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Performance metrics and economics of superior labrum anterior-posterior tear repairs in Major League Baseball pitchers

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Background: Superior labrum anterior-posterior tears (SLAP) can be a career-altering injury for Major League Baseball (MLB) pitchers. Surgery and postoperative rehabilitation keep pitchers on the injured list (IL) for extended time, which results in a significant cost to a team. To date, no analyses have focused on the financial cost of SLAP repairs in MLB pitchers.

Methods: A retrospective review of MLB pitchers with SLAP repair from 2004 to 2019 was conducted utilizing IL and financial contract data from the MLB website. Cost of injury was calculated from salary of the player. Performance metrics including earned run average, walks + hits per innings pitched, and innings pitched (IP) were averaged for one and all seasons played before and after injury. Return to play and return to prior performance rates were calculated and reported.

Results: Of the 55 players identified, 22 players (40%) returned to play and 18 of these 22 players (82%) returned to prior performance. Annual cost increased over the study period ($R^2 = 0.288$) averaging \$3.5 million, and a stable average of 172 days was spent on the IL ($R^2 = 0.001$). Performance was negligible except IP (106.95 vs. 50.85; $P < .01$) for 1 season before and after injury. For all seasons, earned run average and walks + hits per innings pitched significantly increased (4.13 vs. 5.19; $P = .030$, and 1.36 vs. 1.53; $P = .033$, respectively), while IP downtrended without significance ($P = .058$).

Conclusion: SLAP repairs in MLB pitchers have significant financial impact and time spent on the IL, which surprisingly has not changed over time. It is encouraging to know return-to-play pitchers return without profound decline in performance level following SLAP repair.

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With the wide availability of statistics in Major League Baseball (MLB), literature related to player injury is abundant. Recent studies have shown that over the last 2 decades, there has been a gradual, consistent increase in the number of injuries reported in MLB. The total number of days on the injured list (IL) due to injuries (approximately 439 annually) resulted in a net loss of over \$7 billion for the league.^{1,2,15} Proportionally, pitchers spend a greater number of days on the IL than fielders and have the highest incidence for shoulder injuries.^{6,15} In addition, previous studies have shown that pitchers are at a significant risk of developing superior labral anterior-posterior (SLAP) tears, which can cause pain and severely inhibit a player's ability to perform at the highest level, ultimately leading to long-term disability in these athletes.^{7,15} The mean time spent on the IL for players who have undergone SLAP

repair surgery is 315 days. Of these players, only around 62.5% were able to return to play (RTP), but the rate of RTP and prior performance after SLAP repair were lower in pitchers than in all other position players.¹⁸

Cost and outcomes of upper extremity injuries in MLB players have long been areas of interest and the focus of many research studies. However, literature of the effect of SLAP tears on these metrics remains limited. One study evaluated the impact of rotator cuff repair surgery on player performance and found that MLB players who had undergone rotator cuff repair saw a gradual improvement in their performance in the 3 seasons following surgery.¹¹ Evaluating cost and performance metrics of SLAP injuries in the same context would contribute to the existing body of literature regarding common injuries in MLB players. The purpose of this study was to analyze economic impact and player performance after SLAP repair in MLB pitchers. We hypothesized that players who underwent an SLAP repair have significant costs related to recovery but are able to return to preinjury performance levels following surgery.

Institutional review board approval was not required for this study.

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Methods

A retrospective review was performed on MLB pitchers who underwent a SLAP repair surgery from 2004 to 2019. These athletes were identified through the publicly available MLB IL (Major League Baseball Injured List) (previously referred to as the disabled list) database and verified by ESPN statistics.¹¹ Players with multiple shoulder surgeries or other injuries leading to placement on the IL were excluded from the study. Players who did not play in at least 10 innings prior to injury or players who had multiple concomitant injuries at the time of shoulder surgery were also excluded from this study. Player name and length of time on the IL were collected from the MLB database. Player statistics before and after surgery were collected from MLB database and verified based on ESPN and CBS sports websites per previously published methods.¹⁸ We included statistics for earned run average (ERA), walks + hits per inning pitched (WHIP), and innings pitched (IP). ERA is the average of earned runs allowed by a pitcher per 9 IP; thus, a lower ERA is better. Similarly, WHIP is a measurement of the number of base-runners a pitcher has allowed per inning pitched; therefore, a lower WHIP indicates a better performance. To analyze the immediate impact of SLAP repair, average values included 1 full season played prior to the injury, and average values of performance after recovery included 1 full season played after treatment and rehabilitation. To further analyze performance metrics as a career, we compared average values for all full seasons played before the injury; likewise, average values for performance after the player's recovery included all full seasons played after treatment and rehabilitation. Successful RTP was defined as the ability to pitch for a minimum of 1 entire season at the MLB level following SLAP repair. Players who were not able to RTP for at least one complete season following surgery or returned to play at the minor league level were considered a failure of RTP. Return to prior performance (RTPP) was defined as an ERA within 2.00 and WHIP within 0.500 before the injury as previously described by Erickson et al and Fedoriv et al in separate evaluations of MLB pitchers.^{3,7}

