Meniscus Repair Does Not Result in an Inferior Short-term Outcome Compared With Meniscus Resection: An Analysis of 5,378 Patients With Primary Anterior Cruciate Ligament Reconstruction

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Purpose: To compare the preoperative and 1- and 2-year postoperative Knee Injury and Osteoarthritis Outcome Score (KOOS) subscale scores between isolated anterior cruciate ligament reconstruction (ACLR) and ACLR with additional medial meniscus (MM) and/or lateral meniscus (LM) resection or repair. **Methods:** A total of 5,378 patients who underwent primary ACLR, with no associated ligament injuries, at our institution from January 2005 to December 2015 were included. The KOOS subscale scores were used to evaluate patients preoperatively and at 1- and 2-year postoperative follow-up assessments. Patients who underwent isolated ACLR and those who underwent ACLR with additional MM resection, MM repair, LM resection, LM repair, MM plus LM resection, or MM plus LM repair were compared by use of an analysis of covariance, with age, sex, graft, and cartilage injury as covariates. **Results:** Postoperatively, at both 1- and 2-year follow-up assessments, no significant differences were found between the groups for any of the 5 KOOS subscales. Preoperatively, a significant difference between the groups was found for the KOOS Symptoms ($P < .001$), Pain ($P < .001$), Activities of Daily Living (ADL) ($P < .001$), and Sport and Recreation (Sport/Rec) ($P = .01$) subscale scores. The lowest scores were found for the group undergoing ACLR and MM plus LM repair (Symptoms, 70.1 ± 17.3; Pain, 71.4 ± 18.5; ADL, 80.6 ± 20.5; and Sport/Rec, 35.7 ± 28.1), whereas the mean scores for the other groups ranged from 71.2 ± 18.7 to 76.5 ± 17.1 for Symptoms, from 76.1 ± 17.0 to 80.1 ± 15.5 for Pain, from 84.5 ± 16.8 to 88.1 ± 14.2 for ADL, and from 44.2 ± 28.3 to 49.1 ± 28.5 for Sport/Rec. **Conclusions:** Patients undergoing isolated ACLR and those undergoing ACLR with additional MM and/or LM resection or repair obtained equivalent results for each of the KOOS subscales at the 1- and 2-year postoperative follow-up assessments. Differences between the groups were only detectable preoperatively, with patients undergoing ACLR and MM plus LM repair showing the lowest scores for the KOOS Symptoms, Pain, ADL, and Sport/Rec subscales. **Level of Evidence:** Level III, retrospective comparative therapeutic trial.

See commentary on page 1154

The anterior cruciate ligament (ACL)—injured knee has an associated meniscus injury at primary ACL reconstruction (ACLR) in more than 40% of patients.[1] Recognition of the protective function of the meniscus has led to efforts to preserve as much meniscal tissue as possible. The effects of concurrent meniscus resection are known to reduce patient outcomes and increase the rate of osteoarthritis at long-term follow-up. Shelbourne and Gray[2] reported lower outcome scores after partial or total medial meniscus (MM) or lateral meniscus (LM) resection at a mean follow-up of 7.6 years after primary ACLR. Other authors have reported the long-term negative effects of concurrent meniscus resection over meniscus repair during ACLR.[3-5] Several

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studies have reported that meniscus resection results in a higher postoperative rate of radiographic osteoarthritis compared with meniscus repair over the long term.[2,3,6] However, questions remain about how meniscus resection or repair affects short-term outcomes.

Recent large cohort studies have attempted to clarify the effects of additional meniscus resection or repair on postoperative outcomes after ACLR at short-term follow-up.[7,8] It is interesting to note that these studies suggested poorer outcomes for meniscus repair compared with meniscus resection at short-term follow-up. Svantesson et al.[7] reported that patients with meniscus repair have a poorer outcome after ACLR, measured with the Lysholm score at 6 months and the Knee Injury and Osteoarthritis Outcome Score (KOOS) at 12 months postoperatively. LaPrade et al.[8] reported that the 2-year postoperative KOOS in patients with MM resection, LM resection, or LM repair did not differ significantly from that in patients with isolated ACLR for any of the 5 KOOS subscales. On the other hand, the results after MM repair were significantly inferior for the KOOS Symptoms and Quality of Life (QoL) subscales. However, even though both studies comprised large cohorts, they did not identify patients who underwent subsequent meniscus resection at follow-up because of failure of the meniscus repair performed at the index ACLR. A systematic review reported an overall reoperation rate of 14% after meniscus repair performed in conjunction with ACLR. Patients with a failed meniscus repair in conjunction with ACLR may have inferior subjective outcomes.[9] The non-identification of patients with a failed meniscus repair may have affected the results of the previously mentioned studies,[7,8] leading the authors to suggest that meniscus repair results in inferior short-term outcomes compared with meniscus resection in the setting of primary ACLR.

