was the pitcher's fastball velocity. Secondary outcome measures included traditional and advanced statistical measures.

## RESULTS

A total of 129 pitchers were identified as having undergone UCL reconstruction between 2003 and 2011. Seven pitchers were excluded because they required revision reconstruction of the UCL. Eleven pitchers were excluded because of a lack of statistics prior to their year of injury, and 27 players were excluded for no postinjury data. Four pitchers were excluded for a lack of statistics from professional seasons before or after the year of their injury. A group of 80 pitchers were included for overall analysis. The mean age at the time of injury was 29.3 years (range, 22-48 years). Twenty-one (26%) pitchers of this group were left-handed. The mean pre-injury seasons with available data were 3.18 years (range, 1-8 years), and 2.98 postinjury seasons (range, 1-9 years). Since pitch velocity was not available prior to 2003, pitch data were only collected from 2003 for all pitchers, even those with lengthy careers prior to injury. Summary data for this cohort are displayed in Table 1.

Mean pitch velocity before and after injury is displayed in Table 2, and the frequency of each pitch type is shown in Figure 1. Mean fastball velocity was decreased significantly following UCL reconstruction, with preinjury fastball velocity at 91.3 mph and postinjury fastball velocity at 90.6 mph (*P* = .003). Pitchers threw fewer fastballs, with these pitches comprising 64.8% of pitches prior to injury and 60.4% of pitches after injury (*P* = .008). When comparing the 42 pitchers with more than 1 season both before and after injury, both fastball velocity (91.5 mph presurgery vs 90.8 mph postsurgery, *P* = .026) and fastballs as percentage of pitches thrown (67.2% vs 60.1%, *P* = .0002) remained significantly decreased. These results were similar, as pitch velocity for curveballs, sliders, and changeups did not change significantly after injury, and the relative percentage of each of these pitches also showed no statistical difference after surgery, with the exception of an increase in the percentage of sliders thrown in for the entire group (17.6% vs 19.9%, *P* = .04) and the group with more than 1 season before and after injury (18% vs 21.4%, *P* = .016).



**Figure 1.** Relative percentages of various pitch types before and after ulnar collateral ligament reconstruction. \**P* = .0008; <sup>§</sup>*P* = .04.

**TABLE 3**  
Effect of Age on Fastball Velocity Following Ulnar Collateral Ligament Reconstruction

Age Range, y	No. of Pitchers	Presurgery Fastball Velocity <sup>a</sup>	Postoperative Fastball Velocity <sup>a</sup>	<i>P</i> Value <sup>b</sup>
<25	8	91.2 (2.10)	91.7 (1.54)	.64
25-29	38	91.8 (2.50)	91 (2.39)	.0068
30-34	24	90.4 (2.38)	90.3 (2.15)	.79
≥35	10	91.7 (3.62)	88.8 (3.81)	.0048

<sup>a</sup>Values are expressed in units of miles per hour as mean (standard deviation).

<sup>b</sup>*P* value from 2-tailed paired *t* test.

Changes in velocity varied with respect to age at the time of injury (Table 3). For 8 pitchers who were younger than 25 years at the time of surgery, there was no significant difference in fastball velocity before and after UCL reconstruction (91.2 vs 91.7 mph, *P* = .64). The 38 players between 25 and 30 years old demonstrated a significant decrease in fastball velocity (91.8 vs 91.0 mph, *P* = .007). Those pitchers between 30 and <35 years old had no difference in fastball velocity before and after surgery (90.4 mph vs 90.3 mph, *P* = .79), while those 35 years and older had a significant decrease in fastball velocity after UCL reconstruction (91.7 vs 88.8 mph, *P* = .0048).

