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The effects of medial ulnar collateral ligament reconstruction on Major League pitching performance

Robert A. Keller, MD[a,*], Matthew J. Steffes, BA[a], David Zhuo, BA[a], Michael J. Bey, PhD[b], Vasilios Moutzouros, MD[a]

[a]Department of Orthopaedic Surgery, Henry Ford Hospital, Detroit, MI, USA
[b]Department of Orthopedics, Bone and Joint Center, Henry Ford Hospital, Detroit, MI, USA

Background: Medial ulnar collateral ligament (MUCL) reconstruction is commonly performed on Major League Baseball (MLB) pitchers. Previous studies have reported that most pitchers return to presurgical statistical performance levels after MUCL reconstruction.
Methods: Pitching performance data—specifically, earned run average (ERA), walks and hits per inning pitched (WHIP), winning percentage, and innings pitched—were acquired for 168 MLB pitchers who had undergone MUCL reconstruction. These data were averaged over the 3 years before surgery and the 3 years after surgery and also acquired from 178 age-matched, uninjured MLB pitchers.
Results: Of the pitchers who had MUCL reconstruction surgery, 87% returned to MLB pitching. However, compared with presurgical data, pitching performance declined in terms of ERA ($P = .001$), WHIP ($P = .011$), and innings pitched ($P = .026$). Pitching performance also declined in the season before the surgery compared with previous years (ERA, $P = .014$; WHIP, $P = .036$; innings pitched, $P < .001$; winning percentage, $P = .004$). Compared with age-matched control pitchers, the MUCL reconstruction pitchers had significantly more major league experience at the same age ($P < .001$).
Conclusion: MUCL reconstruction allows most players to return to pitching at the major league level. However, after MUCL reconstruction, there is a statistically significant decline in pitching performance. There appears to be a statistically significant decline in pitching performance the year before reconstructive surgery, and this decline is also a risk factor for requiring surgery. In addition, there is an increased risk of MUCL reconstruction for pitchers who enter the major leagues at a younger age.
Level of evidence: Level III, Retrospective Case-Control Design, Treatment Study.

Keywords: Elbow; ulnar collateral ligament; injury; pitcher; baseball

The medial ulnar collateral ligament (MUCL) is the elbow's primary stabilizer to valgus stress between 20° and 120° of elbow flexion.[23] In particular, the anterior bundle of the MUCL is the primary checkrein to valgus stress.[20-23] During overhead baseball pitching, the elbow is subjected to a

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*Reprint requests: Robert A. Keller, MD, Department of Orthopaedic Surgery, Henry Ford Hospital, 2799 W Grand Blvd, Detroit, MI 48202, USA.
E-mail address: robkeller23@gmail.com (R.A. Keller).

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tremendous amount of valgus stress.[14] As a result of these repetitive stresses that occur during overhead throwing, it is not surprising that MUCL injures permeate the sport of baseball. Not only do these injuries cause pain and performance issues, but many require surgical intervention and may stop a player from being able to perform the sport altogether.

It has been well established that elbow injuries are common in overhead athletics such as baseball.[2,5,8] The first description of elbow injuries involved with playing baseball was by Bennett in 1941.[4] Later, in 1946, Waris was the first to describe MUCL injuries of the elbow when he evaluated a cohort of javelin throwers.[27] Historically, MUCL elbow injuries were career ending for baseball pitchers. This was the case until 1974, when Dr. Frank Jobe performed the first MUCL reconstruction in a professional pitcher by the name of Tommy John.[16] After surgical reconstruction, Tommy John went on to play 14 more seasons, winning 164 games, and finished his career with the record for the most seasons played, 26, which was later broken by Nolan Ryan.