The purpose of this study was to compare the preoperative and 1- and 2-year postoperative KOOS subscale scores between isolated ACLR and ACLR with additional MM and/or LM resection or repair. We hypothesized that patients with a successful (no resection at follow-up) MM and/or LM repair with ACLR would not have reduced 1- and 2-year postoperative KOOS subscale scores compared with patients with isolated ACLR or patients with ACLR with concomitant MM and/or LM resection.

Methods

Participants

Patients who underwent primary ACLR, with no concomitant ligament injuries, at our clinic from January 2005 to December 2015 were assessed for eligibility. Patients fulfilling any of the following criteria were excluded: ACL graft rupture or revision ACLR; contralateral ACL injury or reconstruction; meniscus injury without treatment; and combinations of meniscus treatments, such as meniscus repair during resection of the contralateral meniscus. The final primary ACLR cohort was, therefore, divided into 7 groups depending on meniscal treatment: isolated ACLR, MM resection, MM repair, LM resection, LM repair, MM plus LM resection, and MM plus LM repair. Patients who, during follow-up, underwent subsequent meniscus resection after MM repair, LM repair, or MM plus LM repair were identified and formed a separate group (failed meniscus repair group). Patients who underwent meniscus repair at the index ACLR but did not undergo meniscus resection at follow-up were also identified and analyzed separately (successful meniscus repair group). Ethical approval for this study was obtained from the regional ethics committee.

Surgical Technique and Rehabilitation

All patients underwent surgery using a single-bundle autologous hamstring tendon or bone—patellar tendon—bone technique. The graft was chosen according to the surgeon's preference. The femoral tunnel was drilled using an anteromedial-portal technique. Both grafts were routinely fixed using an EndoButton fixation device (Smith & Nephew, Andover, MA) on the femoral side and using No. 2 Ethibond sutures (Ethicon, Somerville, NJ) tied over an AO bicortical screw with a washer as a post or using an interference screw on the tibial side. Meniscus repair was performed with an arthroscopic all-inside technique using a Fast-Fix suture anchor device (Smith & Nephew) for tears located in the dorsal and middle portion of the menisci. Tears located in the anterior portion of the menisci were repaired using an outside-in technique with No. 0 PDS (Ethicon).

All patients followed a standardized postoperative rehabilitation protocol. In the case of isolated ACLR or ACLR with concomitant meniscus resection, full weight bearing and full range of motion were encouraged as tolerated. If meniscus repair was performed, patients wore a postoperative hinged knee brace for 6 weeks. Flexion was limited from 0° to 30° for the first 2 weeks after surgery, from 0° to 60° for the third and fourth weeks, and from 0° to 90° for the fifth and sixth weeks. During the first 6 weeks, partial weight bearing was recommended. From the seventh week, the knee brace was discontinued and progressive weight bearing was allowed. For all patients, quadriceps strengthening was restricted to closed kinetic chain exercises during the first 3 months. On the basis of muscle strength, coordination, and functional performance, patients were allowed to return to sports at the earliest at 6 months postoperatively.