To determine financial impact of SLAP tear, analyzed variables included days spent on the IL, annual salary of injured player, and salary of their temporary replacement which were calculated based on a previously published methodology.¹ Financial impact associated with SLAP injuries per game was determined by dividing a player's annual salary by 182 days (the number of days in regular MLB season). Replacement player salaries per game were calculated using a similar previously established formula: $(\text{annual salary}/182 \text{ days on roster})$, the league minimum salary specific for the year of the SLAP injury divided by 182 days long season, to determine their salary per game, and multiplied by the number of days spent filling the roster spot.

Statistical analysis

Descriptive statistics for the average age, days spent on the IL, and financial costs were calculated. Pitcher performance before injury and after the injury was analyzed using a paired sample *t* tests. To determine the significance of trends over time, a best-fit line was demonstrated to show the change over the years for the days on the IL, costs, and incidence of SLAP injuries. All statistics were performed using Excel (Microsoft Corporation, Redmond, WA, USA) and SPSS software (IBM Inc, Armonk, NY, USA) with a significance level of 0.05.

Results

A total of 55 MLB pitchers who underwent a SLAP repair between 2004 and 2019 were included in this study with a mean age

of 29 years. Of the 55 players, 33 players had a career-ending injury, and 22 players had a successful surgery and RTP at the major league level. The overall RTP following surgery was 40% (22/55) of pitchers. During the study period, the average days spent on the IL was 172 per year. There was no change seen in the average number of days spent on the IL over the study time period ($R^2 = 0.001$) (Fig. 1). Looking at the financial impact of SLAP repair on MLB, the total cost for pitchers on the IL after SLAP repair was \$171,977,859 during the study period, with an average of \$3.5 million per year. Over the study period, the number of SLAP tears and repairs remained stable (Fig. 2). With increasing salaries during our time span, results did demonstrate an increase in average cost of replacing pitchers on the IL ($R^2 = 0.288$) (Fig. 1).

After exclusion of the 33 pitchers with a career-ending SLAP injury, analysis of short-term performance metrics comparing 1 season prior to surgical treatment showed no significant difference for ERA (3.84 vs. 4.78; $P = .145$) and WHIP (1.28 vs. 1.48; $P = .138$). There was a significant decrease in number of IP postsurgical treatment averaging 50.85 IP compared to 106.96 IP before the injury ($P < .01$) (Table I). Of the 22 returning players, 13 players (59%) were able to achieve RTPP in the first season immediately following treatment and rehabilitation. When analyzing performance metrics for all seasons played after surgery, both ERA and WHIP significantly increased (4.13 vs. 5.19; $P = .030$, and 1.36 vs. 1.53; $P = .033$, respectively). There was a strong trend toward decreasing IP to 265.30 including all seasons pitched after injury from 503.63 before injury ($P = .058$) (Table II). A large majority of players (82%) were able to achieve RTPP overall when looking at all seasons combined following treatment and rehabilitation.

Discussion

SLAP tears are a disabling shoulder injury for overhead throwing athletes, particularly for elite-level MLB players.¹⁵ The primary purpose of this study was to analyze the impact of these SLAP injuries resulting in the need for surgery in high-level professional MLB pitchers. Our results demonstrated majority of players were not able to RTP after SLAP repair, and there was a trend of higher costs for these SLAP repairs, due to the increase in the salaries of MLB players over the study period. In addition, the overall incidence of SLAP repairs remained stable throughout the study period, as did the number of days pitchers spent on the IL per year. In contrast, Erickson et al found a decreasing trend in the incidence of type II SLAP repairs over a 10-year period.⁴ Although their study did not specifically evaluate MLB players, this type of SLAP tear is most prevalent in athletic pitchers.⁵

