

Return to Play and Outcomes in Baseball Players After Superior Labral Anterior-Posterior Repairs

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Background: Few studies have documented the outcomes of superior labral anterior-posterior (SLAP) repairs in baseball players. Furthermore, the results of these previous studies varied widely and were based on small numbers of patients.

Hypothesis/Purpose: The purpose was to report return-to-play (RTP) rates and validated subjective outcome scores for baseball players after SLAP repair. It was hypothesized that RTP rates and outcomes would be significantly different between pitchers and nonpitchers, as well as among baseball levels.

Study Design: Case series; Level of evidence, 4.

Methods: A series of 216 baseball players was identified who had isolated SLAP repair or SLAP repair with debridement of partial-thickness (<25%) rotator cuff tear at our surgical centers. Patients were contacted by phone a minimum of 2 years after surgery and asked questions about their ability to RTP. Patients were also asked questions to complete the Western Ontario Shoulder Instability Index (WOSI), Veteran's RAND 12-Item Health Survey (VR-12), and Kerlan-Jobe Orthopaedic Clinic (KJOC) questionnaires. Statistical equivalence in RTP rate, VR-12, and WOSI scores was determined between players with and without concomitant rotator cuff debridement using 2 one-sided tests and risk difference measures. Differences in RTP were tested among baseball levels (high school, college, professional) and positions (pitcher vs nonpitcher) using chi-square analyses ($P < .05$). Differences in outcomes scores were compared using t tests and analyses of variance ($P < .05$).

Results: Of the 216 baseball players, 133 were reached by phone for follow-up interview (mean, 78 months; range, 27-146 months). Overall, 62% successfully returned to play. There were no differences in RTP rates or subjective outcomes among baseball levels or between procedures. RTP rates were 59% for pitchers and 76% for nonpitchers ($P = .060$). Subjectively, the percentage of patients who felt the same or better at follow-up compared to preinjury was significantly higher among nonpitchers (66%) than pitchers (43%). There was no difference in KJOC scores between the pitchers (75.3 ± 19.4) and nonpitchers (76.2 ± 17.4) who successfully returned to play, although these scores were well below the minimum desired score of 90 for healthy baseball players.

Conclusion: SLAP repair should continue to be considered as an option for SLAP tear treatment only after nonsurgical management has failed. Some players may be able to return to baseball after SLAP repair, although regaining preinjury health and performance is challenging.

Keywords: pitcher; high school; college; professional; KJOC; SLAP lesions; shoulder

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Superior labral anterior-posterior (SLAP) tears were first described in 73 overhead athletes by Andrews et al¹ in 1985 and were later classified and coined "SLAP" tears by Snyder et al.³⁷ An understanding of shoulder biomechanics during throwing is paramount for successful treatment of SLAP injuries. During the arm-cocking phase of throwing, the abducted arm is externally rotated, and a posterior shear force is created at the superior labrum due to tension of the long head of the biceps.⁴ Burkhart and Morgan⁴ proposed that SLAP tears occur due to this shear force. In vitro research has shown that the superior labrum must be able to withstand 262 N of shear force in

this position.³³ The arm internally rotates during the arm-acceleration phase, and biceps force is produced to both resist shoulder distraction and decelerate elbow extension.¹¹ The biceps-labrum complex must be able to withstand 508 N of tensile force,³³ and Fleisig et al¹¹ first suggested that the tensile force produced by the biceps tendon near the time of ball release can lead to SLAP tear. J. E. Conway (personal communication, January 2003) proposed that the typical mechanism of SLAP tear may be a combination of both the “peel-back” mechanism during arm cocking suggested by Burkhart and Morgan⁴ and the tension at ball release proposed by Andrews et al.¹

There have been multiple studies evaluating the outcomes of surgical treatments for SLAP lesions.¹¹ Only a few have specifically looked at the results of SLAP repairs in baseball players alone, while almost all had baseball players heterogeneously included with other overhead athletes and throwers. In their systematic review of 506 SLAP repair patients, Sayde et al³¹ reported that 73% returned to their previous level, but only 63% of the subset of 198 overhead athletes (including baseball players) returned to their previous level. However, in the studies that Gorantla et al¹⁵ reviewed, the percentage of baseball players who returned to their previous level of performance ranged from 22% to 64%. Smith et al³⁶ identified 24 Major League Baseball pitchers reported to have had surgery for SLAP tear and found that 63% returned to play in the major leagues. More recently, a case series by Fedoriw et al¹⁰ of professional baseball players with SLAP lesions found that the rate to return to previous level was 24% (16/68) after conservative treatment and 23% (9/40) for those who progressed to surgery; however, the rate was only 7% among pitchers with surgical treatment.