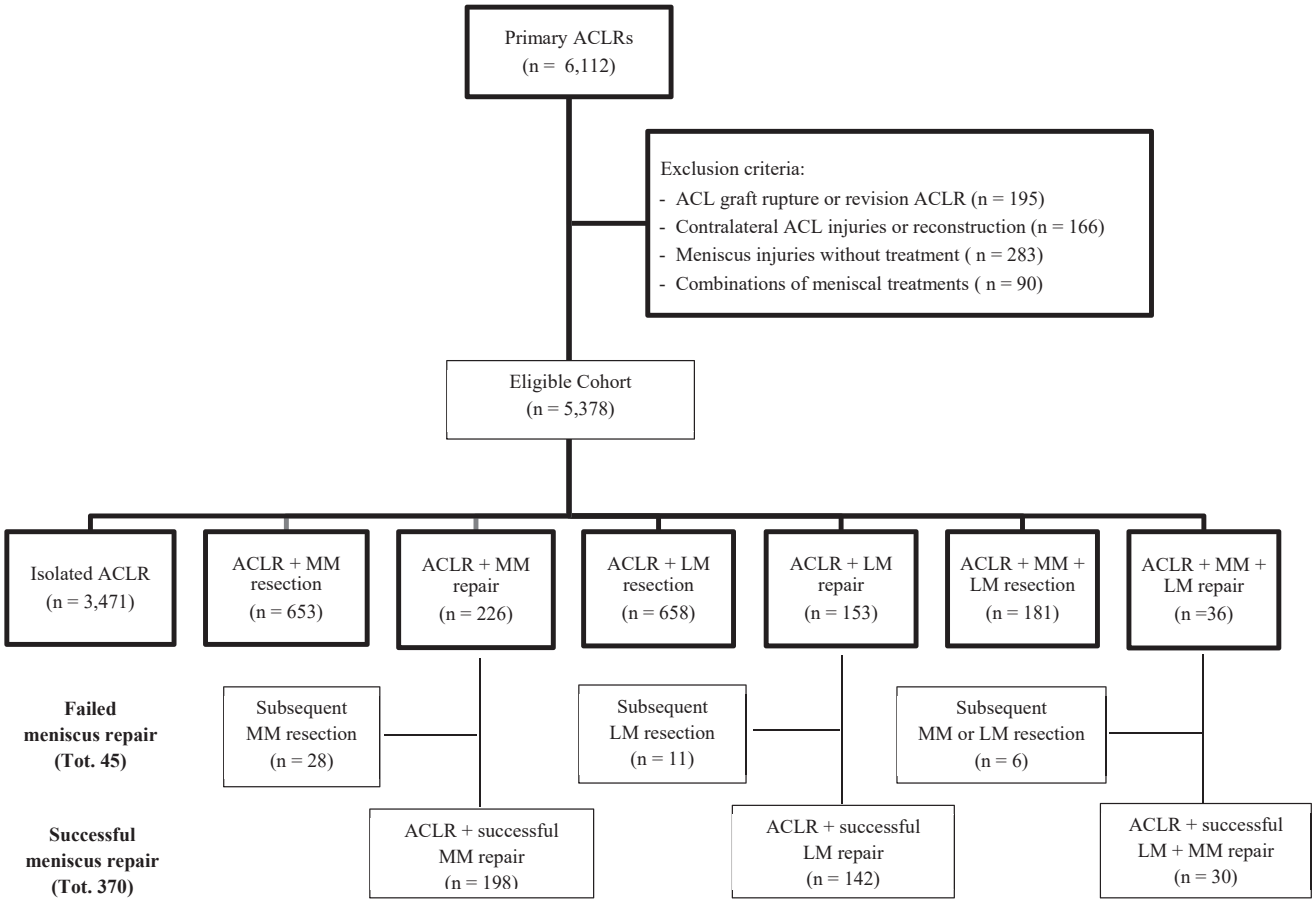

Fig 1. Patient flowchart. The exclusion criteria that led to the eligible cohort and the final analysis groups are described. (ACL, anterior cruciate ligament; ACLR, anterior cruciate ligament reconstruction; LM, lateral meniscus; MM, medial meniscus; Tot, total.)

Outcome

The primary outcome of the study was the KOOS.[10,11] The KOOS is a validated and frequently used disease-specific, patient-reported outcome for measuring the functional knee outcome in patients undergoing ACLR.[7,8,10-14] It is divided into 5 subscales: Pain, Knee-Related Symptoms, Activities of Daily Living (ADL), Sport and Recreation (Sport/Rec), and Knee-Related QoL. Each subscale is scored from 0, representing "extreme knee problems," to 100, representing "no knee problems." It is recommended that the individual subscales be evaluated independently.[11] Only patients with available data preoperatively or at the 1- or 2-year postoperative follow-up assessments were included in the KOOS analysis. The number of patients with available KOOS data was different preoperatively and at the 1- and 2-year postoperative follow-up assessments. Any missing data were treated according to the guidelines described by Roos et al.[11]

Data Sources

Demographic data (age and sex) and information about the time from injury to surgery, graft type, presence of cartilage injury, and meniscus surgery performed at the index ACLR were collected in our local database. Meniscus surgery was classified as follows: no meniscus injuries (isolated ACLR), meniscus resection, or meniscus repair of both the MM and LM. Preoperative and 1- and 2-year postoperative KOOS subscale scores were reviewed.

