

Performance and Return to Sport After Meniscal Repair in Professional Baseball Players

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Background: Meniscal repair is an effective treatment option for certain meniscal injuries to preserve meniscal function and limit the progression of knee osteoarthritis. Outcomes after meniscal repair in professional baseball players are not well documented.

Purposes/Hypothesis: The purposes of this study were to determine performance and return to sport (RTS) in professional baseball players after meniscal repair and compare the results of medial versus lateral meniscal repair. It was hypothesized that there would be a high RTS rate, with no difference in the rate or timing of RTS between players who underwent medial versus lateral meniscal repair.

Study Design: Cohort study; Level of evidence, 3.

Methods: All professional baseball players who underwent meniscal repair between 2010 and 2017 were identified using the Major League Baseball Health and Injury Tracking System database. Descriptive information and performance data (before and after injury) for each player were recorded. The rate and timing of RTS were then compared between players who underwent medial versus lateral meniscal repair.

Results: Included were 31 patients (mean age, 24 ± 3 years). There were 6 players (19%) who had failed repair, underwent subsequent meniscectomy within 2 years of meniscal repair, and were thus excluded from the performance analysis. Of the remaining 31 players, 68% returned to the same or a higher level of play, and 6% of players returned to a lower level of play. Most repair procedures (60%) were performed using the all-inside technique, and 72% of players underwent lateral meniscal repair. The mean time missed was 187 ± 67 days, and the mean time to RTS at full competitive play was 209 ± 84 days. There were no significant differences in the rate or timing of RTS between players who underwent medial versus lateral meniscal repair ($P \geq .999$ and $P = .574$, respectively). Pitchers saw a decrease in usage but no change in performance after meniscal repair. For batters, most metrics were unchanged, but there was a significant decrease in base stealing and on-base percentage after surgery.

Conclusion: The RTS rate after meniscal repair in Major League Baseball players was 74% at a mean of 209 days; 19% of players had failed repair and underwent subsequent meniscectomy within 2 years of repair. No difference in the rate or timing of RTS was observed between players who underwent medial versus lateral meniscal repair.

Keywords: knee; baseball; meniscal repair; return to sport; surgery; outcome

The medial and lateral menisci have several functions in the knee including load transmission, lubrication, proprioception, stability, and protection of cartilage surfaces.^{8,15,19}

Partial or complete loss of the meniscus promotes the early development of chondromalacia and osteoarthritis. Although >700,000 meniscectomy procedures are performed each year in the United States, there are far fewer meniscal repair procedures performed.^{3,21} While meniscal tears commonly occur in the setting of anterior cruciate

ligament (ACL) tears, there are a substantial number of meniscal tears that occur in isolation.

While meniscal repair commonly involves a longer and more intense rehabilitation period as well as a higher risk of reoperations, studies have demonstrated improved long-term results after meniscal repair compared with meniscectomy.¹⁷ Furthermore, the progression to knee arthritis is decreased with meniscal repair compared with meniscectomy.¹⁷ As such, in the setting of a repairable tear, most surgeons recommend meniscal repair over meniscectomy.²⁰ However, the results after meniscal repair in isolation (without concomitant ACL reconstruction) are somewhat limited, especially as they relate to return to sport (RTS). No study to date has evaluated the rate and

