Short-Term Trends in Elbow Ulnar Collateral Ligament Surgery in Collegiate Baseball Players

An Analysis of 25,587 Player-Years

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Background: Trends over time in the incidence of ulnar collateral ligament (UCL) surgeries in National Collegiate Athletic Association Division I baseball players are currently unknown.

Purpose/Hypothesis: The purpose of this study was to evaluate the trends in UCL surgeries over 3 years in Division I baseball programs. We hypothesized that surgical injuries would be consistently high over the course of the study.

Study Design: Descriptive epidemiology study.

Methods: Athletic trainers from Division I baseball programs were invited to participate in an electronic survey over 3 seasons. A total of 155 baseball programs agreed to participate in 2017, 294 programs participated in 2018, and 296 programs participated in 2019. After each of the 3 collegiate baseball seasons, the athletic trainer from each program entered anonymous, detailed descriptive data and surgical information on injured players into a secured database.

Results: During the 3 years of this study, 100% of the enrolled programs successfully completed the survey (155/155 in year 1, 294/294 in year 2, and 296/296 in year 3). This registry of 745 completed surveys over 3 years represented 25,587 player-years from Division I collegiate baseball. The percentage of programs with at least 1 UCL surgery during this time was 57% in 2017, 51% in 2018, and 49% in 2019. The majority of these players were pitchers (84% overall from the 3 years). Seniors underwent a significantly lower percentage of the UCL surgeries (8% in 2017, 10% in 2018, and 13% in 2019) than did underclassmen. Surgeries were performed most often in-season and least often during the preseason. A slight majority of players undergoing surgery originated from warm-weather states, but the number of these players was never significantly higher than was the number of players from cold-weather states. Most surgeries performed each year were UCL reconstruction, but the percentage of UCL repair with ligament augmentation increased each year (10% UCL repairs in 2017, 20% in 2018, and 25% in 2019).

Conclusion: UCL injuries requiring surgery were found to be a major source of morbidity in Division I collegiate baseball, supporting our hypothesis. This study can serve as a baseline for tracking long-term trends in UCL surgeries in collegiate baseball.

Keywords: epidemiology; sports medicine; overhead athlete; UCL; Tommy John surgery

In recent years, the documented increase in ulnar collateral ligament (UCL) injuries in overhead athletes has been a major cause of morbidity and playing time lost. This increase in the reported incidence of injuries has been noted in both amateur and professional baseball.¹ Recent literature has demonstrated significant increases in both the annual rate of UCL surgery and the prevalence of previous UCL surgery in players from Minor League Baseball and Major League Baseball.²,³,⁴,⁵,⁶,⁷,⁸,⁹,¹⁰,¹¹,¹²,¹³,¹⁴,¹⁵,¹⁶,¹⁷,¹⁸,¹⁹,²⁰,²¹,²²,²³,²⁴,²⁵,²⁶,²⁷,²⁸,²⁹,³⁰,³¹,³²,³³,³⁴,³⁵,³⁶,³⁷,³⁸,³⁹,⁴⁰,⁴¹,⁴²,⁴³,⁴⁴,⁴⁵,⁴⁶,⁴⁷,⁴⁸,⁴⁹,⁵⁰,⁵¹,⁵²,⁵³,⁵⁴,⁵⁵. The Orthopaedic Journal of Sports Medicine, 9(7), 23259671211016846 DOI: 10.1177/23259671211016846 © The Author(s) 2021

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descriptive and surgical data regarding UCL injuries requiring surgery in the collegiate baseball population. What remained unknown was how that data would have changed with inclusion of the remaining 48% of Division I baseball programs as well as what short-term trends would develop over time. We recognized the need for a larger, longitudinal study over multiple years to properly address these questions.

The current study advances the knowledge of UCL injuries in collegiate baseball players. The primary purpose was to expand on the descriptive epidemiology data established in our previous study and to analyze short-term trends over the course of the 3 years of data in this study. Our hypothesis was that there would be no significant differences between our original data from a single year and the larger data set from the majority of Division I programs over 3 years of data collection. In addition, this study could advance the discussion regarding rules and recommendations to reduce the substantial morbidity of UCL injuries requiring surgery in collegiate baseball. With potential changes in the collegiate baseball calendar under discussion, we believe that this data set demonstrates a potential to lower the annual incidence of UCL injuries requiring surgery via a longer preseason and later start to in-season play.