Statistical Analysis

SPSS software (version 25.0; IBM, Armonk, NY) was used for the statistical analysis. All variables were summarized with standard descriptive statistics such as frequency, mean, and standard deviation. Differences in patient-specific variables (age at surgery, sex, graft type, and cartilage injury) between the meniscal treatment groups were analyzed. For the variable of age at surgery, a 1-way analysis of variance followed by a post hoc Tukey HSD (honestly significant difference) test was performed. The Pearson χ^2 test was used for the categorical variables, such as sex, graft, and concomitant cartilage injury. Preoperative and 1- and 2-year postoperative KOOS subscale scores were compared among the meniscal treatment groups using an analysis

of covariance, with age at surgery, sex, graft, and concomitant cartilage injury as covariates. These covariates were applied to the model because differences relating to these patient-specific variables were present among the groups and previous studies showed that these factors could potentially influence the KOOS subscale scores before and after ACLR.[12-14] A drop-out analysis was performed to compare patients with versus patients without 2-year KOOS data. For the drop-out analysis, the Pearson χ^2 test was used for categorical variables and the independent *t* test was used for continuous variables. In addition, a comparison of patient-specific variables and 1- and 2-year postoperative KOOS subscale scores between ACLRs with successful meniscus repair and ACLRs with failed meniscus repair was performed. The Pearson χ^2 test was used for categorical variables, and the independent *t* test was used for continuous variables. The level of significance in all the analyses was 5% (2-tailed).

Results

A total of 6,112 patients were reviewed for eligibility. On the basis of the exclusion criteria, we excluded 195 patients with ACL graft rupture or revision ACLR; 166 patients with contralateral ACL injuries or reconstruction; 283 patients with meniscus injuries without treatment; and 90 patients with combinations of meniscus treatments, such as meniscus repair during resection of the contralateral meniscus. Thus, a total of 5,378 patients formed the final study cohort. The patients were then divided into 7 groups depending on the status of the menisci: the baseline group, comprising ACLR without meniscus injuries (i.e., isolated ACLR) (n = 3,471), and 6 groups with different combinations of meniscus surgery—MM resection (n = 653), MM repair (n = 226), LM resection (n = 658), LM repair (n = 153), MM plus LM resection (n = 181), and MM plus LM repair (n = 36). Patients who, during follow-up, underwent subsequent meniscus resection after MM repair (28 of 226 [12.4%]), LM repair (11 of 153 [7.2%]), or MM plus LM repair (6 of 36 [16.7%]), performed during the index ACLR, were identified and formed a separate group called the "failed meniscus repair" group (n = 45). On the other hand, patients who underwent meniscus repair at the index ACLR but did not undergo subsequent meniscus resection at follow-up formed a group called the "successful meniscus repair" group (n = 370) (Fig 1). Patient characteristics for each meniscal treatment group are summarized in Table 1.

Preoperative and 1- and 2-Year Postoperative KOOS Subscale Score Comparison

The total numbers of patients with available preoperative, 1-year postoperative, and 2-year postoperative KOOS subscale scores were 5,031 (94.4%), 5,004 (93.8%), and 2,450 (45.9%), respectively. Preoperatively, a significant difference between the groups was found for the KOOS Symptoms, Pain, ADL, and Sport/Rec subscales. The lowest scores were found for the group undergoing ACLR and MM plus LM repair. Postoperatively, at 1- and 2-year follow-up assessments, no significant differences were found between the groups for any of the 5 KOOS subscales (Table 2).