The Orthopaedic Journal of Sports Medicine, 10(6), 23259671221101914

DOI: 10.1177/23259671221101914

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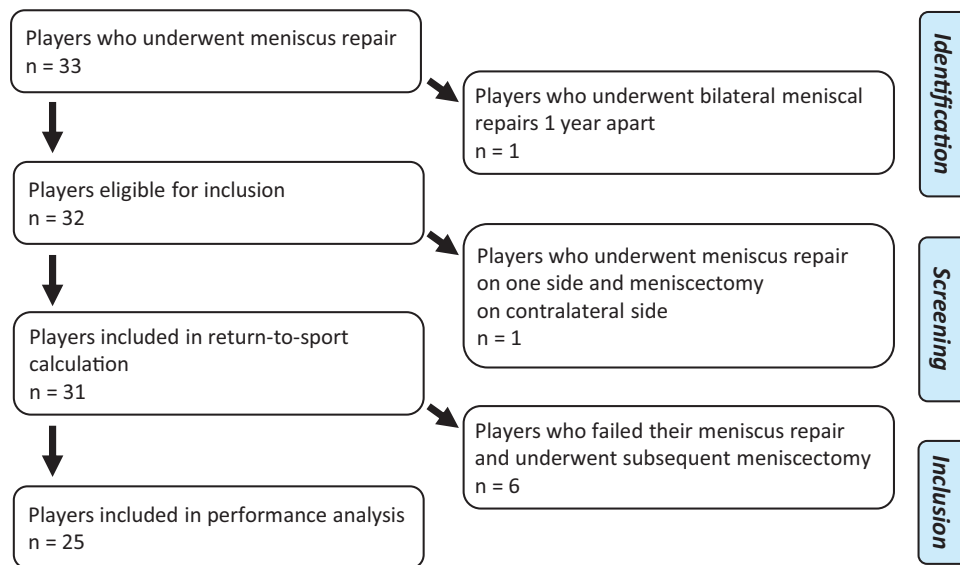


Figure 1. Screening criteria for players included in this study.

timing of RTS after meniscal repair in baseball players. As such, it is difficult to set expectations for these athletes before a surgical intervention.

The primary purpose of this study was to determine the performance and RTS rate in professional baseball players after meniscal repair. A secondary purpose was to compare the rate and timing of RTS in players who underwent medial versus lateral meniscal repair. We hypothesized that there would be a high RTS rate in professional baseball players after meniscal repair, with no significant decline in performance. We also hypothesized that there would be no significant difference in the rate or timing of RTS between players who underwent medial versus lateral meniscal repair.

METHODS

This study was performed with the approval of the Major League Baseball (MLB) Research Committee. All male professional baseball players who underwent meniscal repair between 2010 and 2017 were eligible for inclusion. All players had a minimum 2-year follow-up. Players were included if they underwent concomitant partial

meniscectomy, plica excision, or chondroplasty. Players were excluded if they underwent any other concomitant surgical procedure outside of partial meniscectomy, chondroplasty, or plica excision (ACL reconstruction, collateral ligament repair, microfracture, etc); if they were collegiate (National Collegiate Athletic Association) players at the time of surgery; or if they never participated in a professional baseball game before surgery. Data were analyzed from the MLB Health and Injury Tracking System (HITS) database (Figure 1).

The HITS is a centralized database that contains identified player information and was developed as a league-wide injury surveillance system in 2010 to record player injuries and injury time.¹⁸ The HITS has been used in several prior studies and has been found to be a reliable source of information.^{4-6,9,11} One author (B.J.E.) reviewed all operative reports for each player to confirm that the player underwent meniscal repair. Surgical variables including technique (all-inside, inside-out, outside-in, root repair), number of anchors/sutures used, whether plica excision was performed, whether chondroplasty was performed, and location of chondral injury were recorded for each player. All players identified were included in this study in relation to the RTS rate. A player was deemed to

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Final revision submitted February 8, 2022; accepted March 23, 2022.

One or more of the authors has declared the following potential conflict of interest or source of funding: B.J.E. has received education payments from Arthrex and Smith & Nephew and consulting fees from Arthrex. P.N.C. has received education payments from Active Medical, consulting fees from DePuy/Medical Device Business Services, and nonconsulting fees from Arthrex. S.B.C. has received education payments from Liberty Surgical and consulting fees from Zimmer Biomet. J.R.D. has received consulting fees from Arthrex and DJO, nonconsulting fees from Arthrex, and royalties from Arthrex and In2Bones. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.

Ethical approval for this study was waived by University of Utah (No. 00114699).

have returned to sport if he played in any professional game after surgery. The time to RTS was defined as the time between surgery and when the athlete played in his first game after surgery. An athlete was deemed to have returned to the same level of play if he was able to compete in a game at the same or a higher level as before surgery. Players who underwent repeat surgery, either on the contralateral knee or because of revision surgery on the same knee, were excluded from the analysis of performance statistics, as their data could not be clearly categorized.

