Performance and Return to Sport After Tommy John Surgery Among Major League Baseball Position Players

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Background: The anterior bundle of the medial ulnar collateral ligament (UCL) is the primary restraint to valgus stress at the elbow and is often injured among overhead throwing athletes. Despite prevention strategies, injuries to the elbow UCL are on the rise.

Purpose: To determine (1) the return-to-sport (RTS) rate of Major League Baseball (MLB) position players after elbow medial UCL reconstruction, (2) postoperative career length and games per season, (3) pre- and postoperative performance, (4) postoperative performance versus matched control players, and (5) whether position players changed positions after UCL reconstruction.

Study Design: Cohort study; Level of evidence, 3.

Methods: MLB players who underwent elbow UCL reconstruction were identified (cases). Demographic and performance data were collected for each player. Matched controls were identified. RTS in MLB was defined as playing in at least 1 MLB game after UCL reconstruction. Comparisons between case and control groups and pre- and postoperative time points were made via paired samples Student *t* tests.

Results: Thirty-three players (34 surgical procedures) were identified with a mean ± SD age of 30.2 ± 4.2 years and a mean experience in the MLB of 6.3 ± 3.9 years at the time of surgery. Twenty-eight players (84.8%) were able to RTS in MLB at a mean 336.9 ± 121.8 days. However, players ≥30 years old demonstrated a significantly lower RTS rate (53.3%) than players <30 years old (89.4%; $P < .05$). Catchers had a significantly shorter postoperative career length (2.8 ± 1.8 years) versus matched controls (6.1 ± 1.9 years; $P < .05$). Outfielders had a significantly lower wins above replacement postoperatively (0.8 ± 0.7) versus preoperatively (1.5 ± 1.1; $P < .05$). There were no performance differences between cases and matched controls. Twelve players (48%) returned to a different position postoperatively.

Conclusion: The RTS rate for MLB position players after elbow UCL reconstruction is similar to that of pitchers. Catchers had a significantly shorter career length than that of matched controls. Outfielders performed worse postoperatively versus preoperatively. There is a high rate of position change after Tommy John surgery for infielders and outfielders.

Keywords: ulnar collateral ligament; Tommy John surgery; Major League Baseball; return to sport; position players

The anterior bundle of the medial ulnar collateral ligament (UCL) is the primary restraint to valgus stress at the elbow and is often injured in overhead throwing athletes.[2,4] Despite prevention strategies, injuries to the elbow UCL are on the rise.[11] Chronic attritional tears in baseball players are primarily associated with pain during the late cocking and early acceleration phase of throwing, where as much as 290 N of force can be generated.[4,25] These patients often have medial elbow pain affecting their throwing velocity and accuracy.[3]

Dr Waris[28] was the first to describe elbow UCL ruptures in javelin throwers in 1946, but UCL reconstruction was not popularized until Dr Frank Jobe performed the first UCL reconstruction in 1974 on pitcher Tommy John.[4] Since that time, the frequency of surgical reconstruction has increased dramatically.[11] Multiple prior studies evaluated Major League Baseball (MLB) pitchers after UCL

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reconstruction with return-to-sport (RTS) rates ranging from 80% to 83%.[9,13,17,20] However, no published studies to date have compared postoperative performance statistics with matched controls after elbow UCL reconstruction in MLB position players.

The purpose of this study was to determine (1) the RTS rate of MLB position players after UCL reconstruction, (2) postoperative career length and games per season, (3) pre- and postoperative performance, (4) postoperative performance as compared with matched control players, and (5) whether position players changed positions after UCL reconstruction. We hypothesized that MLB position players who underwent elbow UCL reconstruction would have (1) a greater RTS rate than pitchers (80%), (2) no significant difference in postoperative career length and games per season as compared with matched controls, (3) no significant difference in postoperative versus preoperative performance, (4) no significant postoperative performance difference when compared with matched controls, and (5) a high rate of position change after return.

