Does a Partial Rotator Cuff Tear Affect Pitching Ability?

Results From an MRI Study

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Background: Numerous studies have examined changes in the athletic performance of baseball pitchers after rotator cuff surgery. However, only a few studies have evaluated changes in athletic performance caused by partial rotator cuff tears that are not treated surgically.

Purpose: To examine the course of partial-thickness rotator cuff tears and its possible effect on the athletic performance of professional pitchers.

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

Method: Of 191 professional pitchers who attended our clinic between January 2009 and October 2018, 52 individuals had partial-thickness tears with at least 2 years of follow-up magnetic resonance imaging (MRI) scans and were included in this study. All initial MRI examinations were performed when a season was finished or during the off-season for regular medical check-up purposes. Hence, any abnormal finding on MRI, which suggests damage to the rotator cuff tendon, was assumed to have occurred during the previous season. The mean follow-up MRI period was 40.8 months (range, 24.4-100.9 months). We defined the year before an athlete's first MRI at our clinic as the year of damage, and we evaluated athletic performance during the season before the damage (pre-damage year 1), the season of the damage (damage year), and 1 and 2 seasons after the damage (post-damage years 1 and 2). We evaluated the changes in 5 statistical performance indicators: earned run average (ERA), fielding independent pitching (FIP), walks plus hits divided by innings pitched (WHIP), winning percentage (WPCT), and innings pitched (IP).

Results: The partial-thickness tears progressed in 39 of 52 (75%) patients. Of these 39 patients, 34 (87%) were grade 1 in severity and 5 (12.8%) were grade 2 or higher. The ERA of the pitchers did not increase significantly immediately after damage or at post-damage years 1 and 2. WPCT increased significantly compared with pre-damage year 1 ($P < .001$), and IP decreased significantly during the follow-up period ($P < .001$). Although no significant decrease in pitching ability was noted based on these 3 indices, significant increases were observed for FIP and WHIP.

Conclusion: A partial-thickness rotator cuff tear does not have significant influence on the athletic performance of professional baseball pitchers in the short term based on conventional performance indicators. Our findings suggest that WHIP and IP decline significantly at 2 years after damage is noticed.

Keywords: pitcher; rotator cuff tear; pitching ability

More than 50% of the injuries sustained playing baseball are upper body injuries to pitchers.[18] Over the past 11 years, 48.4% of Major League Baseball players injured were pitchers. The shoulder was the most frequent site of injury (27.8% of all injuries).[5] Common shoulder injuries among baseball players include labral tears, biceps and rotator cuff tendinitis, posterior impingement, superior labrum anterior and posterior injuries, subacromial impingement, and biceps injuries. Of those injury types, rotator cuff tears are often the most serious. Rotator cuff tears are more commonly articular sided rather than subacromial. Partial-thickness cuff tears can progress to full-thickness and require surgical care, and they may even end a career.[12,13,18]

A rotator cuff injury often stems from microtrauma at the subacromial space and articular side caused by repetitive overhead pitching motion. Repetitive damage to the undersurface of the posterior part of the supraspinatus

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TABLE 1
Participant Inclusion and Exclusion Criteria[a]

Inclusion criteria
Underwent treatment or consultation for shoulder pain
Underwent follow-up shoulder MRI for at least 2 years
Had a partial-thickness rotator cuff tear
Exclusion criteria
Had a partial-thickness rotator cuff tear advancing to a full-thickness tear during follow-up
Underwent treatment for shoulder problems other than a rotator cuff tear
Underwent elbow joint surgery, such as Tommy John surgery

[a]MRI, magnetic resonance imaging.

muscle and superior half of the infraspinatus may cause rotator cuff tendinitis and partial- or full-thickness tears.[2,16,22,24]

Many studies have examined the change in athletic performance of pitchers after rotator cuff surgery.[14] However, only a few studies have evaluated the change in performance as a partial-thickness rotator cuff injury progresses without surgical intervention.[9,14] Hence, this study examined the course of rotator cuff tears over the study period and its possible effect on athletic performance in professional pitchers. We hypothesized that partial-thickness rotator cuff tears would decrease pitching performance.

METHODS

Participants

This study was approved by an institutional review board, and we used appropriate methods to gather data. Of 314 professional pitchers who attended the senior author's (J.Y.P) outpatient clinic for at least 2 years between January 2009 and October 2018, there were 191 pitchers who underwent magnetic resonance imaging (MRI) for either diagnosis or treatment. Of these 191 pitchers, 52 (27%) who satisfied the inclusion and exclusion criteria (Table 1) were included in the study. Participant characteristics are shown in Table 2.

