Association Between Previous Meniscal Surgery and the Incidence of Chondral Lesions at Revision Anterior Cruciate Ligament Reconstruction

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Association Between Previous Meniscal Surgery and the Incidence of Chondral Lesions at Revision Anterior Cruciate Ligament Reconstruction

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Background: Knees undergoing revision anterior cruciate ligament (ACL) reconstruction typically have more intra-articular injuries than do knees undergoing primary reconstruction.

Hypothesis: Previous partial meniscectomy (PM) is associated with a higher rate of chondral lesions at revision ACL reconstruction, whereas previous meniscal repair (MR) is not associated with a higher rate of chondral lesions at revision ACL reconstruction, compared with knees undergoing revision ACL with no previous meniscal surgery.

Study design: Cohort study (Prevalence); Level of evidence, 2.

Methods: Data from a multicenter cohort was reviewed to determine the history of prior meniscal surgery (PM/MR) and the presence of grade II/III/IV chondral lesions at revision ACL reconstruction. The association between previous meniscal surgery and the incidence of chondral lesions was examined. Patient age was included as a covariate to determine if surgery type contributes predictive information independent of patient age.

Results: The cohort included 725 ACL revision surgeries. Chondrosis was associated with patient age ($P < .0001$) and previous meniscal surgery ($P < .0001$). After adjusting for patient age, knees with previous PM were more likely to have chondrosis than knees with previous MR ($P = .003$) or no previous meniscal surgery ($P < .0001$). There was no difference between knees without previous meniscal surgery and knees with previous MR ($P = .7$). Previous partial meniscectomy was associated with a higher rate of chondrosis in the same compartment compared with knees without previous meniscal surgery ($P < .0001$) and knees with previous MR ($P \leq .03$).

Conclusion: The status of articular cartilage at the time of revision ACL reconstruction relates to previous meniscal surgery independent of the effect of patient age. Previous partial meniscectomy is associated with a higher incidence of articular cartilage lesions, whereas previous meniscal repair is not. Although this association may reflect underlying differences in the knee at the time of prior surgery, it does suggest that meniscal repair is preferable when possible at the time of ACL reconstruction.

Keywords: meniscectomy, meniscal repair, chondrosis, revision ACL reconstruction

Meniscal and chondral status likely influence the outcomes from revision anterior cruciate ligament (ACL) reconstruction.[2] Knees undergoing revision ACL reconstructions have more intra-articular injuries than knees undergoing primary reconstruction.[8,10] The Multicenter ACL Revision Study (MARS) Group reported that 90% of knees undergoing revision ACL reconstruction had meniscal or chondral injury, with 57% having both at the time of surgery.[30]

Meniscal injury and subsequent surgery has been shown to be associated with an increased risk for osteoarthritis,[5,12,20] likely due to the early sequela of an increased rate of chondrosis. However, there have been limited data to date on the development of chondrosis after meniscal surgery. Meniscal damage[14,26,31] and the amount of meniscus removed at ACL reconstruction[9] have been shown to be associated with the subsequent development of arthrosis. Nevertheless, the association between prior meniscal surgery and the incidence of articular cartilage lesions at the time of revision ACL reconstruction has not been well studied in the literature. The purpose of this study is to test the following hypotheses: (1) previous partial meniscectomy is associated with a higher rate of chondral lesions at the time of revision ACL reconstruction and (2) previous meniscal repair is not associated with a higher rate of chondral lesions at the time of revision

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ACL reconstruction, both compared with knees undergoing revision ACL with no history of previous meniscal surgery.

METHODS

The patients in this study were enrolled in the MARS Group, an American Orthopaedic Society for Sports Medicine (AOSSM)–sponsored, academic and private practice multicenter consortium conducting an ongoing prospective multicenter cohort study of patients undergoing revision ACL reconstruction.[30] Indications for revision ACL reconstructions include functional instability, abnormal laxity testing, or magnetic resonance imaging (MRI) indicating graft tear. Participating surgeons were required to complete a training session and fill out a practice intra-articular grading sheet and a trial surgeon questionnaire. In addition, they had to obtain local institutional review board (IRB) approval before enrolling subjects and were expected to comply with a standardized manual of operations. Patient enrollment required the patient to complete a series of validated patient-oriented questionnaires (Knee Injury and Osteoarthritis Outcome Score, Marx, International Knee Documentation Committee, SF-36, and Western Ontario and McMaster Universities Arthritis Index). At the time of each surgery, surgeons documented mechanism and mode of failure, method of revision ACL reconstruction, and all meniscal and chondral injuries and treatment using a standardized form. The MARS study was made possible through funding from the AOSSM, Smith & Nephew (Andover, Massachusetts), NFL Charities, the Musculoskeletal Transplant Foundation (Edison, New Jersey), and National Institutes of Health (NIH) grant no. 1R01AR0 60846-01A1.