Measures of durability were significantly decreased following return from injury for the overall group of 80 pitchers (Table 4). Number of pitches thrown per season decreased from 1345.5 prior to surgery to 962.1 after surgery (*P* = .0002), and innings pitched declined from 83.0 innings per season to 57.3 innings per season (*P* = .0001). This group of pitchers played in 34.4 games per season before injury and 26.6 games after surgery (*P* = .0019). For 36 starting

**TABLE 4**  
Effect of Ulnar Collateral Ligament Reconstruction on Pitcher Statistical Measures

Statistic	Before Reconstruction <sup>a</sup>	After Reconstruction <sup>a</sup>	<i>P</i> Value <sup>b</sup>
Pitches thrown	1345.5 (862.3)	962.0 (780.3)	.0002
Innings pitched	83.0 (55.5)	57.3 (50.1)	.0001
Earned run average	4.75 (2.16)	4.73 (1.90)	.94
Wins	4.85 (3.78)	3.20 (3.39)	.0002
Losses	4.47 (3.19)	3.33 (2.98)	.0018
Strikeouts per 9 innings	7.23 (1.99)	7.29 (2.24)	.83
Walks per 9 innings	3.93 (1.87)	3.90 (1.79)	.89
Walks + hits per inning pitched	1.48 (0.47)	1.45 (0.31)	.60
Fielding-independent pitching	4.45 (1.06)	4.72 (1.94)	.27

<sup>a</sup>Data listed as mean (standard deviation).

<sup>b</sup>*P* value from 2-tailed paired *t* test.

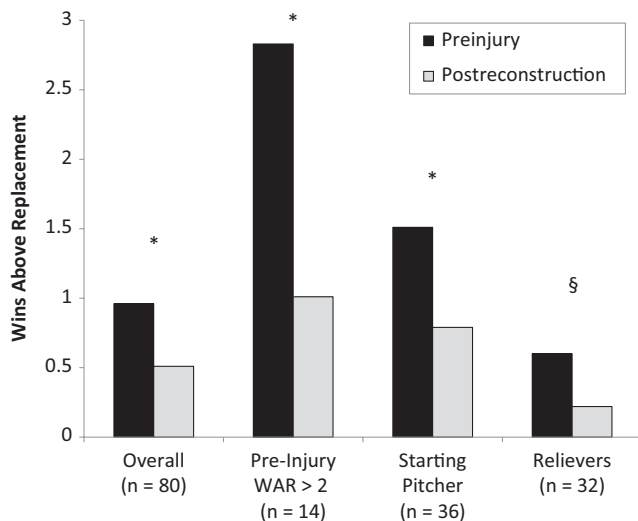
pitchers (defined as players with more than 5 games per year started on average prior to injury), innings pitched decreased from 127.8 innings per year to 82.0 innings per year (*P* = .0004). Innings pitched also decreased for 31 relief pitchers (no games started before or after injury), from 50.1 innings per year to 36.4 innings per year (*P* = .011).

Traditional statistics to assess pitcher effectiveness showed no significant change before and after injury, including FIP, ERA, strikeouts per 9 innings, and walks plus hits per innings pitched (Table 4). The mean wins per year, however, decreased significantly from 4.82 to 3.20 (*P* = .0002). Wins above replacement (WAR) decreased significantly from 0.96 WAR prior to injury to 0.51 after injury (*P* = .0006) (Figure 2). This finding was also seen when evaluating 14 pitchers with a baseline WAR of more than 2, with a decrease from 2.83 WAR before injury to 1.01 after return (*P* = .0001). Starters and relievers both showed a significant decrease in WAR following UCL reconstruction.

Statistics were evaluated for those players who had a minimum of 2 seasons in MLB both before and after their year of injury. The season before and after the year of injury was excluded in an attempt to limit the possible effects of a chronic injury affecting presurgery statistics or a prolonged return to full function after rehabilitation. This group consisted of 42 players. The same general trends were observed. Fastball speed was significantly decreased following return to play, with preinjury velocity at 91.6 mph and postinjury velocity of 90.6 mph (*P* = .0009). Fastballs were 67.5% of pitches thrown before injury and 60.7% of pitches after injury (*P* = .0007). Games and innings pitched were not statistically different, though WAR decreased from 1.06 to 0.60 (*P* = .0032).