The high-velocity throwing motion of MLB pitchers causes repetitive microtrauma to the ball-and-socket joint which can disrupt the intricate anatomy of the shoulder joint. SLAP tears and sometimes repairs in these high-level pitchers can alter their performance because of changes in accuracy and velocity. The literature shows that SLAP tears are associated with significantly high number of days spent on the IL up to even a year.^{13,19} Smith et al concluded that over 60% of MLB pitchers who underwent surgical repair returned to play with recovery days in isolated labrum injuries averaging at 314 days, and 326 days with labrum injuries and rotator cuff injuries concurrently. In our study, the mean time interval for RTP was 172 days, which is lower than that in previous studies.¹⁸ Consistent with previous studies, we found no significant decline in sports performance following surgical repair; more than 70% of MLB pitchers returned to play, at an average of 13 months postoperatively, without significant difference in performance level.¹⁶

Our results indicated an RTP rate of 40% and a successful RTPP rate of 82% over the entire career of players. Previous studies report

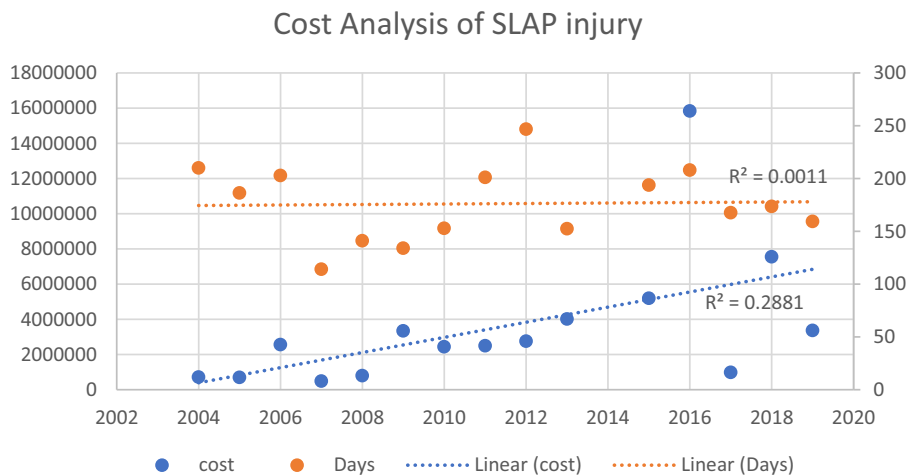


Figure 1 Association of days on the disabled list and associated costs of replacement players per year. SLAP, superior labrum anterior posterior tear.

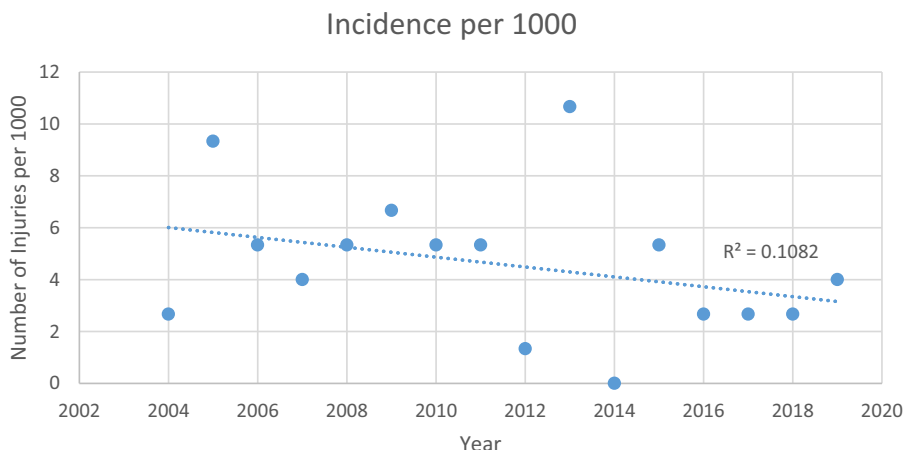


Figure 2 The incidence of SLAP injuries plotted per year. SLAP, superior labrum anterior posterior tear.

Table I Performance metrics of sports activity 1 season before and after injury.

Performance metrics	Before injury	After surgical repair	P value
Earned run average	3.84 ± 1.21	4.78 ± 2.77	.145
WHIP	1.28 ± 0.23	1.48 ± 0.53	.138
Innings pitched	106.95 ± 72.45	50.85 ± 49.18	<.01*

WHIP, walks + hits per inning pitched.
*Denotes significance.

Table II Performance metrics of sports activity in all seasons before and after injury.