Data from the cohort were reviewed to determine the history of prior meniscal surgery (partial meniscectomy/repair) and the presence of grade II, III, and IV chondral lesions, using a modified Outerbridge classification system,[19,21] at revision ACL reconstruction. For each knee, the history of previous medial meniscal surgery was recorded as none, meniscal repair only (if they had a history of previous medial meniscal repair and no other medial meniscal surgery), or partial meniscectomy (if there was any history of previous medial partial meniscectomy or debridement). The same history was recorded for the lateral meniscus. For the overall joint, knees were considered to have no previous meniscal surgery as long as there was no previous surgery in both compartments. If there was a previous meniscectomy in either compartment, then the knee was classified as previous partial meniscectomy, even if there was a previous repair in the other compartment. If the only previous meniscal surgery was a repair in either or both compartments, then the knee was classified as a previous meniscal repair. Information was obtained from previous operative notes (if they could be obtained), the patient questionnaire, and intraoperative findings at the time of ACL revision surgery. The highest chondral lesions in the medial, lateral, and patellofemoral compartments at the time of revision ACL reconstruction were recorded. This approach has been shown to have good reliability and reproducibility among orthopaedic surgeons.[19] The status of any previously repaired meniscus at the time of revision ACL reconstruction was also noted. The association between previous meniscal surgery and the incidence of chondral lesions was examined for the entire knee, the same compartment, and the patellofemoral compartment after adjusting for age.

The cohort included 725 patients undergoing ACL revision surgery. In the overall cohort, mean ± SD patient age was 28.0 ± 9.9 years (range, 12-63 years). Among patients who had no history of previous meniscal surgery, mean ± SD patient age was 26.9 ± 9.9 years (range, 12-63 years). Patients with previous partial meniscectomy had a mean ± SD age of 30.2 ± 9.8 years (range, 14-63 years), whereas patients with previous meniscal repair had a mean ± SD age of 24.8 ± 8.7 years (range, 14-54 years). In total, 421 patients (58%) were male and 304 (42%) were female.

Fifteen knees had undergone previous medial meniscal repair and partial medial meniscectomy and 2 knees with the same history in the lateral compartment. These knees were considered to have a history of partial meniscectomy for the purposes of this analysis. Fifty-six knees had undergone partial medial and lateral meniscectomy, 6 had a history of previous medial meniscal repair and partial lateral meniscectomy, and 6 had a history of previous lateral meniscal repair and partial medial meniscectomy. For analysis of the overall joint and the patellofemoral joint, these knees were considered to have a history of partial meniscectomy. For the tibiofemoral compartments, the knees were assigned to the appropriate group based on the previous intervention in that compartment.

The primary statistical analysis was a comparison of lesion grade across surgical types using generalized estimating equations (GEEs) with a multinomial distribution and cumulative logit link function to account for the ordering of the lesion grade. The effect of patient age as a covariate was included to determine if surgery type contributes