METHODS

MLB players who underwent UCL reconstructions between 1984 and 2015 were identified through MLB team websites, publicly available internet-based injury reports, player profiles and biographies, and press releases. The search was manually conducted by 2 orthopaedic surgery residents, with confirmation of the findings by the senior author (J.D.H.). Searches were performed for all MLB teams and players. This method of data collection was successfully used in multiple prior studies of professional athletes.[1,5,8,9,13-15,20-22]

All players identified were included in this study as related to RTS rate. A player was deemed to RTS if he played in any MLB game after surgery. A player did not RTS if he did not play in any MLB game after surgery. Inclusion criteria were any MLB position player (nonpitcher) on an active roster in the MLB before elbow UCL reconstruction. Players were included if they had elbow UCL reconstruction as reported by at least 2 separate sources. Information from these databases was verified each against the other and through independent web-based searches of team press releases that confirmed the date of surgery for each player.[9,20] Athletes who were injured and underwent procedures before completing their first MLB regular season were excluded. Players who underwent elbow UCL reconstruction in the 2016 season were excluded from analysis because they had a <1-year opportunity to RTS and to obtain postoperative statistics.

Patient data were collected, including each player's age, throwing arm, position, date of injury, and date of surgery. All included players were categorized by position: catcher, infielder (IF) (including first baseman, 1B; second baseman, 2B; shortstop, SS; and third baseman, 3B), (3) outfielder (OF) (including left fielder, center fielder, and right fielder), and (4) designated hitter (DH).

Performance data were collected from publicly available online player databases (www.baseball-reference.com and www.fangraphs.com) before and after surgery. There were no players for whom performance data could not be identified. Each performance data category was divided by the games played to account for discrepancies in the number of games played per season. The 1994 and 1995 MLB strike was taken into account, as the definition of a full season in those years was an average of 113 and 144 games, respectively. The number of games played for players during that time frame was adjusted to reflect a full 162-game season. This includes data only from regular-season MLB games and excludes spring training, minor league games, and playoff games.

Performance data used for comparison (pre- vs postsurgery, case vs control) included the following: games played per season, plate appearances per season, batting average, on base percentage, slugging percentage, on base percentage plus slugging percentage, wins above replacement (WAR), and ultimate zone rating (UZR). The number of projected surgical procedures in the current decade was determined according to the average number of operations per year from 2011 to 2015, as extrapolated over the 10-year time frame.

These last 2 statistics (WAR and UZR) are advanced player statistics that have become popular for reporting a player's value. WAR is calculated from multiple performance statistics to give an overall value of a player's performance as compared with a theoretical replacement player (or a player off the bench).[26] A WAR of 2.0 means that over the course of the season, the player contributed to 2 wins more than a replacement player. It takes into account fielding, hitting, and base-running performance to give the theoretical number of wins attributed to their performance as compared with the replacement player. UZR is an overall fielding performance statistic (for noncatchers) that gives the theoretical number of runs saved or lost attributed to one's performance. UZR is divided into classes per the numeric value, including Gold Glove (+15.0), great (+10.0), above average (+5.0), average (0.0), below average (–5.0), poor (–10.0), and awful (–15.0). UZR was calculated for the season before surgery and the season just after injury. Players with surgery before the 2003 season were excluded from the UZR analysis, owing to UZR not being available before 2002.

Because of the possible benefits or detriments of aging and/or experience on player performance, control players were selected for comparison with the postsurgery performance of the surgically treated players. This control group of MLB players was selected by matching the position, age (±1 year), years of experience (±1 year), body mass index, and performance data before the case's surgery date. Each control was given an index date, which matched the case player's surgery date, to compare postoperative and postindex performance. For example, if a player had surgery 3 years into his career, the control's index date was 3 years into his career.

Position changes after UCL reconstruction were categorized as follows: same position, similar position, and lesser throwing position (Table 1). Same position was defined as a player returning to the exact same position (predominately or in the majority of games) after surgery. Similar position was defined for OF as returning predominately to a different OF position and for IF as returning predominately to the

TABLE 1
Definitions of Position Changes[a]

Position Change	Examples
Similar position	OF to OF, SS to 3B, 3B to SS, 2B to 1B
Lesser throwing position	OF to 1B, OF to DH, SS to 2B, 3B to 2B, 2B to DH

[a]1B, first baseman; 2B, second baseman; 3B, third baseman; DH, designated hitter; OF, outfielder; SS, shortstop.

same side of the diamond (eg, an SS returning as a 3B). A lesser throwing position was defined as a player returning predominately to a position of less need for hard or long throws. An example for OF is returning as a 1B or DH, and an example for IF would be a 3B returning as a 1B.