The goal of this study was to evaluate the outcomes and return-to-play (RTP) rate of a large number of baseball players who underwent isolated SLAP repairs (or SLAP repairs with debridement of a low-grade, concomitant partial-thickness rotator cuff tear). It was hypothesized that RTP rates and outcomes would be significantly different between pitchers and nonpitchers and among high school, college, and professional ballplayers.

METHODS

This study was conducted after approval from the institutional review board of St Vincent's Health System (Birmingham, AL). Patients who had isolated SLAP repair or SLAP repair with partial rotator cuff debridement by the 4 senior authors (J.R.A., J.R.D., E.L.C., R.V.O) from 2004 to 2014 at 2 institutions were identified. All 4 surgeons performed the procedures using a similar approach and arthroscopic technique. Patients who were not baseball players at the high school, collegiate, or professional level at the time of injury were excluded. Furthermore, those with concomitant shoulder pathology, such as partial rotator cuff tears greater than 25%, full-thickness rotator cuff tears, anterior instability, labral tears extending outside

the 11- to 1-o'clock position, impingement, and acromioclavicular joint osteoarthritis, were excluded. Unrepaired partial-cuff tears less than 25% thickness were included in the study because these represent a continuum of SLAP pathophysiology and not a discretely separate entity in the shoulder.^{1,4,6,24,25,37} Levy et al²³ reported more than half of all SLAP tears in patients younger than 50 years had concomitant rotator cuff pathology with no significant effect on short-term outcomes. Preliminary analysis of data from the current study found that patients with and without concomitant rotator cuff pathology were statistically equivalent as measured by the study's primary outcomes: RTP at the same level or higher, the Western Ontario Shoulder Instability Index (WOSI) score,³⁰ and the Veteran's RAND 12-Item Health Survey physical component score (VR-12 PCS).^{18,32} Tests for equivalence of numeric outcomes (WOSI and VR-12) were made using 2 one-sided tests to calculate the mean difference (MD) and its 95% confidence interval (CI); CIs within the minimal clinically important difference (MCID) of each test (10 points for the WOSI and 5 points for the VR-12) were considered equivalent.^{9,19,27} The test for equivalence of the categorical outcome (RTP rate) was made by calculating the chi-square risk difference (RD) estimate and its 95% CI; if the CI included the null value of zero, the groups were considered equivalent. Following these tests, no significant differences in WOSI scores (MD 95% CI, -8.8 to 5.8), VR-12 PCS (MD 95% CI, -1.4 to 3.0), or RTP rates (RD 95% CI, -0.13 to 0.37) were found between the subgroup of patients with partial rotator cuff tear debridement and the subgroup with isolated SLAP repairs.

Patients were identified and their charts reviewed. All patients had failed conservative management and had continued pain with throwing, as well as inability to RTP despite therapy and rest. The diagnosis of SLAP tear was made with a magnetic resonance arthrogram, as well as clinical suspicion based on provocative physical examination findings, such as a positive active compression test result. All SLAP repairs had been performed arthroscopically using suture anchors and an arthroscopic knot-tying technique. No knotless repairs were performed during the time period examined in this study. Simple versus mattress sutures were variable according to surgeon preference. Any partial-thickness rotator cuff pathology was treated with simple debridement, and no repairs were performed in this population. All partial-thickness rotator cuff tearing was confirmed in operative reports as being less than 25%. Each patient underwent physical therapy including a postoperative SLAP repair protocol that progressed to eventual throwing program and RTP throwing exercises.