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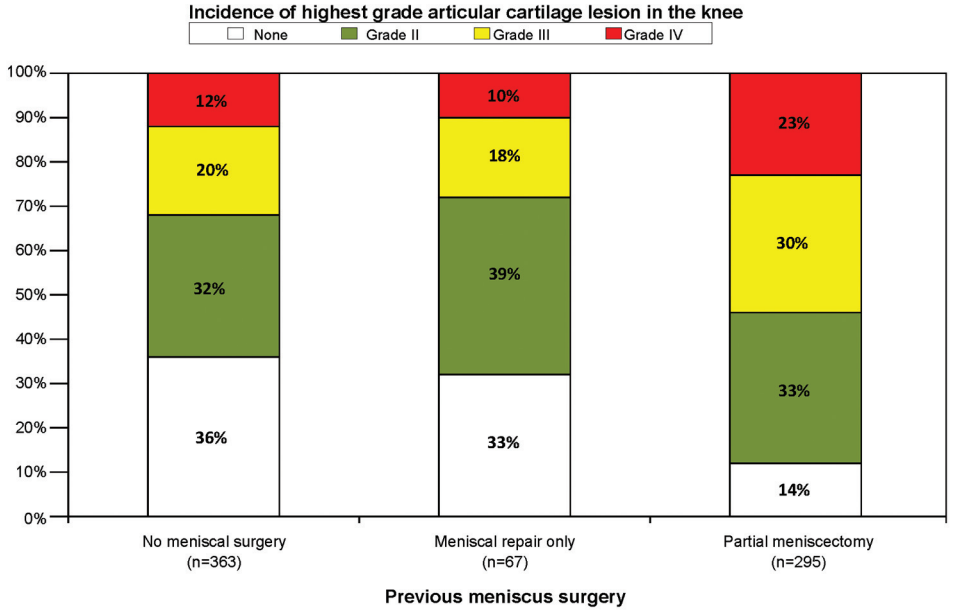

Figure 1. Incidence of highest grade articular cartilage lesion in the knee by previous meniscal surgery. Statistical analysis: age, $P < .0001$; surgery, $P < .0001$; no surgery vs meniscal repair only, $P = .74$; no surgery vs debridement/partial meniscectomy, $P < .0001$; meniscal repair only vs debridement/partial meniscectomy, $P = .003$.

predictive information regarding the incidence of chondrosis above and beyond that provided by patient age. Within the context of the GEE model, statistical contrasts were used to test specific hypotheses regarding between-group differences (ie, no surgery vs meniscal repair only, no surgery vs debridement or partial meniscectomy, meniscal repair only vs debridement or partial meniscectomy). Because of sample size constraints, the GEE model could not be used to compare intact meniscal repairs with meniscal repairs that did not heal or re-tore, nor could age be included as a covariate. These parameters were compared by Wilcoxon's test. *P* values are reported for each statistical contrast as well as for the main effects of age and surgery type. Data are reported as the number of patients (percentage of surgery group). The data analysis was generated using SAS software, version 9.2 of the SAS System for Linux (SAS Institute, Inc, Cary, North Carolina).

RESULTS

The incidence of chondrosis was associated with patient age ($P < .0001$) and a history of *any* previous meniscal surgery ($P < .0001$). After adjusting for the effect of patient age, based on the highest grade chondral lesion in the entire knee (medial, lateral, or patellofemoral compartments), knees with previous partial meniscectomy were more likely to have chondral lesions than were knees with no previous meniscal surgery ($P < .0001$) or previous meniscal repair ($P = .003$) (Figure 1). There was no difference in the prevalence of chondral lesions between knees without previous meniscal surgery and knees with previous meniscal repair. Patients with a history of previous partial meniscectomy were older than patients with no previous meniscal surgery ($P < .0001$) and patients with previous meniscal repair ($P < .0001$). There was no statistically significant difference in age between patients with no previous meniscal surgery and patients with previous meniscal repair.

Knees with previous partial *medial* meniscectomy were more likely to have lesions than were knees without previous medial meniscal surgery ($P < .0001$) or previous medial meniscal repair ($P = .01$) (Table 1). There was no difference between knees without previous medial meniscal surgery and knees with previous medial meniscal repair. Knees with previous partial *lateral* meniscectomy were more likely to have lesions than were knees with no previous lateral meniscal surgery ($P < .0001$) but not previous lateral meniscal repair. Again, there was no difference between knees without previous lateral meniscal surgery and knees with previous lateral meniscal repair.

By compartment, knees with previous partial medial meniscectomy were more likely to have chondrosis in the medial compartment than were knees without previous medial meniscal surgery ($P < .0001$) or previous medial meniscal repair ($P = .003$) (Table 2). Knees with a history of previous medial meniscal repair had a higher incidence of medial compartment chondrosis compared with knees without previous medial meniscal surgery ($P = .03$). Knees with previous partial lateral meniscectomy were more likely to have chondrosis in the lateral compartment than were knees without previous lateral meniscal surgery ($P < .0001$) or knees with previous lateral meniscal repair ($P = .03$). There was no difference between knees without previous lateral meniscal surgery and knees with previous lateral meniscal repair.

