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Epidemiology of ulnar collateral ligament reconstruction in Major and Minor League Baseball pitchers: comprehensive report of 1429 cases

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Background: The primary purpose of this work is to provide an epidemiologic report on every known ulnar collateral ligament (UCL) reconstruction performed in professional baseball with a special focus on outcomes and survivorship.
Methods: Three resources, including the Major League Baseball (MLB) injury tracking system, were combined and cross-referenced to identify all known professional baseball pitchers who had ever undergone UCL reconstruction from 1974 to 2016. Variables analyzed included injury date, surgery date, return to play rates, time out of play, and revision status. Trends over time were analyzed collectively and by level of play at the time of surgery. A minimum of 2 years of follow-up was required for return to play analysis.
Results: We identified 1429 UCL reconstructions. The annual rate of primary and revision UCL reconstructions rose significantly ($P < .001$). Most players (83.7%) returned to any level of play at a mean of 435 days, whereas 72.8% ($P < .001$) returned to their prior level at a mean of 506 days. Major League Baseball players were more likely than Minor League Baseball players to return to any level (94.6% vs. 79.0%, $P < .001$) and their prior level of performance (80.0% vs. 69.1%, $P = .04$). The mean overall survivorship free from revision and still playing was 3.8 years (3.9 for primary vs. 2.9 for revisions, $P = .018$). The revision rate was 6.7% and was higher for Major League Baseball (9.4%) vs. Minor League Baseball (5.2%, $P = .004$).
Conclusions: This study represents the most robust epidemiologic report of UCL reconstruction in baseball to date, and a multitude of novel findings are reported.
Level of evidence: Epidemiology Study; Large Database Analysis

Keywords: ulnar collateral ligament; Major League Baseball; pitchers; Minor League Baseball; professional baseball; elbow; Tommy John

That injuries are on the rise in professional baseball has been well documented, and 50% to 60% of these occur to the shoulder or elbow.[2,3,20] Recent research indicates that shoulder injuries may actually be on the decline in Major League

This study was approved by Major League Baseball, the Major League Baseball Research Committee, the Major League Baseball Players Association, and the Hospital for Special Surgery Institutional Review Board.

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Baseball (MLB); however, this decline is being met with a reciprocal increase in elbow injuries.[2]

Although a number of different types of elbow injuries occur in professional baseball players, the most significant and impactful is injury to the medial ulnar collateral ligament (UCL). Initially considered to be a career-ending injury before the introduction of UCL reconstruction surgery in 1974,[12] players undergoing UCL reconstruction in the modern era generally demonstrate return to play (RTP) rates approaching 80% to 90%.[1,6,8,11,17,18,21] This improvement in RTP rates is likely due to improved detection, surgical techniques, and postoperative rehabilitation and return to throw programs. As these injuries continue to rise and surgical techniques advance, the number of reports on UCL reconstruction in the medical literature is rapidly expanding.

To date, there are a number of robust epidemiologic studies on UCL reconstructions in pitchers.[1,4,5,9,10] These consist primarily of database reviews,[5,9,10] single-surgeon or institutional series,[1,6,7,14] or survey studies.[4] In the largest series published to date, Cain et al[1] report the outcomes of 1266 UCL reconstructions performed in a heterogeneous group of athletes at a single institution. In this report, 83% of the 743 patients with greater than 2 years of follow-up demonstrated excellent outcomes.[1]

Reviews of national[9] and state-wide[10] databases have concluded that UCL reconstruction rates are rapidly increasing annually and that this rise is most profound (as high as 9% annually) among adolescent athletes. In the most comprehensive review of UCL surgery in professional baseball (MLB and Minor League Baseball [MiLB]), Conte et al[4] surveyed more than 5000 professional baseball players and determined that approximately 10% (497 of 5088) of all professional baseball players had undergone at least 1 UCL reconstruction in the past. The prevalence of UCL reconstruction was 15% in MiLB pitchers, whereas 25% of MLB pitchers had undergone the procedure previously.[4] Another study reporting 400 UCL reconstructions performed for MLB players from 1974 to 2015 concluded that the annual incidence increased significantly ($P < .001$) from year to year and that nearly one-third of all procedures were performed in the final 5 years of the 42-year study period.[2]

Although each of these studies has contributed significantly to our understanding of the epidemiology and effect of this rapidly growing procedure, a comprehensive review of all UCL reconstructions performed on professional baseball players is lacking. Such a review is desirable given the tremendous effect of this procedure on all levels of throwing athletes. Thanks in large part to the introduction of the MLB Health and Injury Tracking System[19] and robust online databases, this is now possible. The purpose of this work was to use these resources to (1) provide a robust epidemiologic report on every known UCL reconstruction ever performed in professional baseball pitchers (primary and revision surgery), (2) determine the mean rates and times for RTP, and (3) assess postoperative career duration and overall survivorship. We also sought to compare and contrast these variables as well as primary and revision operations between MLB and MiLB players. We hypothesized that more UCL reconstructions have occurred in professional pitchers than previously thought, that these players are able to RTP at high rates, the time to RTP is longer than commonly expected, and that UCL reconstruction would demonstrate durability over time.

Materials and methods

A comprehensive search was conducted to identify all known baseball pitchers who had ever undergone UCL reconstruction while they were active on an MLB or MiLB team roster. To accomplish this, the MLB Health and Injury Tracking System database and an online search were used and cross referenced. Duplicate procedures were removed, so that each surgical intervention was only included once. All players were deidentified and assigned a random study number to maintain complete anonymity. If a player had multiple operations, the first was considered the primary procedure regardless of whether it was performed before or after the player was drafted. Any subsequent UCL reconstructions were classified as revisions.

Player demographics analyzed included age at the beginning of professional career, age at the time of surgery, age at retirement, overall career length, and level of play (MLB vs. MiLB). Surgical factors studied include date of procedure, RTP status, time required to RTP, career length before and after surgery, revision status, and time between primary and revision surgery.

Trends over time were analyzed collectively by level of play at the time of surgery and revision status. Pitchers were considered to have achieved RTP at any level if and when they made a postoperative appearance in at least 1 professional game. RTP at prior level was defined as pitching in at least 1 game that was at or above the level of play at the time of surgery (ie, Short Season A, A, High A, AA, AAA, or MLB) Because roster data for MLB and MiLB is most robust and accurate from 2005 to the present day, only operations performed between 2005 and 2014 (to ensure a minimum of 2 years of follow-up) were used in calculating RTP analysis (time to RTP, RTP rates, etc).

Multiple comparisons were made between MLB and MiLB, including age at the time of surgery, time from start of career to surgery, RTP rates, mean time to RTP, revision rates, and time between primary and revision surgery. Where applicable, similar comparisons were made between primary and revision operations. Overall survivorship was defined as the length of time after surgery that the player was free from revision and still playing professional baseball. Survivorship was compared between MLB and MiLB and primary and revision surgery. For survivorship analysis, only players retired before the 2017 season were included.

Statistical analysis

Descriptive statistics, including number, mean, standard deviation of the mean, range, median, and frequency, are used to report epidemiologic results where indicated. The significance of the change in trends overtime was assessed by comparing the slope of a best fit line using linear regression. For pairwise comparisons of normally distributed continuous variables, such as time to RTP and survivorship, among others, a Student t test was used to assess for statistical significance. Mean differences (MDs) are reported with 95% confidence intervals (CIs) and P values. For categoric vari-