Our clinic is well known for medical checkups for professional athletes. MRI was conducted when shoulder discomfort was present or as a medical checkup in a patient with a prior history of symptoms. Undergoing a medical checkup implies past symptoms. Hence, we regarded individuals with MRI scans as patients with past or present shoulder discomfort. We assumed that the season before an athlete's first MRI examination at our clinic was the year the damage occurred. Final follow-up MRIs were obtained at a mean of 40.8 months after the initial MRI.

TABLE 2
Demographic Characteristics of the Participants (N = 52)

Characteristic	Mean (Range)
Follow-up, mo	40.8 (24.4-100.9)
Age, y	25 (18-32)
Height, cm	184.38 (177-207)
Weight, kg	88.3 (69-105)

Athletic performance was evaluated by comparing 5 statistical performance indicators (earned run average [ERA], fielding independent pitching [FIP], walks plus hits divided by innings pitched [WHIP], winning percentage [WPCT], and innings pitched [IP]) for 4 seasons: the season before the damage (pre-damage year 1), the season of the damage (damage year), and 1 and 2 seasons after the damage (post-damage years 1 and 2).

MRI Evaluation

MRI examinations were performed on a 1.5-T machine (Achieva; Philips Medical Systems). Sequences included axial T1- and T2-weighted images with spectral presaturation with inversion recovery (SPIR), coronal T1- and T2-weighted images with SPIR, sagittal T1-weighted proton-density-weighted images with SPIR, and oblique coronal T2-weighted images with SPIR (repetition time/echo time, 650/10 ms [T1-weighted images], 2260/60 ms [T2-weighted images]; field of view, 14 cm axial, 16 cm coronal; acquisition matrix number, 300 × 259; acquisition matrix size, 0.5 × 0.6 mm; receiver bandwidth, 263 kHz; section thickness, 3.5 mm; intersection gap, 0.35 mm; acquisition time, 3 minutes 31 seconds). Images were analyzed in the PACS program (Centricity PACS; GE Medical System Information Technologies). Using the Ellman[6] classification, we classified the partial-thickness rotator cuff tears as grade 1 (<25%), grade 2 (25%-50%), or grade 3 (>50%) (Figures 1 and 2).

The classifications were performed by 3 board-certified orthopaedic physicians who were blinded to the study details (J.-Y.P., J.K., J.-H.L.). Intraclass correlation coefficients (ICCs) were calculated and interpreted as follows: <0.50 = poor reliability, between 0.50 and 0.75 = moderate reliability, between 0.75 and 0.90 = good reliability, and >0.90 = excellent reliability.[10] The ICCs were excellent for both the intraobserver (0.920) and interobserver (0.948) measurements.

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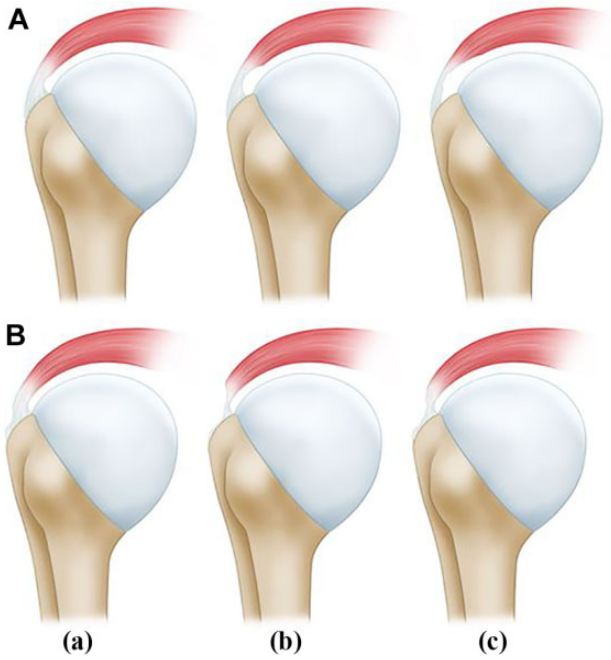

Figure 1. Partial-thickness rotator cuff tears. (A) Articular and (B) bursal sides: Ellman grades 1 (*a*), 2 (*b*), and 3 (*c*).