Starting in August 2014, each patient who met the above criteria was called by phone to answer a combined outcome measure questionnaire. As time progressed, additional patients who had surgery in 2013 or 2014 were added to the study and contacted as they had surpassed 2 years postoperatively. This questionnaire included questions detailing their RTP, competition level to which they returned, return to preinjury performance, WOSI, and the VR-12. The WOSI was selected as it has been previously validated for use in post-SLAP repair populations

¹¹References 3, 8, 10, 13, 15, 20, 23, 25, 26, 28, 29, 31, 36, 41.

TABLE 1
Comparison of Player History Between Those Who Did and Did Not Return to Play^a

	Returned to Play at Same Level or Higher, % (n)	Did Not Return to Play, % (n)	P Value
All players (N = 133)	64 (85)	36 (48)	
Position at time of injury			.23
Pitcher (n = 95)	59 (56)	41 (39)	
Catcher (n = 10)	70 (7)	30 (3)	
Infielder (n = 18)	83 (15)	17 (3)	
Outfielder (n = 10)	70 (7)	30 (3)	
Level at time of injury			.65
High school (n = 47)	62 (29)	38 (18)	
College (n = 63)	60 (38)	40 (25)	
Professional (n = 18)	72 (13)	28 (5)	
Surgery on same arm prior to SLAP repair			.54
Yes (n = 14)	71 (10)	29 (4)	
No (n = 119)	63 (75)	37 (44)	

^aSLAP, superior labral anterior-posterior.

to assess shoulder function,^{34,35} and the VR-12 was chosen as it is a widely used general quality of life measure. Patients who were active baseball players at the time of follow-up also completed a Kerlan-Jobe Orthopaedic Clinic (KJOC) score, as Neri et al²⁵ demonstrated the KJOC score better replicates the true outcome of overhead throwers versus other shoulder outcome scores. Unfortunately, the KJOC survey is not very applicable to patients who are no longer throwers and, for that reason, was not used on our entire patient population.

Using our questionnaire (available in the online version of this article), we were able to determine if the patients had returned to baseball to at least their preinjury level after surgery and postoperative rehabilitation. If they had not, specified reasons for their lack of RTP were documented to determine if their limitation was directly related to the surgery or due to other factors, such as graduating from high school or college, lacking the talent for the next level, or other personal reasons. The questionnaire also asked if they had limitations from the surgery.

All data analyses were performed using SAS 9.4 (SAS Institute). The rates of RTP among competition levels (high school, college, professional) and among positions (pitcher, catcher, infielder, outfielder) were compared with chi-square analyses. WOSI and VR-12 were compared between players who did and did not successfully RTP with Student *t* tests. Outcomes were compared between pitchers and nonpitchers with chi-square analysis. KJOC scores among players still active at follow-up were compared between pitchers and nonpitchers, as well as among competition levels, using *t* test and analysis of variance. Statistical differences were considered significant when *P* < .05.

RESULTS

Of the 216 baseball players who met criteria for inclusion, 62% (133/216) were successfully reached for follow-up. All patients were male. Mean follow-up time was 78 months

(range, 27-146 months), and mean age at time of repair was 19.5 ± 2.8 years (range, 10.3-31.0 years). At the time of injury, 71% (n = 95) were pitchers, 13% (n = 18) infielders, 8% (n = 10) outfielders, and 8% (n = 10) catchers. Furthermore, 47% (n = 63) were collegiate players at the time of injury, 35% (n = 47) were in high school, 14% (n = 18) were playing at the professional level (major and minor leagues), and 4% (n = 5) could not recall their specific level at injury.

Because of the large range of follow-up times (2-14 years), patients were stratified according to follow-up time as having 2 to 5 years or >5 years of follow-up. Outcomes including RTP rate and WOSI, VR-12, and KJOC scores were tested for confounding by follow-up time, but no statistical differences were present; therefore, results for these measures include all patients followed at all time points.

As reported in Table 1, the overall rate for RTP at the same or higher level was 64%. There were no significant differences in RTP rates among positions or among levels. Players were asked if they had ever undergone a previous surgery to their throwing shoulder or elbow, and there was no significant difference in RTP rate between players with previous surgery and players with no previous surgery. Of those who returned to play, 13% (11/85) were forced to change position in order to RTP. Between their SLAP repair and follow-up interview, 26% (35/133) had additional surgery related to baseball. Twenty-three of these additional surgeries were to the shoulder or elbow of the same arm, including 9 revision labral repairs and 1 biceps tenodesis; thus, the overall failure rate of the SLAP repairs was 7.5% (10/133).

