Athletic Hip Injuries in Major League Baseball Pitchers Associated With Ulnar Collateral Ligament Tears

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Background: Ulnar collateral ligament (UCL) reconstruction is a reliable treatment for elite overhand throwers with UCL tears. In recent years, this procedure has become increasingly common among Major League Baseball (MLB) pitchers. Predisposing factors and associated comorbidities, however, have not been fully elucidated.

Purpose/Hypothesis: The purpose of this study was to determine whether professional baseball pitchers who underwent UCL reconstruction had an increased incidence of hip or groin injuries 4 years before or after surgery. We hypothesized that MLB pitchers who sustain hip or groin injuries may be more likely to develop UCL tears because of alterations and overcompensation in the kinetic chain during overhand throwing.

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

Methods: A comprehensive list of all 247 MLB players who underwent UCL reconstruction between 2005 and 2017 was created using publicly accessible online data. The application of inclusion criteria yielded a final sample size of 145 athletes. These athletes' injury histories were identified and cross-referenced with the official MLB disabled list. Matched controls were generated for a comparison of results.

Results: Of the 145 MLB pitchers who underwent UCL reconstruction between 2005 and 2017, 40 (27.6%) endured a proximal lower extremity injury within 4 years of their surgery. Specifically, 16 pitchers sustained hip injuries, 13 suffered hamstring injuries, and 14 experienced groin injuries. A significantly lower rate of hip- and groin-related injuries (17.9%) was identified in matched controls during a similar time frame ($P = .049$).

Conclusion: The results of this study demonstrate that MLB pitchers who required UCL reconstruction sustained a higher frequency of proximal lower extremity injuries both before and after surgery compared with matched controls. This finding is significant as the treatment of antecedent hip lesions, as well as an emphasis on hip and core muscle mobility and strengthening, may help reduce injuries to the UCL.

Keywords: ulnar collateral ligament; femoroacetabular impingement; baseball; pitching

The ulnar collateral ligament (UCL) is a triangular band of tissue in the medial elbow that is critical for resisting the high valgus stress created during the late cocking and early acceleration phases of overhand throwing.[20] UCL injuries range from minor strains to complete tears but are almost universally caused by repetitive, forceful throwing.[6,21] The injury burden of UCL tears has increased in recent years, as has the number of UCL reconstructions being performed annually. In 2000, only 12 Major League Baseball (MLB) players underwent UCL reconstruction,[24] whereas 32 players underwent the procedure in 2012.[18] A 2015 survey further demonstrated that 25% of all MLB pitchers had a history of UCL reconstruction.[3] Of all MLB pitchers undergoing UCL reconstruction, more than 80% make a full return to play,[18] and many show significant improvements in performance 1 year postoperatively compared with before surgery.[5] The increasing prevalence of UCL surgery has been compared with an epidemic, and as such, it necessitates further elucidation of predisposing risk factors to reduce the overall disease burden, avoid operative intervention, and protect young and elite athletes alike.

Factors known to increase the risk of UCL injuries center on the frequency of throwing, throwing velocities, types of pitches thrown, and lack of adequate warm-up.[24] Interestingly, a limited number of investigations have explored how

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lesions of the lower extremities may affect the development of UCL injuries. Hip injuries, specifically femoroacetabular impingement (FAI) and labral tears, are common in professional baseball players[2,7] and are known to cause internal rotation limitations.[10] Pitchers have also been found to have reduced hip internal rotation range of motion (ROM) compared with position players, although the clinical significance of this finding remains unknown.[15] The deleterious effects of FAI exacerbating a pitcher's predisposition for reduced hip internal rotation likely place these throwers at a disadvantage for generating power from the lower extremities. As overhand throwing is a sequence of role-specific events in the kinetic chain coordinated to produce force on the ball,[25] a deficiency of the hips to generate power during the wind-up and early cocking phases may result in overcompensation of the upper extremities during the late cocking and early acceleration phases.[27] This phenomenon has been previously documented in the shoulder, in which the majority of overhand throwers with superior labral from anterior to posterior (SLAP) tears were found to have significant deficits in internal rotation ROM of the hips.[11] If kinetic overcompensation instead manifests at the elbow, it may lead to repetitive microtrauma to the UCL. This can result in the gradual development of chronic changes, including heterotopic calcification and ligamentous attenuation, and ultimately ruptures requiring reconstructive surgery.[22]