Statistical Analysis

All analyses were performed using Excel X (Microsoft Corp) and SPSS Version 21 (IBM Corp). As this is a retrospective study of an uncommon procedure in a specific population cohort, no a priori power analysis was conducted, and all available patients were included. Descriptive statistics were calculated. Data were analyzed for normality using the Kolmogorov-Smirnov test, and parametric and non-parametric tests were used as appropriate. Performance outcomes were averaged before the injury and postoperatively/after the injury. To do so, performance data were categorized as either ≥ 1 year before the injury or ≥ 1 year postoperatively; data within 1 year of surgery were discarded because of potential variations in injury chronicity and rehabilitation. Performance data were analyzed as previously described.^{10,11}

Preoperative and postoperative data were compared using the paired Student *t* test and related-samples Wilcoxon signed rank test as appropriate based on data normality. For each player, maximum preoperative and postoperative levels of play were determined, and each player was then determined to have returned to the same or a higher level of play, returned but to a lower level, or not returned. Preoperative and postoperative performance as well as RTS rates were also compared between players who underwent medial versus lateral meniscal repair using the chi-square test.

RESULTS

A total of 34 knees in 33 patients underwent meniscal repair during the study period. At the time of surgery, 8 patients played in the major leagues, and 25 played in the minor leagues (3 AAA, 6 AA, and 16 A). One patient underwent bilateral meniscal repair 1 year apart from one another, and this patient was excluded from the performance and return-to-play analyses, as it was not believed that this case could be easily categorized. One patient underwent meniscal repair on one side and meniscectomy on the contralateral knee a year later. This patient was also excluded from the performance and return-to-play analyses, as it was not believed that this case could be easily categorized. Therefore, 31 knees in 31 patients were included.

Overall, 6 knees in 6 patients (19%) had failed repair and underwent subsequent meniscectomy on the same knee within 2 years of the primary meniscal repair procedure,

TABLE 1
Characteristics of Included Players (n = 25)^a

Variable	Value	Variable	Value
Side of surgery ^b		Injury activity	
Right	13 (59)	Base running	2 (8)
Left	9 (41)	Fielding	11 (44)
Position		Hitting	1 (4)
Catcher	7 (28)	Sliding	3 (12)
Second baseman	1 (4)	Throwing	4 (16)
Shortstop	1 (4)	Other	4 (16)
Third baseman	1 (4)	Injury location	
Outfielder	5 (20)	Foul territory	2 (8)
Pitcher	9 (36)	Infield	15 (60)
Utility player	1 (4)	Outfield	4 (16)
Handedness		Other	4 (16)
Batting		Field type ^c	
Right	17 (68)	Artificial turf	1 (5)
Left	8 (32)	Natural grass	21 (95)
Throwing		Height, mean \pm SD, cm	185 \pm 5
Right	20 (80)	Weight, mean \pm SD, kg	90 \pm 7
Left	5 (20)	Age, mean \pm SD, y	24 \pm 3

^aData are reported as n (%) unless otherwise stated.

^bSide of surgery was not specified in 3 of the operative reports.

^cField type was not available for 3 players.

leaving 25 knees in 25 patients available for performance analysis. The 6 players who had failed repair were placed in the failed-to-RTS category. Thus, 21 of 31 players (68%) returned to the same or a higher level of play, 2 of 31 players (6%) returned to a lower level of play, and 8 of 31 players (26%) did not return. Of note, of the 6 players who had failed repair and underwent subsequent meniscectomy, 5 (83%) were able to return to the same level after meniscectomy.

