

# Predictive Factors for Failure of Meniscal Repair

## A Retrospective Dual-Center Analysis of 918 Consecutive Cases

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**Background:** Meniscal surgery is one of the most common surgical procedures performed by orthopaedic surgeons. Over the past decade, awareness has increased regarding the importance of meniscal preservation to prevent the development of osteoarthritis in the knee joint. Removal of meniscal tissue can lead to a high risk of cartilage degeneration, and moreover, meniscus-preserving surgery rather than meniscal resection is likely to have better long-term outcomes. Success rates after meniscal repair range from 60% to 95%, but many reports are based on a small number of patients.

**Purpose/Hypothesis:** The purpose of this study was to review all meniscal repairs and potential predictors for failure during a 12-year period. We hypothesized that meniscal anchors, lateral repairs, and repairs made in conjunction with an anterior cruciate ligament reconstruction (ACLR) would have fewer failures than meniscal arrows, medial repairs, and isolated repairs. We also hypothesized that younger patients and acute tears would be associated with fewer failures.

**Study Design:** Case-control study; Level of evidence, 3.

**Methods:** This study was a dual-center, retrospective analysis on consecutive meniscal repairs. The surgical protocols were reviewed, including type of tear, location, associated injury to the knee, and surgery. The study endpoint was failure of repair, defined as a need for reoperation and secondary partial or total meniscal resection, within 3 years. Kaplan-Meier analysis was performed to assess repair survival, with multivariate Cox regression to adjust for confounders.

**Results:** A total of 954 meniscal repairs were performed on 918 patients (536 male patients [58%]; 382 female patients [42%]) with a mean age of 26 years (range, 12-60 years). The failure rate for the entire cohort was 22.5%. Bioabsorbable arrows had significantly more failures than all-inside sutures with anchors (hazard ratio [HR], 1.8; 95% CI, 1.2-2.5;  $P = .002$ ). Medial meniscal repairs had a higher failure rate than lateral meniscal repairs (HR, 3.7; 95% CI, 2.3-6.0;  $P < .001$ ). Simultaneous ACLR resulted in less failure than when no simultaneous ACLR was performed (HR, 0.5; 95% CI, 0.3-0.9;  $P = .009$ ). Age at repair and acuity of tear did not affect the outcome ( $P = .6$  and  $.07$ , respectively).

**Conclusion:** The failure rate after meniscal repair was significantly higher on the medial side, especially when using arrows. Meniscal repairs performed concomitantly with an ACLR result in fewer reoperations.

**Keywords:** meniscal repair; meniscal suture; meniscal arrows; failure; ACL reconstruction

Interest in meniscal repair has increased over the past decade because of the association between the loss of meniscal tissue and the risk of developing osteoarthritis in the future.<sup>6,7,24,27,30,33,35</sup> The initial inside-out and outside-in techniques required additional skin incisions and posed a potential risk of neurovascular injuries; therefore, all-inside methods, such as bioabsorbable arrows, were developed in the 1990s.<sup>4</sup> Surgical time was significantly reduced

with the new techniques,<sup>3</sup> and the development of more user-friendly instruments made meniscal repair more attractive.<sup>16</sup> As studies indicated lower pull-out strength for the bioabsorbable arrows compared with sutures,<sup>9,11</sup> poorer outcome,<sup>13</sup> and a risk of articular cartilage damage,<sup>5,31</sup> second-generation all-inside sutures with anchors were developed.

Studies have reported success rates around 80% to 90% for both the bioabsorbable arrows<sup>3,14,17</sup> and all-inside sutures.<sup>16,19</sup> In a meta-analysis, Nepple et al<sup>26</sup> found no differences in failure rate between open, outside-in, inside-out, and all-inside techniques and reported a pooled failure rate

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of 23% from 14 cohorts, which is in line with previous findings by Lozano et al.<sup>23</sup> In previous studies, the reoperation rates are reported to be lower for lateral repairs<sup>22,27,37</sup> and when a concomitant anterior cruciate ligament reconstruction (ACLR) is performed.<sup>2,10,27,36</sup> Most previous studies are, however, based on small numbers of patients. The main objective for this study was to include a large cohort and investigate the overall failure rate in meniscal repair over a 12-year period during which the fixation method changed from arrows to anchors. The secondary objective was to determine the potential association between pre- and perioperative factors and their outcomes. We hypothesized that meniscal anchors, lateral repairs, and repairs made in conjunction with an ACLR would have fewer failures than meniscal arrows, medial repairs, and isolated repairs. We also hypothesized that younger patients and acute tears would be associated with fewer failures.