The purpose of the current investigation was to determine if there is a connection between injuries of the hip, groin, and hamstring and the development of UCL tears necessitating surgical treatment in MLB pitchers. It was our hypothesis that significant impairment to the lower extremities' contribution to the kinetic chain would place the elbow at an increased risk for injuries. To establish such a connection would prove valuable for developing strategies for players to avoid UCL injuries, as significant hip lesions such as FAI can be surgically managed with excellent outcomes in the majority of patients.[14]

METHODS

Participants

A list of all MLB pitchers who underwent UCL reconstructive surgery between 2005 and 2017 was generated by aggregating publicly accessible online data. Inclusion criteria required UCL reconstruction while on contract with an MLB team and participation in at least 1 MLB game before and after surgery. Players who were on a college, minor league, or non–US baseball team at the time of UCL reconstruction were excluded, as injury data were not accessible before UCL surgery. Similarly, players who underwent UCL surgery after retirement, retired immediately after their surgery, or played only in the minor league after surgery were excluded, as injury data were not accessible after UCL surgery.

Data Collection

Injury data were gathered using systematic online searches of publicly available sources. Player injuries found in sports media articles were cross-referenced with the official MLB disabled list (DL). Hip injuries were defined as FAI, labral tears, chondral damage, flexor strains, hip stiffness, or discomfort. Hamstring injuries were defined as strains or tears and groin injuries as strains or hernia. Injury inclusion criteria required that the athlete missed playing time; however, acute traumatic causes were excluded, such as rushing the mound, tripping over a base, and 1 instance of a dislocation. Four years before or after surgery was selected as the time frame for injuries because the effects of structural lower extremity injuries manifest insidiously over years and to allow for recovery from these injuries as well as sufficient playing time after UCL reconstruction. If pitchers played for less than 4 years after surgery, they were evaluated until their last MLB game. Time missed was used as a measure of the injury's severity and was calculated using the number of days that the player spent on the DL in official designations of either 10, 15, or 60 days.

Matched Controls

To discern whether hip, groin, and hamstring injuries predispose pitchers to UCL tears, matched controls were generated using previously validated methodology.[18] Controls were matched using publicly accessible online data according to age at the time of UCL reconstruction, earned run average (ERA) at the time of UCL reconstruction, number of seasons played at the time of UCL reconstruction, and number of total years played. Players with a history of UCL reconstruction were excluded. These matched controls were then analyzed for a history of proximal lower extremity injuries within 4 years before or after the time at which their matched players underwent UCL surgery. Injuries were cross-referenced with the DL and evaluated for time missed. Injuries with a traumatic cause were again excluded.

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Ethical approval was not sought for the present study.

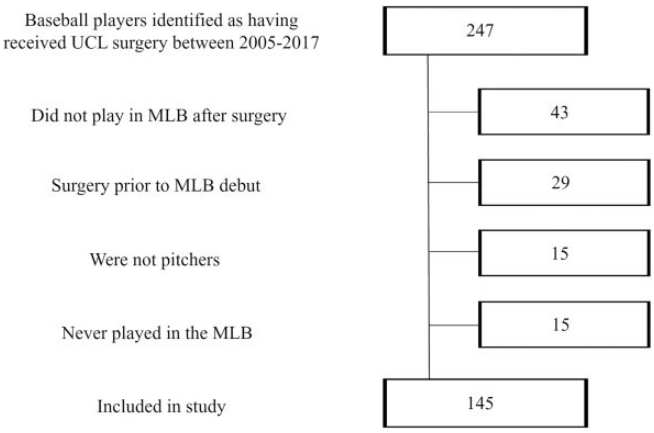

Figure 1. CONSORT (Consolidated Standards of Reporting Trials) flow diagram of inclusion and exclusion criteria for athletes. MLB, Major League Baseball; UCL, ulnar collateral ligament.

