No change in performance metrics in major league baseball players sustaining wrist fractures after being struck by an errant pitch[☆]

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ABSTRACT

Objective: This study aimed to determine the effect of wrist fractures on performance metrics in Major League Baseball Players after they were hit by an errant pitch.

Methods: Players who sustained wrist fractures after being struck by a pitch were identified and changes in performance metrics were calculated.

Results: In both the short- and medium-term analysis, there were no significant differences in all pre- and post-injury offensive statistics following return to play.

Conclusion: Wrist fractures sustained after being struck by an errant pitch do not significantly impact professional baseball player performance if the player is able to return to sport.

1. Introduction

Hand and wrist injuries are among the most frequently reported injuries in sports.¹ Posner et al. found that the number of injuries in Major League Baseball (MLB) players has gradually and consistently increased despite advances in conditioning and treatment.² Among all types of injuries in baseball players, upper extremity injuries are the most common.² Although positional players with lower extremity injuries spend significantly more days on the disabled list, injuries of the wrist and hand account for 17% of fielders' injuries, making it the most injured anatomic region.²

A significant portion of wrist and hand injuries can occur as a result of shearing forces.¹ The most common shear stress causing wrist and hand injuries involves the position of the baseball bat in the athlete's hand during a swing, which can result in a hook of hamate fracture.^{1,3} A prior study performed by Guss et al. showed that there were no significant differences between pre- and post-injury performance after hook of hamate fractures in MLB players.³ However, recent studies have demonstrated that an increasing majority of wrist and hand fractures in professional baseball players can occur through being hit by an errant pitch. A recent study by Rhee et al. examining major league baseball players with hand and wrist injuries found that the most common mechanism of injury was through direct impact from the ball.⁴

While prior studies have identified performance outcomes after

different injuries to position players in MLB, the focus of these studies has generally been on the specific type of injury rather than the mechanism of injury.^{3,5–9} Although rare, injuries sustained after being struck by an errant pitch can have potentially career-altering implications.⁴

The purpose of this study was to determine the effect of wrist fractures sustained after being hit by an errant pitch on performance metrics in MLB athletes. In players able to return after sustaining such wrist fractures, we hypothesized that these injuries would not have a significant impact on their post-injury production in the short- and medium-term periods.

2. Methods

In order to identify players who sustained wrist fractures while playing in the MLB, a search was completed through the MLB transaction list from 2001 to 2017.¹⁰ Using each year's transaction list, players who sustained wrist fractures and were subsequently placed on the disabled list were identified. After identifying players with wrist fractures within this 16-year period, the mechanism of injury was found. This was obtained through searches of injury reports, press releases, and player profiles. Only players who sustained the injury via direct impact from a pitch were included in the final cohort. While the specific details of the anatomic injury and post-injury management

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Fig. 1. Flowchart depicting inclusion and exclusion criteria for the two cohorts analyzed.

Table 1

Demographics of Players Included in the Analysis.^{7,8}

Name	Position	Age at Injury (years)	Batting Handedness (R vs. L)	Laterality of Wrist Fracture	Games Missed
Player 1 *	SS	23	R	R	51
Player 2 *	1B	27	L	L	44
Player 3	OF (RF)	25	R	R	53
Player 4	OF (RF)	37	R	R	15
Player 5 &	1B	26	R	L	52
Player 6	3B	22	R	L	45
Player 7 ^	SS	34	R	R	RETIRE
Player 8	OF (RF)	24	R	L	46
Player 9 ~	OF (CF)	29	R	L	37
Player 10	SS	25	R	L	33
Player 11	3B	23	R	R	64
Player 12	OF (RF)	36	R	L	60
Player 13	C	29	R	R	67
Player 14 *, ~	SS	31	R	L	25
Player 15	C	24	R	L	26
Player 16 ^	OF (RF)	35	R	L	41
Player 17	OF (RF)	26	R	R	39
Player 18 ^	C	28	R	R	70
Player 19 #, &	3B	23	R	R	47
Player 20 *	1B	23	L	L	43
Player 21	OF (LF)	29	R	L	12
Player 22 &	OF (LF)	24	R	L	74
Player 23 &	SS	27	R	R	1
Player 24	OF (RF)	29	L	L	81
Player 25 #	3B	22	R	R	30
Player 26	1B	30	R	L	59

Legend 1. * denotes player injured in season following injury. ^ denotes player retired the season following injury. # denotes player injured or did not play in season prior to injury. ~ denotes that injury occurred in spring training. & denotes season-ending injury and return in subsequent season. 1B- Firstbase, SS- Shortstop, 3B- Third Base, C- Catcher, OF- Outfield, RF- Right Field, LF- Left field, CF- Center Field. R- Right, L- Left, RETIRE-retired from major league baseball.

