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| **CRITICALLY APPRAISED TOPIC** |

**FOCUSED CLINICAL QUESTION**

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| In a 27 year old male professional baseball pitcher who sustained his first UCL tear in his pitching arm (right), will the Docking Procedure and conventional post-operative physical therapy result in improved pitching performance compared to Tommy John’s surgery in conjunction with conventional post-operative physical therapy? |

**AUTHOR**

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**CLINICAL SCENARIO**

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| A continuing education course at the Hospital for Special Surgery’s 10th Annual Sports Medicine Symposium on the upper extremity in baseball pitchers inspired this project. During the conference, top-tiered sports medicine physicians that specialized in the treatment of professional baseball pitchers discussed a new surgical technique, known as the Docking Procedure, for the treatment of ulnar collateral ligament (UCL) tears in elite baseball pitchers. Due to a significant number of upper extremity injuries secondary to softball pitching over the course of my athletic career, I have developed a deep interest in this topic, and plan to earn a position as a sports physical therapist upon graduation. Considering baseball is the second-most popular sport in the United States, there is a very high chance that I will encounter a number of baseball players experiencing upper extremity injuries throughout my career.1 In fact, there are approximately 11.5 million baseball players in the United States,2 868 of which are Major League Baseball (MLB) players.3 Approximately 25-30 MLB pitchers undergo Tommy John surgery per year, and rate continues to rise.”4 Considering the large number of baseball players and the relatively high rate of UCL tears, I anticipate providing care for a large number of baseball patients that have sustained UCL injuries. Thus, it is imperative for my professional development and the treatment of my patients that I that have a solid understanding of current treatment options and the best return to play protocols as supported by evidence. Thus, the intention of this project is to determine if elite baseball pitchers have higher rates of return to pre-injury level if they undergo a docking procedure versus the traditional Tommy john surgery following a UCL tear.  |

**SUMMARY OF SEARCH**

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| 3 electronic databases were searched, and 10 studies were identified that met the inclusion/exclusion criteria, including 2 systematic reviews, 3 retrospective cohorts, and 5 case series. 3 studies were selected as “best evidence” based on clinical relevance and methodological quality, and were reviewed in detail. Evidence from the three studies identified as the “best’ evidence and selected for critical appraisal * UCL reconstruction is not usually a career ending procedure for MLB baseball pitchers. In fact, a majority of MLB pitchers have a high rate of return to pitching in MLB baseball following UCL reconstruction.
* Following UCL reconstruction, most pitchers do not have statistically significant differences in pitching performance outcomes compared to pitchers without a history of UCL reconstruction that match in sex, age, body mass index (BMI), years of experience in the MLB, pitching performance in the MLB, year of injury, pitching position, and handedness.
* Future research is warranted that investigates pitching performance following different UCL reconstruction techniques because no studies to date have differentiated between the effects of the Docking Technique and Tommy John Surgery on post-reconstruction pitching performance among MLB players. These studies need to perform a priori power analyses, and they should include information regarding post-operative protocols and changes in pitching position/styles in order to improve the clinical significance of the results.
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**CLINICAL BOTTOM LINE**

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| While there are no studies to date that have differentiated between the effects of the Docking Technique and Tommy John Surgery on post-reconstruction pitching performance among MLB players, the “best’ available evidence at this time suggests that UCL reconstruction is not a career ending procedure, and that a majority of professional baseball pitchers can return to the MLB with pitching performance outcomes that are not significantly different from those of MLB pitchers without a history of UCL reconstruction. A physical therapist can use these results to justify patient prognosis during post-operative rehabilitation.  |

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| ***This critically appraised topic has been individually prepared as part of a course requirement and has been peer-reviewed by one other independent course instructor*** |

**SEARCH STRATEGY**

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| **Terms used to guide the search strategy** |
| **P**atient/Client Group | **I**ntervention (or Assessment) | **C**omparison | **O**utcome(s) |
| baseball pitchermajor league baseball pitcherMLB pitcherprofessional pitcherelite pitcheroverhand pitchermajor league baseballMLBprofessional baseballelite baseballUCL injuryUCL tearUCL ruptureulnar collateral ligament injuryulnar collateral tearulnar collateral rupture | docking procedure docking techniquedocking surgeryphysical therapyrehabilitation physiotherapy | Tommy john Tommy john procedureTommy john techniqueTommy john surgeryphysical therapyrehabilitationphysiotherapy | return to play return to sportreturn to activityreturn to baseballreturn to pitching |

**Final search strategy:**

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| **Search** | **Query** | **Items found** | **Time** |
| #49 | Search #35 AND #37 AND #38 | 6 | 12:46:49 |
| #48 | Search #35 AND #36 AND #38 | 4 | 12:46:14 |
| #47 | Search #35 AND #37 AND #39 | 9 | 12:45:38 |
| #46 | Search #35 AND #36 AND #39 | 12 | 12:44:57 |
| #45 | Search #35 AND #37 | 14 | 12:42:10 |
| #44 | Search #35 AND #36 | 27 | 12:41:47 |
| #43 | Search #34 AND #35 AND #37 | 6 | 12:41:07 |
| #42 | Search #34 AND #35 AND #36 | 3 | 12:40:35 |
| #41 | Search #33 AND #35 AND #37 | 3 | 12:39:51 |
| #40 | Search #33 AND #35 AND #36 | 1 | 12:39:17 |
| #39 | Search "return to play" OR "return to sport" OR "return to activity" OR "return to baseball" or "return to pitching" | 2687 | 12:36:25 |
| #38 | Search physical therapy OR physiotherapy OR rehabilitation | 604510 | 12:36:07 |
| #37 | Search "tommy john" OR "tommy john procedure" OR "tommy john technique" OR "tommy john surgery" | 36 | 12:35:40 |
| #36 | Search "docking procedure" OR "docking technique" OR "docking surgery" | 1227 | 12:35:15 |
| #35 | Search (UCL OR "ulnar collateral ligament") AND (injury OR tear OR rupture) | 1938 | 12:34:50 |
| #34 | Search "major league baseball" OR MLB OR "professional baseball" OR "elite baseball" | 790 | 12:34:32 |
| #33 | Search (baseball OR "major league baseball" OR MLB or professional OR elite OR overhand) AND pitcher | 243 | 12:34:16 |

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| **Databases and Sites Searched** | **Number of results** | **Limits applied, revised number of results (if applicable)** |
| PUBMED Sport DiscusCINAHL | 43 Results12 Results 35 Results | No limits were necessary because there was already a limited number of articles on this topic. A lot of the searches in PUBMED generated the same articles. I did however cross reference the references to determine if there were any additional and applicable studies that did not show up in my initial search. I found an additional 2 articles that were applicable to this topic after reviewing the references. Due to the limited number of articles I reviewed lines 40-49 in the search strategy above, and found 43 different articles on this topic.The original search strategy used in PUBMED did not yield any results so I had to broaden my search with two additional searches: 1. ("docking procedure" OR "docking technique" OR "docking surgery") AND ("return to play" OR "return to sport" OR "return to activity" OR "return to baseball" or "return to pitching") 2. ("tommy john" OR "tommy john procedure" OR "tommy john technique" OR "tommy john surgery") AND ("return to play" OR "return to sport" OR "return to activity" OR "return to baseball" or "return to pitching")Also had to expand this search with 1. ("docking procedure" OR "docking technique" OR "docking surgery") AND ("return to play" OR "return to sport" OR "return to activity" OR "return to baseball" or "return to pitching") 2. ("tommy john" OR "tommy john procedure" OR "tommy john technique" OR "tommy john surgery") AND ("return to play" OR "return to sport" OR "return to activity" OR "return to baseball" or "return to pitching") |

## INCLUSION and EXCLUSION CRITERIA

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| **Inclusion Criteria** |
| * Systematic reviews, randomized controlled trials, cohort studies, case-control studies, and case series (level IV evidence and higher)
* Protocol must include UCL reconstruction with post-operative rehabilitation
* Studied a population of overhand throwers
* Published in English
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| **Exclusion Criteria** |
| * Abstracts, conference proceedings, dissertations, case reports, expert opinions, and letters to the editor
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**RESULTS OF SEARCH**