A Kaplan-Meier survivorship curve with retirement as the endpoint was constructed postoperatively for cases and postindex for controls. Comparisons between case and control groups and pre- and postoperative time points were made with 2-tailed paired samples Student t tests. Chi-square was used to compare RTS between age groups. Statistical significance was defined by a P value $<.05$.

RESULTS

Thirty-three players (34 surgical procedures) were identified with a mean ± SD age of 30.2 ± 4.2 years and a mean experience in the MLB of 6.3 ± 3.9 years at the time of surgery (Figure 1). One player underwent 2 operations 1 year apart on the same elbow and did not RTS in between. He was counted as a single event. The number of UCL reconstructions in position players has increased over the past 4 decades (Figure 2). The largest proportion of surgical procedures (42.4%, 14 of 33) was performed on OFs (Table 2). All operations were performed on dominant throwing arms (30 right and 4 left).

Twenty-eight players (84.8%) were able to RTS in the MLB at a mean 336.9 ± 121.8 days after UCL reconstruction (Table 2). Players who returned to sport were significantly younger at the time of surgery than those who did not return (29.1 ± 4.1 vs 33.1 ± 3.0 years, P = .012). The RTS rate was 53.3% and 89.4% for players aged ≥30 and <30 years at the time of surgery, respectively (P = .018). However, there was no significant difference in MLB experience by seasons between those who returned (6.1 ± 4.0 seasons) and those who did not (6.8 ± 3.6 seasons) ($P > .05$).

The overall 1-year MLB career survival rate of players undergoing elbow UCL reconstruction was 73.5%, as opposed to 91.2% for controls (Figure 3). Catchers in the control group (6.1 ± 1.9 years) were in the MLB significantly longer (P = .014) than players who underwent elbow UCL reconstruction (2.8 ± 1.8 years) (Table 3). After index and elbow UCL reconstruction, the remaining position players had similar career lengths and played in a similar number of games per season ($P > .05$) (Table 3).

There were no significant ($P > .05$) differences in data in terms of demographics, performance, and games per season between cases and matched controls presurgery and preindex (Table 4). When the pre- and postsurgery

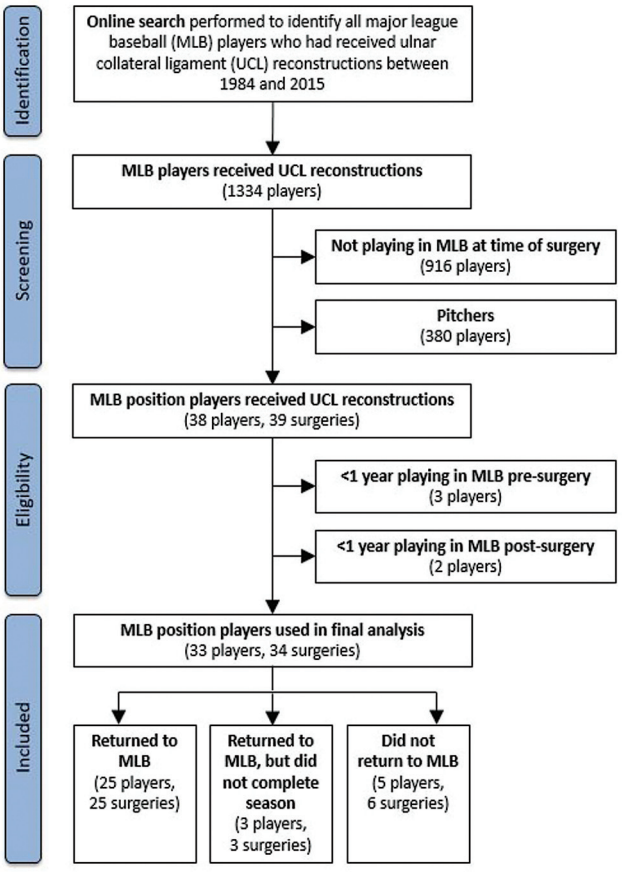

Figure 1. PRISMA flowchart illustrating application of exclusion criteria to determine the final number of Major League Baseball (MLB) position players analyzed in this study. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-analyses.