TABLE 1
Incidence of Highest Grade Articular Cartilage Lesion in the Knee Related to Previous Meniscal Surgery by Compartment[a]

	Surgery Type					
	Medial Meniscus			Lateral Meniscus		
Highest Knee Chondrosis	None (n = 438)	Meniscal Repair (n = 53)	Debridement/PM (n = 234)	None (n = 578)	Meniscal Repair (n = 30)	Debridement/PM (n = 117)
None	148 (34)	13 (25)	32 (14)	169 (29)	11 (37)	13 (11)
Grade II	142 (32)	25 (47)	71 (30)	191 (33)	8 (27)	39 (33)
Grade III	91 (21)	10 (19)	73 (31)	130 (22)	6 (20)	38 (32)
Grade IV	57 (13)	5 (9)	58 (25)	88 (15)	5 (17)	27 (23)
P values	Main Effects: age, $P < .0001$; surgery, $P < .0001$; no surgery vs meniscal repair only, $P = .60$; no surgery vs debridement/PM, $P < .0001$; meniscal repair only vs debridement/PM, $P = .01$			Main Effects: age, $P < .0001$; surgery, $P = .0002$; no surgery vs meniscal repair only, $P = .65$; no surgery vs debridement/PM, $P < .0001$; meniscal repair only vs debridement/PM, $P = .13$		

[a]Values presented as No. (%). PM, partial meniscectomy.

TABLE 2
Incidence of Highest Grade Articular Cartilage Lesion in the Same Compartment[a]

	Surgery Type					
	Medial Meniscus			Lateral Meniscus		
Same-Compartment Chondrosis	None (n = 438)	Meniscal Repair (n = 53)	Debridement/PM (n = 234)	None (n = 578)	Meniscal Repair (n = 30)	Debridement/PM (n = 117)
None	294 (67)	28 (53)	66 (28)	394 (68)	18 (60)	38 (32)
Grade II	88 (20)	17 (32)	77 (33)	109 (19)	9 (30)	48 (41)
Grade III	41 (9)	4 (8)	52 (22)	46 (8)	1 (3)	18 (15)
Grade IV	15 (3)	4 (8)	39 (17)	29 (5)	2 (7)	13 (11)
P values	Main Effects: age, $P < .0001$; surgery, $P < .0001$; no surgery vs meniscal repair only, $P = .03$; no surgery vs debridement/PM, $P < .0001$; meniscal repair only vs debridement/PM, $P = .003$			Main Effects: age, $P = .003$; surgery, $P < .0001$; no surgery vs meniscal repair only, $P = .28$; no surgery vs debridement/PM, $P < .0001$; meniscal repair only vs debridement/PM, $P = .03$		

[a]Values presented as No. (%). PM, partial meniscectomy.

In the patellofemoral compartment, there was a higher incidence of chondrosis in knees with a history of previous partial medial meniscectomy ($P < .0001$) and previous partial lateral meniscectomy ($P = .02$) compared with knees without previous meniscectomy (Table 3). Knees with a previous partial medial meniscectomy had a higher incidence of patellofemoral chondrosis than did knees with a history of previous medial meniscal repair ($P = .03$), but there was no significant difference between partial meniscectomy and repair in the lateral compartment. There was no difference in the incidence of patellofemoral chondrosis between knees without a history of previous meniscal surgery and with a history of previous medial meniscal repair or previous lateral meniscal repair.

Among 67 knees with a history of meniscal repair (and no previous partial meniscectomy) before their revision ACL reconstruction, 44 had a meniscal tear at the time of ACL revision, suggesting the meniscal repair did not heal or re-tore. Approximately 25% of the medial meniscal repairs (12/46) were intact at the time of ACL revision compared with about half of the lateral meniscal repairs (14/26). Knees with an intact meniscal repair at the time of ACL revision had less chondrosis in the overall knee and the medial compartment but not in the lateral compartment, although the differences were not statistically significant (Table 4).