Subjective scores are compared in Table 2. At the time of follow-up, those with successful RTP had a significantly greater WOSI score (85.4 ± 14.2) than those who did not return (78.0 ± 18.0), as well as greater VR-12 PCS scores (50.4 ± 4.2) than those who did not (48.7 ± 5.0), although neither statistical difference exceeded the MCID for the respective outcome measure. There was no difference in VR-12 mental scores.

TABLE 2
Comparison of Subjective Outcomes (Mean \pm SD)
Between Players Who Did and Did Not Return to Play^a

	Returned to Play at Same Level or Higher	Did Not Return to Play	<i>P</i> Value
WOSI	85.4 \pm 14.2	78.0 \pm 18.0	.010
VR-12: Physical	50.4 \pm 4.2	48.7 \pm 5.0	.042
VR-12: Mental	56.4 \pm 5.7	56.5 \pm 6.3	.93

^aVR-12, Veteran's RAND 12-Item Health Survey; WOSI, Western Ontario Shoulder Instability Index.

Only 59% of pitchers were able to RTP, while 76% of nonpitchers returned (Table 3), a difference that trended toward statistical significance ($P = .060$). Most (73%) of the pitchers who did not RTP said it was due to the surgery, while less than half of nonpitchers blamed their inability to RTP on the surgery. While this difference was notable, it only trended toward statistical significance due to the small number of players who did not RTP. Regardless of whether they RTP to the same level, all patients were asked to rate their postoperative performance compared to preinjury as "much better," "a little better," "about the same," "a little worse," or "much worse." Only 41% of pitchers felt the same or better at follow-up compared to preinjury, whereas significantly more (64%) nonpitchers felt the same or better.

KJOC scores were compared among players still active at time of follow-up. There was no difference in KJOC score between pitchers and nonpitchers (Table 3). KJOC scores seemed to decrease as level increased (high school, 79.2 \pm 16.8; college, 77.7 \pm 17.7; professional, 64.5 \pm 23.9), but this was not statistically significant with the small sample size of active players ($P = .10$).

DISCUSSION

Results from the current study were similar to those for SLAP repairs in previous smaller investigations.^{10,13,17,25} Two hundred sixteen baseball players underwent SLAP repair in a 10-year period at our institutions, of which 133 could be reached. For the 133 baseball players in the current study, 63% returned to play at the preinjury level or higher, which was very similar to the 63% rate reported by Ide et al¹⁷ among 19 Japanese baseball players and to the 60% to 63% rate in professional baseball players reported by Fedoriw et al¹⁰ and Smith et al.³⁶ Neri et al²⁵ cited a 57% RTP among 23 collegiate and professional overhead athletes, and Friel et al¹³ reported a 54% RTP rate among 13 collegiate overhead athletes. Most (20/23) of the subjects in the Neri et al²⁵ study were baseball players, whereas Friel et al¹³ did not mention how many of their subjects played baseball. Neuman et al²⁶ reported 81% RTP among 21 baseball and softball players but did not separate out the baseball players. As there may be biological and biomechanical differences between male baseball players and female softball players—particularly

TABLE 3
Comparison of Outcomes
Between Pitchers and Nonpitchers^a

	Pitchers, % (n)	Nonpitchers, % (n)	<i>P</i> Value
Subjective assessment			.018
Same or better	41 (37)	64 (23)	
Worse	59 (54)	36 (13)	
Returned to play			.060
Yes	59 (56)	76 (29)	
No	41 (39)	24 (9)	
Reason for not returning			.089
Surgery	73 (26)	38 (3)	
Other	27 (9)	62 (5)	
Postsurgical limitation (n = 29)			
Pain	42 (11)	67 (2)	.57
Stiffness/tightness	42 (11)	33 (1)	.99
Laxity/instability	27 (7)	0 (0)	.56
Weakness	46 (12)	33 (1)	.99
Decreased performance	73 (19)	67 (2)	.99
Infection	0 (0)	0 (0)	.99
Other	15 (4)	0 (0)	.99
Successful KJOC (≥ 90)			.74
Success	31 (15)	23 (3)	
Failure	69 (33)	77 (10)	

^aKJOC, Kerlan-Jobe Orthopaedic Clinic.

among pitchers—it is difficult to interpret combined baseball and softball data.

