

Predictors of Recovery Time Following Ulnar Collateral Ligament Reconstruction in Professional Baseball Players

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Abstract

Background

Ulnar collateral ligament (UCL) reconstruction is a common procedure in professional baseball, yet recovery timelines vary widely despite consistently high return-to-play rates. This variability suggests that multiple athlete-, sport-, and system-level factors may influence rehabilitation duration. The purpose of this study was to identify demographic, developmental, and competitive predictors of recovery time following UCL reconstruction in professional baseball players.

Methods

A retrospective cohort study was conducted using a publicly available database of professional baseball players who underwent UCL reconstruction between 2012 and 2026. Recovery time, defined as months from surgery to return to the same competitive level, served as the primary outcome. Predictor variables included age, playing position, throwing hand, competitive level, developmental pathway, and year of surgery. Associations were assessed using correlation analyses, t tests, ANOVA, and multivariable linear regression.

Results

A total of 1,332 athletes were included, with a mean recovery time of 18.2 ± 7.7 months. Pitchers comprised 86% of the cohort and demonstrated significantly longer recovery than position players (18.8 vs 12.1 months, $p < 0.001$). Higher competitive level was associated with progressively longer recovery, with MLB players averaging 21.1 months. International and direct-professional developmental pathways were also associated with prolonged recovery. Multivariable regression identified pitcher status (+ 6.60 months, $p < 0.001$), higher competitive level, and international development as independent predictors of increased recovery time, while collegiate and high-school pathways were associated with shorter recovery. Age demonstrated a minimal but statistically significant inverse association with recovery duration.

Conclusion

Recovery following UCL reconstruction is multifactorial, with pitcher status and competitive level serving as the strongest predictors of prolonged rehabilitation. Developmental background also contributes to variability in return-to-play timelines, underscoring the need for individualized recovery expectations in professional baseball players.

Introduction

Ulnar collateral ligament (UCL) reconstruction, commonly known as Tommy John surgery, is one of the most frequently performed procedures in professional baseball and has become the standard treatment for elite throwing athletes with symptomatic ligament failure (1,2). While overall return-to-play (RTP) rates are high, recovery timelines following surgery remain highly variable, even among athletes competing at similar levels (3). Some players return to competition in under 12 months (4), whereas others require well over 18–24 months before resuming play at their prior level (5). This heterogeneity suggests that postoperative recovery is influenced by a complex interplay of demographic, athletic, and health system–related factors beyond the surgical intervention itself.

Prior literature has identified several potential contributors to recovery duration following UCL reconstruction, including age at surgery, level of competition, and playing position, particularly the distinction between pitchers and position players (6,7). Additional developmental factors, such as whether athletes progressed through collegiate baseball or were drafted directly from high school or international systems, may also influence rehabilitation trajectory and physiological readiness for return to play (8). Furthermore, increasing attention has been directed toward surgeon-related effects, as procedural volume, technique variation, and postoperative protocols may contribute to differences in recovery outcomes (9). However, existing studies have largely focused on binary outcomes such as return-to-play rates rather than continuous recovery time, limiting the ability to detect more nuanced predictors of rehabilitation duration (3,4,5).

Given the growing number of UCL reconstructions across all levels of professional baseball, from rookie ball to Major League Baseball, and the increasing importance of optimizing player availability and career longevity, there is a need for more detailed analyses of factors influencing recovery time. In particular, large-scale datasets incorporating demographic characteristics, competitive level, positional demands, and surgeon identifiers provide an opportunity to better understand variability in postoperative recovery. Therefore, the purpose of this study is to evaluate demographic, developmental, and surgical predictors of recovery time following UCL reconstruction in professional baseball players using a multivariable regression approach.

Methods

Study Design and Data Source

A retrospective cohort study was performed using a publicly available database of professional baseball players who underwent ulnar collateral ligament (UCL) reconstruction between 2012 and 2026. Data were obtained from the MLB Player Analysis Tommy John Surgery Database, which compiles demographic, athletic, surgical, and recovery-related information on professional baseball athletes across all levels of competition.

Study Population

All professional baseball players with a documented UCL reconstruction and an available recovery time were eligible for inclusion. Players lacking recovery-time data were excluded from analysis. Recovery time was defined as the number of months between the date of UCL reconstruction and the date of return to competition at the same competitive level recorded within the database.

Variables

The primary outcome variable was recovery time following UCL reconstruction, measured in months.