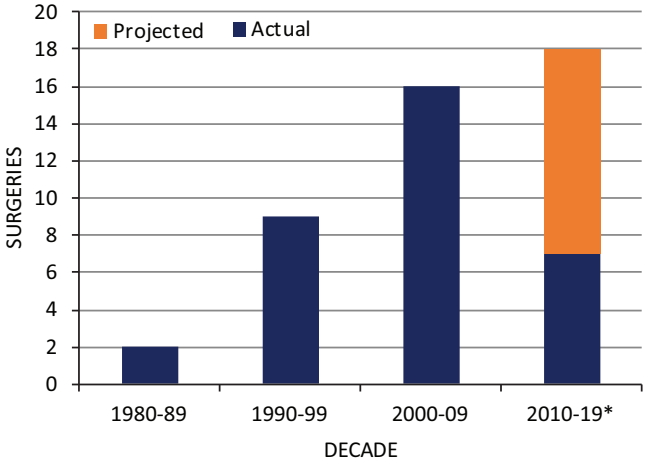

Figure 2. Number of ulnar collateral ligament reconstructions in Major League Baseball by decade. *Projected.

TABLE 2
Return to Sport After UCL Reconstruction (Cases)[a]

Position	n	RTS, %[b]	Days to RTS
Catcher	7	71.4	280.0 ± 100.2
Infielder	12	91.7	362.4 ± 144.9
Outfielder	14	85.7	337.3 ± 107.4
Overall	33	84.8	336.9 ± 121.8

[a]RTS, return to sport; UCL, ulnar collateral ligament.

performance was compared for the cases (Table 5), OFs had a significant decrease in WAR postsurgery (0.8 ± 0.7 vs 1.5 ± 1.1, P = .024). Eleven players (4 IFs and 7 OFs) were included in UZR analyses. There were no significant differences ($P > .05$) between pre- and postsurgery IF UZR (5.5 ± 8.0 and 0.5 ± 5.3) or OF UZR (3.0 ± 5.3 and 0.8 ± 5.5).

Thirteen players (52%, 13 of 25) were able to return to the same position that they had played presurgery, including 4 catchers, 4 IFs, and 5 OFs (Figure 4). The remaining 12 players changed positions from OF to OF (n = 4), OF to 1B (n = 2), OF to DH (n = 1), IF to IF (similar) (n = 2), IF to IF (lesser) (n = 2), and IF to DH (n = 1).

DISCUSSION

Our hypotheses were partially confirmed with the following exceptions: the RTS rate of position players was comparable with pitchers; postoperatively, catchers had shorter careers than matched controls; OFs had decreased WAR after surgery versus before surgery; and there was a high rate of position change upon RTS.

Little attention is paid to position players within the literature, and this is, in part, because Tommy John surgery is less common in this group. For example, only 9% (38 of 418) of the active MLB players who underwent UCL reconstruction in this study were position players. Overall, 85% of position players returned to sport after UCL reconstruction, which is comparable with pitchers. Prior studies showed RTS rates of 81% for pitchers[9,13,17,20] (352 of 432 pitchers; range, 79%-83%) and 77% for pitchers and position players (ie, mixed studies; 233 of 303 players; range, 50%-100%).[2,4,6,7,18,23-25,27] RTS rates were significantly higher (89% vs 53%) for players <30 years old.

Interestingly, catchers represented only 21.2% (7 of 33) of position players in this study. However, given that there is only 1 catcher on the field at a time as compared with 4 IFs and 3 OFs, this number becomes more significant. This relatively high prevalence of Tommy John surgery in catchers among position players is potentially related to the high demand placed on catchers' throwing arms. Catchers make more throws than any other position during a single game (including individual pitchers), and many play in the majority of games throughout the year.