## METHODS

Patients who underwent an arthroscopic meniscal repair of a vertical, longitudinal tear at 1 of 2 clinics from 1999 to 2011 and 1999 to 2010, respectively, were identified retrospectively. Patient characteristics were collected. The surgical protocols were reviewed, including type of tear, tear vascularization zone (ie, red-on-red, red-on-white, and white-on-white zone), associated injury in the knee, surgical procedure, postoperative rehabilitation, and follow-up. Overall, the surgical procedures were performed by 65 different surgeons.

Meniscal arrows (Biofix, Bionx Implants; hereafter referred to as “arrows”) were the predominant method of fixation of meniscal tears until circa 2004. The replacement fixation technique at both clinics was all-inside sutures with plastic anchors (by far most commonly FasT-Fix, Smith & Nephew but also Sequent, Conmed; Rapid Loc, DePuy Mitek; and Viper, Arthrex; hereafter referred to as “anchors”). No isolated inside-out or outside-in techniques were included in the analysis.

Meniscal tears were described as vertical and longitudinal and classified according to vascularization zone perioperatively by the surgeon.

Inclusion criteria were as follows: (1) sutured lateral and/or medial meniscus, (2) with or without associated ligamentous injury, (3) age 12 to 60 years, and (4) no previous meniscal surgery in index knee. Both clinics used similar standardized rehab protocols, where full weightbearing was allowed from day 1. All patients wore a hinged knee brace that was limited to a range of motion of 0° to 30° for 2 weeks, 0° to 60° for 2 more weeks, and 0° to 90° for an additional 2 weeks. The patients

were instructed to avoid squatting for another 6 weeks. No standardized protocol was used regarding return to running and pivoting sports. Most surgeons advocated 3 to 4 months before running after isolated meniscal repair and 3 months before running after ACLR. For pivoting sports, the predominant recommendation was 6 months of rehab after isolated meniscal repair and 9 months for meniscal repairs performed in conjunction with an ACLR. The minimum follow-up period was 3 years.

Data were collected through only chart review. The initial review identified 933 patients. A total of 15 patients had visited both clinics, but only 1 visit was registered in line with the study. A total of 918 patients were therefore eligible for inclusion in the analysis. The main study endpoint was failure of repair. Definition of failure was a need for reoperation with a partial or total meniscal resection within 3 years of the first surgery.

The study was approved by the regional ethics committee.

## Statistical Analysis

Statistical analyses were conducted using SPSS Statistics (Version 23; IBM). Statistical significance was considered at  $P < .05$ , and  $P < .01$  was regarded as highly significant. A test of independence was performed using the chi-square test for parametric data. The Mann-Whitney  $U$  test was used to compare age and days to surgery for skewed data. Repair device survival was assessed with Kaplan-Meier analysis. Results are expressed as hazard ratios (HRs) with 95% CIs, and factors affecting survival were assessed with Cox regression.

## RESULTS

Baseline characteristics are presented in Table 1. A total of 954 meniscal repairs were performed on 918 patients. The mean follow-up time was 8 years, and 89% had a follow-up time of more than 3 years. The number of patients requiring surgical meniscal resection for a failed repair was 22.5%. Survival of meniscal repair during the entire study period is presented in Figure 1.

Medial meniscal repairs had significantly higher failure rates within 3 years (28.3%) than lateral repairs (11.7%). Survival curves for medial versus lateral repairs are presented in Figure 2.

Repair with arrows on the medial meniscus resulted in reoperation in 40% of cases within 3 years, whereas the reoperation rate for anchors was 25% on the medial side ( $P = .001$ ). Survival curves are presented in Figure 3.

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Ethical approval for this study was obtained from the Stockholm Regional Ethics Review Board.