METHODS

Establishment as well as annual maintenance of this deidentified collegiate baseball player registry was designated as nonhuman subjects research by Sterling institutional review board and therefore did not require formal review board approval. During the 2016-2017 academic year, 157 baseball programs were contacted, and 155 agreed to participate in the study, representing 51.8% of the 299 NCAA Division I programs that year. During the 2017-2018 and 2018-2019 academic years, all Division I programs were invited to participate (297 programs in 2018 and 299 programs in 2019). In 2017-2018, 294 of 297 programs (99.0%) agreed to participate. In the following year, 296 of 299 programs (99.0%) enrolled in the study. The 2 programs that declined in the first year and the 3 programs that did not participate in the second and third years of the study had specific restrictions against participating in outside research from their respective institutions.

The recruitment process began with email or telephone contact with the athletic trainers responsible for the baseball program at each institution. After the program agreed either orally or in writing to participate, an electronic survey compliant with the Health Insurance Portability and Accountability Act and created using SurveyMonkey (Momentive AI) was sent by email to the athletic trainer at each participating baseball program after that team had concluded its season (including postseason play). A critical aspect of this survey was the anonymous design to protect players’ personal health information. This allowed for a deidentified collection of player data throughout collegiate baseball. The survey tracking anonymous player descriptive data and surgical information was linked to a separate response form that notified our institution which school had completed the survey. However, this did not allow us to identify which survey responses were submitted by a specific school. Therefore, the identity of the players and the privacy of the health statistics from each baseball program were preserved. The participating institutions were not compensated financially for their participation.

The survey included questions regarding both deidentified personal descriptive data and technical surgical details. Personal descriptive data included player age, primary position, academic level at the time of surgery, and the state in which the player attended high school. Surgical data included time of year of surgery, type of UCL surgery performed (reconstruction vs repair), primary versus revision UCL surgery, additional elbow procedures performed at the time of surgery, and any previous shoulder or elbow surgeries undergone by the player. To protect player anonymity, we asked about “season” of surgery as opposed to an exact surgical date. We identified 4 phases of the calendar year in relation to the traditional baseball season: “previous summer” (from the end of the previous season to August 31), “fall” (from September 1 to November 30), “preseason” (from December 1 to the first game of the season), and “in-season” (from the first game of season to the last game of season). Players were delineated into having attended high school in warm-weather or cold-weather states, with cold-weather states defined by the National Oceanic and Atmospheric Administration as having an average annual temperature of 55°F or lower.

Proportions among subgroups (position, academic year, geographic location of high school) were compared using Poisson regressions. Differences were considered significant when \( P < .05 \).

RESULTS

After the conclusion of the 2017-2019 baseball seasons, 100% of the baseball programs that enrolled in the study...
The overall mean age of players at the time of surgery was 19.9 years (19.7 years in 2017, 20.0 years in 2018, and 19.8 years in 2019). Table 3 demonstrates the comparative percentage of players who underwent UCL surgery by academic year during each year of the study. For surgeries that occurred in the previous summer, players were included with their rising academic year cohort. Significantly fewer surgeries took place during the senior year than the other 3 academic years. The percentage of surgeries in seniors increased each year, but this trend was not statistically significant (P = .07).

Table 4 demonstrates the percentage of surgeries for each phase of the baseball calendar year. Among the 4 seasons, the number of surgeries was greatest in-season and least during the preseason. We found no statistical difference across the 3 years of the study.

Table 5 demonstrates the percentage of collegiate players who attended high school in warm-weather and cold-weather states. Nearly all players were from the United States (583/587), with 1 player from Canada and 3 players unaccounted for, as the athletic trainer did not know the state of origin for those players. Excluding these players, a nonsignificant majority of players undergoing surgery each year originated from warm-weather states. In 2016-2017, significantly more surgeries were performed in athletes from warm climates than from cold climates. The trend of more surgeries for athletes from warm climates than cold climates was seen in the subsequent 2 years as well, but the differences were not statistically significant. Figure 2 depicts where each injured player played high school baseball throughout the 3 years of data collection, with red states representing the warm-weather states and blue states representing the cold-weather states.