Currently, there is little to no information in the literature regarding position players returning to their primary positions after Tommy John surgery. In this study, 45% of

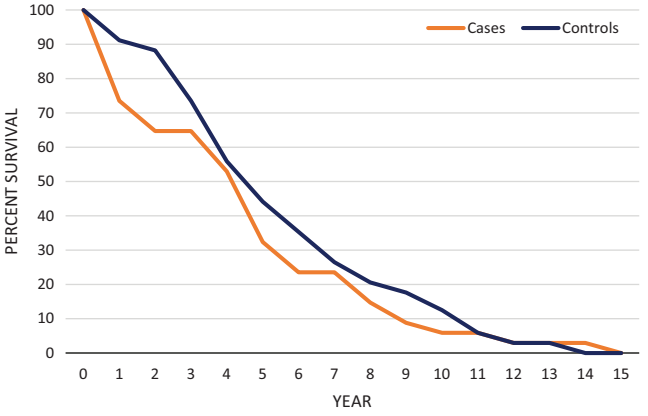

Figure 3. Kaplan-Meier survival analysis for cases and controls. Zero signifies year of surgery for cases and index year for controls.

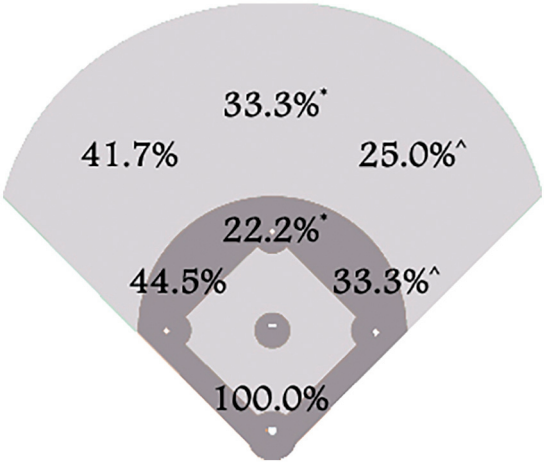

Figure 4. Percentage of players returning to same position, similar position (*), and lesser throwing position (^).

IFs, 42% of OFs, and 100% of catchers remained in their prior positions after UCL reconstruction. In addition, 24% of all position players returning (33% and 25% of IFs and OFs, respectively) changed to a position requiring less forceful throws over a shorter distance (ie, OF to 1B/DH, left-sided IF [3B or SS] to right-sided IF [2B or 1B], or IF to DH). There is a high volume of studies on pitching biomechanics; however, there is a paucity of literature regarding throwing dynamics in other positions.[10,12,19,29] The large differences in release point (OFs), body position (catchers), and required arm torque (right-sided IFs) as compared with pitchers may account for the position changes seen in this study. In addition, no statistically significant differences were found in defensive performance (UZR), although IF did drop from "above average" to "average" after surgery.

Career length was not significantly different between cases and control players, except for catchers, who had a significantly shorter postoperative career by 3 seasons.

TABLE 3
Performance Data After UCL Reconstruction (Cases) or After Index Year (Controls)[a]

	Catcher			Infielder			Outfielder		
Statistic	Cases	Controls	*P* Value	Cases	Controls	*P* Value	Cases	Controls	*P* Value
Seasons	2.8 ± 1.8	6.1 ± 1.9	.014[b]	6.7 ± 4.1	6.4 ± 3.7	.824	4.9 ± 1.7	5.3 ± 3.2	.803
G/s	99.2 ± 38.0	81.2 ± 20.5	.491	91.6 ± 27.3	91.0 ± 45.0	.968	90.0 ± 32.3	82.4 ± 37.8	.646
PA/s	333.7 ± 148.8	281.0 ± 92.3	.579	295.0 ± 167.3	330.3 ± 213.4	.670	338.5 ± 162.9	316.9 ± 179.1	.296
BA	.224 ± .0195	.247 ± .005	.050	.284 ± .050	.242 ± .048	.615	.270 ± .024	.271 ± .027	.273
OBP	.306 ± .011	.331 ± .021	.106	.342 ± .055	.302 ± .069	.900	.345 ± .029	.344 ± .031	.958
SLG	.390 ± .087	.391 ± .051	.684	.411 ± .089	.396 ± .081	.897	.442 ± .053	.451 ± .054	.614
OPS	.696 ± .096	.722 ± .058	.388	.753 ± .141	.663 ± .144	.993	.787 ± .073	.794 ± .076	.665
WAR	0.5 ± 0.7	0.9 ± 0.6	.498	0.7 ± 1.5	0.9 ± 1.2	.586	0.8 ± 0.7	1.3 ± 1.2	.272