**Summary of articles retrieved that met inclusion and exclusion criteria**

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| --- | --- | --- | --- |
| **Author (Year)** | **Study quality score** | **Level of Evidence** | **Study design** |
| **Gibson BW, Webner D, Huffman GR, Sennett BJ. (2007)** | **Modified Downs and Black Checklist: 17/29** | **II** | **Retrospective Cohort** |
| **Bowers AL, Dines JS, Dines DM, Altchek DW. (2010).** | **Modified Downs and Black Checklist: 11/17** | **IV** | **Case Series** |
| **Cain EL, Andrews JR, Dugas JR, et al. (2010).** | **Modified Downs and Black Checklist: 14/29** | **IV** | **Case Series** |
| **Paletta GA,**[**Wright RW**](http://www.ncbi.nlm.nih.gov/pubmed/?term=Wright%20RW%5BAuthor%5D&cauthor=true&cauthor_uid=16832125)**. (2006)** | **Modified Downs and Black Checklist: 12/29** | **IV** | **Case Series** |
| [**Erickson BJ**](http://www.ncbi.nlm.nih.gov/pubmed/?term=Erickson%20BJ%5BAuthor%5D&cauthor=true&cauthor_uid=26862538)**,**[**Bach BR Jr**](http://www.ncbi.nlm.nih.gov/pubmed/?term=Bach%20BR%20Jr%5BAuthor%5D&cauthor=true&cauthor_uid=26862538)**,**[**Cohen MS**](http://www.ncbi.nlm.nih.gov/pubmed/?term=Cohen%20MS%5BAuthor%5D&cauthor=true&cauthor_uid=26862538)**,**[**Bush-Joseph CA**](http://www.ncbi.nlm.nih.gov/pubmed/?term=Bush-Joseph%20CA%5BAuthor%5D&cauthor=true&cauthor_uid=26862538)**,**[**Cole BJ**](http://www.ncbi.nlm.nih.gov/pubmed/?term=Cole%20BJ%5BAuthor%5D&cauthor=true&cauthor_uid=26862538)**, [Verma NN](http://www.ncbi.nlm.nih.gov/pubmed/?term=Verma%20NN%5BAuthor%5D&cauthor=true&cauthor_uid=26862538),**[**Nicholson GP**](http://www.ncbi.nlm.nih.gov/pubmed/?term=Nicholson%20GP%5BAuthor%5D&cauthor=true&cauthor_uid=26862538)**,**[**Romeo AA**](http://www.ncbi.nlm.nih.gov/pubmed/?term=Romeo%20AA%5BAuthor%5D&cauthor=true&cauthor_uid=26862538)**. (2016)** | **Modified Downs and Black Checklist: 13/29** | **IV** | **Case Series** |
| [**Koh JL**](http://www.ncbi.nlm.nih.gov/pubmed/?term=Koh%20JL%5BAuthor%5D&cauthor=true&cauthor_uid=17084295)**,**[**Schafer MF**](http://www.ncbi.nlm.nih.gov/pubmed/?term=Schafer%20MF%5BAuthor%5D&cauthor=true&cauthor_uid=17084295)**, [Keuter G](http://www.ncbi.nlm.nih.gov/pubmed/?term=Keuter%20G%5BAuthor%5D&cauthor=true&cauthor_uid=17084295),**[**Hsu JE**](http://www.ncbi.nlm.nih.gov/pubmed/?term=Hsu%20JE%5BAuthor%5D&cauthor=true&cauthor_uid=17084295)**. (2006)** | **Modified Downs and Black Checklist: 12/29** | **IV** | **Case Series** |
| [**Erickson BJ**](http://www.ncbi.nlm.nih.gov/pubmed/?term=Erickson%20BJ%5BAuthor%5D&cauthor=true&cauthor_uid=24352622)**,**[**Gupta AK**](http://www.ncbi.nlm.nih.gov/pubmed/?term=Gupta%20AK%5BAuthor%5D&cauthor=true&cauthor_uid=24352622)**,**[**Harris JD**](http://www.ncbi.nlm.nih.gov/pubmed/?term=Harris%20JD%5BAuthor%5D&cauthor=true&cauthor_uid=24352622)**,**[**Bush-Joseph C**](http://www.ncbi.nlm.nih.gov/pubmed/?term=Bush-Joseph%20C%5BAuthor%5D&cauthor=true&cauthor_uid=24352622)**,**[**Bach BR**](http://www.ncbi.nlm.nih.gov/pubmed/?term=Bach%20BR%5BAuthor%5D&cauthor=true&cauthor_uid=24352622)**,**[**Abrams GD**](http://www.ncbi.nlm.nih.gov/pubmed/?term=Abrams%20GD%5BAuthor%5D&cauthor=true&cauthor_uid=24352622)**,**[**San Juan AM**](http://www.ncbi.nlm.nih.gov/pubmed/?term=San%20Juan%20AM%5BAuthor%5D&cauthor=true&cauthor_uid=24352622)**,**[**Cole BJ**](http://www.ncbi.nlm.nih.gov/pubmed/?term=Cole%20BJ%5BAuthor%5D&cauthor=true&cauthor_uid=24352622)**,**[**Romeo AA**](http://www.ncbi.nlm.nih.gov/pubmed/?term=Romeo%20AA%5BAuthor%5D&cauthor=true&cauthor_uid=24352622)**. (2014)** | **Modified Downs and Black Checklist: 16/29** | **III** | **Retrospective Cohort** |
| [**Wymore L**](http://www.ncbi.nlm.nih.gov/pubmed/?term=Wymore%20L%5BAuthor%5D&cauthor=true&cauthor_uid=27519677)**,**[**Chin P**](http://www.ncbi.nlm.nih.gov/pubmed/?term=Chin%20P%5BAuthor%5D&cauthor=true&cauthor_uid=27519677)**,**[**Geary C**](http://www.ncbi.nlm.nih.gov/pubmed/?term=Geary%20C%5BAuthor%5D&cauthor=true&cauthor_uid=27519677)**, [Carolan G](http://www.ncbi.nlm.nih.gov/pubmed/?term=Carolan%20G%5BAuthor%5D&cauthor=true&cauthor_uid=27519677),**[**Keefe D**](http://www.ncbi.nlm.nih.gov/pubmed/?term=Keefe%20D%5BAuthor%5D&cauthor=true&cauthor_uid=27519677)**, [Hoenecke H](http://www.ncbi.nlm.nih.gov/pubmed/?term=Hoenecke%20H%5BAuthor%5D&cauthor=true&cauthor_uid=27519677), [Fronek J](http://www.ncbi.nlm.nih.gov/pubmed/?term=Fronek%20J%5BAuthor%5D&cauthor=true&cauthor_uid=27519677). (2014)** | **Modified Downs and Black Checklist: 17/29** | **III** | **Retrospective Cohort** |
| [**Watson JN**](http://www.ncbi.nlm.nih.gov/pubmed/?term=Watson%20JN%5BAuthor%5D&cauthor=true&cauthor_uid=24220014)**,**[**McQueen P**](http://www.ncbi.nlm.nih.gov/pubmed/?term=McQueen%20P%5BAuthor%5D&cauthor=true&cauthor_uid=24220014)**,**[**Hutchinson MR**](http://www.ncbi.nlm.nih.gov/pubmed/?term=Hutchinson%20MR%5BAuthor%5D&cauthor=true&cauthor_uid=24220014)**. (2014)** | **AMSTAR: 6/11** | **I** | **Systematic Review** |
| [**Vitale MA**](http://www.ncbi.nlm.nih.gov/pubmed/?term=Vitale%20MA%5BAuthor%5D&cauthor=true&cauthor_uid=18490476)**,**[**Ahmad CS**](http://www.ncbi.nlm.nih.gov/pubmed/?term=Ahmad%20CS%5BAuthor%5D&cauthor=true&cauthor_uid=18490476)**. (2008)** | **AMSTAR: 4/11** | **I** | **Systematic Review** |

**BEST EVIDENCE**

The following 3 studies were identified as the ‘best’ evidence and selected for critical appraisal. Reasons for selecting these studies were:

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| * Wymore L, Chin P, Geary C, et al. Performance and Injury Characteristics of Pitchers Entering the Major League Baseball Draft After Ulnar Collateral Ligament Reconstruction. *Am J Sports Med*. August 2016. doi:10.1177/0363546516659305
* 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*. 2014;42(3):536-543. doi:10.1177/0363546513510890.
* Gibson BW, Webner D, Huffman GR, Sennett BJ. Ulnar collateral ligament reconstruction in major league baseball pitchers. *Am J Sports Med*. 2007;35(4):575-581. doi:10.1177/0363546506296737
* These three articles were selected because they were the only three studies that assessed pitching performance (average velocity, peak velocity, innings pitched, games played, games started, innings per game, ERA, WHIP, wins, winning percentages, losses, saves, batters faced, and innings pitched per year, as well as hits, runs, home runs allowed, strikeouts, batters walked, and batters struck per inning) in MLB baseball pitchers following UCL reconstruction via Tommy Johns Surgery or the Docking Procedure. Aside from the two low-quality systematic reviews, these three studies also have the highest level of evidence because they are cohort studies. Currently, randomized controlled trials do not exist on this topic, and a majority of the remaining studies are level IV case series studies.
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**SUMMARY OF BEST EVIDENCE**

**(1) Description and appraisal of Performance and Injury Characteristics of Pitchers Entering the Major League Baseball Draft After Ulnar Collateral Ligament Reconstruction by Wymore L, Chin P, Geary C, Carolan G, Keefe D, Hoenecke H, Fronek J; 2016.**