In addition to collecting anonymous personal descriptive data, the survey also collected deidentified surgical data for the 587 players who underwent UCL surgery over the 3 years of the study. Nearly all players underwent surgery on the dominant extremity (586/587; 99.8%). Overall, 97% of patients underwent a primary UCL procedure (572/587), and 3% underwent a revision procedure for tear of a graft.
No significant change was noted in this low rate of revision surgery across the 3 years, with a 3.0% revision rate in 2017 (4/134), 2.6% in 2018 (6/230), and 2.2% in 2019 (5/223). The most common additional procedure performed at the time of surgery was ulnar nerve transposition, which was performed in 29% of the overall surgeries (169/587). This number of ulnar nerve transpositions varied slightly by year, with 36% in 2017 (48/134), 22% in 2018 (51/230), and 31% in 2019 (70/223). A minority of the players each year had undergone previous surgery to the ipsilateral shoulder and elbow, including shoulder labral repair, previous UCL reconstruction, bone spur removal, ulnar nerve transposition, cervical fusion, and thoracic outlet decompression. The previous ipsilateral shoulder/elbow surgery rate was 15% in 2017 (20/134), 11% in 2018 (25/230), and 9% in 2019 (19/223), for an overall rate of previous ipsilateral surgery of 11% (64/587).

The annual survey also inquired about the type of UCL surgical procedure performed on the injured elbow. Although a small number of procedures was listed as “unknown,” the type of surgical procedure performed was submitted for 97% of the injuries recorded over the 3 years of the study (570/587). Of these, 80% of players had a reconstructive procedure using a graft (458/570). The remaining 20% of the players (112/570) underwent the recently described UCL repair using internal brace augmentation. As shown in Table 6, the rate of UCL repairs performed increased significantly each year.

Of the players undergoing UCL reconstruction using an autograft, the type of graft was recorded for 88% of UCL reconstructions (404/458). From these players with a known graft type, the overall rate of using palmaris longus tendon (71%; 288/404) was significantly greater than the rate of using gracilis tendon graft (29%; 116/404). The annual breakdown was not significantly different each year, with use of a palmaris longus tendon reported in 66% in 2017 (73/110), 74% in 2018 (108/146), and 72% in 2019 (107/148) versus use of a gracilis tendon reported in 34% in 2017 (37/110), 26% in 2018 (38/146), and 28% in 2019 (41/148).

### DISCUSSION

Two previous studies included longitudinal data from 2 Division I conferences over the course of several seasons and also a computer extrapolation of the limited data entered into an electronic injury surveillance system. These studies reported a low rate of UCL injuries requiring surgery in Division I collegiate baseball, inconsistent with anecdotal reports of a high rate of injury requiring surgery. More recently, we published the first national study looking at the incidence of UCL injuries requiring surgery in

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**TABLE 3**

| Ulnar Collateral Ligament Surgeries per Academic Level<sup>a</sup> |
|---------------------|---------------------|---------------------|---------------------|
| Baseball Season     | Freshman | Sophomore | Junior | Senior<sup>b</sup> |
| 2016-2017            | 37 (50)  | 28 (38)   | 26 (35) | 8 (11)            |
| 2017-2018            | 27 (62)  | 29 (67)   | 33 (77) | 10 (24)           |
| 2018-2019            | 39 (87)  | 24 (53)   | 25 (55) | 13 (28)           |

<sup>a</sup>Data are reported as % (n).

<sup>b</sup>There were significantly fewer surgeries in seniors compared with the other academic levels (P < .05).