TABLE 1  
Demographic and Intraoperative Characteristics<sup>a</sup>

		Total, N (%)	Failed Fixation N		P Value
			No, n (%)	Yes, n (%)	
Number of patients		918	711	207	
Age, y	Mean (range)	26 (12-60)			n.s.
	<20	363 (39.5)	269 (74.1)	94 (25.1)	
	21-30	292 (31.8)	234 (80.1)	58 (19.9)	
	31-40	191 (20.8)	148 (77.5)	43 (22.5)	
	>40	72 (7.8)	60 (83.3)	12 (16.7)	
Sex	Female	382 (41.6)	298 (78)	84 (22)	n.s.
	Male	536 (58.4)	413 (77.1)	123 (22.9)	
Meniscus	Lateral	317 (34.5)	280 (88.3)	37 (11.7)	<.001
	Medial	565 (61.5)	405 (71.7)	160 (28.3)	
	Both	36 (3.9)	26 (72.2)	10 (27.8)	
Repair method	Anchor	680 (74.1)	544 (80)	136 (20)	.004
	Arrow	226 (24.6)	157 (69.5)	69 (30.5)	
	Both	12 (1.3)	10 (83.3)	2 (16.7)	
ACL	No ACL injury	344 (37.5)	258 (75)	86 (25)	.015
	ACL injury, not simultaneously reconstructed	276 (30.1)	205 (74.3)	71 (25.7)	
	Simultaneous ACL reconstruction	298 (32.5)	248 (83.2)	50 (16.8)	
Days to surgery	Median (range)	53 (0-3284)			n.s.
	0-30	377 (41.9)	291 (77.2)	86 (22.8)	
	31-90	159 (17.7)	115 (72.3)	44 (27.7)	
	90-365	261 (29.0)	199 (76.2)	62 (23.8)	
	≥366	102 (11.3)	90 (88.2)	12 (11.8)	
Vascularization zone	Red-on-red zone	254	190 (74.8)	64 (25.2)	.044
	Red-on-white zone	374	300 (80.2)	74 (19.8)	
	White-on-white zone	33	21 (63.6)	12 (36.4)	

<sup>a</sup>Failed fixation within 3 years. ACL, anterior cruciate ligament; n.s., not significant.

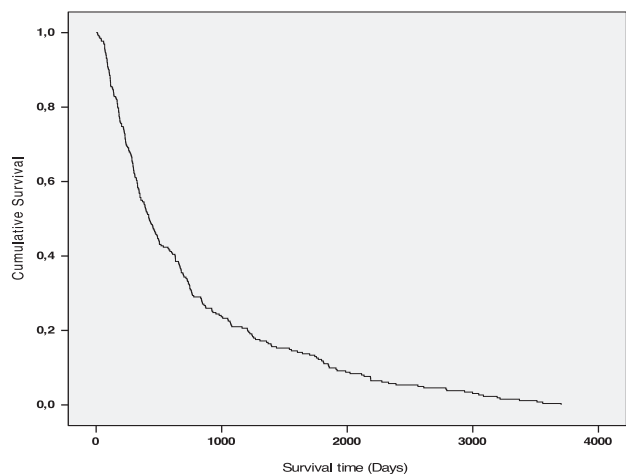


Figure 1. Total distribution of failures.

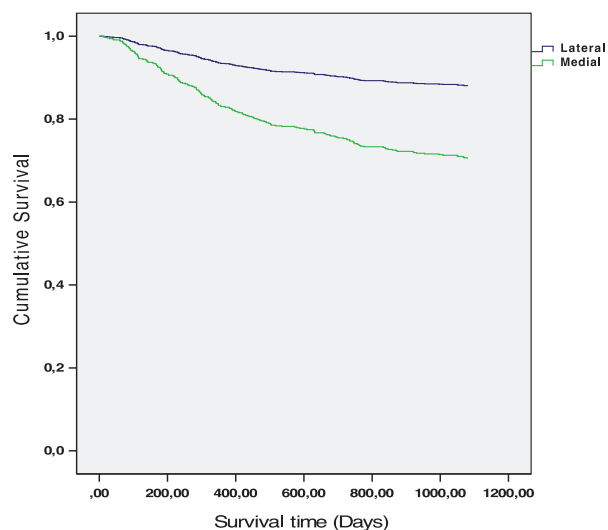
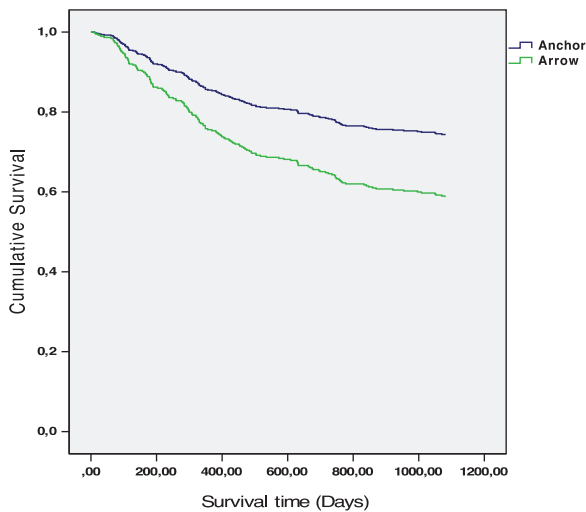