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| **Aim/Objective of the Study/Systematic Review:** |
| The primary objective of the study was to assess, within a cohort of MLB pitchers who underwent UCL reconstruction surgery during their amateur years, their professional advancement, pitching performance, and injury rate compared with age-matched, height-matched, weight-matched, handedness-matched, and position-matched controls from the MLB draft that did not undergo UCL reconstruction prior to the draft.  |
| **Study Design**[e.g., systematic review, cohort, randomised controlled trial, qualitative study, grounded theory. Includes information about study characteristics such as blinding and allocation concealment. When were outcomes measured, if relevant]Note: For systematic review, use headings ‘search strategy’, ‘selection criteria’, ‘methods’ etc. For qualitative studies, identify data collection/analyses methods. |
| * A quantitative, retrospective, quasi-experimental, case-control cohort study
* The researchers obtained permission from the MLB Medical Committee and approval by the Scripps Clinic Institutional Review Board prior to study initiation.
* 3 control pitchers were selected for each study pitcher. The control pitchers were matched for age, height, and handedness as the injured pitcher, and they were drafted within 30 picks of the study pitcher.
* Post-draft data was collected in 2014 (follow-up of 4 to 8 years). No specific time-points were provided.
* Statistical Analyses:
	+ Were all performed using the SPSS version 12.
	+ Findings were summarized using means and frequencies.
	+ Chi-square tests (categorical data) and independent-samples *t* tests (continuous data) were utilized to compare groups on performance statistics and injury rates.
	+ Continuous variables with non-normal distributions required the use of Mann-Whitney U tests.
	+ Significance was set to less than 0.05.
 |
| **Setting**[e.g., locations such as hospital, community; rural; metropolitan; country] |
| Not specified. No information is given regarding the specific location of each pitcher’s surgery and rehabilitation. |
| **Participants**[N, diagnosis, eligibility criteria, how recruited, type of sample (e.g., purposive, random), key demographics such as mean age, gender, duration of illness/disease, and if groups in an RCT were comparable at baseline on key demographic variables; number of dropouts if relevant, number available for follow-up]Note: This is not a list of the inclusion and exclusion criteria. This is a description of the actual sample that participated in the study. You can find this descriptive information in the text and tables in the article. |
| * A purposive sample of 38 professional baseball players were identified in the MLB drafts between 2006 and 2010 that had undergone UCL reconstruction during their amateur baseball careers.
* No information regarding potential exclusion of professional pitchers in the MLB draft during this time period was provided.
* N = 152 professional pitchers
	+ 38 = UCL reconstruction group
	+ 114 = control group
* Demographics – there were no statistically significant differences between the UCL reconstruction group and the control group regarding age (P=0.050) and height (P=0.612) at the time of the MLB draft. The researchers claim the controls also matched the study pitchers in weight (with a set range of a ten pound weight limit); however, there was a statistically significant difference in weight between the two groups at the time of the MLB draft (P=0.046). The pitchers in the UCL reconstruction group were approximately six pounds heavier than their respective control pitchers.
	+ UCL reconstruction group (mean ± SD)
		- Age in years: 21.8 ± 1.2
		- Height in inches: 74.5 ± 2.3
		- Weight in pounds: 209.6 ± 18.3
	+ Control group (mean ± SD)
		- Age in years: 21.4 ± 1.3
		- Height in inches: 74.3 ± 2.0
		- Weight in pounds: 203.5 ± 15.7
* Amateur level at time of draft – a majority of the included pitchers attended a 4-year college prior to the draft.
	+ UCL reconstruction group
		- 4-year college = 30 pitchers (19.7% of sample)
		- Junior college = 5 pitchers (3.3% of sample)
		- High school = 3 pitchers (2.0% of sample)
	+ Control group
		- 4-year college = 90 pitchers (59.2% of sample)
		- Junior college = 15 pitchers (9.9% of sample)
		- High school = 9 pitchers (5.9% of sample)
* Position
	+ UCL reconstruction group
		- Starting pitchers = 6
		- Relieving pitchers = 3
		- Pitchers with multiple designations = 29
	+ Control group
		- Starting pitchers = 17
		- Relieving pitchers = 12
		- Pitchers with multiple designations = 85
* Do to the retrospective design the number of drop-outs and loss to follow-up were not applicable
 |
| **Intervention Investigated**[Provide details of methods, who provided treatment, when and where, how many hours of treatment provided] |
| *Control* |
| There was no control intervention; however, a group of age-matched, position-matched, height-matched, and handedness-matched pitchers that did not have a history of UCL reconstruction were studied as a comparison. |
| *Experimental* |
| The intervention group included baseball pitchers that had undergone UCL reconstruction prior to being drafted into the MLB between 2006 and 2010. No information was given regarding each pitcher’s providing physician/surgeon, surgical location, specific surgical technique, and postoperative rehabilitation. |
| **Outcome Measures** (Primary and Secondary)[Give details of each measure, maximum possible score and range for each measure, administered by whom, where] |
| **Primary Outcomes** * Professional advancement – they determined the highest level of play obtained by each pitcher (Rookie, A, AA, AAA, and MLB) and used this data to calculate and compare the average professional advancement for the entire UCL reconstruction group to that of the control group. They also used this information to calculate and compare the number of people that advanced to each level of play.
* Relative risk of injury – they calculated the number of pitchers placed on the disabled list (DL), the median value and range for the number of days spent on the DL, the number of pitchers placed on the DL secondary to elbow injury, and the number of pitchers that had a UCL tear or re-tear. They calculated these measures for both groups, and then compared the groups using significance testing.
* Pitching performance statistics
	+ Statistics collected and analysed included total innings pitched, games pitched, games started, innings pitched per game, earned run average (ERA), and walks and hits per innings pitched (WHIP) over the pitcher’s career. They also assessed the average number of hits allowed, runs allowed, home runs allowed, strikeouts, walks, and struck batters per inning. The following performance statistics were also assessed per year: average number of games pitched, games started, wins, losses, saves, batters faced, and innings pitched. Amateur and professional maximum pitch velocity in miles per hour were also analysed. They compared all of these values between groups using significance testing.

**Secondary Outcome*** None

No information was provided regarding who specifically performed the outcome measure calculations |
| **Main Findings**[Provide summary of mean scores/mean differences/treatment effect, 95% confidence intervals and p-values etc., where provided; you may calculate your own values if necessary/applicable] |
| **Highest Professional Level Achieved** – there was no statistically significant difference when calculating the average professional advancement for the entire UCL reconstruction group based on the highest level of play obtained by each player and comparing that to that of the control group (0.723). There was also no statistically significant difference regarding the number of people that advance to each level of play. * P-values for comparing professional advancement between the UCL reconstruction group and the control group at each baseball level of play
	+ Rookie = 0.406
	+ A = 0.834
	+ AA = 0.905
	+ AAA = 0.579
	+ MLB = 0.295

**Relative Risk of Injury** – there was a statistically significant difference between the UCL reconstruction group and the control group regarding their relative risk of injury, but there was no statistically significant difference between groups regarding the number of days spent on the DL, the number of pitchers on the DL secondary to elbow injuries, and the number of pitchers that sustain a UCL tear or re-tear.* P-values for comparing relative risk of injury between the UCL reconstruction group and the control group at each baseball level of play
	+ Number of pitchers on the DL = **0.008**
	+ Number of days on the DL = 0.316
	+ Number of pitchers on the DL secondary to elbow related injuries = 0.877
	+ Number of pitchers that sustained a UCL tear or re-tear = 0.425

**Pitching Performance Statistics** – there were no statistically significant differences between the UCL reconstruction group and the control group in any of the pitching performance statistics with the exception of the number of home runs allowed per inning (0.022). The control group allowed 0.01 more home runs per inning compared to the UCL reconstruction group. * P-values for comparing pitching performance statistics between the UCL reconstruction group and the control group at each baseball level of play
	+ Career Performance Measures
		- Innings pitched = 0.412
		- Games pitched = 0.836
		- Games started = 0.359
		- Innings pitched per game = 0.114
		- ERA = 0.442
		- WHIP = 0.137
	+ Performance Statistics per Inning
		- Hits = 0.511
		- Runs = 0.432
		- Home runs allowed = **0.022**
		- Strikeouts = 0.563
		- Walks = 0.066
		- Struck Batters = 0.189
	+ Performance Statistics per Year
		- Games pitched = 0.907
		- Wins = 0.136
		- Losses = 0.117
		- Saves = 0.943
		- Batters faced = 0.101
		- Innings pitched= 0.98
 |
| **Original Authors’ Conclusions**[Paraphrase as required. If providing a direct quote, add page number] |
| * The authors concluded that pitchers with a history of UCL reconstruction prior to the MLB draft can advance through the minor league ranks with roughly the same success as age-matched, height-matched, weight-matched and handedness-matched pitchers with no previous history of UCL reconstruction.
* They also found that pitchers with a prior UCL reconstruction had a greater risk of being assigned to the DL compared to the control group; however, they were not at risk for spending more time on the DL or having an increased number of elbow related injuries compared to matched controls.
* Based on the findings, UCL reconstruction during amateur baseball does not negatively affect pitching performance statistics per inning, per year, and over the course of a pitcher’s professional baseball career compared to matched control pitchers.
* The authors recommended extreme caution when attempting to generalize these results to all amateur baseball pitchers rather than baseball pitchers entering the MLB draft because the study sample was not representative of all amateur pitchers.
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| **Critical Appraisal** |
| **Validity**[Identify the strengths and limitations of the study, including potential sources of bias. Comment on the overall methodological quality (including the score) as you determined from your assessment of the article. Comment on anything you believe was missing in the paper.] |
| **Modified Downs and Black Checklist** – This measure contains 27 items that are divided amongst 5 subscales: reporting (10 items), external validity (3 items), bias (7 items), confounding (6 items), and power (1 item). All items are scored with either a 0 or 1, except for two items, one in the reporting subscale and power, which are scored on a 0 to 2 scale. The maximum possible score is 29.* Total Score: 17/29

**Limitations:*** Due to the retrospective study design, participants and researchers were not blinded to the intervention, and no information was given regarding attempts to blind those measuring the outcome measures so there was the potential for bias.
* No information was provided regarding intervention specifics (i.e. surgeon, surgical technique, intervention location, rehabilitation protocols, rehabilitation location, and rehabilitation compliance) so it is impossible to assess whether or not differences in treatment protocols existed, whether procedures were typical, and whether or not these potential differences may have served as confounding variables in the study. Thus, generalization of the results to all drafted MLB baseball players that have UCL reconstruction during their amateur years should be done with caution. Also, the study only included pitchers that were drafted into the MLB, so generalization of the results to all amateur baseball players that undergo UCL reconstruction should also be done with extreme caution.
* It is unclear whether or not all follow-up times were consistent between pitchers in the intervention group and their respective controls. Although pitchers with prior UCL reconstructions and their control pitchers were selected during the safe draft year, differences in career longevity between groups can affect follow-up times, which in turn can affect the overall career performance statistics, performance statistics per inning, performance statistics per year, and risk of future injury of each group. Whether or not this effect is statistically significant is unknown.
* As the authors stated, the follow-up time period of 4-8 years may also not be of sufficient duration to capture players that advanced to a higher level of play over a longer period of time.
* A repeat study on a new set of subjects that match the original inclusion and exclusion criteria of the study was not performed to evaluate the consistency of the intervention’s effect; however, the authors did recommend future analyses on pitching performance variables and the risk of injury following UCL reconstruction to further elucidate the effects of this procedure considering their results differed in some respects from those of a prior study that looked at similar outcome measures following UCL reconstruction.
* They provided estimations of random variability in each outcome measure via ranges rather than standard deviation so we do not have any information regarding the average absolute distance of every individual score from the mean, nor were we provided a mean value. The authors only gave the median value for each outcome measure in both groups.
* No power analyses were performed to detect the necessary small sample size needed to reduce the risk of type II error. Thus, the sample size may be too small to detect significant differences between groups.
* I agree with the authors that the number of players on the DL, the number of days spent on the DL, and the number of pitchers on the DL secondary to elbow related injuries are not ideal measures of the risk of injury following UCL reconstruction because these statistics do not provide information regarding the magnitude of injury or the cause of injury. Thus, it is impossible to truly compare the severity of injuries between groups and it is impossible to determine whether or not the injuries that occurred in the UCL reconstruction group were attributed to post-operative UCL complications. That being said, the authors used the same outcome measures for assessing risk of injury in both groups, which should minimize the effects this has on their results and conclusions.
* Pitchers may have been downgraded in the draft due to a history of UCL reconstruction despite performance statistics and talent indicating a higher level of play resulting in different pitching performance statistics between groups at baseline. As the authors stated, draft grades are both multifactorial and subjective so there is no way to determine how much the pitcher’s surgical history may have affected their placement in the draft (rookie, A, AA, AAA, and MLB). Pitchers who were initially downgraded may have attained their highest level of play earlier on and may have appeared to have a greater professional advancement compared to their matched control. It is unclear how statistically significant the effects of downgrading pitchers are on the overall results and conclusions of the study.
* Although the authors reported probability values for the main outcomes, in addition to the group median and range for each outcome measure, the raw data for each individual player was not included so it is not possible to check the accuracy of their math/results.