**TABLE 4**

| Ulnar Collateral Ligament Surgeries per Season<sup>a</sup> |
|-------------------------------|---------------------|---------------------|---------------------|
| Baseball Season               | Previous Summer | Fall | Preseason<sup>b</sup> | In-Season<sup>c</sup> |
| 2016-2017                     | 16 (22)     | 22 (30) | 13 (17) | 49 (65)     |
| 2017-2018                     | 28 (65)     | 19 (43) | 12 (27) | 41 (95)     |
| 2018-2019                     | 23 (51)     | 23 (51) | 17 (37) | 38 (84)     |

<sup>a</sup>Data are reported as % (n).

<sup>b</sup>There were significantly fewer surgeries during preseason compared with the other seasons (P < .05).

<sup>c</sup>There were significantly more surgeries in-season compared with the other seasons (P < .05).

**TABLE 5**

| Ulnar Collateral Ligament Surgeries in Players Who Played High School Baseball in Warm and Cold Regions<sup>a</sup> |
|-----------------------------|---------------------|---------------------|
| Baseball Season             | Attended High School in Warm Climate | Attended High School in Cold Climate |
| 2016-2017<sup>b</sup>       | 65 (87)             | 35 (46)             |
| 2017-2018                    | 53 (120)            | 47 (107)            |
| 2018-2019                    | 53 (119)            | 47 (104)            |

<sup>a</sup>Data are reported as % (n).

<sup>b</sup>There was a significantly greater percentage of surgeries in players from a warm climate compared with those from a cold climate in 2016-2017 (P < .05).
Division I collegiate baseball over the course of 1 year. We found the incidence of surgeries over the course of the 2016-2017 year to be quite high, with 155 participating programs reporting 134 UCL surgeries, generating a rate of 0.86 surgeries per program. The baseline data from that 1 year demonstrated that pitchers and underclassmen were at an increased risk of needing UCL surgery, whereas climate of origin played no significant role in surgery risk to players. This initial study was very successful, with all 155 enrolled programs successfully submitting the electronic survey. The unexpected 100% response rate in that first year established baseline epidemiology data on these injuries that were previously unknown and incompletely studied. We were pleased with both the response from the individual athletic training staffs at the enrolled schools and the quality of the data. Therefore, we elected to continue and expand the study to include all Division I baseball programs over the following 2 years. This allowed us to analyze short-term trends in the data generated for a total of 3 years, resulting in 25,587 player-years of data. Again, we were pleased that the phenomenal response of the local athletic trainers continued, with a 100% response rate during the 2017-2018 and 2018-2019 years as well.

As the data collection expanded from 51% of Division I programs in 2016-2017 to 99% of programs in 2017-2018 and 2018-2019, the total number of surgeries increased as well. The mean number of surgeries per program decreased slightly each year, however, from 0.86 in 2017 to 0.78 in 2018 and 0.75 in 2019. This does not represent a significant decrease, demonstrating a relatively stable rate of UCL injuries requiring surgery during this time. In 2018 and 2019, almost half of the programs had at least 1 player with a UCL injury requiring surgery. In all 3 years of the study, a stable number of programs (21-22%) had multiple players undergo UCL surgery. This raw number of injuries each year, the surgery rate per program, and the percentages of schools affected each year are all drastically higher than are the previously reported estimates in other studies.

Throughout the 3 years of data collection, pitchers comprised the vast majority of players who underwent surgery. This remained relatively stable, between 83% and 86% of surgeries over the 3 years. Previous biomechanical studies have demonstrated that pitchers experience extremely high varus torque about the elbow during pitching, so this predominance of injuries requiring surgery among pitchers is expected. Of all position players, catchers had the highest incidence of injury each year. The distribution of injuries throughout the infield and outfield was both low and stable throughout the 3 years of the study. There was no significant change in the relative incidence by position when the study was expanded to all of Division I for the 2017-2018 and 2018-2019 years.

### Table 6

| Baseball Season | UCL Reconstruction | UCL Repair |
|-----------------|--------------------|------------|
| 2016-2017       | 90 (114)           | 10 (12)    |
| 2017-2018       | 80 (177)           | 20 (44)    |
| 2018-2019       | 75 (167)           | 25 (56)    |

aData are reported as % (n). UCL, ulnar collateral ligament.

bThere was a significant change in percentage of UCL repairs per year (P < .05).

cThere were significantly more UCL reconstruction surgeries than UCL repairs (P < .05).