TABLE 1
Demographic Data for Players and Controls[a]

	Players	Controls	*P* Value
Age at time of surgery, y	27.70 ± 4.20	27.60 ± 3.73	.820
Earned run average at time of surgery	4.25 ± 1.22	4.18 ± 1.08	.600
No. of seasons played at time of surgery	4.86 ± 3.75	4.81 ± 3.61	.910
No. of total years played	7.22 ± 4.33	8.21 ± 4.36	.050
Fastball velocity, mph	92.20 ± 2.74	91.00 ± 7.34	.068
Fastballs, %	63.10 ± 7.64	61.70 ± 9.33	.199

[a]Data are shown as mean ± SD.

Statistical Analysis

Statistical analyses were performed using GraphPad Prism version 7.0b (GraphPad Software). Statistical significance was determined using a 2-tailed Student *t* test when comparing the means of 2 groups and a chi-square test to analyze continuous data. Statistical significance was set at $P < .05$.

RESULTS

A total of 247 professional baseball players were identified as having undergone UCL reconstruction between 2005 and 2017. After applying our inclusion criteria, 102 players were eliminated, yielding a final sample size of 145 (Figure 1).

Demographic data were collected for players and matched controls (Table 1). In the player group, the mean age at the time of surgery was 27.70 years, the mean ERA at the time of surgery was 4.25, the mean number of seasons played in the MLB at the time of surgery was 4.86, and the mean number of total years played to date was 7.22. Additionally, with an aim to control for confounding variables, the mean velocity of fastballs and the percentage of fastballs thrown were analyzed, as these metrics have been cited as risk factors for UCL injuries.[19,23] There were no significant differences identified in any demographic data between players and controls.

TABLE 2
Injury Rates Among Players and Controls[a]

	Players	Controls	*P* Value
Total injuries			
n (%)	40 (27.6)	26 (17.9)	**.049**
No. of individual injuries	46	39	
Time spent on DL, d	25	22	.540
Noted on official DL, n (%)	23 (50.0)	34 (87.2)	.094
Hip injuries			
n (%)	16 (11.0)	6 (4.1)	**.027**
No. of individual injuries	17	7	
Time spent on DL, d	30	41	.530
Noted on official DL, n (%)	6 (35.3)	4 (57.1)	.324
Hamstring injuries			
n (%)	13 (9.0)	10 (6.9)	.514
No. of individual injuries	13	12	
Time spent on DL, d	23	15	.180
Noted on official DL, n (%)	5 (38.5)	12 (100.0)	**.001**
Groin injuries			
n (%)	14 (9.7)	14 (9.7)	.999
No. of individual injuries	16	20	
Time spent on DL, d	24	26	.870
Noted on official DL, n (%)	12 (75.0)	18 (90.0)	.230

[a]Not all injuries included in this study were listed on the Major League Baseball official disabled list (DL) due to off-season occurrence and time missed less than 10 days. It was the authors' intention to be as inclusive as possible regarding injuries that may be involved in this pathologic process. The percentage of each injury type that was reported on the DL is recorded above. Boldfaced values indicate statistical significance ($P < .05$).

Of the 145 MLB pitchers who underwent UCL reconstruction during the study period, 40 (27.6%) sustained a proximal lower extremity injury within 4 years of surgery (Table 2). Of these players, 16 athletes sustained 17 hip injuries, 13 athletes suffered hamstring injuries, and 14 athletes experienced 16 groin injuries. Only 1 player sustained a quadriceps injury that resulted in missed playing time, so quadriceps injuries were excluded. Hip injuries proved to be the most debilitating, as players missed a mean of 30 days, followed by 24 days for groin injuries and 23 days for hamstring injuries. The majority of these lower extremity injuries (n = 25, 54.3%) occurred before players' UCL reconstruction (Figure 2). Hip injuries occurred nearly twice as often before UCL reconstruction as compared with after, but there were no significant correlations between the timing of surgery and hamstring or groin injuries.

The injury rate of matched controls during a similar time frame was significantly lower than the injury rate of players, as 26 (17.9%) controls sustained an injury about the hip, hamstring, or groin ($P = .049$) (Table 2). This represents an odds ratio of 1.74, indicating that players who underwent UCL reconstruction were 74% more likely to have sustained a hip, groin, or hamstring injury within an 8-year time frame compared with matched controls.