## DISCUSSION

The primary purpose of this study was to investigate the results of UCL reconstruction in MLB pitchers as it pertained to velocity, pitch type, and pitching outcome metrics.



**Figure 2.** Wins above replacement (WAR) for pitchers following ulnar collateral ligament reconstruction.

\* $P < .005$ ; § $P < .05$ .

The results from this study demonstrate that mean fastball velocity decreases after UCL reconstruction in professional baseball pitchers. This is the first study, to our knowledge, that incorporates objective measurements of velocity both before UCL reconstruction and after rehabilitation. Pitchers sustained a small but significant decrease in fastball velocity. While the overall decrease in fastball velocity was small, pitchers older than 35 year lost 2.9 mph after UCL reconstruction. In an attempt to control for the possibility of the results being influenced by a presurgery decrease in performance from a chronic injury or incomplete rehabilitation at the time of return to play, these seasons were excluded from analysis for all pitchers with a minimum of 2 presurgery and postsurgery seasons played. This significant change in fastball velocity persisted even in this group. Additionally, advanced statistical metrics were significantly decreased after returning from reconstruction.

Ulnar collateral ligament reconstruction has altered the outlook for baseball pitchers with elbow injuries. What was once accepted as a career-ending injury has become one with a successful clinical solution. The first cohort of players with this reconstruction was reported by Jobe et al<sup>7</sup> in 1986, with a successful return-to-play rate of 63%. The efficacy of treatment has improved since that time, with recent published reports of return to play ranging from 50% to 97%.<sup>2,4,8</sup> The return-to-play rate within this cohort was 79.1%. In a report on the docking technique, Dodson et al<sup>4</sup> described a cohort of 100 patients with a mean follow-up time of 36 months. This modification to the original surgical technique of Jobe et al<sup>7</sup> allows for preservation of the flexor muscle origin. Ninety percent of these patients were able to return to at least the same level as prior to injury. Complications were noted in 3 patients, and poor results were seen in only 2 patients. Similarly, Koh et al<sup>8</sup> reported the results from 20 elite throwing athletes at the professional or collegiate level.<sup>8</sup> Eighteen of their patients returned to sport at the same preoperative level.

An excellent outcome was achieved in 17 patients, and 2 patients had a good outcome. Cohen et al<sup>2</sup> reviewed the return-to-play rates after UCL reconstruction for professional baseball players, including those at the Minor League level.<sup>2</sup> The return rate was 50% for players reaching the same level or higher in a 4-year period.

The decrease in velocity observed does not appear to be isolated to the year immediately following return or secondary to a chronic, overlooked injury that was present prior to the player undergoing a surgical procedure. When excluding 1 season before and after the year of surgery, similar results were observed. Fastball velocity still decreased by 0.7 mph after reconstruction, and the percentage of fastballs thrown decreased as well.

Gibson et al<sup>6</sup> evaluated performance measures for Major League players returning from UCL reconstruction. They demonstrated that players most often return to play within 2 seasons of surgical treatment, with 82% of players returning at a mean of 18.5 months. Performance measures of the pitchers returning from injury reached the level of a control group of players by the second and third seasons following reconstruction. Similar to our cohort, innings pitched decreased significantly in the season immediately after injury, but this returned to the level of control pitchers after 2 seasons. In light of this previous comparison with a control group of pitchers that demonstrated a similar decrease in innings pitched, it is likely best to attribute the decrease seen in the group of pitchers presented here as an expected drop in innings pitched. ERA and walks plus hits per innings pitched increased significantly in the year of injury and also returned to the levels of control pitchers in later seasons. This study provided a comprehensive review of the change in statistical measures after UCL reconstruction relative to a group of control pitchers, but pitch velocity and pitch selection were not evaluated.