**Strengths:*** The authors provided enough detail regarding data collection methods and outcome measures that the study can easily be replicated in the future.
* The inclusion criteria, exclusion criteria, hypotheses, outcome measures, and p-value were clearly defined and established prior to data collection and assessment, which would indicate that the authors did not perform any data-dredging that would increase the risk of bias.
* They selected subjects for the intervention group and control group from the same population and over the same time period, which helps to improve the internal validity of the study.
* The use of matched controls minimizes the risk of confounding variables at baseline between groups that could potentially effect outcomes of the study.
* Due to the retrospective nature of the study, subject attrition and lost to follow-up was not a concern.
* The statistical tests they used to assess the main outcomes were appropriate for the types of data collected.
* They discussed potential strengths and limitations of the study
* Additional strengths as determined by the authors: (1) inclusion of pitchers from the MLB draft that had UCL reconstruction prior to the draft eliminated selection bias; (2) the use of three controls per every UCL reconstruction pitcher provided more data for comparisons between groups; (3) the use of the same performance statistics as other studies means the results and analyses can be used to expand current knowledge on this topic; (4) it is the first study to assess the effects of UCL reconstruction during amateur years on the professional advancement of baseball players in the MLB.
 |
| **Interpretation of Results**[This is YOUR interpretation of the results taking into consideration the strengths and limitations as you discussed above. Please comment on clinical significance of effect size / study findings. Describe in your own words what the results mean.] |
| Due to a lack of detailed information regarding the surgical interventions and postop protocols, we do not know the specific effects that each UCL reconstruction technique has on pitcher outcomes in the MLB. For example, it is unclear how many subjects underwent Tommy John Surgery, the Modified Jobe technique, the Docking technique, or a slightly modified version of one of the three surgical techniques just mentioned. If one procedure had significantly better outcomes than the others and a majority of subjects had that specific reconstruction technique, then the results may be skewed and the median value may be significantly higher than the true average for each specific reconstruction technique. Thus, although there appeared to be no statistically significant difference between groups for a majority of the outcome measures, it would not be accurate to assume that pitchers that underwent the other surgical techniques would have similar professional advancement, relative risk of injury, and pitching performance statistics as their age-matched controls. The lack of a priori power analyses to determine the necessary number of subjects in order to detect a statistically significant difference between groups, and the relatively short follow-up time period compared to some MLB careers further reduces the clinical significance of the results. We cannot assume that the sample size was appropriate, nor can be conclude that the duration of follow-up was sufficient to detect statistically significant changes. Also, unidentified differences in career longevity between groups may have resulted in different follow-up times over the 4-8 year data collection period, which in turn may have affected the overall career performance statistics, performance statistics per inning, performance statistics per year, and risk of future injury of each group. As previously mentioned, whether or not this effect is statistically significant is unknown. It is also unclear how statistically significant the effects of downgrading UCL reconstruction pitchers in the draft may be on the overall results. As mentioned, pitchers who were initially downgraded may have attained their highest level of play earlier on, and they may have appeared to have a greater professional advancement compared to their matched control. While the results indicate that UCL reconstruction is not a career ending procedure, they are currently inconclusive regarding the effects UCL reconstruction has on professional advancement, pitching performance, and risk of injury in professional baseball pitchers compared to matched control pitchers. Due to the large number of limitations and unknowns, generalization of the results to all drafted MLB baseball pitchers that have UCL reconstruction during their amateur years should be done with caution. Also, the study only included pitchers that were drafted into the MLB, so generalization of the results to all amateur baseball pitchers that undergo UCL reconstruction should be done with extreme caution. That being said, this was the first paper to assess professional advancement through the MLB following UCL reconstruction during the years of amateur play so study limitations and potential improvements are expected. This study serves as an excellent building block for future research on this topic so we can hopefully develop more clinically meaningful results to apply to future patients contemplating UCL reconstruction. Repeat studies on a new set of subjects that match the original inclusion and exclusion criteria and that also addresses the limitations in the current study will help evaluate the consistency of the intervention’s effect.  |

**(2) Description and appraisal of Rate of Return to Pitching and Performance After Tommy John Surgery in Major League Baseball Pitchers by Erickson BJ, Gupta AK, Harris JD, Bush-Joseph C, Bach BR, Abrams GD, San Juan AM, Cole BJ, Romeo AA; 2014.**

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| **Aim/Objective of the Study/Systematic Review:** |
| The primary objectives of the study were to determine (1) the rate of return to pitching (RTP) in the MLB following UCL reconstruction, (2) the rate of RTP in the MLB and minor leagues combined following UCL reconstruction, (3) pitching performance following RTP after UCL reconstruction; and (4) the difference in RTP rate and pitching performance statistics between pitchers that underwent UCL reconstruction and matched controls without a history of UCL reconstruction. |
| **Study Design**[e.g., systematic review, cohort, randomised controlled trial, qualitative study, grounded theory. Includes information about study characteristics such as blinding and allocation concealment. When were outcomes measured, if relevant]Note: For systematic review, use headings ‘search strategy’, ‘selection criteria’, ‘methods’ etc. For qualitative studies, identify data collection/analyses methods. |
| * A quantitative, retrospective, quasi-experimental, case-control cohort study
* RTP was defined as pitching in at least 1 MLB game following UCL reconstruction. Players that RTP following surgery were included in the statistical analyses of pitching performance prior to injury and post-reconstruction.
* Control pitchers were matched to the injured pitchers for sex, age, body mass index (BMI), years of experience in the MLB, pitching performance in the MLB, year of injury, pitching position, and handedness. An “index year” was developed for controls, which was analogous to the UCL reconstruction year for the injured players so that injured pitchers and their matched controls pitched the same number of years prior to surgery/index year.
* In game performance data was collected and analysed for every injured player and their matched controls for 3 individual season before and after the surgical/index year. No specific time points for data collection were provided.
* Statistical Analyses:
	+ All statistical analyses were performed using the PASW Statistics Student Version 18.0.0.
	+ Paired-sample student *t* tests (continuous data) were utilized to perform single-variable analyses within groups of normally distributed data. Normality of the data was confirmed with one-sample Kologorov-Sirnov goodness-for-fit tests.
	+ Number of wins, losses, completed games, shutouts, and saves were normalized to the number of games played per season.
	+ Number of strikeouts, walks, hits given up, runs given up, and home runs given up were normalized to the number of innings pitched per season.
	+ Linear regression was used to identify any significant increase in the incidence of UCL tears each year.
	+ P-values were used to compare groups on length of MLB career, mean scores of individual pitching performance statistics for all years of MLB play prior to and following reconstruction year/index year, and mean scores on individual pitching performance statistics for each individual year before and after reconstruction year/index year (up to 3 years).
	+ Significance was set to less than 0.05.
 |
| **Setting**[e.g., locations such as hospital, community; rural; metropolitan; country] |
| Not specified. No information is given regarding the specific location of each pitcher’s surgery and rehabilitation. |
| **Participants**[N, diagnosis, eligibility criteria, how recruited, type of sample (e.g., purposive, random), key demographics such as mean age, gender, duration of illness/disease, and if groups in an RCT were comparable at baseline on key demographic variables; number of dropouts if relevant, number available for follow-up]Note: This is not a list of the inclusion and exclusion criteria. This is a description of the actual sample that participated in the study. You can find this descriptive information in the text and tables in the article. |
| * A purposive sample of 179 professional baseball pitchers were identified from the MLB that had undergone UCL reconstruction and met the inclusion criteria.
* 2 orthopaedic specialists conducted a search for MLB pitchers that underwent UCL reconstruction using MLB team websites and internet-based injury reports from public websites. Researchers used the MLB database to cross-reference the players’ profiles, biographies, press releases, and other pitcher information with the publicly available information in order to improve information accuracy.
* Subjects were included if they were male baseball pitchers that pitched in at least 1 MLB game after being drafted or prior to UCL tear, and that had a history of UCL reconstruction with a minimum follow-up of 18 months. Pitchers that underwent UCL revision surgery were also included, but they were only counted once.
* Collegiate pitchers, pitchers that never pitched in the MLB, and non-pitcher players were excluded.
* N = 358 MLB pitchers
	+ 179 = UCL reconstruction group
	+ 179 = Control group
* Demographics – there were no statistically significant differences between the UCL reconstruction group and the control group before UCL reconstruction and the index year for age at time of injury/index year; BMI; handedness; pitching position (starter, middle reliever, closer); year of surgery/index year; seasons of MLB experience; seasons of MLB experience prior to reconstruction/index year; and 25 different pitching performance statistics
* Do to the retrospective design the number of drop-outs and loss to follow-up were not applicable
 |
| **Intervention Investigated**[Provide details of methods, who provided treatment, when and where, how many hours of treatment provided] |
| *Control* |
| There was no control intervention; however, a group of MLB pitchers that were matched to the injured pitchers were studied as a comparison. |
| *Experimental* |
| The intervention group included MLB baseball pitchers with a history of UCL reconstruction and possible UCL revision surgery with a minimum follow-up of 18 months. No information was given regarding each pitcher’s providing physician/surgeon, surgical location, specific surgical technique, and postoperative rehabilitation. |
| **Outcome Measures** (Primary and Secondary)[Give details of each measure, maximum possible score and range for each measure, administered by whom, where] |
| **Primary Outcome:*** Rate of RTP in the MLB following UCL reconstruction - number of pitchers that pitch in at least 1 MLB game
	+ Maximum possible score = 100% (179 pitchers)
	+ Minimum possible score = 0% (0 pitchers)
* Rate of RTP in the MLB and minor leagues combined following UCL reconstruction - number of pitchers that pitch in at least 1 MLB game and 1 minor league game
	+ Maximum possible score = 100% (179 pitchers)
	+ Minimum possible score = 0% (0 pitchers)
* Pitching performance following RTP after UCL reconstruction
	+ Statistics collected and analysed before and after UCL reconstruction included innings pitched per game; innings pitched per season; games played per season; wins per season; wins (normalized to number of games played); losses per season; losses (normalized to number of games played); ERA per season; complete games per season; complete games (normalized to number of games played); shutouts per season; shutouts (normalized to number of games played); saves per season; saves (normalized to number of games played); hits given up per season; hits given up (normalized to number of innings pitched); runs given up per season; runs given up (normalized to number of innings pitched); home runs given up per season; home runs given up (normalized to number of innings pitched); walks given up per season; walks given up (normalized to number of innings pitched); strikeouts per season; strikeouts (normalized to number of innings pitched); and WHIP per season. They used significance testing to compare performance on these measures before and after UCL reconstruction.
* The difference in RTP rate and pitching performance statistics between pitchers that underwent UCL reconstruction and matched controls without a history of UCL reconstruction – they used significance testing to compare the two groups on the number of seasons played in the MLB after surgery/index year; total innings pitched after surgery/index year; total games played after surgery/index year; total wins after surgery/index year; total losses after surgery/index year; and the 25 pitching performance statistics listed above.