In their case series of the 68 professional baseball players with SLAP tears, Fedoriw et al¹⁰ reported that 77% of those treated conservatively were able to RTP at least 1 game of professional baseball, while the remaining players either opted for surgery or retired. Of the players with SLAP repair, 60% successfully returned to at least 1 game of professional baseball. Fedoriw et al¹⁰ further analyzed their data to determine return to prior performance (RPP), defined as returning to previous level (A, AA, AAA, Major League Baseball) and to previous pitching or batting statistics. Of the players who tried conservative treatment, 52% were able to RPP, whereas only 23% of players RPP after SLAP repair. They concluded that for SLAP tears, baseball players should be treated conservatively if at all possible. To our knowledge, there are few proponents advocating for immediate surgical treatment in these athletes. The issue that arises among the 23% of players who cannot RTP and the 48% who cannot RPP with conservative treatment is that surgery is the last remaining option if a return to sport is the desired outcome. Players are unfortunately left with 2 options: receive surgical treatment or quit playing baseball. While surgical management of SLAP tears is imperfect, our results demonstrate relative success and can return some players to the field.

The hypothesis that RTP rates and subjective outcomes would be different among the levels was not supported by the current study. There was no significant difference among high school, college, and professional baseball players in RTP rates or KJOC scores.

The hypothesis that RTP rates and subjective outcomes would be different between pitchers and nonpitchers was generally supported by the data. Significantly more nonpitchers (66%) than pitchers (43%) felt the same or better at follow-up compared to preinjury ($P = .02$). The 76% RTP rate for nonpitchers was nearly statistically greater ($P = .06$) than the 59% RTP rate for pitchers. Fedoriw et al¹⁰ found a bigger difference in RTP rates after SLAP repair between nonpitchers (85%) and pitchers (33%). Furthermore, Fedoriw et al¹⁰ showed that 54% of nonpitchers RPP compared to only 7% of pitchers after SLAP repair. Morgan et al²⁴ reported 84% of their 44 baseball pitchers returned to their previous level after SLAP repair. We do not have any explanation for the higher rate for RTP in pitchers reported by Morgan et al²⁴ in comparison to Fedoriw et al¹⁰ and the current study. Among those who did not RTP in the current study, 73% of pitchers said it was due to their surgery, while only 38% of nonpitchers pointed to surgery ($P = .054$).

Among patients in the current study who did RTP, there was no difference in KJOC scores between pitchers (mean, 75.3) and nonpitchers (mean, 76.2). Neuman et al²⁶ reported similar KJOC scores among their 14 active pitchers (73.0) and 7 active nonpitchers (70.5), even though this included baseball and softball players. Neri et al²⁵ found similar KJOC scores (76.9) among their 23 overhead athletes; of note, these results include KJOC scores for their 4 athletes no longer playing due to pain. Overall, the KJOC scores for baseball players with history of SLAP repair in the current study, in Neuman et al,²⁶ and in Neri et al²⁵ were poor, as scores below 90 are considered potential cause for concern.^{12,14,21}

Laughlin et al²² showed that even pitchers who successfully RTP after SLAP repair demonstrated compromised shoulder biomechanics. Specifically, pitchers with a history of SLAP repair demonstrated less horizontal abduction and less external rotation when pitching than did a control group with no injury history. Biomechanical studies have also shown modified motions of the trunk and lower extremities in pitchers with a history of SLAP repair.^{7,22} Thus, subjective and objective measures indicate it is challenging to return to normal shoulder function and performance in pitching after SLAP repair.