Performance metrics	Before injury	After surgical repair	P value
Earned run average	4.13 ± 0.82	5.19 ± 2.19	.030*
WHIP	1.36 ± 0.19	1.53 ± 0.36	.033*
Innings pitched	503.63 ± 500.53	265.30 ± 237.46	.054

WHIP, walks + hits per inning pitched.
*Denotes significance.

a 62.5% RTP in pitchers following shoulder surgery, based on performance equivalent to preinjury level.¹⁸ Smith et al also reported an RTP rate of 86.7% for pitchers who were able to RTP.¹⁸ Similar to our results, their study concluded no significant difference in

pitching statistics before and after surgical repair except for IP for players that were able to RTP. In general, there remains a lower expected RTP for baseball players than for other overhead athletes, and literature varies regarding RTP for patients who participate in pitching.^{10,14} Gilliam et al reported a similar RTP in pitchers averaging 59% and a higher RTP of 76% for nonpitchers; however, their study also noted pitchers did not feel the same or better than how they were before injury.⁸ Conversely, a systematic review of elite pitchers highlighted that postoperatively overhead players demonstrated excellent results on patient-reported outcomes but with a decreased performance.^{9,17} Neri et al reported that 57% of elite overhead athletes returned to play at a preinjury level of sports performance.¹² Consequently, 26% (6/23) in their study still suffered from pain upon RTP. Neuman et al also found that baseball players compared to other overhead athletes had a lower percentage of RTP after SLAP repair, with pitchers more likely to RTP than position players.¹³

In proportions, upper extremity injuries are higher in MLB pitchers than in those at all other positions.¹⁵ In particular, SLAP tear is debilitating to both the pitcher and the team with regard to performance and economics. Seventeen percent of players who suffered a SLAP tear never pitched again competitively,¹² and only a small percentage of players (14%) returned to play during the same season.¹⁶ With such extended lengths of time spent on the IL,

previous studies of MLB injuries have shown that the financial impact of replacing injured players is substantial.¹ We found that pitchers with SLAP tears incur a mean annual cost of \$3,546,155, resulting in a total of \$171,977,859. In comparison to the total costs reported by Conte et al (\$7,618,817,407), the magnitude of SLAP injuries alone in our study is approximately 2.3%. Their study was based on data of 8357 MLB players assigned to the IL over a period of 18 years. The injuries evaluated were those of multiple body regions, including shoulder, elbow, chest/back/spine, wrist/hand/fingers, lower leg/knee, and the upper leg/thigh.¹

It is encouraging to say that aside from the high financial impact of this injury, players are able to RTP and do not face a significant decline in outcomes as assessed by our performance statistics analysis, suggesting there is still a need to investigate and consider other management options for MLB players indicated for surgical repair.¹³

Although other reports have shown promising successful outcomes following surgical repair of SLAP, nonsurgical treatment may show different results in the RTP rate of MLB players. Fedoriw et al reported that out of 45 pitchers with documented SLAP lesions, RTP was 40%, and the RTPP was 22% for those that underwent nonsurgical treatment.⁷ Pitchers that had surgical treatment of the SLAP lesion showed a higher RTP (48%) but a much lower rate of RTPP (7%). When compared to baseball players at all positions, pitchers had the lowest rates of RTP.⁷ A study examining over 300 patients with an SLAP injury had 15 overhead athletes who underwent nonsurgical treatment and showed only 67% returned to their preinjury performance level compared to 71% who had surgical treatment.⁵ These comparative outcomes of surgical vs. nonsurgical treatment are nearly equivalent, suggesting that surgical repair of SLAP may not always be the best treatment modality. Our study was not able to compare performance metrics among pitchers that underwent surgical vs. nonsurgical treatment. Further studies are warranted to evaluate difference in recovery time for overhead athletes successfully treated with a nonsurgical approach from those who underwent surgical intervention.

Our study has several limitations. Aside from those inherent in retrospective study designs, data that would have enabled us to make this study more robust were largely unavailable. For example, we did not have access to players' complete treatment history, and so we could only assess outcomes based on 1 known (surgical) intervention. In addition, we did not have 1-year clinical follow-up data, and therefore, we were unable to determine players' progress and extent of recovery.

Conclusion

Our study shows that while players who suffer SLAP tears spend an extensive number of days on the IL and often results in a hefty financial burden for teams, those who undergo surgical repair for SLAP tears are able to RTP at a level commensurate with their preinjury performance. Given the overall negative impact of SLAP tear injuries, implementation of techniques aimed at preventing or reducing SLAP tears during the preseason may be the most efficacious and beneficial way of addressing this issue moving forward.

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