Drop-out Analysis

A comparison between patients with 2-year KOOS data and patients with no 2-year KOOS data is detailed in Table 3. Patients with no 2-year KOOS data were significantly younger ($P < .001$), although the

Table 1. Patient Characteristics of Each Meniscal Treatment Group

	Isolated ACLR	ACLR and MM Resection	ACLR and Successful MM Repair	ACLR and LM Resection	ACLR and Successful LM Repair	ACLR and MM Plus LM Resection	ACLR and Successful MM plus LM Repair
Patients, n	3,471 (65.1)	653 (12.2)	198 (3.7)	658 (12.3)	142 (2.7)	181 (3.4)	30 (0.6)
Age at surgery, mean ± SD, yr	28.8 ± 10.5	33.7 ± 10.7	23.9 ± 8.9	27.8 ± 9.7	20.9 ± 9.3	32.4 ± 10.9	21.7 ± 8.7
Sex							
Male	1,858 (53.5)	399 (61.1)	91 (46.0)	414 (62.9)	76 (53.5)	120 (66.3)	13 (43.3)
Female	1,613 (46.5)	254 (38.9)	107 (54.0)	244 (37.1)	66 (46.5)	61 (33.7)	17 (56.7)
Time from injury to surgery							
Mean ± SD, mo	16.3 ± 9.2	27.2 ± 12.1	14.5 ± 9.8	14.9 ± 8.3	12.9 ± 7.4	27.2 ± 13.1	13.4 ± 8.6
Patients with available data	3,259 (93.9)	589 (90.2)	189 (95.5)	606 (92.1)	136 (95.8)	156 (86.2)	28 (93.3)
Graft							
HT	3,111 (89.6)	613 (93.9)	196 (99.0)	602 (91.5)	133 (93.7)	166 (91.7)	29 (96.7)
BPTB	360 (10.4)	40 (6.1)	2 (1.0)	56 (8.5)	9 (6.3)	15 (8.3)	1 (3.3)
Cartilage injury	586 (17.1)	183 (28.0)	35 (17.7)	132 (20.1)	29 (20.4)	61 (33.7)	6 (20.0)

NOTE. Data are reported as number (percentage) unless otherwise indicated.

ACLR, anterior cruciate ligament reconstruction; BPTB, bone—patellar tendon—bone; HT, hamstring tendon; LM, lateral meniscus; MM, medial meniscus; SD, standard deviation.

Table 2. Preoperative and 1- and 2-year Postoperative KOOS Subscale Scores for Each Meniscal Treatment Group