Statistical Analyses

We evaluated the statistical significance of the changes in the 5 performance indicators (ERA, FIP, WHIP, WPCT, and IP) from pre-damage year 1 to post-damage year 2. We compared pre-damage year 1 data to each of the other time points. The paired *t* test was used to analyze these data. SPSS software (v 21.0; SPSS Inc) was used to perform the analyses. The level of statistical significance was set to $P < .05$.

RESULTS

In 39 of the 52 pitchers (75%), the partial-thickness tears progressed from initial to follow-up MRI (Figure 3). Of the 39 patients who experienced progression of their partial tears, 34 (87%) tears progressed by 1 grade, and 5 (12.8%) tears progressed by 2 or more grades.

Table 3 and Figure 4 show the changes in the 5 performance indicators, from pre-damage year 1 to post-damage year 2. The ERA was 6.00 in pre-damage year 1, decreased to 4.74 in the damage year, and was 5.52 and 4.66 in post-damage years 1 and 2, respectively. Overall, the ERA was lower for the damage year. However, no significant difference in ERA was found in post-damage years 1 ($P = .136$) and 2 ($P = .071$) compared with pre-damage year 1.

Regarding the other performance indicators, the WPCT was 46% in pre-damage year 1; it increased to 60% ($P < .001$) in the damage year and was 60% ($P < .001$) and 55% ($P = .003$) in post-damage years 1 and 2, respectively. The FIP was 4.32 in pre-damage year 1, increased to 4.91 in the damage year ($P = .12$), and was 5.06 ($P = .032$) and 4.86 ($P = .013$) in post-damage years 1 and 2, respectively. The WHIP (average on-base percentage per innings) was 1.61 in pre-damage year 1, decreased to 1.27 ($P = .004$) in the damage year, and was 1.46 ($P = .052$) and 1.86 ($P = .033$) in post-damage years 1 and 2, respectively. Although the WHIP decreased in the damage year, it increased gradually over post-damage years 1 and 2. The IP was 46.67 in pre-damage year 1, decreased drastically to 21.89 ($P < .001$) in the damage year, and decreased to 19.72 ($P < .001$) and 15.78 ($P < .001$) in post-damage years 1 and 2, respectively.

DISCUSSION

Pitchers frequently sustain partial rotator cuff tears; this may be due to the repetitive overhead throwing, which overloads the shoulders causing internal impingement[7] and damage to the superoposterior labrum.[22] In turn, this can lead to pseudo-instability and limitation in the range of motion. Sometimes pitchers with an unstable shoulder joint may need a stabilizer to ensure shoulder stability; hence, the rotator cuff is more prone to damage in these individuals than in those with stable shoulder joint.[8,11]

In adolescent overhead athletes who experience high-grade partial tear (higher than grade 3) or full-thickness

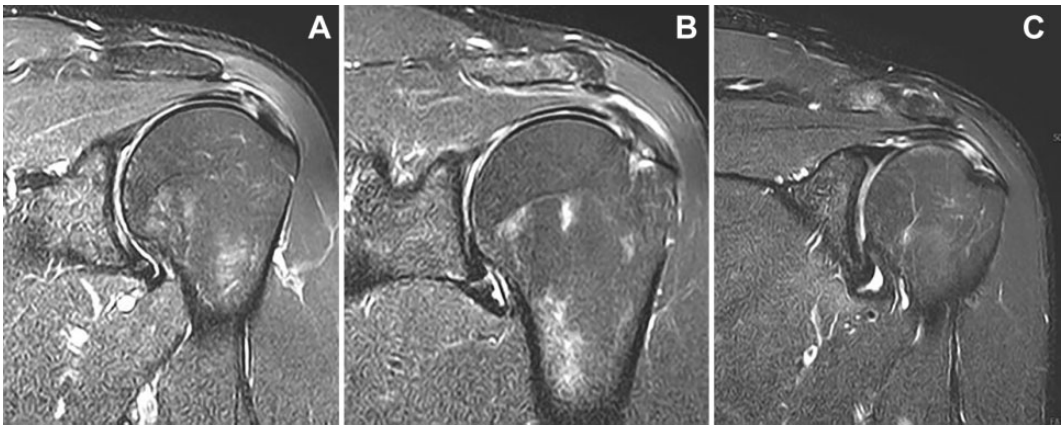

Figure 2. Ellman classifications for (A) grade 1 (<25%), (B) grade 2 (25%-50%), and (C) grade 3 (>50%) partial-thickness tears.