While players encompassed a variety of positions, catchers and pitchers represented the majority of the cohort (Table 1). The most common mechanism of injury was fielding in the infield, and most injuries occurred on natural grass. All injuries were listed in the database as "acute" injuries, with none listed as "overuse" injuries. Intraoperatively, more lateral than medial menisci were repaired (Table 2). Most menisci were repaired using an all-inside technique, and concomitant cartilage damage was an infrequent finding (Table 3). No patients received a concomitant injection of stem cells or bone marrow aspirate concentrate at the time of surgery, while 20% received a concomitant injection of platelet-rich plasma. Of the 6 players who had failed repair and went on to future meniscectomy, 4 players underwent medial meniscal repair, and 2 players underwent lateral meniscal repair; 2 players underwent repair via the inside-out technique, and 4 players underwent repair via the all-inside technique; 3 were catchers, 2 were center fielders, and 1 was a pitcher; and 2 received an injection of platelet-rich plasma at the time of meniscal repair.

Among pitchers, 7 of 10 (70%) returned to the same or a higher level of play, and 3 of 10 (30%) did not return to play. When examining pitching performance, players saw a

decrease in usage but no change in performance after meniscal repair (Table 4).

Among fielders, 15 of 23 (65%) returned to the same or a higher level of play, 2 of 23 (9%) returned to a lower level of play, and 6 of 23 (26%) did not return to play. One player who was both a pitcher and a fielder returned to the same level of pitching but did not return to batting. Examining batting performance, there was a significant decrease in base stealing and on-base percentage postoperatively (Table 5).

On average, the number of days missed from participation in practice was 187 ± 67 days, while the mean time to return to full competitive play was 209 ± 84 days. There was no significant difference in RTS rates between players with meniscal repair procedures that involved the medial meniscus (7/11 [64%]) and those with procedures that involved the lateral meniscus (18/20 [90%]) ($P \geq .999$). There were no significant differences in the time to RTS between players with repair procedures that involved the medial meniscus ($183 \pm$

63 days) and those with procedures that involved the lateral meniscus (207 ± 104 days) ($P = .574$).

DISCUSSION

Meniscal repair has become a well-accepted treatment method for certain meniscal tears in an effort to preserve knee function and prevent the progression to arthritis. Our hypotheses were partly confirmed, as there was a high RTS rate in professional baseball players after meniscal repair. However, with the low incidence of meniscal repair procedures during the interval studied, there was no significant difference in the rate or timing of RTS between players who underwent medial versus lateral meniscal repair. However, there was a decline in several performance variables, including on-base percentage, after meniscal repair.

While many meniscal tears are not amenable to repair, it is the preference of many surgeons to repair tears that could potentially heal in an attempt to protect the knee from future degeneration.¹² There are several techniques for meniscal repair including inside-out, outside-in, and all-inside. The majority of patients in this study (60%) underwent meniscal repair via an all-inside technique. While the inside-out technique was previously considered the criterion standard, many surgeons have adopted the all-inside technique when possible to minimize the morbidity associated with the inside-out technique. Fillingham et al¹³ performed a systematic review of 27 studies and compared the results of inside-out (676 patients) versus all-inside (548 patients) meniscal repair. The authors found no significant difference in the clinical or anatomic failure rate or complication rate between the 2 techniques, indicating that the all-inside technique is a viable option for meniscal repair. In the current study, 27% of the all-inside repair procedures failed, while 67% of the inside-out repair procedures failed. Tear size was not documented, so it is unclear if larger tears were treated more commonly with the inside-out technique and if the all-inside technique was used for smaller tears. Our sample size was not large enough to make a comparison between the techniques.

There have been few studies on the outcomes after meniscal repair in isolation without concomitant ACL reconstruction.^{2,14} DePhillipo et al⁷ reported the healing rates of 64 patients who underwent meniscal repair at the

TABLE 2
Surgical Characteristics of Included Players (n = 25)

Variable	n (%)
Laterality	
Medial	7 (28)
Lateral	18 (72)
Repair type	
All-inside	15 (60)
Inside-out	3 (12)
Outside-in	3 (12)
Root	1 (4)
Combined all-inside and inside-out	3 (12)
No. of repair devices placed	
1	4 (16)
2	6 (24)
3	6 (24)
4	3 (12)
10	1 (4)
Not available	5 (20)
Plica excision	2 (8)
Cartilage damage	8 (32)
Concomitant chondroplasty	4 (16)
Concomitant platelet-rich plasma injection	5 (20)