**Secondary Outcome*** Average length of time until pitchers returned to the MLB following UCL reconstruction – measured in months using the mean and standard deviation
* Pitching performance of the matched controls following the index year – the researchers used significance testing to compare pitching performance before and after the index year using the measures listed above that were used to compare pitching performance before and after UCL reconstruction.
* Is there a significant increase in the number of UCL reconstructions performed on MLB pitchers from 1986-2012?

No information was provided regarding who specifically performed the outcome measure calculations |
| **Main Findings**[Provide summary of mean scores/mean differences/treatment effect, 95% confidence intervals and p-values etc., where provided; you may calculate your own values if necessary/applicable] |
| **Primary Outcomes*** **Rate of RTP in the MLB following UCL reconstruction** = 83% (148 pitchers)
* **Rate of RTP in the MLB and minor leagues combined following UCL reconstruction** = 97.2% (174 pitchers)
* **No RTP in the MLB or minor league** = 2.8% (5 pitchers)
* **Pitching performance following RTP after UCL reconstruction –** there were statistically significant differences in the following pitching performance statistics between pre and post UCL reconstruction. Black bolded p-values indicate that the performance value was better before reconstruction, and blue bolded p-values indicate that the performance value was better after reconstruction.
	+ Innings pitched per game: **P-value =** **0.011**
	+ Innings pitched per season: **P-value =** **0.001**
	+ Wins per season: **P-value =** **0.003**
	+ Wins normalized to number of games played: **P-value =** **0.21**
	+ Losses per season: **P-value =** **<0.001**
	+ Losses normalized to number of games played: **P-value =** **0.001**
	+ ERA per season: **P-value =** **<0.001**
	+ Complete games per season: **P-value =** **0.001**
	+ Complete games normalized to number of games played: **P-value =** **<0.001**
	+ Shutouts per season: **P-value = 0.009**
	+ Shutouts normalized to number of games played: **P-value = 0.004**
	+ Hits given up per season: **P-value = 0.001**
	+ Runs given up per season: **P-value = 0.002**
	+ Home runs given up per season: **P-value = 0.002**
	+ Walks given up per season: **P-value = <0.001**
	+ Strikeouts per season: **P-value = 0.004**
	+ WHIP per season: **P-value = < 0.001**
* **The difference in RTP rate and pitching performance statistics between pitchers that underwent UCL reconstruction and matched controls without a history of UCL reconstruction –** there was no statistically significant difference in RTP rate between the UCL reconstruction group and the control group following surgery/index year (P-value = 0.333); however, there were statistically significant differences in the following pitching performance statistics between the two groups following surgery/index year. The following statistics were all significantly better in the UCL reconstruction than the control group.
	+ Losses per season following surgery/index year: **P-value = 0.003**
	+ Losses after surgery/index year: **P-value = <0.001**
	+ ERA per season after surgery/index year: **P-value = <0.001**
	+ Saves after surgery/index year: **P-value = 0.40**
	+ Hits given up after surgery/index year normalized to innings pitched: **P-value = <0.001**
	+ Runs given up per season/index year: **P-value = 0.033**
	+ Home runs given up per season/index year: **P-value = 0.016**
	+ Walks given up per season after surgery/index year: **P-value = 0.081**
	+ Strikeouts after surgery/index year normalized to innings pitched: **P-value = 0.005**
	+ WHIP per season after surgery/index year: **P-value = <0.001**

**Secondary Outcome*** **Average length of time until pitchers returned to the MLB following UCL reconstruction** = 20.5 ± 9.72 months
* **Pitching performance of the matched controls following the index year -** there were statistically significant differences in the following pitching performance statistics between pre and post index year. Black bolded p-values indicate that the performance value was better before reconstruction, and blue bolded p-values indicate that the performance value was better after reconstruction.
	+ Innings pitched per game: **P-value = 0.036**
	+ Innings pitched per season: **P-value =** **0.029**
	+ Wins per season: **P-value = <0.001**
	+ Wins normalized to number of games played: **P-value = <0.001**
	+ Complete games per season: **P-value =** **0.029**
	+ Complete games normalized to number of games played: **P-value =** **0.023**
	+ Shutouts per season: **P-value = 0.022**
	+ Shutouts normalized to number of games played: **P-value = 0.027**
	+ Hits given up normalized to innings pitched: **P-value = 0.004**
	+ Runs given up normalized to number of innings pitched: **P-value = 0.002**
	+ Home runs given up normalized to the number of innings pitched: **P-value = 0.008**
	+ Walks given up per season: **P-value = 0.21**
	+ Strikeouts per season: **P-value = 0.038**
* **There was a statistically significant increase in the number of UCL reconstructions performed on MLB pitchers from 1986-2012 (P-value = <0.001).**
 |
| **Original Authors’ Conclusions**[Paraphrase as required. If providing a direct quote, add page number] |
| * The authors concluded that their hypothesis (there will be a high rate of RTP in the MLB and MLB and minor league combined following UCL reconstruction in MLB pitchers, and there will be no significant difference between the rate of RTP or pitching performance statistics between the injured pitchers and their matched controls) was partially confirmed. Although there was a high rate of RTP in the MLB and the MLB and minor league combined, the UCL reconstruction group performed significantly better on several pitching performance measures.
* The authors also concluded that MLB pitchers who undergo UCL reconstruction can have a successful and predictable return to professional baseball.
* They found that pitching performance typically declines before surgery, but improves after surgery.
* They also found a statistically significant increase in the number of UCL reconstructions performed on MLB pitchers every year.
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| **Critical Appraisal** |
| **Validity**[Identify the strengths and limitations of the study, including potential sources of bias. Comment on the overall methodological quality (including the score) as you determined from your assessment of the article. Comment on anything you believe was missing in the paper.] |
| **Modified Downs and Black Checklist** – This measure contains 27 items that are divided amongst 5 subscales: reporting (10 items), external validity (3 items), bias (7 items), confounding (6 items), and power (1 item). All items are scored with either a 0 or 1, except for two items, one in the reporting subscale and power, which are scored on a 0 to 2 scale. The maximum possible score is 29.* Total Score: 16/29

**Limitations:*** Due to the retrospective study design, participants and researchers were not blinded to the intervention, and no information was given regarding attempts to blind those measuring the outcome measures so there was the potential for bias.
* No information was provided regarding intervention specifics (i.e. surgeon, surgical technique, intervention location, rehabilitation protocols, rehabilitation location, and rehabilitation compliance) so it is impossible to assess whether or not differences in treatment protocols existed, whether procedures were typical, and whether or not these potential differences may have served as confounding variables in the study. Thus, generalization of the results to all drafted MLB baseball players that have UCL reconstruction should be done with caution. Also, the study excluded minor league pitchers, collegiate pitchers, amateur pitchers, MLB pitchers with minor UCL tears that were treated non-operatively, and other position players so generalizations of the results to these players should be done with extreme caution.
* As the authors stated, exclusion of minor league pitchers with a history of UCL reconstruction and MLB pitchers with a partial UCL tear can potentially result in selection bias.
* It is unclear whether or not all follow-up times were consistent between pitchers in the intervention group and their respective controls. Although an “index year” was developed for controls, which was analogous to the UCL reconstruction year for the injured players, differences in time-points between groups for obtaining outcome measures can affect the overall career performance statistics, performance statistics per inning, and performance statistics per year.
* The study only assessed pitching performance statistics per year for a limited number of years before and after UCL surgery so it is difficult to assess whether or not pitchers returned with different roles (starters, middle relief, closer) or different pitching styles.
* A repeat study on a new set of subjects that match the original inclusion and exclusion criteria of the study was not performed to evaluate the consistency of the intervention’s effect; however, the authors did recommend future studies that assess changes in pitching role and pitching style following UCL reconstruction.
* No priori power analysis was performed to reduce the risk of type II error. Thus, the sample size may be too small to detect significant differences between groups.
* I agree with the authors that the use of publicly available data may have introduced observer bias; however, the amount of observer bias is likely minimal considering the information obtained from the internet was cross-referenced with the MLB injury database.
* I also agree with the authors that the lack of information regarding injury severity and chronicity; potential concomitant injury; patient-reported outcomes; and clinician-measured outcomes can affect RTP performance; however, it is unclear how statistically significant the effects of these variables are on RTP performance measures.
* As the authors concluded, confounding variables unaccounted for in the study like leadership and teammate motivation can affect pitching performance measures. It is unclear how statistically significant the effects of these confounders are on the overall results and conclusions of the study.
* Although the authors reported probability values for the main outcomes, in addition to the group mean and standard deviation for each outcome measure, the raw data for each individual player was not included so it is not possible to check the accuracy of their math/results.