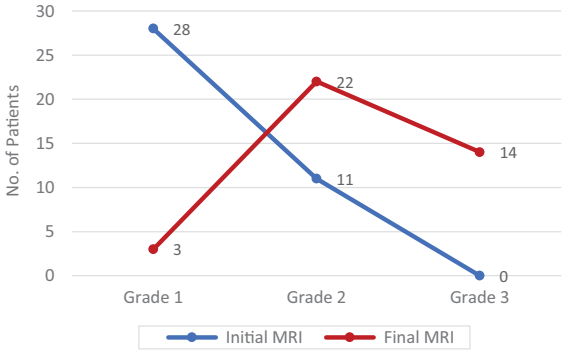

Figure 3. Change in Ellman grade distributions of the partial-thickness tears for patients whose tears progressed from initial to final follow-up MRI (n = 39 patients). MRI, magnetic resonance imaging.

TABLE 3
Changes in the Pitchers' Performance Indicators[a]

	Pre1	Damage	Post1	Post2	Average of the 4 Seasons
ERA	6.00	4.74	5.52	4.66	5.23
FIP	4.32	4.91	5.06	4.86	4.79
WHIP	1.61	1.27	1.46	1.86	1.55
WPCT	46%	60%	60%	55%	55%
IP	46.67	21.89	19.72	15.78	26.01

[a]ERA, earned run average; FIP, fielding independent pitching; IP, innings pitched; Pre1, 1 season before damage; Post1, 1 season after damage; Post2, 2 seasons after damage; WHIP, walks plus hits divided by innings pitched; WPCT, winning percentage.

tear, 93% have returned to the same level of sports after surgical repair.[4] One study on the outcome of debridement without restoration for a partial-thickness rotator cuff tear reported that 82% of professionals returned to the field, and 55% achieved the same level of athletic performance as before the injury.[19] Other studies have reported that 22% to 85% of professionals return to the field when only arthroscopic debridement is used for the treatment of partial-thickness rotator cuff tears.[3,20,21] In cases of full-thickness rotator cuff tear, according to one study only 8% of professionals were able to achieve the same level of athletic performance as before injury.[15] Although many studies have examined the outcomes of surgery to treat pitchers with rotator cuff tears, only a few studies have examined the natural course of rotator cuff tears (ie, without surgical intervention).[9,14]

We examined the progression of rotator cuff tears in pitchers with at least 2 years of follow-up MRI data. The presence of a rotator cuff tear had little effect on the ERA among the pitchers in this study. The change in the ERA over the 4-year study period was not significant. A possible explanation for this is that numerous factors affect the ERA, such as the performance of other players and whether the pitcher is a starter or a reliever, so relying solely on the ERA to evaluate a pitcher's performance can be misleading.[17] Moreover, ERA is calculated as the runs given up by the pitcher divided by IP; however, this simple formula does not consider external factors, such as stadium size and the level of competition within a league.[1] Hence, the ERA has limited utility for evaluating a pitcher's performance; the fact that partial-thickness rotator cuff tears did not have much effect on the ERA of the pitchers in this study supports this view.

The FIP, which is not affected by defensive aspects, increased sharply from 4.32 in pre-damage year 1 to 4.91 in the damage year ($P = .12$) and remained high thereafter.

In this study, WHIP was 1.86 at post-damage year 2, which represents a significant increase from the values of 1.61 in pre-damage year 1 ($P = .033$) and 1.27 in the damage year ($P = .004$). The IP decreased markedly from 46.67 in pre-damage year 1 to 15.78 at post-damage year 2 (difference of 30.89 innings; $P < .001$).

The WPCT was 46% in pre-damage year 1 and increased significantly to 60% and 55% in post-damage years 1 and 2, respectively (all $P < .05$). It seems unusual that WPCT increased in the seasons after the rotator cuff tear in the pitchers in our study, although the WPCT can be affected by the performance of other players and be different for relief pitchers versus starters.[1]

Compared with pre-damage year 1, FIP and WHIP increased by 0.54 and 0.25, respectively, at post-damage year 2, whereas IP decreased by 30.89. Interestingly, although both WHIP and FIP do represent an evident decline in performance over 4 years of follow-ups, they do not show a linear decline in performance. A possible explanation for this is that due to the gravity of rotator cuff tear, the pitchers received more extensive medical care and rehabilitation to prevent other injuries.[23] Rehabilitation helps pitchers to maximize external rotation by increasing shoulder laxity while also achieving a stable position of the humeral head inside the should joint.[23]