Figure 2. Survival function for medial and lateral meniscal repairs.

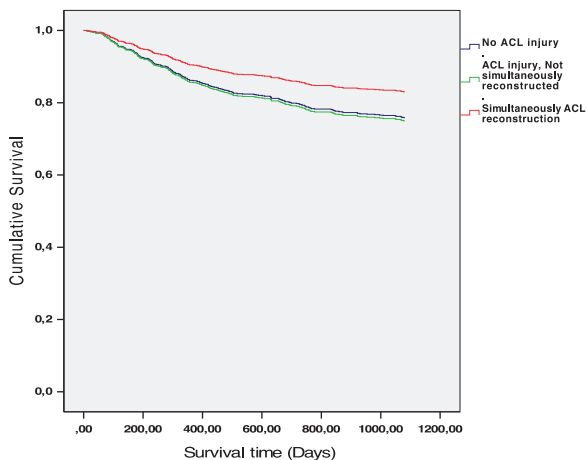
For medial meniscal repairs, a simultaneous ACLR resulted in 19% failed meniscal repairs, an unreconstructed ACL-deficient knee resulted in 32% failed meniscal repairs, and lack of associated ACL injury resulted in 35% failed meniscal repairs within 3 years. Survival curves are presented in Figure 4.

Results for the Cox regression are presented in Table 2. A total of 11 multiligament reconstructions were identified: 1

ACL + posterior cruciate ligament (PCL); 5 PCL + medial collateral ligament (MCL); 1 PCL, MCL + lateral collateral ligament (LCL); and 4 MCL + LCL. Postoperatively, these patients were allowed partial weightbearing in a brace for a minimum of 6 weeks depending on the combination of



**Figure 3.** Survival function for medial anchors versus arrows.



**Figure 4.** Survival function for medial meniscal repairs in association with anterior cruciate ligament (ACL).

injuries. None of these patients had any failure of the meniscal repair.

## DISCUSSION

The factors that were found to have a positive influence on the success of meniscal repair were surgical technique using sutures with anchors, repair of the lateral meniscus, and meniscal repairs performed in conjunction with an ACLR. The factors that did not have any significant effect on outcome were age of the patient, acuity of the tear, and vascularity of the tear.

### Meniscal Sutures

Meniscal sutures with anchors are superior to bioabsorbable arrows. This has been described in previous

studies.<sup>9,18</sup> Kise et al<sup>18</sup> found a 3.6 times higher risk of reoperation using the Biofix arrows compared with the Fast-Fix suture. Their plan was to include 120 patients to be able to detect a 10% difference, but because the preliminary data aborted recruitment, only 46 patients were included. The size of our study gives reliable support to these findings.

The overall failure rate of 22.5% is consistent with previous reports.<sup>3,14,16,17,19,26,38</sup>

### Lateral Repair

Lateral repairs resulted in less failure than medial repairs that have nearly a 4 times higher risk of failure. This is supported by data from a recent systematic review,<sup>27</sup> which concluded that lateral repairs result in fewer reoperations than medial repairs. The lateral meniscus is not as firmly attached as the medial meniscus to the tibial plateau allowing greater mobility and is therefore potentially more forgiving for stress.