TABLE 3
Cartilage Damage Details in Included Players (n = 25)^a

Region	Damage	Outerbridge Grade				
		0	1	2	3	4
Trochlea	2 (8)	23 (92)	0 (0)	2 (8)	0 (0)	0 (0)
Patella	3 (12)	22 (88)	2 (8)	0 (0)	1 (4)	0 (0)
Lateral femoral condyle	2 (8)	23 (92)	0 (0)	2 (8)	0 (0)	0 (0)
Medial femoral condyle	1 (4)	24 (96)	0 (0)	1 (4)	0 (0)	0 (0)
Medial tibial plateau	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lateral tibial plateau	4 (16)	21 (84)	0 (0)	2 (8)	2 (8)	0 (0)

^aData are reported as n (%).

TABLE 4
Pitching Performance Statistics^a

Variable	Preoperative	Postoperative	Mean Difference (95% CI)	<i>P</i>
Wins per year	4 ± 3	2 ± 1	-2 (-6 to 1)	.127
Losses per year	5 ± 2	2 ± 1	-2 (-5 to 1)	.085
Games per year	27 ± 9	17 ± 14	-11 (-36 to 15)	.274
Games started per year	11 ± 8	5 ± 3	-7 (-18 to 5)	.162
Games finished per year	7 ± 7	4 ± 4	-3 (-18 to 13)	.590
Complete games per year	0.0 ± 0.0	0.1 ± 0.2	0.1 (-0.2 to 0.0)	.391
Shutouts per year	0 ± 0	0 ± 0	0 (0 to 0)	NA
Saves per year	1.3 ± 2.3	0.6 ± 0.7	-0.7 (-5.1 to 4.0)	.643
Innings pitched per year	84 ± 30	36 ± 26	-47 (-88 to -6)	.035
Hits per year	82 ± 26	38 ± 25	-44 (-75 to -14)	.019
Runs per year	40 ± 16	22 ± 14	-19 (-34 to -4)	.029
Earned runs per year	34 ± 13	20 ± 13	-14 (-29 to 1)	.058
Home runs per year	6 ± 4	4 ± 3	-2 (-7 to 3)	.309
Balls batted per year	26 ± 14	17 ± 13	-9 (-18 to 0)	.051
Intentional walks per year	0.59 ± 0.67	0.08 ± 0.17	-0.51 (-1.70 to 1.00)	.267
Strikeouts per year	73 ± 18	33 ± 23	-41 (-63 to -18)	.011
Hit batters per year	3.5 ± 2.7	2.5 ± 2.6	-1.0 (-2.3 to 0.0)	.099
Balks per year	0.38 ± 0.48	0.08 ± 0.17	-0.29 (-0.84 to 0.00)	.188
Wild pitches per year	5 ± 1	3 ± 2	-2 (-6 to 1)	.132
Batters faced per year	355 ± 126	165 ± 114	-190 (-345 to -36)	.030
Win-loss percentage	0.47 ± 0.21	0.38 ± 0.26	-0.09 (-0.69 to 1.00)	.652
Earned run average	3.72 ± 0.69	20.25 ± 31.51	16.53 (-34.24 to 67.00)	.376
Runs allowed per 9 innings	4.47 ± 1.00	20.46 ± 31.37	15.99 (-34.95 to 67.00)	.391
Walks plus hits per inning pitched	1.31 ± 0.06	3.33 ± 3.79	2.02 (-4.10 to 8.00)	.370
Hits per 9 innings	8.88 ± 0.55	23.44 ± 29.40	14.56 (-32.09 to 61.00)	.394
Home runs per 9 innings	0.59 ± 0.27	4.06 ± 6.30	3.47 (-6.44 to 13.00)	.346
Walks allowed per 9 innings	2.92 ± 0.81	6.58 ± 4.77	3.65 (-4.83 to 12.00)	.264
Strikeouts per 9 innings	8.37 ± 1.73	9.56 ± 2.70	1.18 (-4.89 to 7.00)	.579
Strikeouts per walk	3.31 ± 1.08	1.84 ± 0.66	-1.46 (-3.43 to 1.00)	.098
Fielding independent pitching	NA	NA	NA	NA
Wins above replacement	NA	NA	NA	NA