DISCUSSION

The status of articular cartilage at the time of revision ACL reconstruction is related to patient age and previous meniscal surgery in this cohort. Independent of the effect of patient age, partial meniscectomy is associated with an increase in

TABLE 3
Incidence of Highest Grade Articular Cartilage Lesion in the Patellofemoral Compartment by Previous Meniscal Surgery[a]

	Surgery Type					
	Medial Meniscus			Lateral Meniscus		
Patellofemoral Chondrosis	None (n = 438)	Meniscal Repair (n = 53)	Debridement/PM (n = 234)	None (n = 578)	Meniscal Repair (n = 30)	Debridement/PM (n = 117)
None	277 (63)	35 (66)	99 (42)	336 (58)	21 (70)	54 (46)
Grade II	96 (22)	12 (23)	61 (26)	134 (23)	8 (27)	27 (23)
Grade III	46 (10)	4 (8)	55 (24)	77 (13)	0	28 (24)
Grade IV	19 (4)	2 (4)	19 (8)	31 (5)	1 (3)	8 (7)
P values	Main Effects: age, $P < .0001$; surgery, $P = .0002$; no surgery vs meniscal repair only, $P = .85$; no surgery vs debridement/PM, $P < .0001$; meniscal repair only vs debridement/PM, $P = .03$			Main Effects: age, $P < .0001$; surgery, $P = .06$; no surgery vs meniscal repair only, $P = .67$; no surgery vs debridement/PM, $P = .02$; meniscal repair only vs debridement/PM, $P = .15$		

[a]Values presented as No. (%). PM, partial meniscectomy.

TABLE 4
Incidence of Highest Grade Articular Cartilage Lesion by Status of Meniscal Repair

	Meniscus Status: Entire Knee		Medial Meniscus Status: Medial Compartment		Lateral Meniscus Status: Lateral Compartment	
Chondrosis	Intact	New/Recurrent Tear	Intact	New/Recurrent Tear	Intact	New/Recurrent Tear
None	10 (42)	12 (28)	8 (67)	15 (44)	7 (50)	7 (58)
Grade II	10 (42)	16 (37)	3 (25)	12 (35)	6 (43)	3 (25)
Grade III	3 (13)	9 (21)	1 (8)	3 (9)	0	1 (8)
Grade IV	1 (4)	6 (14)	0	4 (12)	1 (7)	1 (8)
P values[b]	.10		.16		.89	

[a]Values presented as No. (%).
[b]Within each compartment, *P* values compare chondrosis grades for intact versus new/recurrent tear by Wilcoxon's 2-sample test.

the incidence of chondrosis, whereas meniscal repair is not. This relationship holds up over the entire knee, in the same compartment as the meniscal surgery, and in the patellofemoral joint. The association between partial meniscectomy and chondrosis in the same compartment appears to be similar on the medial and lateral sides of the knee.

It has been shown previously that meniscal tears are associated with the development of chondrosis and, ultimately, osteoarthritis in the knee.[6,12,20,23,24] The meniscus serves a load-bearing[25] and shock-absorbing[28] role in the tibiofemoral joint by increasing the surface area for load transmission.[1,4,15,16,18,22,29] Biswal et al[6] previously demonstrated that meniscal tears were significantly associated with progression of cartilage disease on MRI. There is an increased risk of developing osteoarthritis after meniscectomy,[20] and an inverse relationship has been demonstrated between function of the knee and the amount of meniscal tissue resected.[12] Degenerative changes have been reported in 38% of patients after arthroscopic partial medial meniscectomy and 24% of patients after arthroscopic partial lateral meniscectomy at an average follow-up of 4.5 years.[23] Scheller et al[24] found degenerative changes in approximately 80% of knees at a mean follow-up of 12.3 years after partial lateral meniscectomy. One study reported a 6-fold increase in the incidence of arthrosis in knees with concomitant partial meniscectomy at the time of ACL reconstruction.[14] A recent systematic review found those with a partial meniscectomy to be 5 times more likely to exhibit radiographic findings than those with intact menisci.[17] The results of those with repaired menisci were more heterogeneous but also showed a trend toward lesser degrees of chondral wear similar to that seen with the menisci intact. At least one previous study has not found any association between meniscal injury at the time of ACL reconstruction and subsequent development of arthrosis.[8]

Our data show similar relative and absolute rates of chondrosis in the medial and lateral compartments after previous partial meniscectomy. Although the lateral side may be more susceptible to changes in joint-loading

mechanics after partial meniscectomy due to the more convex nature of the opposing bony surfaces, the medial side may be at risk in ACL-deficient knees if the medial meniscus acts as a secondary stabilizer of the knee. Because we lack information on the length of time from previous surgery and the degree of chondrosis at the time of previous surgery, it is not possible in this study to compare the rate at which chondrosis develops after partial meniscectomy between the medial and lateral compartments.