Our data demonstrated that either revision SLAP repair or biceps tenodesis was required in only 7% of our patients. With the historical problems associated with both surgical and nonsurgical treatment of SLAP tears in overhead athletes, several studies have explored alternatives for treatment of SLAP lesions in both baseball players and overhead athletes alike. One proposed option in the literature is biceps tenodesis, with good reported results for either primary treatment of SLAP tears or treatment for failed previous SLAP repairs in certain populations.^{2,16,29} Chalmers et al⁷ concluded SLAP repairs may alter pitching biomechanics more so than biceps tenodesis when compared to normal controls. This seems to intuitively conflict with historically understood biomechanics of the shoulder.^{1,4,5,24,37} Our concern is that when continuing to pitch after subtraction of a joint-spanning structure like the long head of the biceps, the long-term effects on other

stabilizers in the shoulder have not been well-defined. Proper patient selection and prevention of humeral fractures upon return to sports after biceps tenodesis still need to be investigated.¹⁶

Significant thought and consideration have been given over time to improving the outcomes of SLAP repairs since these outcomes have been less than gratifying, especially in overhead throwers, as demonstrated in this study. Given the high volume of SLAP pathology seen at our institutions and extensive experience in treatment of these lesions, we have shifted over time to treating these nonoperatively whenever possible. As previously mentioned, Fedoriw et al¹⁰ demonstrated a higher RTP rate with conservative management of baseball players with SLAP lesions. We have also adopted changes in our preoperative rehabilitation protocols over time to focus on the restoration of total arc of motion. This concept has been demonstrated to play a large role in shoulder pain and injury in the throwing athlete.⁴⁰ If SLAP repair was performed, we also have placed a large emphasis on altering the postoperative rehabilitation protocols, particularly focusing on limiting passive external rotation/abduction in the early weeks after surgery, as arm cocking in throwing has been demonstrated in vitro to place significant stress across the SLAP repair site.³³ We also have extended the return to throwing and RTP progression time in the postoperative period. We do not start any overhead throwing program until around 5 months postoperatively, and this throwing program progresses slowly based on the patient's clinical response, with the patient returning to competition about 1 year after surgery.³⁹ It is stressed prior to surgery that recovery time varies for individual players. Further study would be required to definitively determine if these above variations have clinically affected the long-term outcome of our SLAP repairs. Last, as technology in orthopaedic implants evolves as well, newer techniques such as knotless repairs of the superior labrum may prove to have superior outcomes to simple suture repairs, in part by eliminating the knot stack created from simple suture tying.³⁸ Yang et al⁴¹ found no difference between knotless versus simple suture fixation in 46 patients, but further study may be needed in overhead throwers.

This study had limitations, most important being its retrospective nature and low follow-up percentage (although our 133 baseball players surveyed is the largest reported thus far). As with all retrospective studies, there is recall bias during follow-up; to minimize such bias, the focus of this study was on RTP after surgery and subjective outcomes at the time of follow-up. Many of the patients underwent surgery more than a decade before follow-up and had not participated in baseball for several years; however, there were no significant differences in subjective outcomes or RTP rates between patients with 2 to 5 years of follow-up and those with greater than 5 years of follow-up. Also, this study lacked preoperative data (KJOC, WOSI, etc) to compare patient outcome measures. Thus, the study did not measure changes from preinjury and pre-surgery, but it did document satisfaction and performance outcomes. The data also included some patients who underwent concomitant rotator cuff debridement for low-

grade (<25%) tearing or fraying. However, we demonstrated statistical equivalence within the MCID of each of the outcome measures collected, so the inclusion of these patients should not bias our results in any way.

CONCLUSION

Of the 133 baseball players studied, 62% successfully RTP after SLAP repair. There were no statistically significant differences in RTP rates or subjective outcomes between high school, collegiate, and professional baseball players. RTP rates were 59% for pitchers and 76% for nonpitchers, similar to the rates previously reported by smaller case series. Subjectively, the percentage of patients who felt the same or better at follow-up compared to preinjury was significantly higher among nonpitchers (66%) than pitchers (43%). There was no difference in KJOC scores between the pitchers (75.3 ± 19.4) and nonpitchers (76.2 ± 17.4) who successfully RTP, although these scores were well below the minimum desired score of 90 for healthy baseball players. Thus, SLAP repair should continue to be considered as an option for SLAP tear treatment only after nonsurgical management has failed, but outcomes are unpredictable. Some players may be able to return to baseball after SLAP repair, but the majority of pitchers will not regain preinjury subjective function.

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