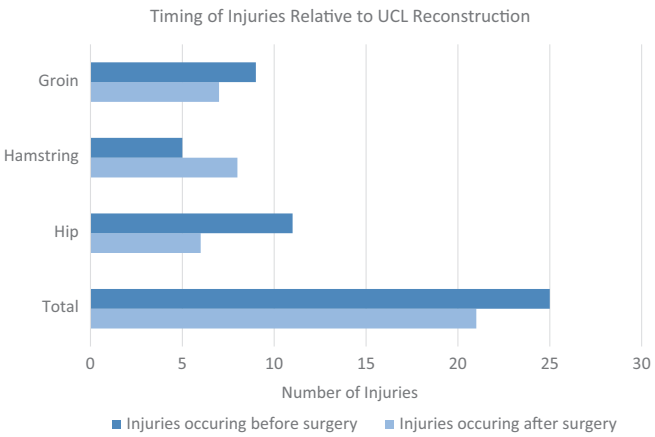

Figure 2. Timing of proximal lower extremity injuries relative to ulnar collateral ligament (UCL) surgery stratified by injury cause. Hip injuries occurred at a ratio of 11:6 before versus after UCL surgery.

In the control group, 6 players sustained 7 hip injuries, 10 players sustained 12 hamstring injuries, and 14 players sustained 20 groin injuries. In comparing injury rates between players and controls, only the decreased incidence of hip injuries in controls was significant ($P = .027$). Similar to the injured players, hip injuries in controls resulted in a significantly longer amount of time missed compared with hamstring and groin injuries: 41 days compared with 15 and 26 days, respectively ($P = .015$). There was no significant difference in the mean time missed for hip, hamstring, and groin injuries between players and controls.

Regarding the cause of injuries, among the 17 hip injuries in the player group, 8 (47.1%) were reported as labral or FAI lesions, all of which required surgical treatment. Of these FAI or labral injuries, three-fourths occurred in the player's stride leg. The remainder included 6 cases of strains or tightness and 3 unspecified injuries. All groin and hamstring injuries were reported as strains, except 1 complete tear of the hamstring that required surgery and 1 instance of athletic pubalgia. In comparison, matched controls suffered 3 FAI or labral injuries, 2 of which required surgical intervention, while the other resolved after a single cortisone injection. The remainder of the control group's hip injuries were reported as either strains or tightness. The majority of all groin and hamstring injuries in the control group were also reported as strains. Interestingly, matched controls required operative treatment for 2 groin injuries and 1 core muscle injury.

DISCUSSION

As the frequency of UCL reconstructions continues to rise in professional baseball, understanding the factors that predispose athletes to UCL tears is increasingly important. The pivotal finding of this study is that players who underwent UCL reconstruction were 74% more likely to have sustained a hip, groin, or hamstring injury within 4 years before or after surgery compared with matched controls ($P = .049$). Specifically, the incidence of hip injuries in pitchers who required UCL reconstruction was significantly higher than the injury incidence of matched controls ($P = .027$). Additionally, nearly twice the number of hip injuries occurred before UCL reconstruction compared with after, indicating that pitchers who have undergone UCL surgery are more likely to have sustained a hip injury before their surgery. These data support our hypothesis that hip injuries, specifically FAI and labral lesions, may lead to overcompensation at the elbow during overhand throwing, potentially leading to the development of UCL tears.

The act of throwing requires the athlete's hips to be in "at-risk positions" that can make the thrower susceptible to developing labral tears. For example, repetitive, forceful stance-leg hip rotation contributes to rotational instability. Meanwhile, abutment of the anterior-superior labrum between the femoral head and acetabulum of the stride leg during the acceleration phase can result in chondrolabral damage. Furthermore, widening of the stride distance in an effort to throw faster increases the risk for lateral rim impingement.[13] This is significant, as FAI was the most common cause of hip injuries in pitchers with a history of UCL reconstruction. Additionally, the rate of FAI causing athletes to miss time from playing was 2.7 times higher in pitchers with a history of UCL reconstruction compared with controls.