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Figure 2. Total number of surgeries per state of high school origin throughout the 3 years of data collection. Red indicates warm-weather state. Blue indicates cold-weather state.
Overall, there were significantly fewer surgeries among seniors than underclassmen. There are multiple possible explanations for why underclassmen undergo surgery at a higher rate. First, there are typically fewer seniors on an individual collegiate team roster compared with other academic years. With fewer players, there are fewer total number of injuries. In addition, incoming freshmen may opt to undergo surgery upon enrolling in college and use a medical red shirt at the beginning of their college eligibility, treating a preexisting injury from high school. Incoming freshmen also likely have more variability in their pitching mechanics compared with upperclassmen, potentially increasing injury risk.\textsuperscript{23} Attrition bias also likely exists, where the players who are drafted to play professionally after their junior season are often pitchers who pitch more often and at higher velocities, making them more susceptible to injury than are their peers who remain on the team. The healthy upperclassmen may also represent a survival bias compared with peers who sustained career-ending injuries in high school or college. Finally, seniors often likely decide to treat a UCL injury nonoperatively if they do not intend to pursue competitive baseball after their senior collegiate season.

At the beginning of our initial study during the 2016-2017 year, we defined different times of the year as specific “seasons” to analyze a possible temporal relationship between surgical dates and the baseball calendar. The in-season phase was the longest season that we defined, running from the first game of the season (roughly mid-February) to the final game of the season for each team (variable from mid-May to the conclusion of the College World Series in late June). In-season surgeries represented 49\% of surgeries in the first year, a significant plurality. The predominance of in-season surgeries continued throughout the subsequent 2 years (41\% during the 2018 season and 38\% in 2019), presumably reflecting immediate surgery after injuries during an active season. Although the survey designed for this study did not specify at what point during the active season the injury and surgery occurred (to protect player anonymity), anecdotal evidence from the athletic trainers throughout the 3 years identified a bimodal distribution of in-season injuries—typically the opening and closing weeks of the active season. This suggests 2 different types of UCL injuries requiring surgery in collegiate baseball. The injuries at the beginning of the active season after a short preseason likely represent injuries resulting from insufficient conditioning, whereas the injuries at the end of the season are more characteristic of overuse injuries. This distinction suggests 2 possible opportunities, namely, prevention of injuries early in-season by expanding the preseason conditioning period and prevention of overuse injuries late in-season using rigorous obedience to pitch count guidelines throughout the season.

In the past, considerable discussion and debate have surrounded the potential effect of climate on UCL injuries. Previous literature has implied that players who originated from warmer climates could potentially be at higher risk of injury compared with players who played in colder weather.\textsuperscript{17,23,41,54} We therefore believed that this was an important element to analyze in our study, and we included a question on climate of origin in our electronic survey. A difficulty in the analysis of climate includes how to properly frame the question to most accurately determine the effect of temperature on player risk. We elected to have the athletic trainer who completed the survey report the state of high school origin for a player who underwent UCL surgery, believing that this would most effectively capture the effect of climate at the time when the majority of the cumulative playing time occurred in these players. We previously found that athletes who played high school baseball in warm-weather states underwent UCL surgery at a slightly, although not significantly, higher rate during our first year of data collection.\textsuperscript{46} This disparity narrowed during the 2017-2018 and 2018-2019 years, demonstrating nearly an even distribution of surgeries between warm-weather and cold-weather high school origin. The equilibration of surgeries between warmer and colder climates is likely caused by 2 recent developments: the creation of indoor baseball facilities throughout the northern United States and Canadian provinces allowing for year-round play and the disappearance of the multi-sport athlete in recent years. These factors have led to players participating in organized baseball activities throughout the calendar year, despite the climate. Therefore, players today seem to have equally high risk of UCL injury regardless of their climate of origin.

Of the 587 total UCL surgeries recorded in our study, 572 (97.4\%) were primary procedures. The low revision rate for UCL surgery (2.6\% overall) was relatively stable between 2.2\% and 3.0\% throughout the 3 years. As reported in our previous study, this revision rate is significantly lower than the 13.2\% revision rate reported in professional baseball players.\textsuperscript{6,32,37} The lower rate of revision surgery in the collegiate population compared with professional baseball is expected, but the recent high incidence in primary UCL surgery in collegiate players raises concern that the revision rate could potentially increase in the future.