**Strengths*** Overall, there was no significant difference between the intervention group and the control group in demographic or performance variables before UCL reconstruction/index year.
* The rate of RTP of MLB pitchers following UCL reconstruction matches that of previous studies (83%), helping to validate the results of previous studies and adding to current knowledge on this subject.
* The authors provided enough detail regarding data collection methods and outcome measures that the study can easily be replicated in the future.
* The inclusion criteria, exclusion criteria, hypotheses, outcome measures, and p-value were clearly defined and established prior to data collection and assessment, which would indicate that the authors did not perform any data-dredging that would increase the risk of bias.
* They selected subjects for the intervention group and control group from the same population, which helps to improve the internal validity of the study.
* The use of matched controls minimizes the risk of confounding variables that could potentially effect outcomes of the study.
* Due to the retrospective nature of the study, subject attrition and lost to follow-up was not a concern.
* The use of the same performance statistics as other studies means the results and analyses can be used to expand current knowledge on this topic
* The statistical tests they used to assess the main outcomes were appropriate for the types of data collected.
* They did a great job providing rationale for a majority of the outcomes they observed.
* They provided estimations of random variability using standard deviation so readers have information regarding the average absolute distance of every individual score from the mean.
* They discussed potential strengths and limitations of the study

Additional strengths as determined by the authors include: (1) the case-control study design, in which pitchers in the intervention group were matched to controls regarding demographics and pitching performance measures; (2) the use of sports specific performance measures. |
| **Interpretation of Results**[This is YOUR interpretation of the results taking into consideration the strengths and limitations as you discussed above. Please comment on clinical significance of effect size / study findings. Describe in your own words what the results mean.] |
| The study lacks detailed information regarding the surgical interventions and postop protocols like the Wymore et al study. Thus, we do not know the specific effects that different UCL reconstruction techniques have on rate of RTP and pitching performance measures. As previously mentioned, if one procedure had significantly better outcomes than the other procedures, and a majority of subjects had that specific reconstruction technique, then the results may be skewed, and the mean value for performance measures may be significantly higher than the true average for each specific reconstruction technique. Thus, it would inaccurate to assume that all MLB pitchers that undergo UCL reconstruction will have the same successful return to pitching in the MLB as depicted in this study. The lack of an a priori power analysis to determine the number of subjects needed to detect a statistically significant difference between groups, the use of publicly available data and the potential observer bias it introduces, and the possible inconsistencies in follow-up times reduce the clinical significance of the results. Readers cannot assume that the sample size was appropriate and that observer bias was not present. Nor can they ignore differences in follow-up times because these differences can affect overall outcomes on career performance statistics, performance statistics per inning, and performance statistics per year. As previously mentioned, whether or not these effects are statistically significant is unknown. It is also unclear how unaccounted for confounding variables and the lack of information regarding injury severity and chronicity; potential concomitant injury; patient-reported outcomes; clinician-measured outcomes affect RTP performance. Unfortunately, the study design also made it difficult to assess whether or not pitchers returned with different roles (starters, middle relief, closer) or different pitching styles. This missing information is very important clinically because pitchers and coaches need to have realistic expectations regarding player returns, and they need to know if changes in pitching mechanics and training methods are warranted to improve pitcher and team success in the MLB following UCL reconstruction.Despite the limitations of the study, the results do hold some clinical significance. Based on the findings, it is evident that UCL reconstruction is not a career ending procedure. In fact, a majority of MLB pitchers have a very high rate of RTP in professional baseball. They also have similar success in regards to pitching performance outcomes. Following UCL reconstruction, most pitchers do not have significant differences in pitching performance outcomes compared to matched controls. There were only nine statistically significant differences between groups out of the twenty-five pitching performance variables assessed in the study, and all nine were better in the intervention group. In other words, therapists can tell their patients contemplating UCL reconstruction that they will likely have a successful return to pitching in the MLB following surgery; however, whether the success is associated with changes in pitching style, an excellent rehabilitation program, teammate success/motivation, or other confounding variables is unknown so future studies are warranted that assess the effect of various confounders on the rate of RTP and pitching performance following UCL reconstruction. Future studies are also needed that evaluate and compare the biomechanical performance and pitching performance following different UCL reconstruction techniques in order to fully elucidate prior results. That being said, the rate of RTP of MLB pitchers following UCL reconstruction matches that of previous studies (83%), helping to validate the results of previous studies and adding to current knowledge on this subject.Although there is some clinical significance to the results, it is important to not generalize these results to populations other than MLB pitchers because the study excluded minor league pitchers, collegiate pitchers, amateur pitchers, MLB pitchers with minor UCL tears that were treated non-operatively, and other position players. |

**(3) Description and appraisal of Ulnar collateral ligament reconstruction in major league baseball pitchers by Gibson BW, Webner D, Huffman GR, Sennett BJ; 2007.**

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| **Aim/Objective of the Study/Systematic Review:** |
| The aim of the study was to identify the results of UCL reconstruction in major league pitchers, to compare pitching performance of these pitchers before and after UCL reconstruction, to identify risk factors for undergoing this procedure, and to identify factors associated with a successful return to pitching in MLB. |
| **Study Design**[e.g., systematic review, cohort, randomised controlled trial, qualitative study, grounded theory. Includes information about study characteristics such as blinding and allocation concealment. When were outcomes measured, if relevant]Note: For systematic review, use headings ‘search strategy’, ‘selection criteria’, ‘methods’ etc. For qualitative studies, identify data collection/analyses methods. |
| * A quantitative, retrospective, quasi-experimental, case-control cohort study
* Every 5th pitcher from a complete alphabetical roster of MLB pitchers without a history of UCL reconstruction from the 2001 season was selected for comparison. The 2001 season was developed as an “index year” for controls.
* Outcome measures for both the intervention group and control group were taken for a total of 7 seasons in the MLB (3 pre-surgical/pre-index seasons, surgical year/index year, and 3 post-surgical/post-index seasons). No specific time points for data collection were provided.
* Statistical Methods:
	+ Were all performed using STATA 8.0.
	+ Findings were summarized using means and standard deviations
	+ Student t tests were used to compare demographics, MLB experience, and pitching performance measures between groups prior to surgery/index year.
	+ Paired means testing was used to analyse pre- and post-surgery/index year pitching performance measures within each group of pitchers.
	+ Handedness and pitching position (starter or relief) were compared between groups using Fisher’s exact probability test.
	+ No information was provided as to what the researchers set as the significance value.
 |
| **Setting**[e.g., locations such as hospital, community; rural; metropolitan; country] |
| Not specified. No information is given regarding the specific location of each pitcher’s surgery and rehabilitation. |
| **Participants**[N, diagnosis, eligibility criteria, how recruited, type of sample (e.g., purposive, random), key demographics such as mean age, gender, duration of illness/disease, and if groups in an RCT were comparable at baseline on key demographic variables; number of dropouts if relevant, number available for follow-up]Note: This is not a list of the inclusion and exclusion criteria. This is a description of the actual sample that participated in the study. You can find this descriptive information in the text and tables in the article. |
| * A purposive sample of 68 MLB baseball pitchers who pitched in at least one MLB game before undergoing UCL reconstruction between 1998 and 2003 were identified.
* Researchers identified MLB pitchers that underwent Tommy John Surgery for UCL tears using team injury reports, press releases, and the Standard Form of Diagnosis, which is a from used in Club Applications to place injured players on the disabled list.
* No information regarding potential exclusion of professional pitchers in the MLB draft during this time period was provided.
* N = 180 MLB pitchers
	+ 68 = UCL reconstruction group
	+ 112 = control group
* Demographics - there were no statistically significant differences between the UCL reconstruction group and the control group before UCL reconstruction and the index year regarding age (P-value = 0.26), major league experience (P-value = 0.26), height (P-value = 0.58), weight (P-value = 0.54), body mass index (0.73), and throwing handedness (P-value = 0.60). There was a statistically significant difference between the UCL reconstruction group and the control group regarding pitching position (P-value = 0.005). Only 36% of pitchers in the control group were starting pitchers, whereas 57% of pitchers in the UCL reconstruction group were starting pitchers.
	+ UCL reconstruction group
		- Age in years (mean ± SD): 28.2 ± 0.4
		- Major league experiences in seasons (mean ± SD): 5.1 ± 0.1
		- Height in meters (mean ± SD): 1.89 ± 0.03
		- Weight in kilograms (mean ± SD): 95.6 ± 1.4
		- Body mass index (mean ± SD): 26.9 ± 0.4
		- % Right-handed pitchers = 78%
		- % Starting pitchers = 57%
	+ Control group
		- Age in years (mean ± SD): 29.1 ± 0.3
		- Major league experiences in seasons (mean ± SD): 5.9 ± 0.1
		- Height in meters (mean ± SD): 1.88 ± 0.02
		- Weight in kilograms (mean ± SD): 94.7 ± 0.8
		- Body mass index (mean ± SD): 26.8 ± 0.2
		- % Right-handed pitchers = 74%
		- % Starting pitchers = 36%
* Pre-index Pitching Performance Measures – there was no statistically significant difference between groups before UCL reconstruction and the index year regarding the average number of innings pitched per season (P-value = 0.58); however, there were statistically significant differences between groups regarding mean ERA (P-value = 0.03) and mean WHIP (P-value = 0.04). The control group had a higher mean ERA and mean WHIP.
	+ UCL reconstruction group
		- Average innings pitched per season = 92.98
		- Mean ERA = 4.16
		- Mean WHIP = 1.362
	+ Control group
		- Average innings pitched per season = 87.11
		- Mean ERA = 4.37
		- Mean WHIP = 1.384
 |
| **Intervention Investigated**[Provide details of methods, who provided treatment, when and where, how many hours of treatment provided] |
| *Control* |
| There was no control intervention; however, MLB pitchers without a history of UCL reconstruction were selected from the 2001 MLB season for comparison.  |
| *Experimental* |
| The intervention group included MLB pitchers that had pitched in at least one MLB game prior to undergoing UCL reconstruction between 1998 and 2003. No information was given regarding each pitcher’s providing physician/surgeon, surgical location, specific surgical technique, and postoperative rehabilitation. |
| **Outcome Measures** (Primary and Secondary)[Give details of each measure, maximum possible score and range for each measure, administered by whom, where] |
| Outcome measures were taken for a total of 7 seasons in the MLB (3 pre-surgical/pre-index seasons, surgical year/index year, and 3 post-surgical/post-index seasons). The average for each pitching performance measure over 3 consecutive seasons prior to the surgical/index year was defined as the pitcher’s pre-index performance. The average for each pitching performance measure over 3 consecutive seasons after the surgical/index year was defined as the pitcher’s post-index performance.**Primary Outcomes*** Return to major league pitching – the authors did not define what they considered a “return to major league pitching.” They provided the number and percent of UCL reconstructed pitchers that returned to MLB pitching at different time points (surgical year, first post-index season, second post-index season, and third post-index season).
	+ Maximum possible score = 100% (179 pitchers)
	+ Minimum possible score = 0% (0 pitchers)
* Player performance – statistics collected and analysed included total innings pitched per season, mean ERA, and mean WHIP. The researchers used significance testing to compare performance on these measures within groups (between pre and post UCL reconstruction/index year) and between groups.
* Risk factors for UCL reconstruction – the researchers performed univariate analyses to calculate odds ratios, confidence intervals, and p-values so they could determine if age, major league experience, starting pitcher position, right-handedness, mean innings pitched, mean ERA, and mean WHIP were statistically significant risk factors for UCL reconstruction. An odds ratio of 1 indicates no association, whereas values >1 and <1 respectively, indicate positive and negative association of the tested variable with the outcome.
* Factors predicting successful return to MLB - the researchers performed univariate analyses to calculate odds ratios, confidence intervals, and p-values so they could determine if age, major league experience, starting pitcher position, right-handedness, mean innings pitched, mean ERA, and mean WHIP were statistically significant factors for predicting successful return to the MLB following UCL reconstruction. An odds ratio of 1 indicates no association, whereas values >1 and <1 respectively, indicate positive and negative association of the tested variable with the outcome.