### Anterior Cruciate Ligament

A concomitant ACLR has a beneficial effect on meniscal repair. There were significantly lower failure rates for medial meniscal repairs when a concurrent ACLR was performed. This has been described in earlier studies.<sup>1,2,10,27,36</sup> This might be caused by factors such as richness in blood and growth factors that postoperatively favor healing of the meniscus. It is also probable that patients with ACLR are more careful regarding activities during the healing phase, and not least that the ACLR actually makes the knee more stable. It is also plausible that an isolated meniscal tear indicates biological deficits in the meniscal tissue, making it more susceptible to failure of repair.

### Age

We did not find any support for our hypothesis that younger patients at the time of surgery would have fewer failures. Based on theories of tissue degeneration, young age at the time of repair had previously been considered beneficial for the outcome.<sup>12</sup> There are recent studies<sup>8,10,18,32,34</sup> supporting a lack of correlation between age and an increased risk for reoperation. Some studies<sup>20,25</sup> even indicate that younger patients might be at higher risk of failure than older patients. This study did not reveal any significant correlation between age and failure. There were fewer reoperations in the older age group (>40 years), which can be explained by lower physical activity level or more conservative case selection by the surgeon, both in selection for repair and reoperation.

### Vascularity Zone

Previous literature<sup>10,15</sup> report superior healing for peripheral repairs suggesting richer blood supply (ie, red-on-red zone) being a potential explanation. In this study, the univariate analysis indicated a possible effect,

TABLE 2  
Variables Affecting Failure of Meniscal Repair Analyses with Cox Regression<sup>a</sup>

Variable	Univariate Cox Regression			Multivariate Cox Regression		
	HR	95% CI	P	HR	95% CI	P
Age, y			.3			.6
≤20 (ref)		1			1	
21-30	0.8	0.5-1.1	.1	0.8	0.5-1.2	.2
31-40	0.9	0.6-1.2	.6	0.8	0.5-1.3	.4
>40	0.6	0.4-1.2	.4	0.9	0.5-1.8	.8
Sex						
Male (ref)		1			1	
Female	0.9	0.7-1.2	.6	0.8	0.6-1.1	.2
Meniscus			<.001			<.001
Lateral (ref)		1			1	
Medial	2.7	1.9-3.8	<.001	3.7	2.3-6.0	<.001
Both	2.5	1.2-5.0	.01	4.2	1.8-9.7	.001
Fixation			.002			.009
Anchor (ref)		1			1	
Arrow	1.7	1.3-2.2	<.001	1.8	1.2-2.5	.002
Both	0.7	0.2-3.1	.7	0.9	0.2-3.8	.9
ACL pathology			.009			.024
No ACL pathology (ref)		1			1	
No concomitant ACL reconstruction	1.1	0.8-1.4	.7	1.0	0.7-1.5	≥.999
Concomitant ACL reconstruction	0.6	0.4-0.9	.008	0.5	0.3-0.9	.009
Days-to-surgery			.03			.07
0-30 (ref)		1			1	
31-90	1.3	0.9-1.8	.2	1.5	1.0-2.3	.08
91-365	1.0	0.7-1.4	.9	1.4	0.9-2.2	.1
>366	0.5	0.3-0.9	.016	0.7	0.3-1.5	.3
Vascularization zone			.048			.2
Red-on-red zone (ref)		1			1	
Red-on-white zone	0.8	0.6-1.1	.1	0.7	0.5-1.0	.09
White-on-white zone	1.6	0.8-2.9	.2	1.1	0.6-2.1	.7

<sup>a</sup>Multivariate analysis adjusted for age, sex, meniscus, fixation, ACL pathology, and days to surgery. *P* values in bold represent statistically significant difference. ACL, anterior cruciate ligament; HR, hazard ratio.

but in the adjusted model, the effect was not significant, indicating less effect on healing from the documented vascular zone than from fixation or concomitant ACLR. One fact that might have affected this result is a high number of incomplete surgical reports; almost one-third (28%) did not report what vascularization zone the tear was located in. The effect of vascularity zone, therefore, should be interpreted with care. However, the factor vascularization might be difficult to assess in all studies because there is a risk that the surgeon overestimated the vascularity of the tear once the decision for repair has been rendered.