In addition to analyzing the short-term trends in the descriptive data of the players undergoing surgery, we were interested in technical details regarding the surgical procedure performed on these players. One recent development in the surgical management of elite overhead athletes is the opportunity to repair the native ligament in a certain, specific population of injured players.\textsuperscript{15,16,24,49,52} In players who present with chronic, attritional damage to the UCL, surgical reconstruction using a graft remains the most common and appropriate treatment option. This is often the case in older professional players later in their careers. However, with the exponential increase in the incidence of UCL injuries in a younger population, these athletes often display joint stability and high-quality native ligament tissue. In these patients, a primary repair using brace augmentation allows for a possibly earlier return to throwing and a preservation of the native tissue in the appropriate candidates. We previously reported that in 2016-2017, 10\% of Division I collegiate baseball players analyzed in our study who underwent UCL surgery had a primary repair using brace augmentation. In the subsequent 2 years, this percentage of players undergoing UCL repair consistently increased to 20\% in 2017-2018 and then to 25\% in 2018-2019. Although preliminary, the early outcome data on
overhead athletes undergoing modern UCL repair have been encouraging. We expect this short-term trend of young amateur players in collegiate baseball undergoing UCL repair to continue to trend upward in the coming years.

The primary goals of this project included establishing baseline epidemiology data for UCL injuries requiring surgery in collegiate baseball and generating potential prevention strategies to decrease the incidence in the future. When we decided to continue the study beyond its initial year of data collection, we had hoped to collect 5 consecutive years of data to generate a significant volume of data and short-term trends to analyze. Because the 2020 baseball season was suspended because of the COVID-19 pandemic, we believed that data from a year without a baseball season would have changed the stable short-term trends that we observed through the previous 3 years, confounding potential conclusions. In addition, the recent proposed alterations to the collegiate baseball calendar allowing for an expanded spring training and later start to the season created an important opportunity to present and discuss our findings. If these changes are adopted in the near future, we anticipate potential positive differences in the incidence of UCL injuries requiring surgery. As discussed, we believe a longer preseason period could be beneficial to players by reducing injuries due to inadequate conditioning and preparation. This change in the baseball calendar could possibly lower the overall number of annual injuries. Therefore, despite ending our data collection to analyze short-term trends sooner than anticipated, we plan to collect data again in the future if the new proposed calendar is adopted in order to evaluate its potential effect on preventing these common injuries in collegiate baseball.

Limitations

This study had several limitations. The primary limitation was the inability to verify the accuracy of the epidemiology data submitted by each athletic training staff at each Division I baseball program. These data were submitted using an electronic survey completed by the head athletic trainer, baseball athletic trainer, or graduate assistant at the various institutions. We believed that the local athletic training staff had the most intimate knowledge of the individual players undergoing surgery, and therefore the information would be as accurate as possible; however, this was impossible to verify. In addition, because the player information was deidentified, postoperative outcomes could not be assessed. This data set did not account for players who had previously played at the junior college level, representing an unknown number of players in this age range. Finally, the climate data could have been misrepresented by players who changed geographic locations during high school.

CONCLUSION

UCL injuries requiring surgical intervention in NCAA Division I collegiate baseball represent substantial morbidity to young overhead athletes. Over the course of this 3-year study, the annual incidence of UCL injuries requiring surgery remained high, with approximately one-half of collegiate baseball programs experiencing at least 1 player undergoing surgery each year. Pitchers who were underclassmen were at increased risk of an injury requiring surgery. Most surgeries occurred during an active season, possibly caused by inadequate conditioning for the beginning of the season and overuse late in the season. Climate of origin played no significant role in surgical risk throughout the study. Although most surgical procedures were UCL reconstructions, the percentage of UCL repairs increased each year. These descriptive epidemiology data and short-term trends should be considered in creating potential injury prevention strategies for collegiate baseball players.

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