^aData are reported as mean ± SD unless otherwise stated. Boldface *P* values denote a significant difference between preoperative and postoperative measurements (*P* < .05). NA, not available/not applicable.

time of bone grafting (first stage) for 2-stage ACL reconstruction. On second-look arthroscopic examination at the time of revision ACL reconstruction, the authors noted that 82% of the meniscal repair procedures had healed. This study did not evaluate the clinical success long term but simply the ability of the meniscus to heal before the patient tried to RTS and test the knee. Hagmeijer et al¹⁴ reported the results of 32 patients with an average age of 16 years who underwent meniscal repair at an average follow-up of 17 years to determine clinical outcomes and failure rates. The authors noted an overall failure rate of 42%, with complex tears and bucket-handle tears having higher failure rates than simple tears. Interestingly, all of the failures in this group occurred within 2 years of meniscal repair, and no patients who made it past the short term sustained a re-tear in the midterm or long term. These results regarding the timing of failure are similar to those of the current study, as all failures in this study that required subsequent meniscectomy occurred within 2 years of the initial repair procedure. However, the failure rate in our study (19%) was slightly lower than the 42% rate reported by Hagmeijer et al. Finally, Ardizzone et al² performed a systematic review of 15 studies including 763 patients who underwent

meniscal repair for bucket-handle tears and found an overall failure rate of 30%. This failure rate is consistent with that of the current study. This is important information to relay to patients, as setting proper preoperative expectations is critical to achieving a successful outcome.

Although no studies in the literature have focused on the success of meniscal repair in baseball players, Alvarez-Diaz et al¹ reported the results of 29 competitive soccer players after meniscal repair at a follow-up of 6 years. The authors noted that 2 patients (6.9%) required revision arthroscopic surgery with partial meniscectomy before RTS. They reported that 90% of players returned to the same level of play after meniscal repair. However, at their final follow-up, only 28% were still playing soccer at the same or higher level. Compared to our study, the study of Alvarez-Diaz et al¹ showed a much higher RTS rate and a much lower failure rate initially, but these results deteriorated over time. It is unclear exactly why the revision and RTS rates were different between the 2 studies, as soccer players place a significant amount of stress on their menisci during practice and competition.

One of the more interesting findings of this study was the number of patients who underwent lateral meniscal