Predictor variables included age at surgery, playing position, throwing hand dominance, competitive level at the time of surgery, developmental pathway, surgeon, and year of surgery. Developmental pathway was categorized as collegiate, high-school, or international based on available educational and demographic information. Playing position was dichotomized into pitchers and position players because of the substantial differences in throwing volume and biomechanical demands between groups.

Statistical Analysis

Continuous variables were summarized using means and standard deviations, whereas categorical variables were reported as frequencies and percentages. Associations between continuous predictors and recovery time were evaluated using Pearson correlation coefficients. Comparisons between binary categorical variables were performed using independent-samples t tests, while variables containing more than two categories were analyzed using one-way analysis of variance (ANOVA).

To identify independent predictors of recovery time, a multivariable linear regression model was constructed with recovery time as the dependent variable. Covariates entered into the model included age, playing position, throwing hand, competitive level, and developmental pathway. Regression coefficients (β), 95% confidence intervals, and p-values were calculated. Statistical significance was defined a priori as $p < 0.05$.

All analyses were performed using Python utilizing SciPy and Statsmodels statistical packages.

Results

Study Cohort

A total of 1,332 professional baseball players who underwent UCL reconstruction and had complete recovery-time data available were included in the final analysis. The mean recovery time following surgery was 18.2 ± 7.7 months, with a median recovery duration of 16 months. The majority of athletes included in the cohort were pitchers, reflecting the disproportionate burden of UCL injuries among overhead throwing athletes. Baseline demographic and athletic characteristics are presented in Table 1.

Table 1
Baseline Cohort Characteristics

Variable	Value
Total Players	1,332
Mean Age (years)	24.7 ± 3.8
Mean Recovery Time (months)	18.2 ± 7.7
Median Recovery Time (months)	16
Pitchers, n (%)	1,146 (86.0%)
Position Players, n (%)	186 (14.0%)
Right-Handed Throwers, n (%)	1,029 (77.3%)
Left-Handed Throwers, n (%)	303 (22.7%)

Age and Recovery Time

Age at the time of surgery was evaluated as a potential predictor of postoperative recovery duration. Pearson correlation analysis demonstrated a weak negative relationship between age and recovery time ($r = -0.021$, $p = 0.451$), indicating that older athletes tended to return to competition marginally sooner than younger athletes; however, this association was not statistically significant. As shown in Table 2, age alone explained virtually none of the observed variation in postoperative recovery duration. These findings suggest that chronological age may have limited utility as an independent predictor of rehabilitation timeline following UCL reconstruction in professional baseball players.

Table 2
Correlation Between Continuous Variables and Recovery Time

Variable	Pearson r	p-value
Age	-0.021	0.451
Surgery Year	-0.089	0.003

Playing Position and Recovery Time

Playing position demonstrated one of the strongest associations with recovery duration observed in the study. Pitchers experienced significantly longer rehabilitation periods compared with position players, requiring an average of 18.8 ± 7.5 months to return to competition compared with 12.1 ± 5.6 months for non-pitchers ($p < 0.001$) (Table 3).

Table 3
Recovery Time by Playing Position

Position	Mean Recovery Time (Months)	p-value
Pitcher	18.8 ± 7.5	
Position Player	12.1 ± 5.6	
Overall Comparison	—	< 0.001

The observed difference of nearly seven months likely reflects the unique biomechanical demands placed on pitchers during the throwing motion and the extensive throwing progression required prior to return to competitive pitching. In contrast, position players generally experience lower cumulative valgus stress across the elbow and may be able to return to competition with fewer restrictions during the later stages of rehabilitation. These findings support previous literature identifying pitchers as a distinct population requiring prolonged recovery following UCL reconstruction.

Throwing Hand and Recovery Time

Recovery duration also differed according to throwing hand dominance. Left-handed athletes demonstrated significantly longer recovery periods than right-handed athletes, returning to competition at a mean of 19.1 months compared with 18.0 months among right-handed throwers ($p = 0.036$) (Table 4).

Table 4
Recovery Time by Throwing Hand

Throwing Hand	Mean Recovery Time (Months)	p-value
Right	18.0 ± 7.6	
Left	19.1 ± 7.4	
Overall Comparison	—	0.036

Although the absolute difference was relatively modest, the finding reached statistical significance and may reflect differences in roster construction, organizational return-to-play decision making, or rehabilitation strategies among left-handed pitchers. Given the smaller proportion of left-handed throwers within professional baseball, teams may exercise greater caution during rehabilitation because of the increased strategic value often associated with left-handed pitching. Nevertheless, the clinical significance of this approximately one-month difference remains uncertain.