**Secondary Outcomes*** None

No information was provided regarding who specifically performed the outcome measure calculations. |
| **Main Findings**[Provide summary of mean scores/mean differences/treatment effect, 95% confidence intervals and p-values etc., where provided; you may calculate your own values if necessary/applicable] |
| **Return to major league pitching** * 56 (82%) UCL reconstructed pitchers returned to the MLB pitching at a mean of 18.5 months (range, 10-49 months) after surgery.
* 0 (0%) UCL reconstructed pitchers returned to the MLB during the surgical year.
* 32 (47%) UCL reconstructed pitchers returned to MLB pitching by the first post-surgical season.
* 50 (74%) UCL reconstructed pitchers returned to MLB pitching by the second post-surgical season.
* 53 (78%) UCL reconstructed pitchers returned to MLB pitching by the third post-surgical season.
* 3 (4%) UCL reconstructed pitchers returned to MLB pitching after 3+ years following the surgical year.

**Player performance -** Pre-surgical/pre-index averages could not be obtained for 1 UCL reconstructed pitcher and 23 control pitchers that did not pitch in any MLB games prior to the surgical/index year. Post-surgical/post-index year averages could not be calculated for 12 reconstructed pitchers that failed to return to the MLB post UCL reconstruction, 3 UCL reconstructed pitchers that returned to MLB pitching more than 3 seasons after the surgical year, and 13 control pitchers that did not return to the MLB following the index year. 6 controls pitchers only played in the MLB during the index year so pre-index and post-index averages could not be calculated for these players. Significant p-values are in bold. * **Player performance within groups –** there was a statistically significant decrease in the mean number of innings pitched per season in the UCL reconstruction group after surgery **(P-value = 0.003)** and in the control group following the index year **(P-value = 0.02)**. There was no statistically significant difference in mean ERA (P-value = 0.14) or mean WHIP (P-value = 0.83) between pre- and post- surgery for the UCL reconstruction group. There was also no statistically significant difference in mean ERA (P-value = 0.47) or mean WHIP (P-value = 0.97) between pre- and post- index year for the control group.
* Player Performance:
	+ Mean innings pitched per season
		- Pre-surgical/pre-index mean for innings pitched per season
			* UCL reconstruction group = 97.10 innings per season
			* Control group = 94.73 innings pitched per season
		- Post-surgical/post-index mean for innings pitched per season
			* UCL reconstruction group = 70.17 innings per season
			* Control group = 79.29 innings per season
* **Player performance between groups –** pitching performance was compared over the course of 7 MLB seasons.
* **Mean innings pitched -** There was no statistically significant difference between the UCL reconstruction group and the control group in the mean number of innings pitched in any of the 3 pre-surgical/pre-index seasons (P-value = 0.58, P-value = 0.58, and P-value = 0.77, respectively), nor was there a statistically significant difference between groups in the mean number of innings pitched in the surgical/index year, second post-surgical/post-index season, and the third post-surgical/post-index season (P-value = 0.06, P-value = 0.71, and P-value = 0.76, respectively). There was, however, a statistically significant difference between groups in the mean number of innings pitched during the first post-surgical/post-index season **(P-value = 0.001)**. 41% of the UCL reconstructed pitchers that returned during the first post-surgical season missed more than half of the season.
	+ Mean innings pitched per season in the first post-surgical/post-index season
		- UCL reconstruction group = 44.91 innings
		- Control group = 82.98 innings
* **Mean ERA** - There was no statistically significant difference between groups in the first and second pre-surgical/pre-index season regarding mean ERA (P-value = 0.83 and P-value = 0.19, respectively), nor was there a statistically significant difference between groups in mean ERA during the surgical/index year (P-value = 0.92) and all 3 post-surgical/post-index seasons (P-value = 0.31, P-value = 0.18, and P-value = 0.69, respectively). However, the UCL reconstruction group did have a significantly better mean ERA during the third pre-surgical/pre-index seasoncompared to the control group **(P-value = 0.01).**
	+ Mean ERA during the third pre-surgical/pre-index season
		- UCL reconstruction group = 4.19
		- Control group = 4.54
* **Mean WHIP -** There was no statistically significant difference between groups during the first and second pre-surgical/pre-index seasons regarding mean WHIP (P-value = 0.89 and P-value = 0.43, respectively), nor was there a statistically significant difference between groups during the surgical/index year (P-value = 0.48) and all 3 post-surgical/post-index seasons (P-value = 0.11, P-value = 0.12, and P-value = 0.84, respectively). During the third pre-surgical/pre-index season the UCL reconstruction group had a significantly better mean WHIP than the control group **(P-value = 0.007)**.
	+ Mean WHIP during the third pre-surgical/pre-index season
		- UCL reconstruction group = 1.368
		- Control group = 1.417

**Risk factors for UCL reconstruction –** following the performance of a multivariate analysis to adjust for potential demographic and performance confounding variables, the only significant risk factor for undergoing UCL reconstruction was being a starting pitcher **(Odds ratio = 2.62, 95% CI 1.03-6.67, and P-value = 0.04).** After a backward stepwise multivariate logistic regression and exclusion of any variables that had greater than a 10% probability of an association by chance, the only significant risk factor for undergoing UCL reconstruction was being a starting pitcher **(Odds ratio = 2.45, 95% CI 1.21-4.98, P-value = 0.01).** Greater major league experience **(Odds ratio = 0.88 per year, 95% CI 0.80-0.95, and P-value = 0.002)** and a higher pre-surgical ERA **(Odds ratio = 0.76 per earned run, 95% CI 0.61-0.95, P-value = 0.02)** were associated with a significantly less risk of undergoing UCL reconstruction. **Factors predicting successful return to MLB –** following univariate analysis and performance of a multivariate analysis to adjust for potential demographic and performance confounding variables, there was no statistically significant factors predictive of a successful return to pitching in the MLB after UCL reconstruction. |
| **Original Authors’ Conclusions**[Paraphrase as required. If providing a direct quote, add page number] |
| * A majority of pitchers that undergo UCL reconstruction return to the MLB by the second season after surgery and do not have a significant decline from pre-surgical pitching performance statistics.
* Starting pitchers are at a significantly greater risk for undergoing UCL reconstruction compared to relief pitchers, which supports the concept of overuse as a risk factor for UCL injury. That being said, their return to play rate to the MLB is not statistically different from that of relief pitchers following UCL reconstruction.
* Pitchers with a better mean ERA and less major league experience are also at increased risk for UCL reconstruction.
* Age, years of major league experience, handedness, pitching position, mean number of innings pitched, mean ERA, and mean WHIP are not predictive factors for a successful return to MLB pitching following UCL reconstruction.
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| **Critical Appraisal** |
| **Validity**[Identify the strengths and limitations of the study, including potential sources of bias. Comment on the overall methodological quality (including the score) as you determined from your assessment of the article. Comment on anything you believe was missing in the paper.] |
| **Modified Downs and Black Checklist** – This measure contains 27 items that are divided amongst 5 subscales: reporting (10 items), external validity (3 items), bias (7 items), confounding (6 items), and power (1 item). All items are scored with either a 0 or 1, except for two items, one in the reporting subscale and power, which are scored on a 0 to 2 scale. The maximum possible score is 29.* Total Score: 17/29

**Limitations*** Due to retrospective study design, participants and researchers were not blinded to the intervention, and no information was given regarding attempts to blind those measuring the outcome measures so there was the potential for bias.
* No information was provided regarding intervention specifics (i.e. surgeon, surgical technique, intervention location, rehabilitation protocols, rehabilitation location, and rehabilitation compliance) so it is impossible to assess whether or not differences in treatment protocols existed, whether procedures were typical, and whether or not these potential difference may have served as confounding variables in the study. Thus, generalization of the results to all MLB baseball players that have UCL reconstruction should be done with caution. Also, the study only included MLB pitchers so generalization of the results to all minor league pitchers, collegiate pitchers, and amateur baseball pitchers that undergo UCL reconstruction should also be done with extreme caution.
* The follow-up time period of 3 years following the surgical year was not long enough to capture post-surgical averages for all UCL reconstructed pitchers. There was also incomplete data for several UCL reconstructed pitchers because they either did not pitch in any MLB games prior to UCL surgery or they failed to return to the MLB post-surgery. Data is also missing for several control pitchers.
* As the authors stated, the injury reports may not be 100% accurate and/or there may lack information regarding patient injuries so the study may not have captured ALL MLB pitchers that underwent UCL reconstruction during the study period. In other words, they cannot accurately and reliably infer the rate of return to pitching following UCL reconstruction, pitching performance after UCL surgery, and risk factors for UCL reconstruction.
* No a priori power analyses were performed to detect the necessary small sample size needed to reduce the risk of type II error. Thus, the sample size may be too small to detect significant differences between groups.
* Controls were not matched, nor were they selected form the same time period as the intervention pitchers. Thus, there was a statistically significant difference between groups regarding pitcher position prior to surgery/index year. Only 36% of pitchers in the control group were starting pitchers, whereas 57% of pitchers in the UCL reconstruction group were starting pitchers.
* Researchers did not provide significance value.
* The authors do not define what they considered a “return to major league pitching.”
* All figures were omitted from the article.
* According to the inclusion criteria study pitchers were required to pitch in at least 1 MLB game before undergoing UCL reconstruction. When assessing pitching performance outcomes post UCL reconstruction, the authors stated that they could not calculate pre-index averages for 1 reconstructed pitcher because he did not appear in any MLB games prior to surgery. In other words, they did no abide by their inclusion criteria.
* It lacked information regarding injury severity and chronicity; potential concomitant injury; patient-reported outcomes; and clinician-measured outcomes, which can affect RTP performance; however, it is unclear how statistically significant the effects of these variables are on RTP performance measures.
* Confounding variables unaccounted for in the study can affect pitching performance measures. It is unclear how statistically significant the effects of these confounders are on the overall results and conclusions of the study.
* Although the authors reported probability values for the main outcomes, in addition to the group mean and confidence intervals for each outcome measure, the raw data for each individual player was not included so it is not possible to check the accuracy of their math/results.
* A repeat study on a new set of subjects that match the original inclusion and exclusion criteria of the study was not performed to evaluate the consistency of the intervention’s effect; however, the authors did recommend future analyses on pitching performance variables and the risk of injury following UCL reconstruction to further elucidate the effects of this procedure considering their results differed in some respects from those of a prior study that looked at similar outcome measures following UCL reconstruction.