TABLE 5
Batting Performance Statistics^a

Variable	Preoperative	Postoperative	Mean Difference (95% CI)	P
Games per year	84 ± 17	84 ± 36	0 (-22 to 23)	.978
Played appearances per year	341 ± 78	314 ± 145	-27 (-115 to 62)	.524
At bats per year	299 ± 69	280 ± 134	-19 (-100 to 62)	.622
Runs per year	42 ± 14	37 ± 19	-6 (-16 to 5)	.286
Hits per year	82 ± 24	72 ± 38	-10 (-31 to 11)	.319
Doubles per year	17.4 ± 6.1	15.6 ± 8.0	-1.7 (-6.8 to 3.0)	.475
Triples per year	2.1 ± 1.7	1.6 ± 1.4	-0.5 (-1.3 to 0.0)	.155
Home runs per year	7.2 ± 2.9	9.1 ± 6.1	1.9 (-2.5 to 6.0)	.372
Runs batted in per year	40 ± 12	38 ± 21	-2 (-16 to 12)	.800
Stolen bases per year	5 ± 6	2 ± 2	-3 (-6 to 0)	.027
Caught stealing per year	2.2 ± 1.7	1.1 ± 1.0	-1.1 (-1.9 to 0.0)	.017
Walks per year	32 ± 13	26 ± 15	-6 (-15 to 3)	.170
Strikeouts per year	63 ± 18	71 ± 32	8 (-13 to 29)	.421
Total bases per year	126 ± 35	118 ± 64	-7 (-45 to 31)	.689
Double plays grounded per year	7.1 ± 2.1	6.9 ± 4.5	-0.2 (-2.7 to 2.0)	.856
Hit by pitch per year	4.7 ± 2.0	3.8 ± 2.1	-0.9 (-2.0 to 0.0)	.128
Sacrifice hits per year	1.4 ± 0.8	1.0 ± 0.8	-0.4 (-1.1 to 0.0)	.187
Sacrifice flies per year	3.1 ± 1.1	2.6 ± 1.2	-0.5 (-1.4 to 0.0)	.192
Intentional walks per year	0.77 ± 0.61	0.96 ± 0.86	0.19 (-0.37 to 1.00)	.471
Hits per at bat	0.27 ± 0.02	0.25 ± 0.03	-0.02 (-0.04 to 0.00)	.013
On-base percentage	0.35 ± 0.03	0.32 ± 0.04	-0.03 (-0.05 to 0.00)	.026
Slugging percentage	0.41 ± 0.04	0.40 ± 0.06	-0.01 (-0.05 to 0.00)	.546
Wins above replacement	-7.62 ± 1.38	-2.75 ± 3.47	4.87 (-0.75 to 10.00)	.070
Weighted on-base average	-7.77 ± 1.08	-3.25 ± 2.98	4.53 (-0.28 to 9.00)	.058
On-base plus slugging plus	6.7 ± 16.8	54.2 ± 36.6	47.4 (-8.5 to 103.0)	.074
Walk rate	-7.81 ± 1.04	-3.41 ± 2.90	4.40 (-0.29 to 9.00)	.058
Strikeout rate	-7.79 ± 1.05	-3.32 ± 2.92	4.47 (-0.27 to 9.00)	.058
Batting average on balls in play	-7.77 ± 1.07	-3.28 ± 2.98	4.49 (-0.32 to 9.00)	.059

^aData are reported as mean ± SD unless otherwise stated. Boldface *P* values denote a significant difference between preoperative and postoperative measurements (*P* < .05).

repair (72%) compared with medial meniscal repair (28%). While the exact reason for this is unknown, it could be that surgeons were more aggressive in attempting lateral meniscal repair, as the lateral meniscus plays a more significant role in maintaining joint congruity, given the convex shape of the lateral tibial plateau compared with the concave shape of the medial tibial plateau. Krych et al¹⁶ reviewed 141 patients with meniscus root tears and noted that 100% of those with lateral meniscus root tears underwent surgical repair while only 27% of those with medial meniscus root tears underwent repair. This is a similar finding to that of the current study. Krych et al¹⁶ also noted that the outcomes after lateral meniscus root repair were better than those after medial meniscus root repair. Meniscal repair in professional baseball players is a viable treatment option and appears to be a more common choice for lateral meniscal tears than medial meniscal tears.

Limitations

This study utilized the MLB HITS database and was therefore subject to data entry errors. The cause of meniscal injuries was broadly classified, but while club athletic trainers do an outstanding job of entering information on all of these athletes, it is possible that some of this information was entered incorrectly. This was a retrospective

study with a small number of patients. This study did not examine when it was safe to allow a baseball player to RTS after meniscal repair; rather, it reported when these players were able to return based on previously recorded data. As such, a recommendation on when it is safe to allow RTS after meniscal repair is beyond the scope of this study and is something to be explored in future studies. Players with a chondral injury could not be separated out into a separate group and compared to those without a cartilage injury, as the type and severity of cartilage injury varied too much to form 1 homogeneous group. Information on why the repair procedures were performed using the all-inside technique versus other techniques was not available, so we cannot comment on this. Finally, this study involved professional baseball players and therefore may not be generalizable to high school and collegiate baseball players.

CONCLUSION

The RTS rate after meniscal repair in professional baseball players was 74% at a mean of 209 days. With the numbers available for analysis, no difference in the rate or timing of RTS was observed between players who underwent medial versus lateral meniscal repair. Additionally, 19% of players

had failed repair and underwent subsequent meniscectomy within 2 years of repair.

ACKNOWLEDGMENT

The authors acknowledge the Professional Baseball Athletic Trainers Society for its continued efforts in updating the MLB injury database and the care of these athletes.

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