Table 2a
Demographic Features and Games Missed for Players who Sustained Wrist Fractures from being Struck by a Pitch.^{7,8}

Average Years of Age	27.35
Percentage of right-handed batters	88.46%
Percentage of fractures in dominant hand ^a	53.8%
Mean number of games missed due to injury	44.6 games
Median number of games missed due to injury	45 games
Range of games missed due to injury	1-81 games
30-Game post-injury cohort's average number of games missed	44.6 games
1-Season post-injury cohort's average number of games missed	45.63 games

^a Dominant hand is defined as an injury to their right wrist if they are a right-handed batter and injury to the left wrist if they are a left-handed batter.

Table 2b
Percentage of players with wrist fractures from errant pitches by position.⁸

Position	Percentage of total players
C	11.5%
1B	15.4%
2B	0%
3B	15.4%
SS	19.2%
OF	38.5%

C- Catcher, 1B- First Base, 2B- Second Base, 3B- Third Base, SS- Shortstop, OF- Outfield.

Table 3
Average Difference in Performance Metrics for the 30 Games Before and After Injury in the 25 players from the 30-Game Post-Injury Cohort.

	Hits	Home Runs	RBI	AVG	SLG
Average Difference ^a	1.74	0.07	1.54	0.01	0.01
Standard Deviation	7.16	2.80	5.21	0.07	0.12

^a Average Difference was calculated as follows: [Post-Injury Value] – [Pre-Injury Value]. RBI- Runs batted in, AVG- Batting average, SLG- Slugging Percentage.

were not delineated in these reports, wrist fractures were defined as distal radius, distal ulna, and carpal fractures. Players with fractures of the radial shaft, ulnar shaft, metacarpals, or phalanges were excluded. The included players were not further stratified by specific diagnosis or treatment modality.

Once players who sustained wrist fractures after being hit by a pitch were identified, two cohorts were created based on strict inclusion and exclusion criteria (Fig. 1). The purpose of these cohorts was to determine short- and medium-term changes in performance metrics following injury. The first cohort (30-game post-injury cohort) consisted of players who played at least 30 games prior to sustaining the injury and 30 games after returning to play from the disabled list. Players qualified for this cohort if these 30 games spanned two seasons. The second cohort (1-season post-injury cohort) consisted of players who played at least 100 games in the season prior to the injury and 100 games in the season after the injury. Players from the 1-season post-

injury cohort were also included within the 30-game post-injury cohort if applicable. Players were excluded from the study if the injury ended the player's career or did not allow the athlete to play at least 30 games in the MLB following injury.

After these cohorts were created, performance statistics for these players were obtained through www.baseball-reference.com.¹¹ This methodology has been previously validated in order to determine return-to-play rates and performance outcomes for athletes across a variety of different sports.^{3,12–16} For the 30-game post-injury cohort, purely offensive statistics were analyzed: batting average, hits, home-runs, runs batted in (RBIs), and slugging percentage. The changes in these performance metrics were calculated by subtracting statistics from the pre-injury 30-game period from the statistics in the post-injury 30-game period.

For the 1-season post-injury cohort, the same offensive statistics were obtained, but in addition, Wins Above Replacement (WAR) was also collected. WAR is intended to represent how one player affects the amount of wins his team would have in one year with him in the lineup versus a replacement player.¹¹ WAR is based on runs and is calculated by how many more runs the player contributes to his team compared with the runs provided by a replacement player. All statistics for the 1-season post-injury cohort were collected only for the seasons before and after the injury. If the player played less than 162 games (full MLB season) in the seasons before or after injury, their hits, homeruns, and RBIs in the total games played (which was > 100 games by definition) in each season were extrapolated across 162 games. This was done by calculating the total number of hits, homeruns, and RBIs in the games played that season, dividing the sum total of each of these statistics by the total number of games played that season, and then multiplying this new value by 162. This was only performed for hits, homeruns, and RBIs, as these were the only variables that were cumulative figures, increasing with the number of games played per season.

Once this was done, differences in all performance metrics were calculated by subtracting statistics in the season prior to injury from statistics in the season after sustaining the injury. After the differences were calculated on an individual level, the average difference for each statistic was calculated, as well as the standard deviation (SD).