This observation can be explained by the fact that the functional hip ROM required by the elite thrower often exceeds the physiological limitations imposed by the abnormal osteochondral junction of hips with FAI.[17] As such, the thrower cannot depend on hip ROM for the successful transfer of energy from the lower extremity to the trunk and ultimately to the upper extremity during the kinetic chain of throwing.[8,9,15] To maintain throwing power, athletes with FAI may need to overcompensate with the distal end of the kinetic chain, placing increased stress on specific structures, such as the UCL.[12] It is also interesting that groin and hamstring injuries were not independently associated with significantly increased UCL injuries in players compared with matched controls. This may be secondary to the fact that the muscles of the groin and hamstring do not play as critical a role in internal rotation of the hips. However, it is more likely that the lack of significance is attributable to the acuity of hamstring strains, which accounted for nearly all of the hamstring injuries in our player group. This is in contrast to the chronic deconditioning known to occur with injuries such as FAI and labral tears, which accounted for half of the players' hip injuries.

Prior investigations support the notion that decompensation of the proximal lower extremity can lead to overcompensation in the upper extremity. In a 10-year review of throwers, Kibler et al[11] noted that 50% of elite overhand throwers with SLAP tears had significant deficits in internal rotation of the hips and in hip abductor and extensor strength. The authors also found that the majority of these patients had kinetic chain deficits. It is speculated that insufficient hip internal rotation ROM impairs the transfer of energy from the lower to upper extremity, precipitating kinetic chain alterations and increasing stress loads at the

shoulder, resulting in injuries.[4,15,29] The current investigation is the first to make a similar connection to UCL injuries and is supported by previous research concluding that insufficient hip internal rotation is a risk factor for elbow pain and injuries.[26]

Our findings on lower extremity injuries, particularly their timing in relation to UCL reconstruction, make an argument for elite overhand throwers to take precautions after athletic hip injuries. It was previously accepted that skeletally immature athletes should limit the number of breaking pitches (curveball, slider, or cutter) thrown because they place increased stress on the shoulder and elbow and can predispose to elbow and shoulder pain as well as UCL tears.[1,16,28] Recently, fastballs have come under similar scrutiny.[19,23] It is the hope of this research that hip injuries, specifically FAI and labral lesions, will likewise be regarded as a predisposing factor for UCL tears in the future. In this investigation, all of the pitchers in the player group who had documented FAI or labral lesions before their UCL reconstruction underwent surgical intervention of the hip. This suggests that successful operative correction of hip injuries alone does not preclude the development of UCL damage. Therefore, medical professionals should increase their cognizance of the pathological link between these 2 joints and create better postoperative rehabilitation courses focused on throwing mechanics for elite pitchers who sustain hip injuries, with the goal of preventing deleterious kinetic chain alterations and ultimately UCL tears.

The limitations of this study stem from its retrospective nature. The number of players undergoing UCL surgery has increased each year; thus, nearly three-quarters (71%) of our sample underwent UCL reconstruction in the past 6 years compared with 29% of our sample having undergone surgery in the 6 years prior. Additionally, because of the 4-year window for injuries, athletes who underwent surgery in or after 2014 did not have equal potential for lower extremity injuries after UCL reconstruction. Similarly, players who underwent UCL surgery less than 4 years into their MLB career did not have equal time for injuries before UCL reconstruction. While matched controls increased the internal validity of this study's design, the external validity remains low, as inference between professional pitchers and the general population would be inappropriate. Calculations of time missed were skewed by the DL's exclusion criteria for off-season injuries and injuries that persist for more than 60 days. Additionally, although the literature supports a correlation between hip rotational deficits in patients with FAI and biomechanical changes in the throwing motion, we cannot confirm with our retrospective methodology that the athletes documented with FAI examined in this study had such deficits. Nor can we account for any asymptomatic FAI or hip motion deficits undocumented in our player or control groups. Finally, not all injuries included in this study were noted on the DL; however, it was our aim to be as inclusive as possible toward injuries that may be linked to this pathological process.

CONCLUSION

In MLB pitchers who have undergone UCL reconstruction, there exists a significantly increased rate of hip injuries compared with nonoperative age- and ERA-matched controls. This may be indicative of a pathological connection between the hip and elbow as a series of coordinated events in the overhand throwing motion in which decompensation at the hip leads to overcompensation of the elbow, predisposing it to injuries. Pitchers who sustain hip injuries, particularly FAI, should be counseled on their increased risk for UCL tears and ensure appropriate throwing mechanics before returning to competitive throwing.

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