It is difficult to conclude whether the observed decrease in fastball velocity is a clinically important decrease. Similar to the cohort of Gibson et al,<sup>6</sup> performance statistics on a per-innings basis were not significantly different between the pre- and postsurgery groups. These findings suggest that pitchers are able to adapt despite their new lower speed fastball. The pitch selection, however, did change between these groups. After injury, pitchers threw fewer fastballs, possibly because of the decreased velocity and perhaps a corresponding decreased effectiveness of this pitch.

For this study, secondary outcomes of performance statistics were chosen to investigate the effects of UCL reconstruction. These measures function as surrogates for patient-reported outcome measures in this elite group of overhead athletes and provide insight as to the effectiveness of surgical treatment to regaining preoperative condition. The advanced metrics presented here, including FIP and WAR, add additional value to the standard measures such as ERA and wins. These newer statistics allow for a comparison of pitcher value independent of the external factors of his team outside of the pitcher's control. The WAR statistic provides a comparison against other players, with a value of 0 reflecting the contribution from a "replacement-level" pitcher. Multiple calculations of WAR are publicly

available with different formulations of the statistic. The FanGraphs WAR was selected for this study as it is based on FIP. The postreconstruction statistics show a decrease in the player's value after elbow reconstruction, and this decrease is even more pronounced in those pitchers who were more valuable prior to their injury. This decline in value is likely a reflection of decreased number of innings pitched. These advanced statistics do rely on complex calculations and comparisons that are possibly less objective than traditional counting statistics, yet they also offer insight into individual performance, which is the goal of this study.

Perhaps more important, these results must be evaluated in the context of prior studies on high school and college throwing athletes. Petty et al<sup>9</sup> suggested that the effectiveness of UCL reconstruction may be slightly lower in high school pitchers as compared with higher levels of competition. Their cohort consisted of 31 high school baseball players who underwent UCL reconstruction. Seventy-four percent of these players were able to return at the same level or higher. The group of pitchers included in this study has access to the highest levels of medical care and rehabilitation facilities. A lack of this specialized treatment in younger throwers could result in possibly more dramatic effects on throwing velocity after reconstruction.

Recent studies have shown that UCL reconstructions are performed at an increasingly high rate, especially in high school athletes.<sup>5,9</sup> This concerning finding may be a reflection of the common perception that this surgery is harmless, routine, or even beneficial to the player's career. Warnings of the ill effects of overuse and pitch selection in developing players may be negated by the anecdotal reports of improved performance and velocity following UCL reconstruction. The findings of this study should dispel the myth of improved velocity after UCL reconstruction.

There are potential weaknesses to this study. First, we have relied on the accuracy of injury reports from publicly available sources. Only documented cases of UCL reconstruction were included, so there is the possibility of missed injuries. Pitch velocity and pitch type are additional sources of potential error. Velocity may vary based on stadium location and altitude, weather patterns, and between various radar guns. We would expect that any variability is evenly distributed between the preinjury and postinjury groups and would not significantly affect the overall findings. Additionally, no control group of uninjured pitchers was included. We believe that this group of patients is

sufficient to show that velocity decreases after UCL reconstruction, and the interpretation of a decrease in velocity relative to other pitchers would not add meaning to the results. The primary strength of this study is the evaluation of outcomes after UCL reconstruction with relevant metrics, including pitch selection, pitch velocity, and performance measures.

## CONCLUSION

This retrospective evaluation of MLB pitchers before and after UCL reconstruction provides an objective evaluation of fastball velocity that has been absent from previous studies on this topic. The findings here should serve as encouragement to throwing athletes to take precautions as necessary to avoid this overuse injury and should provide information to physicians to counsel pitchers regarding the lasting effects of UCL reconstruction. To be clear, this procedure is one that has clearly allowed for a remarkable return to a high level of function for overhead athletes, though public perception about its benefits does not align with recorded measures of velocity.

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