### Time to Surgery

Time to surgery is another variable that is difficult to assess. In our study, time to surgery was highly left skewed and nonparametrically distributed, with the mean around the 75th percentile. The median was 53 days, but mode was 5 days. We did not find any association between days to surgery and failure. Few studies have looked specifically at failure after repair of chronic tears. Results similar to those for repairs of acute tears have been presented.<sup>28,29</sup> It

is possible that there is a selection bias affecting time to surgery. A chronic tear might not undergo early surgery because it does not cause as many symptoms as an acute tear that receives early surgery. This, in turn, might reflect that the chronic tear receiving late surgery is not as unstable as the acute tear receiving early surgery, which might result in a better healing potential for the chronic case compared with the acute case.

The definition of failure is highly important when discussing and comparing results after meniscal repair. In the literature, the definition of failure has varied. Generally, there is a requirement for recurrent meniscal symptoms, usually leading to an operative intervention with confirmation of a failed repair. However, in 1 study,<sup>21</sup> patients who experienced clinical failure but who chose not to undergo further surgery have also been included. This might yield a higher number of failures. Some studies also use magnetic resonance imaging or second-look arthroscopy to determine a potential failure of meniscal repair, where asymptomatic failures or partial failures may be detected. Failure in this study was defined as a need for reoperation and secondary partial or total meniscectomy, as this would confirm whether a failure had occurred. Using a need for

reoperation based on clinical symptoms as a definition of failure could very well lead to an underestimation of incompletely healed meniscal repairs. A previous study<sup>30</sup> has indicated that even a partially healed meniscal repair might protect against future osteoarthritis, and even though our study does not provide any evidence to this theory, leaving an asymptomatic, potentially partially healed repaired meniscus appears preferable to resection.

The clinical impression is that a failing meniscal repair is usually present within the first year, but presentation after 2 to 3 years is also common after a low-energy incident such as a squat. We believe 3 years is the clinically most relevant time span to assess the failure of a meniscal repair. Failure after 3 years is likely to be dependent on other factors than an unhealed repair, such as new trauma or biological deficiencies. It is generally difficult to determine whether a tear in a previously repaired meniscus is actually a failure or just a new rupture, but after 3 years, this task is increasingly demanding. A longer observation period would also increase the risk of loss to follow-up; thus, failures would not be detected. Even though one can argue that 22.5% failure is also 77% saved menisci, there still needs to be more effort put into trying to improve the results after meniscal repair. With the development of new devices and improvements in surgical techniques, it is hoped that the failure rates for meniscal repair will decrease with time. Furthermore, the potential role of orthobiologics might have beneficial effects on meniscal repairs in the future.

This study has its own limitations. One obvious limitation is the retrospective design. It is difficult to be certain of the comparability of the different meniscal tears, as no general classification was used during the study period. Another limitation is the inconsistent reporting of the meniscal zone, which makes the assessment of failure owing to poor vascularization uncertain. Some might argue that the heterogeneity of the study with different repair methods and devices and the large number of surgeons would also be considered limitations. In our opinion, this is, however, reflecting a clinical reality and therefore gives the study external validity. In this study, no repairs using isolated inside-out or outside-in sutures were detected. These sutures are considered the gold standard, and most pull-out strength comparisons use the inside-out as reference. There are, however, studies indicating that the modern all-inside devices provide equal properties. The chart analysis was incomplete in terms of body mass index for most cases. Body mass index is described as a potential factor for failure, and the lack of this information limits the study. In the nature of the study, there were no criteria regarding what injuries or which patients should undergo a meniscal repair. To our belief, this does however also make the study represent a clinical reality. The tears included in this study were only vertical and longitudinal. No root or radial tears were included in the analysis. Furthermore, we did not have any data on patient activity levels. In many cases, we did not have access to the physical therapist's records. Even if the rehab protocol was standardized in terms of restrictions, many physical therapists build their program based on different exercises and

various criteria for progression. The lack of a similar set of exercises for all patients is a limitation of the study.

The large number of cases, all consecutively repaired during a 12-year period, is a strength of the study.

## CONCLUSION

In this large cohort study, meniscal sutures with anchors were superior to bioabsorbable arrows. Both lateral meniscal repairs and meniscal repairs performed concomitantly with an ACLR result in fewer reoperations. Age of the patient and time from injury to surgery did not affect the outcome. Given the importance of the meniscus in knee function and potential prevention of degeneration of the knee joint, an overall survival of 75% of the repairs makes us advocate for repair of a meniscal tear whenever possible, especially at the time of ACLR.

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