[a]BA, batting average; G/s, games played per season; OBP, on base percentage; OPS, on base percentage plus slugging percentage; PA/s, plate appearances per season; seasons, seasons played after surgery or after index year; SLG, slugging percentage; UCL, ulnar collateral ligament; WAR, wins above replacement.
[b]$P < .05$.

TABLE 4
Performance Data Before UCL Reconstruction (Cases) or Before Index Year (Controls)[a]

	Catcher			Infielder			Outfielder		
Statistic	Cases	Controls	*P* Value	Cases	Controls	*P* Value	Cases	Controls	*P* Value
Age, y	30.6 ± 3.9	30.1 ± 3.0	.717	28.6 ± 4.8	28.8 ± 4.6	.682	29.1 ± 3.8	29.2 ± 3.8	.483
Experience, y	6.6 ± 4.1	5.3 ± 2.5	.476	5.2 ± 4.3	5.5 ± 4.9	.435	6.6 ± 4.0	6.2 ± 3.9	.397
BMI	26.0 ± 2.0	27.7 ± 2.5	.162	25.1 ± 1.8	25.1 ± 2.2	.993	25.5 ± 2.8	25.9 ± 2.7	.699
G/s	103.7 ± 33.2	84.7 ± 39.6	.310	88.5 ± 32.6	81.3 ± 37.7	.574	103.7 ± 28.6	97.4 ± 34.2	.397
PA/s	375.2 ± 168.4	304.2 ± 177.0	.391	330.1 ± 169.9	301.0 ± 166.0	.660	390.6 ± 159.3	370.1 ± 153.8	.491
BA	.251 ± .015	.255 ± .013	.567	.268 ± .020	.264 ± .027	.109	.278 ± .032	.271 ± .029	.070
OBP	.326 ± .018	.324 ± .024	.398	.318 ± .025	.333 ± .022	.264	.352 ± .020	.343 ± .035	.077
SLG	.423 ± .025	.387 ± .023	.242	.375 ± .025	.381 ± .051	.112	.465 ± .047	.450 ± .067	.204
OPS	.749 ± .027	.712 ± .025	.343	.693 ± .070	.714 ± .060	.050	.817 ± .055	.793 ± .096	.106
WAR	1.2 ± 0.7	1.3 ± 0.8	.622	0.8 ± 1.3	0.6 ± 1.0	.183	1.5 ± 1.1	1.4 ± 1.2	.918

[a]Age, age at time of injury or index; BA, batting average; BMI, body mass index; experience, years played at the Major League Baseball level; G/s, games played per season; OBP, on base percentage; OPS, on base percentage plus slugging percentage; PA/s, plate appearances per season; SLG, slugging percentage; UCL, ulnar collateral ligament; WAR, wins above replacement.

TABLE 5
Performance Data Before and After UCL Reconstruction (Cases)[a]