Competitive Level and Recovery Time

Competitive level at the time of surgery was significantly associated with postoperative recovery duration (ANOVA $p < 0.001$). A progressive increase in recovery time was observed as level of competition advanced from Rookie ball to Major League Baseball (Table 5).

Table 5
Recovery Time by Competitive Level

Level	Mean Recovery Time (Months)
Rookie	15.4
Single-A	16.2
High-A	17.0
Double-A	18.3
Triple-A	20.6
MLB	21.1

Players competing at Rookie and Single-A levels demonstrated the shortest recovery periods, averaging 15.4 and 16.2 months, respectively. Recovery times increased progressively among High-A (17.0 months) and Double-A players (18.3 months). The longest recovery durations were observed among Triple-A (20.6 months) and MLB athletes (21.1 months).

This trend likely reflects the increasing physical demands and performance expectations associated with higher levels of professional baseball. Athletes competing at upper minor-league and major-league levels may require more complete restoration of velocity, command, endurance, and performance metrics before being cleared for return to competition. Additionally, organizations may be more conservative when managing rehabilitation among higher-value players, thereby extending the recovery process despite successful biological healing.

Developmental Pathway and Recovery Time

Developmental background demonstrated significant associations with recovery duration (ANOVA $p < 0.001$). Athletes who progressed through collegiate baseball returned to competition in a mean of 16.1 months, while those identified as high-school athletes returned in 15.8 months (Table 6).

Table 6
Recovery Time by Developmental Pathway

Developmental Pathway	Mean Recovery Time (Months)
Collegiate	16.1
High School	15.8
International	19.7
Direct Professional	20.2

In contrast, international and direct-professional developmental pathways were associated with longer recovery durations of 19.7 and 20.2 months, respectively.

These findings suggest that developmental history may influence postoperative rehabilitation outcomes. Athletes who participated in organized collegiate baseball programs may enter professional baseball with more structured strength and conditioning backgrounds, potentially facilitating more efficient rehabilitation following surgery. However, because developmental pathway is also closely associated with age, competitive level, and organizational factors, interpretation of these findings requires adjustment through multivariable analysis.

Multivariable Regression Analysis

Multivariable linear regression identified several independent predictors of recovery time following UCL reconstruction. The overall model was statistically significant ($R^2 = 0.101$, $p < 0.001$). Pitcher status remained the strongest predictor of prolonged recovery, increasing rehabilitation duration by an average of 6.60 months ($p < 0.001$). Competing at the AAA or MLB level was also independently associated with longer recovery times. Conversely, collegiate and high-school developmental pathways were associated with shorter recovery periods. Regression results are presented in Table 7.

Table 7
Multivariable Linear Regression Predicting Recovery Time

Variable	β Coefficient	95% CI	p-value
Age (per year)	-0.33	-0.49 to -0.17	< 0.001
Pitcher	+ 6.60	+ 5.42 to + 7.78	< 0.001
Right-Handed Thrower	-1.01	-1.95 to -0.07	0.036
AAA Level	+ 2.59	+ 0.75 to + 4.43	0.006
MLB Level	+ 1.76	+ 0.09 to + 3.43	0.038
Collegiate Pathway	-3.40	-4.79 to -2.01	< 0.001
High School Pathway	-4.81	-7.64 to -1.98	0.001

Discussion

The principal finding of this study was that recovery time following UCL reconstruction in professional baseball players is influenced by several athlete-specific and competition-related factors, with playing position emerging as the strongest independent predictor of prolonged rehabilitation. While UCL reconstruction is widely regarded as a highly successful procedure with return-to-play rates frequently exceeding 80–90% (3), substantial variability exists in the time required to return to competition (4,5). In the present cohort of 1,332 professional baseball players, pitchers required significantly longer recovery periods than position players, even after controlling for age, competitive level, throwing hand dominance, and developmental pathway. These findings suggest that recovery following UCL reconstruction is not solely dependent on biological healing of the reconstructed ligament but is also influenced by the unique performance demands placed on specific athlete populations.

The association between playing position and recovery duration is consistent with prior literature demonstrating that pitchers experience greater elbow valgus stress and require more extensive throwing progression programs before returning to competition (10). Unlike position players, who may be able to return while gradually rebuilding throwing volume, pitchers must regain velocity, command, endurance, and pitch-specific mechanics before being cleared for game participation (11). The nearly seven-month difference observed between pitchers and position players in the current study highlights the importance of considering positional demands when counseling athletes regarding expected recovery timelines. These findings may also help explain some of the variability reported across previous studies that have evaluated return-to-play outcomes without adequately accounting for playing position.