Since the first "Tommy John" surgery in 1974, many professional pitchers have undergone MUCL reconstruction. A report by *USA Today* estimated that 1 in 9 Major League Baseball (MLB) pitchers in the early 2000s had undergone MUCL reconstruction.[9] Previous research suggests that approximately 80% to 90% of pitchers who have MUCL reconstruction return to their previous level of sports participation.[3,5,10,11,19,26] Pitching success by MLB pitchers who have undergone MUCL reconstruction has guided the public perception of this surgical procedure. In fact, many in the general public believe that MUCL reconstruction may make a pitcher even better than the preinjury level.[1]

Few studies have investigated the effects of MUCL reconstruction on statistical pitching performance in MLB pitchers.[11,15,19] These studies contrast in regard to performance outcomes after reconstruction. The first study, by Gibson et al, reported a trend toward return to presurgical statistical levels.[15] More recently, Erickson et al and Makhni et al described cohorts similar to this study's cohort with contrasting results; the study of Erickson et al demonstrated increased statistical performance markers after surgery, whereas the study of Makhni et al found decreased performance. Consequently, the primary objective of this study was to investigate the effects of MUCL reconstruction on pitching performance in a large cohort of MLB pitchers.[11,19] A secondary objective was to identify risk factors for MUCL injury in MLB.

Materials and methods

We conducted a retrospective case-control study.

MUCL-reconstructed pitchers

A cohort of 168 MLB pitchers who pitched in at least 1 major league game before undergoing MUCL reconstruction between the years of 1982 and 2010 were identified. Previous studies have used similar temporal cohorts.[5,11] Reconstructed pitchers were identified by team websites, press releases indicating that players had undergone MUCL reconstruction, personal websites, and baseball statistical websites including baseballreference.com. In finding the cohort, Tommy John surgery was considered an acceptable reference. To verify each pitcher's surgery date, we cross-referenced each player's reported surgical date with a gap in pitching statistics. We excluded players who had a second MUCL reconstruction and players who had not performed in the major leagues before their reconstruction.

For each pitcher, we recorded the year of MUCL reconstruction, the pitcher's age, and the number of years of MLB experience. In addition, we recorded each pitcher's height, weight, body mass index (BMI), pitching arm, and pitching role (starting pitcher vs relief pitcher). We also assessed whether the pitcher returned to MLB pitching after MUCL reconstruction.

Pitching statistics were evaluated in the 3 seasons before surgery and the 3 seasons after return from surgery. As in the previously published study of MLB pitchers,[15] 3 seasons worth of pitching data were used to attain an adequate trend in pitching performance. Only major league performance statistics were evaluated. The major league pitching data that were recorded for each pitcher included the number of wins, number of losses, winning percentage, earned run average (ERA), number of innings pitched, walks plus hits per inning pitched (WHIP), and salary. These data were averaged for the 3 years of pitching before MUCL reconstruction and for the 3 years of pitching after return from MUCL reconstruction.

Control pitchers

A blinded, randomized, age-matched control group of MLB pitchers was identified so that the MUCL reconstruction pitchers' performance could be compared with a representative level of MLB pitching performance during a similar period. Our method for selection of a control cohort was similar to that of previous literature.[6,11,15,24] The median year of surgery for the MUCL reconstruction pitchers was 2004.4, so we began the process of selecting the cohort of control pitchers by identifying each MLB team's opening day roster of pitchers for the 2004 and 2005 seasons. Two seasons of pitchers (2004 and 2005) were necessary to identify an adequate number of aged-matched control pitchers. For selection of the control pitchers, every fifth player was selected from the complete roster of all opening day pitchers for the 2004 and 2005 seasons and age matched with a corresponding MUCL reconstruction pitcher. This process of identifying the fifth name from the complete roster of pitchers continued until 178 age-matched controls had been selected. This process required just more than 7 cycles through the 2004 and 2005 rosters. Pitchers with a known history of MUCL reconstruction were excluded from being part of the control cohort. No other exclusion criteria were used for the control pitchers.

For the control pitchers, we recorded age, MLB experience, height, weight, BMI, pitching arm, and pitching role (starting pitcher vs relief pitcher) in their index year, that is, the roster year (2004 or 2005) from which they were selected. Pitching performance was then determined for each control pitcher with only major league data 3 years before the index year and 3 years after the index year.

Statistical analysis

We analyzed both pre-index and post-index performance measures of each MLB pitcher in the reconstructed and control groups by paired analysis. Continuous variables were checked for normality