For the 1-season post-injury cohort, not only were the average differences in pre- and post-injury statistics calculated, but these differences were compared to differences in age-matched seasons for a control group. This control set allowed for additional analysis of the players' post-injury performance metrics relative to similar players at that position. As such, the control set of data was specific to each injured player and comprised players that were similar in terms of "similarity scores" as defined by www.baseball-reference.com. Similarity scores provide a medium for identifying specific players that are comparable in terms of offensive production at their respective position. For each injured subject, five control players that had high similarity scores were identified. This methodology has been previously validated in studies comparing performance outcomes after injury.¹² Previously, authors have used a 1-to-1 matched control group on the basis of age, experience, position, performance, time frame, and overall "similarity score" provided by an online database.¹¹ In order to improve the strength of this comparison, we used 5-to-1 matched control groups rather than the 1-to-1 matched control groups used in previous

Table 4
Average difference in performance metrics for the season before and after injury in the 1-season post-injury cohort.

	Hits	Home Runs	RBI	AVG	SLG	WAR
Average Difference ^a	– 0.950	– 1.026	– 1.164	0.001	– 0.002	– 0.225
Standard Deviation	27.087	7.073	14.803	0.036	0.054	2.100
Average Normalized Difference	0.158	0.172	0.154	0.304	0.317	0.150

^a Average Difference was calculated as follows: [Post-Injury Value] – [Pre-Injury Value]. RBI- Runs batted in, AVG- Batting average, SLG- Slugging Percentage, WAR- Wins above replacement.

Fig. 2. Distribution of normalized differences in (a) batting average, (b) hits, (c) home runs, (d) RBIs for all players within the 1-Season Post-Injury Cohort; (e) slugging percentage, (f) WAR for all players within the 1-Season Post-Injury Cohort.

reports.¹²

Once these five control players were identified, their statistics in the seasons they played at the ages corresponding with the injured player's ages before and after injury were recorded. Similar to the previous calculation of season-based statistics for the 1-season post-injury cohort, the hits, homeruns, and RBIs of the controls in the specific seasons analyzed were extrapolated to a full 162 games played. With these full-

season statistics for the controls, performance metrics at the ages corresponding to the pre-injury ages were subtracted from the performance metrics at the ages corresponding to the post-injury ages. These differences in statistics across these two seasons were then averaged across all five players for each control group. Once these season-based, age-matched differences in statistics for the control players were acquired, they were used to provide a distribution of data for which to

compare the change in statistics of the injured player. The change in statistics of each injured player was compared to the standard deviation of their respective control groups. From this comparison, each injured player's performance metrics were assigned a normalized difference, representing the number of standard deviations away from their respective control group's average difference for that statistic. These normalized differences for each player were averaged across all injured players included in the 1-season post-injury cohort. By assessing normalized differences, the effect of confounding factors such as professional baseball experience and age could be mitigated.

In the analysis of normalized differences for the 1-season post-injury cohort, any result outside of two standard deviations from the mean was considered a statistically significant change in performance metrics.

3. Results

3.1. Demographics

From 2001 to 2017, 26 players were found to have sustained wrist fractures after being hit by a pitch. Of these, one player retired immediately following the injury. This left 25 players for analysis in the 30-day post-injury cohort (Fig. 1).

In addition to the one player who retired immediately after injury, two others returned from injury during the same season but retired the following offseason. Four other players were injured in the following season and played less than 100 games during that season, resulting in exclusion for analysis in the 1-season post-injury cohort. Three more players were injured during the season preceding the wrist injury and played less than 100 games during that season, also excluding them from analysis in the 1-season post-injury cohort. Thus, 16 players met criteria for inclusion in the 1-season post-injury cohort (Fig. 1).

Out of the initial 26 players who were found to have wrist fractures after being hit by a pitch, 14 of the players fractured their dominant wrist (Table 1). The average age of the injured players was 27.35 years old and the average games missed due to injury was 44.6 games (Table 2a). Outfielders were the most common position to sustain wrist fractures from an errant pitch; however, the outfield category includes 3 individual positions, comprising a greater total percentage of overall players. After outfielders, the most likely position to be hit by an errant pitch was shortstops (Table 2b).

3.2. 30-Game post-injury performance analysis

Among the 25 players included in the 30-game post-injury cohort analysis, there was, on average, an increase in all performance metrics in the 30 games following injury relative to the 30 games prior to injury. Specifically, relative to the 30 games prior to injury, the average hits increased by 1.74 (SD: 7.16), home runs increased by 0.07 (SD: 2.80), RBIs increased by 1.54 (SD: 5.21), batting average increased by 0.01 (SD: 0.07), and slugging percentage increased by 0.01 (SD 0.12) in the 30 games following injury (Table 3).