**Strengths*** This was the first study to assess UCL outcomes in exclusively MLB pitchers, and it was the first study to assess post UCL reconstruction outcomes using mean number of innings pitched, mean ERA, and mean WHIP.
* The Standard Form of Diagnosis from the Club Application for placing an injured player on the disabled list requires a signature from the team physician, club official, and MLB Commissioner. Thus, it improves the reliability of using injury reports as the primary means to identify pitchers for the study.
* As the authors said, comparing the two groups pitching performances per season better accounts for expected decline in innings pitched among UCL reconstructed pitchers during their recovery.
* The pitching performance statistics of the control group were statistically representative of the mean pitching performance statistics of all MLB pitchers that played in the 2001 MLB season.
* The rate of return to pitching in MLB pitchers following UCL reconstruction matches that of previous studies (82%), helping to validate the results of previous studies and adding to current knowledge on this subject.
* Considering a majority of pitchers do not complete a full season of MLB play after UCL reconstruction resulting in statistically fewer innings pitched, it was good the authors also assessed pitching performance outcomes post-surgery using mean ERA and mean WHIP. Unlike the mean number of innings pitched, these are both weighted outcomes so they may serve as better indicators of pitching performance in the first season post UCL reconstruction.
* The statistical tests they used to assess the main outcomes were appropriate for the types of data collected.
* They used multivariate analysis to try and minimize the effects of potential confounding variables.
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| **Interpretation of Results**[This is YOUR interpretation of the results taking into consideration the strengths and limitations as you discussed above. Please comment on clinical significance of effect size / study findings. Describe in your own words what the results mean.] |
| This was the first study to assess post UCL reconstruction outcomes in exclusively MLB pitchers, and the first study to assess post UCL reconstruction outcomes using specific pitching performance statistics; however, the poor study design severely limits the clinical significance of the results. Not only did the study lack an a priori power analysis to determine the number of subjects needed to detect a statistically significant difference between groups, but it used publicly available data, which can introduce observer bias. The study also used unmatched controls, potentially selected over a different time period than the intervention pitchers, to serve as comparisons for the UCL reconstructed pitchers, and there was incomplete and possibly inaccurate data on numerous subjects. Thus, readers cannot assume that the sample size was appropriate and that observer bias was not present. It is also inappropriate to assume that differences between groups prior to the surgical/index year did not affect pitching performance outcomes; that the researchers captured all MLB pitchers that underwent UCL reconstruction during the study period; and that the incomplete/missing data on 58 pitchers did not affect the results of the study. Whether or not these effects are statistically significant is unknown so until future research on this topic is performed, readers cannot accurately and reliably infer the rate of return to pitching following UCL reconstruction, pitching performance after UCL surgery, and risk factors for UCL reconstruction.It is also unclear how significantly confounding variables, such as changes in pitching styles following post-UCL reconstruction; surgeon experience; injury severity and chronicity; potential concomitant injury; patient-reported outcomes; and clinician-measured outcomes affect return to pitching performance. This missing information is extremely important clinically because pitchers and coaches need to have realistic expectations regarding player returns, and they need to know if changes in pitching mechanics and training methods are warranted to improve pitcher and team success in the MLB.The study also lacked detailed information regarding the surgical interventions and postop protocols. Thus, readers are unaware of the specific effects that different UCL reconstruction techniques have on rate of return to pitching in the MLB and pitching performance measures so it would be inaccurate to assume that all MLB pitchers that undergo UCL reconstruction will have the same successful return to pitching in the MLB as depicted in this study. In addition to the study design faults previously mentioned, the authors did not follow their described methods. According to the inclusion criteria study pitchers were required to pitch in at least 1 MLB game before undergoing UCL reconstruction; however, when assessing pitching performance outcomes post UCL reconstruction, the authors stated that they could not calculate pre-index averages for 1 reconstructed pitcher because he did not appear in any MLB games prior to surgery. In other words, they did no abide by their inclusion criteria. Due to this discrepancy, it would have been nice to review the raw data for each individual player and the figures depicting the results of the outcome measures in order to check the accuracy of the researchers’ math/results. Unfortunately, both the raw data and the figures were omitted. Even if they had been included, it would have been difficult to interpret the results considering the authors did not provide a significance value nor did they define what they considered a “return to major league pitching.”Overall, the results of this study have little clinical significance. Based on the findings, it is fairly safe to conclude that UCL reconstruction does not appear to be a career ending procedure for most MLB pitchers, and that overuse is a potential risk factor for future UCL reconstruction; however, the specific results regarding pitcher performance post-UCL reconstruction should be taken with a grain of salt considering the large number of study limitations. Despite the limitations, this paper serves as a building block for future studies on this topic considering no prior studies have exclusively assessed MLB pitcher performance following UCL reconstruction, nor have they used specific pitching performance statistics to assess post-surgical outcomes amongst this population. In other words, repeat studies on a new set of subjects that match the original inclusion and exclusion criteria and that also address the limitations in the current study will help evaluate the consistency of the intervention’s effects and will help develop more clinically meaningful results to apply to future patients contemplating UCL reconstruction. |

**EVIDENCE SYNTHESIS AND IMPLICATIONS**

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| Overall, there is very limited research that addresses pitching performance post UCL reconstruction via the Docking Procedure or Tommy Johns Surgery. The literature search produced a mere three studies that included professional baseball pitchers and the assessment of specific pitching performance outcomes following UCL reconstruction like average velocity, peak velocity, innings pitched, games played, games started, innings per game, ERA, WHIP, wins, winning percentages, losses, saves, batters faced, and innings pitched per year, as well as hits, runs, home runs allowed, strikeouts, batters walked, and batters struck per inning.8,9,14 All three studies lacked blinding and randomization secondary to their cohort design, limiting the results to level II and level III evidence. There was also the potential for recall bias secondary to the studies’ retrospective designs. Unfortunately, there were numerous other design flaws that reduced the clinical significance of all three studies.First off, neither the Wymore et al nor the Gibson et al studies differentiated between the Docking Procedure and Tommy John surgery.9,14 In both cases, it is unclear how many subjects underwent Tommy John Surgery, the Modified Jobe technique, the Docking technique, or a slightly modified version of one of the three surgical techniques just mentioned. If one procedure had significantly better outcomes than the others, and a majority of subjects had that specific reconstruction technique, then the results may be skewed, and the average value for pitching performance measures may be significantly better than the true average for each specific reconstruction technique. Thus, although there appeared to be no statistically significant difference between intervention pitchers and control pitchers for a majority of the outcome measures, it would not be accurate to assume that MLB pitchers that underwent the other surgical techniques would have similar pitching performance statistics as the control pitchers. Unfortunately, the Erickson et al study only assessed outcome measures following Tommy John Surgery so the results did not help to differentiate between the expected pitching performance outcomes associated with the Docking Technique compared to Tommy John Surgery.8 All three studies also lacked a priori power analyses so it would be inappropriate to assume that the sample sizes in each study were large enough to detect statistically significant differences between the intervention group and the control group. Considering that the researchers did not provide any detailed information regarding postoperative protocols or post-surgical changes in pitching position (starter, middle reliever, and closer), pitching styles (overhead, side-arm, fastball, change-up, breaking) and training methods, it would also be inappropriate to conclude that the successful return to MLB pitching without a significant decline in pitching performance following UCL reconstruction surgery, which was observed in all three studies, is not due to confounding variables like specific rehabilitation interventions, physical therapist expertise, strong adherence to a post-op protocol, intense strength training, changes in pitching mechanics, changes in pitching position, and etcetera. This missing information is extremely important clinically because pitchers and coaches need to have realistic expectations regarding player returns, and they need to know if changes in pitching mechanics, pitching position, and training methods are warranted to further improve post-surgical pitcher and team success in the MLB.Despite these limitations all three studies provided some clinically meaningful information regarding the patient case. According to all three studies, the UCL tear in the pitching arm of the 27 year old male professional baseball pitcher is unlikely to be a career ending injury. Although the Wymore et al and Gibson et al studies provide inconclusive results regarding the effects that UCL reconstruction will have on his professional advancement and pitching performance, the results of the Erickson et al study suggest that he will have a very high chance of returning to the MLB with pitching performance outcomes similar to those of matched pitchers (matched for sex, age, body mass index (BMI), years of experience in the MLB, pitching performance in the MLB, year of injury, pitching position, and handedness) without a history of UCL reconstruction. Thus, therapists can tell the patient that he will likely have a successful return to MLB pitching following surgery; however, the degree of success may be associated with surgeon experience, graft choice, UCL reconstruction technique, changes in pitching position, changes in pitching style, rehabilitation protocol, teammate success/motivation, or other confounding variables. It is important to make the patient aware that the effects of these potentially confounding variables are currently unknown, and that future research on this topic is warranted to determine their effects on post-operative pitching performance, and to help therapists and coaches make the necessary adjustments to post-surgical interventions in order to improve the player’s success in the MLB. Future studies are also needed that evaluate pitching performance following different UCL reconstruction techniques because no studies to date have differentiated between the effects of the Docking Technique and Tommy John Surgery on post-reconstruction pitching performance among MLB players. These studies need to perform a priori power analyses, and they should include information regarding post-operative protocols and changes in pitching position/styles in order to improve the clinical significance of the results.  |

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