Limitations

This study had some limitations. First, the length of the follow-up was relatively short: 4 years worth of statistics are insufficient to evaluate a pitcher's athletic performance accurately. Second, our study did not include any minor league pitchers. Third, the study did not consider pitcher age. Fourth, the timing of the MRI studies differed among the players, with some scans performed during the baseball season and others in the off-season. Fifth, we are not sure when each player's injury was sustained, but we assumed that the season before an athlete's first MRI examination at our clinic was the year the damage occurred. Sixth, partial rotator cuff tears of pitchers are not unusual, and statistical values can vary. Seventh, we did not separate starters from relievers, and this could explain some of the changes in innings pitched. Eighth, we focused on the effect of partial tears alone, and not full-thickness tears, on performance. Ninth, if some pitchers had more than 1 partial-thickness tear, their performance may have been affected differently from the pitchers with a single tear. Tenth, because the study examined only pitchers, the results cannot be

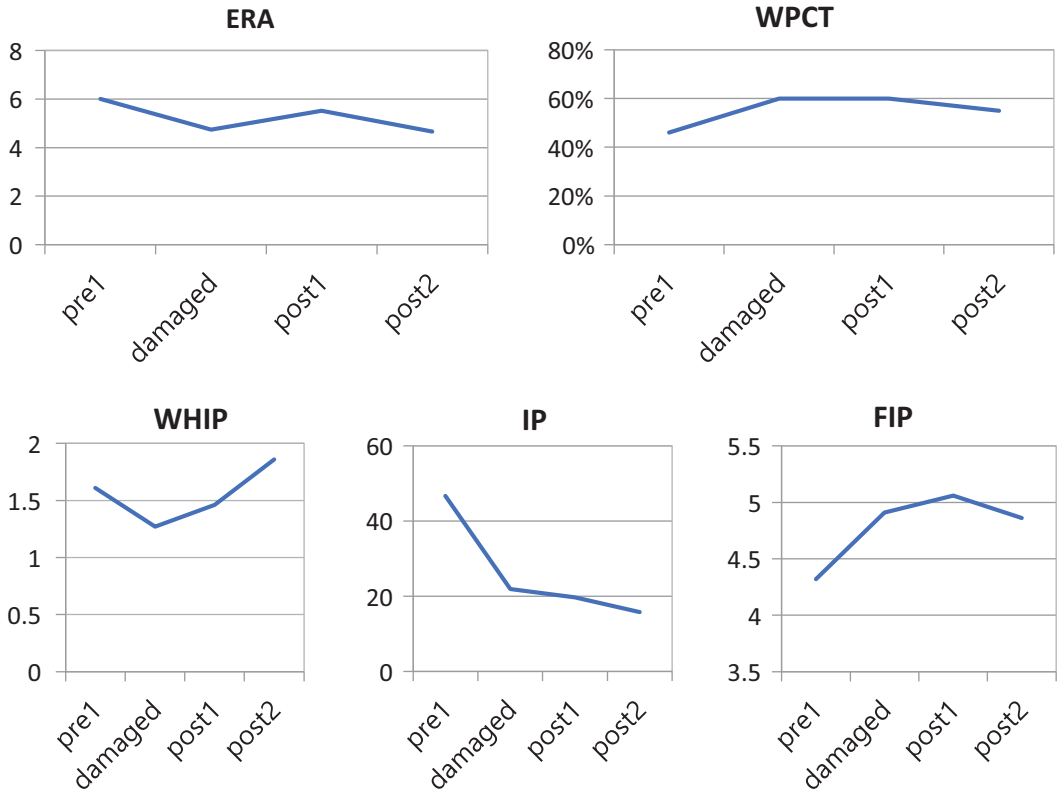

Figure 4. Graphs showing changes in the pitchers' performance indicators from 1 season before the damage was found (pre1) to 1 and 2 seasons after (post1 and post2, respectively). ERA, earned run average; FIP, fielding independent pitching; IP, innings pitched; WHIP, walks plus hits divided by innings pitched; WPCT, winning percentage.

generalized to players in other positions, who should be examined in future studies.

CONCLUSION

We examined the course of partial rotator cuff tears in professional pitchers and its possible effect on athletic performance. Overall, 75% of the pitchers experienced worsening of their rotator cuff tears.

Our findings suggest that WHIP and IP decline significantly at 2 years after damage is noticed.

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