	Catcher			Infielder			Outfielder		
Statistic	Presurgery	Postsurgery	*P* Value	Presurgery	Postsurgery	*P* Value	Presurgery	Postsurgery	*P* Value
Seasons	6.2 ± 3.7	2.8 ± 1.8	.209	5.5 ± 4.2	6.7 ± 4.1	.532	6.3 ± 4.2	4.9 ± 1.7	.363
G/s	103.7 ± 33.2	99.2 ± 38.0	.885	88.5 ± 32.6	91.6 ± 27.3	.833	103.7 ± 28.6	90.0 ± 32.3	.214
PA/s	375.2 ± 168.4	333.7 ± 148.8	.735	330.1 ± 169.9	295.0 ± 167.3	.665	390.6 ± 159.3	338.5 ± 162.9	.320
BA	.251 ± .015	.224 ± .0195	.110	.268 ± .020	.284 ± .050	.608	.278 ± .032	.270 ± .024	.621
OBP	.326 ± .018	.306 ± .011	.147	.318 ± .025	.342 ± .055	.950	.352 ± .020	.345 ± .029	.201
SLG	.423 ± .025	.390 ± .087	.247	.375 ± .025	.411 ± .089	.821	.465 ± .047	.442 ± .053	.777
OPS	.749 ± .027	.696 ± .096	.212	.693 ± .070	.753 ± .141	.866	.817 ± .055	.787 ± .073	.486
WAR	1.2 ± 0.7	0.5 ± 0.7	.158	0.8 ± 1.3	0.7 ± 1.5	.830	1.5 ± 1.1	0.8 ± 0.7	.024[b]

[a]BA, batting average; G/s, games played per season; OBP, on base percentage; OPS, on base percentage plus slugging percentage; PA/s, plate appearances per season; seasons, seasons played after surgery or after index year; SLG, slugging percentage; UCL, ulnar collateral ligament; WAR, wins above replacement.
[b]$P < .05$.

Again, this is potentially due to the high-volume demand on catchers' throwing arms throughout the season. Within the seasons played after surgery, there was no significant difference in the games played per season or the number of plate appearances per season for any group. When players were compared with themselves before and after UCL reconstruction, the only significant difference was a lower WAR for OFs. All other performance measures showed no significant differences before and after surgery. Between cases and controls, there were no significant differences in any position. This study drew conclusions similar to those of previous studies of pitchers undergoing UCL reconstruction. Erickson et al[9] discovered that pitchers who underwent UCL reconstruction had an improvement in performance as compared with before surgery: they demonstrated a lower earned run average (ERA), lower walks plus hits per inning pitched (WHIP), and lower losing percentage, and they gave up fewer hits per inning. In contrast, a decline in performance after UCL reconstruction was noted by Gibson et al[13] (ERA, WHIP, innings pitched), Jiang and Leland[17] (pitch velocity), and Makhni et al[20] (ERA, batting average against, WHIP, percentage of pitches thrown in the strike zone, innings pitched, percentage of fastballs thrown, and average fastball velocity). However, in all 3 studies, the decline was not significantly different from that of control pitchers, and in the Makhni et al[20] study, significant improvement was seen 2 seasons after surgery.

There are limitations to this study. The use of publicly available data to identify players who underwent elbow UCL reconstruction is prone to selection, reporting, and observer bias. However, this method of data acquisition has been used in multiple previous studies.[1,5,8,9,13-16,20-22] By including only the highest level of professional baseball players, these data may apply to only elite-level athletes. Professional baseball players (MLB and Minor League Baseball) have had a higher rate of return to play than nonprofessional players.[4] This is believed to be due to the inherently high talent and determination present at this level, with higher income potential.[4] We may not have been able to identify all previous elbow surgical procedures for the included players, which has been shown to have an effect on the outcomes of UCL reconstruction.[2] Also, career length and performance were not adjusted for "time missed" for players who underwent UCL reconstruction. Each player's time in the league was in fact longer than reported; however, the number of seasons spent playing (ie, career length) after surgery is accurate. Inherent to this type of study are multiple unknown confounding variables, such as no direct physical contact or access to medical records to corroborate diagnosis. The use of public data limits the ability to determine the chronicity and severity of the injury or to differentiate complete or partial ligament injuries. We were also unable to reliably determine what operative technique was used for UCL reconstruction. Heterogeneity of surgeons, surgeon skill, and surgical technique also present limitations. Others include the absence of patient-reported outcomes, incomplete follow-up, and career length for players still in the MLB. There was no group treated nonoperatively. Also, the small number of players increases the risk of beta error.

CONCLUSION

The RTS rate for MLB position players is similar to that of pitchers. Catchers had a significantly shorter career length than matched controls after Tommy John surgery. OFs performed worse postoperatively versus preoperatively. There is a high rate of position change after Tommy John surgery for IFs and OFs.

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