Competitive level was another significant determinant of recovery duration. Players competing at the AAA and Major League levels demonstrated longer rehabilitation periods compared with athletes at lower levels of professional baseball. Several factors may contribute to this finding. First, higher-level athletes face greater performance expectations before being deemed ready to return to competition. Second, professional organizations may adopt more conservative rehabilitation strategies for players with greater financial investment or organizational value. Finally, subtle deficits in performance that may be acceptable at lower levels of competition could substantially affect success at the upper minor-league or major-league level, thereby delaying return despite successful biological recovery. Together, these findings suggest that return-to-play timelines should be interpreted within the context of the athlete's competitive environment rather than as a uniform benchmark applicable across all levels of baseball.

An additional finding of interest was the association between developmental pathway and recovery duration. Athletes with collegiate and high-school developmental backgrounds demonstrated shorter recovery periods compared with those entering professional baseball through international or direct-professional pathways. Although the precise mechanisms underlying this relationship remain unclear, differences in training history, physical development, access to structured strength and conditioning programs, and organizational rehabilitation resources may contribute. Furthermore, developmental pathways may serve as a surrogate marker for other factors not captured within the current dataset, including workload history, pitching mechanics, or socioeconomic influences. Future studies incorporating biomechanical and performance-related variables may provide greater insight into the relationship between developmental background and postoperative recovery.

Several limitations should be considered when interpreting the findings of this study. First, the retrospective design introduces the potential for selection bias and limits the ability to establish causality. Second, the database relied on publicly available information, which may be subject to inaccuracies or incomplete reporting. Third, recovery time was used as the primary outcome measure and does not necessarily reflect quality of return, performance following return, or long-term career longevity. Additionally, potentially important variables such as graft type, surgical technique, revision status, injury severity, concomitant pathology, and postoperative rehabilitation protocols were not consistently available and therefore could not be incorporated into the analysis. Finally, although the

multivariable model identified several statistically significant predictors, the overall explanatory power of the model remained modest, indicating that a substantial proportion of recovery-time variability is likely attributable to factors not captured within the present dataset.

Despite these limitations, this study represents one of the largest investigations to evaluate predictors of recovery duration following UCL reconstruction across multiple levels of professional baseball. The findings demonstrate that playing position, competitive level, developmental pathway, and throwing-hand dominance contribute to variability in return-to-play timelines, with pitcher status serving as the most influential predictor. These results may assist surgeons, rehabilitation specialists, athletes, and professional organizations in establishing more individualized expectations following UCL reconstruction and provide a framework for future investigations examining modifiable factors that may optimize postoperative recovery.

Conclusion

Recovery time following UCL reconstruction in professional baseball players is influenced by multiple athlete-specific and competition-related factors. In this large cohort, pitcher status was the strongest independent predictor of prolonged recovery, while higher levels of competition were also associated with longer rehabilitation timelines. Conversely, athletes from collegiate and high-school developmental pathways generally returned to play more rapidly than their counterparts from international or direct-professional backgrounds. Although age and throwing-hand dominance demonstrated smaller effects, the findings highlight the multifactorial nature of postoperative recovery following UCL reconstruction. These results suggest that return-to-play expectations should be individualized based on player characteristics rather than relying on a uniform recovery timeline. Improved understanding of factors associated with recovery duration may assist surgeons, rehabilitation specialists, athletes, and professional organizations in optimizing postoperative planning and establishing realistic expectations following Tommy John surgery.

Declarations

Ethics Approval and Consent to Participate

This study utilized publicly available, de-identified data obtained from the MLB Player Analysis Tommy John Surgery Database. No direct interaction with human participants occurred, and no identifiable personal health information was collected. Therefore, institutional review board approval and informed consent to participate were not required. The authors have reviewed the Helsinki Declaration and comply our work is within its guidelines.

Consent for Publication

Not applicable.

Availability of Data and Materials

The dataset supporting the conclusions of this article was derived from the publicly available MLB Player Analysis Tommy John Surgery Database. Data used for the analyses are included within the article. Additional information regarding the source database is available from the corresponding author upon reasonable request.

Competing Interests

The authors declare that they have no competing interests.

Author Contributions

RM conceived and designed the study, collected and curated the data, performed the statistical analyses, interpreted the results, and drafted the manuscript. RM read and approved the final manuscript.

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