In this cohort, previous meniscal repair was associated with a lower incidence of chondrosis in knees undergoing revision ACL reconstruction compared with previous partial meniscectomy. Whether this arises due to an underlying difference in the initial primary injury to the knee or as a result of the repair is unknown, but it does suggest that meniscal repair is preferable, when possible, at the time of ACL reconstruction. In the medial compartment, meniscal repair was associated with a lower incidence of chondrosis than partial meniscectomy but a higher rate of chondrosis than in knees with no previous medial meniscal surgery. In the lateral compartment, meniscal repair was associated with a lower incidence of partial chondrosis than was partial meniscectomy, and there was no significant difference from knees without previous lateral meniscal surgery. It is not clear why this difference between the lateral and medial joints exists. This may reflect compartmental differences in the initial injury pattern to the joint, changes in the joint kinematics following ACL reconstruction, or differences in healing between the medial meniscus and lateral meniscus following repair. We found that more of the lateral meniscal repairs were intact at the time of revision ACL reconstruction, but this did not appear to influence the rate of chondrosis in the lateral compartment. An intact medial meniscal repair at the time of revision ACL reconstruction may be associated with less chondrosis in the medial compartment. However, we do not know whether a tear in a previously repaired meniscus indicates the repair did not heal or if a new tear occurred over time or at the recurrent ACL injury.

The association between previous meniscal surgery and chondrosis in the patellofemoral joint is an interesting finding. We are unaware of any previous studies that have demonstrated a relationship between meniscal surgery and the subsequent development of patellofemoral chondrosis. This may be related to a more diffuse injury pattern in ACL ruptures with associated meniscal tears that need surgery compared with isolated ACL tears. Another possible explanation is that abnormal meniscal function following partial meniscectomy could set up a degradative biochemical response in the knee, leading to more diffuse cartilage changes. It is also possible that graft choice plays a role in this relationship.

Previous studies have shown that meniscal and chondral lesions are associated with worse outcomes after ACL reconstruction.[13,26,31] The presence of chondral lesions at the time of revision ACL reconstruction has been associated with worse outcomes of the revision surgery.[3,7,11,27] Given the decreased incidence of chondrosis at the time of revision ACL reconstruction in patients with a history of meniscal repair compared with partial meniscectomy, meniscal repair may be preferable when possible at the time of ACL reconstruction. This does not imply that all meniscal tears can or should be repaired at the time of ACL reconstruction or that all repaired meniscal tears actually heal and function as intact menisci.

Limitations of the current study include the potential variability in observer-reported chondrosis data and the potential variability in the accuracy of reported previous meniscal surgery. It is not known how the previous meniscal repairs were performed (ie, inside-out sutures or all-inside devices) or whether the previously repaired menisci healed, although it is reasonable to assume they were not particularly symptomatic because the knees had not undergone subsequent debridement before the current revision ACL reconstruction. Previous chondral injury and the status of the articular cartilage at the time of previous ACL reconstruction and meniscal surgery are confounding variables that were not available in this data set. Furthermore, the size and type of previous meniscal tears were unknown. Unfortunately, other important potential confounders such as the length of time between initial injury and initial ACL reconstruction, previous knee surgery and the current revision ACL reconstruction, and the most recent graft failure and the current revision ACL reconstruction were not consistently available for this cohort. Another limitation, which may also be a strength, is the fact that this study included patients who have undergone surgery by a wide variety of surgeons.

Despite these limitations, this study demonstrates that previous partial meniscectomy is associated with a higher rate of chondral changes at the time of revision ACL reconstruction. The incidence of chondrosis is lower after meniscal repair compared with meniscectomy. Although this association may reflect underlying differences in the knee at the time of prior ACL injury and surgery, it does suggest that meniscal repair is preferable, when possible, at the time of ACL reconstruction.

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