	Isolated ACLR (n = 3,471)	ACLR and MM Resection (n = 653)	ACLR and Successful MM Repair (n = 198)	ACLR and LM Resection (n = 658)	ACLR and Successful LM Repair (n = 142)	ACLR and MM Plus LM Resection (n = 181)	ACLR and Successful MM Plus LM Repair (n = 30)	*P* Value
Preoperative KOOS								
Symptoms	76.5 ± 17.1	74.9 ± 18.4	73.9 ± 17.7	74.4 ± 17.8	73.3 ± 19.5	71.2 ± 18.7	70.1 ± 17.3	<.001*
Pain	80.1 ± 15.5	78.8 ± 17.4	79.9 ± 15.4	78.0 ± 16.5	79.6 ± 17.3	76.1 ± 17.0	71.4 ± 18.5	<.001*
ADL	88.1 ± 14.2	86.9 ± 16.3	86.7 ± 13.6	86.3 ± 15.5	85.8 ± 16.4	84.5 ± 16.8	80.6 ± 20.5	<.001*
Sport/Rec	49.1 ± 28.5	47.9 ± 28.8	44.2 ± 28.3	46.5 ± 28.6	46.6 ± 30.8	45.5 ± 29.0	35.7 ± 28.1	.01*
QoL	38.3 ± 23.1	37.2 ± 23.3	34.2 ± 21.7	37.3 ± 22.6	38.7 ± 25.0	35.0 ± 23.9	32.9 ± 21.5	.08
Patients with available data, n (%)	3,261 (93.9)	621 (95.1)	188 (94.9)	626 (95.2)	136 (95.8)	170 (93.9)	29 (96.7)	
1-yr KOOS								
Symptoms	81.8 ± 16.4	81.8 ± 16.6	80.1 ± 15.6	81.7 ± 15.5	82.4 ± 16.1	84.6 ± 16.5	77.8 ± 19.7	.14
Pain	88.4 ± 12.5	89.5 ± 12.1	88.1 ± 11.5	88.4 ± 12.2	89.5 ± 10.6	90.6 ± 12.4	87.3 ± 11.3	.10
ADL	94.6 ± 9.7	95.5 ± 9.0	95.0 ± 6.9	94.6 ± 9.2	95.8 ± 5.3	95.7 ± 9.2	95.4 ± 8.9	.16
Sport/Rec	71.9 ± 24.9	73.4 ± 24.3	71.6 ± 24.0	71.6 ± 23.5	72.6 ± 23.0	74.3 ± 25.0	71.5 ± 22.4	.55
QoL	63.1 ± 23.7	64.3 ± 24.0	63.6 ± 23.8	62.2 ± 23.1	64.6 ± 24.0	64.7 ± 24.9	66.2 ± 19.5	.68
Patients with available data, n (%)	3,260 (93.9)	607 (93.0)	196 (99.0)	605 (92.0)	139 (97.9)	168 (92.8)	29 (96.7)	
2-yr KOOS								
Symptoms	82.5 ± 16.2	83.0 ± 15.2	79.3 ± 15.1	81.1 ± 17.2	80.9 ± 19.1	82.9 ± 15.2	80.6 ± 18.3	.45
Pain	88.3 ± 13.6	89.1 ± 13.0	86.6 ± 12.7	87.9 ± 14.2	88.2 ± 13.5	89.0 ± 14.9	88.9 ± 13.4	.82
ADL	93.8 ± 10.8	94.6 ± 10.2	94.1 ± 9.7	93.0 ± 12.0	95.1 ± 8.8	93.8 ± 13.2	94.4 ± 11.6	.74
Sport/Rec	72.5 ± 25.3	73.7 ± 24.9	69.4 ± 24.8	71.0 ± 25.9	71.4 ± 25.7	74.5 ± 24.0	69.4 ± 35.8	.74
QoL	66.8 ± 23.7	66.7 ± 23.1	64.4 ± 23.5	66.0 ± 24.1	66.2 ± 21.6	68.2 ± 21.1	66.0 ± 28.4	.96
Patients with available data, n (%)	1,651 (47.6)	291 (44.6)	84 (42.4)	286 (43.3)	51 (35.9)	74 (40.9)	13 (43.3)	

NOTE. Data are presented as mean ± standard deviation unless otherwise indicated. Covariates applied to the model are age, sex, graft, and cartilage injury (analysis of covariance).

ACLR, anterior cruciate ligament reconstruction; ADL, activities of daily living; KOOS, Knee Injury and Osteoarthritis Outcome Score; LM, lateral meniscus; MM, medial meniscus, QoL, quality of life; Sport/Rec, sport and recreation.

*Statistically significant ($P < .05$).

difference in mean age between the groups was only 1.8 years. In addition, men were significantly more likely than women to be lost to 2-year follow-up ($P < .001$). Female patients were represented to a significantly greater degree in the cohort with 2-year KOOS data in comparison to the cohort with no 2-year KOOS data (51.1% vs 38.8%). Meanwhile, no other significant differences were found between the groups regarding patient characteristics or the prevalence of the different meniscal treatment groups.

Comparison Between Successful and Failed Meniscus Repair Groups

A comparison between ACLRs with successful meniscus repair (MM, 198; LM, 142; MM plus LM, 30; and total, 370) and ACLRs with failed meniscus repair (MM, 28; LM, 11; MM plus LM, 6; and total, 45) is detailed in Table 4. No significant differences were found between the groups in terms of patient characteristics. However, patients in the failed meniscus repair group obtained significantly lower scores for all KOOS subscales at 1 year postoperatively and a significantly lower score for the KOOS Symptoms subscale at 2 years postoperatively.

Discussion

The most important finding of this study was that postoperatively, at 1- and 2-year follow-up assessments, patients with isolated ACLR and those with ACLR with additional MM and/or LM resection or repair reported equivalent results for each of the 5 KOOS subscales. Our hypothesis—patients with successful (no resection at follow-up) MM and/or LM repair with ACLR would not have lower 1- and 2-year postoperative KOOS subscale scores compared with patients with isolated ACLR or patients with ACLR with additional MM and/or LM resection—was therefore confirmed.

The findings of this study indicate that, regardless of the status of the menisci, all patients obtain equivalent KOOS subscale scores at short-term follow-up.