3.3. 1-Season post-injury performance analysis

The changes in performance metrics among the 16 players included in the 1-season post-injury cohort analysis are depicted in Table 4. Relative to the season prior to injury, the average hits decreased by 0.950 (SD: 27.087), home runs decreased by 1.026 (SD: 7.073), RBIs decreased by 1.164 (SD: 14.803), batting average increased by 0.001 (SD: 0.036), slugging percentage decreased by 0.002 (SD 0.054), and WAR decreased by 0.225 (SD: 2.100) in the season following injury (Table 4).

After comparing each of the 16 injured players to their respective control groups, the average normalized differences in performance metrics between the injured subjects and the matched control groups

were obtained (Fig. 2a–f). The average normalized difference was 0.158 for hits, 0.172 for home runs, 0.154 for RBIs, 0.304 for batting average, 0.317 for slugging percentage, and 0.150 for WAR (Table 4). Because all of these normalized differences were less than 2, the average difference in performance metrics between the pre-injury season and post-injury season for the injured players fell within 2 standard deviations of the average change in performance metrics for the matched control group. Consequently, the average normalized differences were not statistically significant for all analyzed performance metrics, indicating that there was no statistically significant difference in injured player performance metrics when compared to typical season-dependent changes in performance metrics for uninjured, matched controls.

4. Discussion

This study aimed to determine the effects of wrist fractures caused by errant pitches on short- and medium-term player performance metrics in MLB athletes. The major finding of this analysis was that in the short-term study period (30-game post-injury period), the effect of prior wrist fracture on post-injury performance metrics was minimal, with all short-term, post-injury metrics improving slightly relative to pre-injury metrics. Within the medium-term study period (1-season post-injury period), the effect of prior wrist fracture on post-injury performance metrics was also minimal, with slight decreases noted for most performance metrics. A comparison of these medium-term changes in performance metrics was done against matched controls in order to mitigate the effects of time-dependent confounding factors, such as age or player experience. In that analysis, there was no significant medium-term change in the performance metrics of the injured cohort in comparison to uninjured, matched controls over the same time span. As a whole, these findings indicate that as long as players return to the MLB after sustaining wrist fractures from errant pitches, there is, on average, no significant change in offensive performance after return to play.

Although return-to-play was a favorable prognostic sign for matching prior offensive production following wrist fracture, there were several players who were not able to return after such injuries. In the season following injury, seven players either retired or were unable to play in at least 100 games, demonstrating the variable severity of this injury mechanism and the ability of such an injury to alter the trajectory of MLB players' careers. The average time missed by players as a result of these wrist fractures was 44.6 games, demonstrating that while many players may return to their pre-injury level of play, the injury can still result in a significant temporary burden to their team's level of competitiveness.

Injuries to the wrist and hand can result in a considerable amount of time missed from sport. Direct blow injuries are rarer across sports but can occur more frequently in baseball, football, and soccer when the ball strikes the individual's hand or wrist. A scaphoid fracture is the most common traumatic injury of the wrist suffered in athletes.¹ While most scaphoid fractures in athletes are sustained through a fall, direct blow injuries comprise a small portion of this type of fracture.¹ In one meta-analysis of scaphoid fractures in athletes, non-operatively managed scaphoid fractures had a return to sport rate of 90% and a mean time to return of 9.6 weeks.¹⁷ For those scaphoid fractures treated surgically, the return to sport rate was 98% with a mean time to return of 7.3 weeks, indicating that operative management of these injuries may be preferred in athletes.¹⁷ Lunate and pisiform fractures occur less commonly in athletes, and time to return to sport after these injuries usually ranges from 6 to 8 weeks.¹ As with the scaphoid, operative fixation of hand and wrist injuries in general can allow for faster return to play in competitive athletes.¹⁸ Overall, while wrist fractures typically do not permanently inhibit athletes from returning to play, significant time away from sport can occur depending on the severity of the injury.^{3,17,18}