Table 3. Patient Characteristics and Baseline KOOS Subscale Scores at Time of ACL Reconstruction for Patients With 2-Year KOOS Data and Patients With No 2-Year KOOS Data (Drop-out Analysis)

	Patients With 2-yr KOOS Data (n = 2,450)	Patients With No 2-yr KOOS Data (n = 2,883)	*P* Value
Age at surgery, mean ± SD, yr	29.9 ± 11.0	28.1 ± 10.2	<.001*
Sex			<.001*
Male	1,199 (48.9)	1,764 (61.2)	
Female	1,251 (51.1)	1,119 (38.8)	
Time from injury to surgery			.93
Mean ± SD, mo	17.9 ± 9.8	17.9 ± 10.1	
Patients with available data	2,321 (94.7)	2,737 (94.9)	
Meniscal treatment			.07
Isolated ACLR	1,651 (67.4)	1,890 (65.6)	
ACLR and MM resection	291 (11.9)	332 (11.5)	
ACLR and MM repair	84 (3.4)	104 (3.6)	
ACLR and LM resection	286 (11.7)	362 (12.5)	
ACLR and LM repair	51 (2.1)	86 (3.0)	
ACLR and MM plus LM resection	74 (3.0)	95 (3.3)	
ACLR and MM plus LM repair	13 (0.5)	14 (0.5)	
Graft			.08
HT	2,256 (92.0)	2,596 (90.0)	
BPTB	194 (8.0)	287 (10.0)	
Cartilage injury			.63
Yes	490 (20.3)	566 (19.6)	
No	1,960 (79.7)	2,317 (80.4)	
Preoperative KOOS, mean ±SD			
Symptoms	75.5 ± 17.5	75.7 ± 17.7	.57
Pain	79.4 ± 16.0	79.6 ± 16.2	.23
ADL	87.5 ± 14.9	87.4 ± 14.7	.99
Sport/Rec	46.8 ± 28.0	49.2 ± 29.0	.004*
QoL	36.8 ± 21.4	38.3 ± 24.3	.019*
Patients with available data	2,301 (93.9)	2,730 (94.7)	

NOTE. Data are reported as number (percentage) unless otherwise indicated.

ACL, anterior cruciate ligament; ACLR, anterior cruciate ligament reconstruction; ADL, activities of daily living; BPTB, bone–patellar tendon–bone; HT, hamstring tendon; KOOS, Knee injury and Osteoarthritis Outcome Score; LM, lateral meniscus; MM, medial meniscus; QoL, quality of life; SD, standard deviation; Sport/Rec, sport and recreation.

*Statistically significant ($P < .05$).

Patients who had an injury to both menisci that progressed to MM and LM repair reported the lowest preoperative KOOS subscale scores, but they were able to "catch up" with all the other groups by the time of the 1- and 2-year postoperative follow-up assessments.

The results of our study are in contrast to those found in recent investigations that studied the effects of additional meniscus resection or repair on postoperative outcomes after ACLR at short-term follow-up.[7,8,15] Svantesson et al.[7] reported that patients with meniscus repair have poorer subjective knee function than patients with meniscus resection at both 6- and 12-month follow-up assessments. They found inferior results for the Lysholm score at 6 months postoperatively for both MM and LM repair and a significantly lower score for the KOOS Symptoms subscale at 1-year follow-up for MM repair. LaPrade et al.[8] reported similar results in a previous study based on the Norwegian knee ligament registry. They found that the 2-year postoperative KOOS in patients with MM resection, LM resection, or LM repair did not differ significantly from that in patients with isolated ACLR for any of the 5 KOOS subscales. However, patients who underwent ACLR with additional MM repair had significantly poorer scores for the KOOS Symptoms and QoL subscales. The results of both studies led the authors to conclude that meniscus repair results in inferior short-term outcomes compared with meniscus resection in the setting of primary ACLR, especially for the MM. LaPrade et al.[8] hypothesized that the reduced mobility of the MM in comparison to the LM[16] and the differing insertion geometries of the medial and lateral meniscal roots[17,18] may explain the improved subjective outcomes for LM repair compared with MM repair at short-term follow-up. It should, however, be noted that both studies did not identify patients who underwent subsequent meniscus resection at follow-up because of failure of the meniscus repair performed at the index ACLR. This may have affected the results. In a systematic review, Paxton et al.[9] reported an overall reoperation rate of 14% after meniscus repair performed in conjunction with ACLR. In detail, they found that the reoperation rate in the short-term follow-up period (0-4 years) was 12.4% for MM repair and 8% for LM repair performed during ACLR. These findings are in line with the results of our study, showing reoperation rates of 12.4% for MM repair, 7.2% for LM repair, and 16.7% for MM plus LM repair during follow-up (0-2 years). This study also shows that patients with failed meniscus repair in conjunction with ACLR reported significantly inferior scores for all 5 KOOS subscales at the 1-year follow-up assessment and for the KOOS Symptoms subscale at the 2-year follow-up assessment. The non-identification of patients with failed meniscus repair and their subsequent inclusion in the KOOS analysis in the previously mentioned studies[7,8] may have led the authors to an erroneous interpretation of the data, suggesting that meniscus repair results in inferior short-term outcomes compared with meniscus resection in the setting of primary ACLR. In contrast, our study shows that patients with a