In analyzing the impact of hand and wrist injuries in baseball, injuries caused by direct impact from the ball are an important

consideration. In one study on professional baseball players who sustained wrist and hand injuries between 2011 and 2016, the most common mechanism of injury was direct contact with a baseball, accounting for 43% of all injuries in this region.⁴ Furthermore, 40% of all wrist and hand injuries sustained in this population occurred while the athlete was batting.⁴ Of those wrist and hand injuries that did not end the players' seasons, the mean number of days missed was 17.3⁴. In addition, 7.1% of all wrist and hand injuries required surgery, with scaphoid and hook of hamate fractures being the most common operatively treated injuries.⁴ While this analysis by Rhee et al. included more generalized hand and wrist injuries including contusions, blisters, ligamentous injuries and sprains, contact with the baseball nonetheless represented the most common injury mechanism.⁴ This is in contrast to other injuries of the upper extremity, including elbow and shoulder pathology, which are more frequently attributed to indirect mechanisms such as overuse injuries.^{2–4,7} Given the frequency of wrist and hand injuries sustained after direct blow from a baseball, our study provides valuable prognostic information with respect to player performance following return to sport. This information, when combined with knowledge of the precise anatomic injury and treatment plan, can help inform decisions regarding whether it would be beneficial to responsibly accelerate a player's recovery plan based on the team's needs.

Few previous studies have examined changes in performance metrics following wrist and hand fractures in baseball players, irrespective of injury mechanism. One study on MLB athletes by Guss et al. found that there was no significant difference between pre- and post-injury WAR after players sustained and underwent operative treatment of hook of hamate fractures.³ Similar to our study, their analysis consisted of a control group and compared WAR for the two seasons prior to injury and the two seasons following injury.³ Another study on baseball players by Burleson et al. found that if players continued to play through hook of hamate fractures, the fractured fragments could be excised at a later time with minimal impact on player activity.⁸ Specifically, the median time to return to play was 5 weeks, and by 7 weeks, players had returned to their pre-injury level of activity.⁸ Given the paucity of data on this topic, the present study provides the first generalized analysis of player performance after wrist fractures.

This study is not without limitations. There is currently no publicly available injury database for the MLB. Therefore, searches for eligible subjects were based solely on publicly available transaction list reports.^{10,11} The list provided dates only as early as 2001, limiting the scope of the study. In addition, information on the extent and severity of the fractures in the athletes was unavailable, as was the choice of treatment modality. The details of the injuries were found through press releases and articles, which varied in the degree of descriptiveness for each injury. Thus, this study has insufficient data to suggest guidelines for treating these injuries. However, our findings can be used as a relative prognostic indicator for professional baseball athletes sustaining an injury with this mechanism.

Players were excluded if they retired or did not play in at least 100 games in the season following injury. This creates the possibility of selection bias, as the excluded players may have had more severe wrist injuries but were not included in the final medium-term analysis. Of note, in some cases, failure to play in at least 100 games in the season following wrist fracture was also due to unrelated injuries occurring in that season.

While a wide range of ability exists within the MLB, controls for the injured players were based off similarity scores of players that were the same age as the injured subject at the time of injury. However, many of the identified players who were most similar to the injured players were playing in the MLB more than 20 years ago. While the rules of baseball have not changed, the game has evolved tremendously, and the performance of players 20–30 years ago may not translate to performance in the modern era. We aimed to resolve this problem by taking the average of five different matched players for each injured player, rather than relying on a single, matched control player.

The reliance on offensive statistics to determine the value of a player in the MLB is another limitation of this study. While defensive metrics do exist, it is difficult to make a defensive comparison of baseball players across different positions. This is due to the variability in the amount of chances certain positions have to make defensive plays compared to others. Thus, this study relied mainly on offensive statistics to determine performance outcomes.

Finally, the players analyzed in this study were primarily average to above-average position players. Players who are average to below-average were more likely to be excluded from the analysis, as the study parameters required players to return to playing in the major leagues after injury (as opposed to playing in minor leagues). Above average players were less likely to be replaced, and therefore, these were the players who met criteria for inclusion in this analysis.

5. Conclusion

This study demonstrates that wrist fractures sustained after getting hit by an errant pitch do not significantly impact short- or medium-term player performance if the player is able to return to play. However, these injuries often result in players missing a significant number of games, highlighting the fact that they can still potentially result in a significant burden to the team's level of competitiveness during the recovery period. To the authors' knowledge, this is the first study in the literature analyzing performance metrics following return-to-sport in players who sustained wrist fractures from errant pitches. Further studies are needed to delineate the effects of fracture location, injury severity, and treatment modalities on performance outcomes in baseball players.

Contributions

Pradip Ramamurti – Data curation, formal analysis, original draft writing.

Seth Stake – Manuscript original draft writing.

Safa C. Fassihi – Manuscript original draft writing.

Rajeev Pandarinath – Manuscript review and editing.

Teresa Doerre – Manuscript review and editing.

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