Table 4. Patient Characteristics and 1- and 2-Year Postoperative KOOS Subscale Scores for ACLR With Successful and Failed Meniscus Repair

	ACLR and Successful Meniscus Repair (n = 370)	ACLR and Failed Meniscus Repair (n = 45)	*P* Value
Age at surgery, mean ± SD, yr	22.6 ± 9.1	23.0 ± 10.0	.60
Sex			.53
Male	180 (48.6)	22 (48.9)	
Female	190 (51.4)	23 (51.1)	
Time from injury to surgery			.45
Mean ± SD, mo	13.7 ± 8.9	14.4 ± 9.2	
Patients with available data	353 (95.4)	42 (93.3)	
Graft			.28
HT	358 (96.7)	43 (95.6)	
BPTB	12 (3.3)	2 (4.4)	
Cartilage injury			.16
Yes	70 (18.9)	10 (22.2)	
No	300 (81.1)	35 (77.8)	
Time from ACLR and meniscus repair to subsequent meniscus resection, mean ± SD, mo	NA	14.2 ± 6.4	
1-yr KOOS, mean ± SD			
Symptoms	81.5 ± 15.3	75.8 ± 16.6	.03*
Pain	89.4 ± 10.1	82.7 ± 14.1	.007*
ADL	96.1 ± 6.4	90.8 ± 11.9	.01*
Sport/Rec	73.1 ± 22.9	58.8 ± 30.2	.007*
QoL	63.0 ± 22.4	51.3 ± 25.5	.003*
Patients with available data	364 (98.4)	38 (84.4)	
2-year KOOS, mean ±SD			
Symptoms	81.6 ± 17.5	71.7 ± 23.1	.04*
Pain	88.6 ± 14.3	82.0 ± 19.9	.13
ADL	94.9 ± 10.4	91.8 ± 16.8	.38
Sport/Rec	73.2 ± 25.1	63.3 ± 29.9	.07
QoL	67.0 ± 23.9	61.4 ± 25.9	.29
Patients with available data	148 (40.0)	23 (51.1)	

NOTE. Data are reported as number (percentage) unless otherwise indicated.

ACLR, anterior cruciate ligament reconstruction; ADL, activities of daily living; BPTB, bone–patellar tendon–bone; HT, hamstring tendon; KOOS, Knee injury and Osteoarthritis Outcome Score; NA, not applicable; QoL, quality of life; SD, standard deviation; Sport/Rec, sport and recreation.

*Statistically significant ($P < .05$).

successful MM and/or LM repair with ACLR do not have inferior short-term outcomes compared with patients with isolated ACLR or patients with ACLR with concomitant MM and/or LM resection. The findings of this study are important for surgeons in clinical practice when it comes to clinical decision making and counseling patients on the expected short-term outcomes after the different meniscal treatment options in the setting of primary ACLR.

The meniscus is an essential structure for load bearing and preserved knee health. It has been shown that the survival of ACLR is predicted by the condition of the meniscus as present or deficient. Robb et al.[19] found that, at 2-year follow-up, patients were 4.9 times more likely to have an ACLR failure if they had a deficient MM or LM, whereas patients who underwent meniscus repair did not show any increased risk of failure. Meniscus resection results in significantly lower subjective outcome scores and activity levels, increased osteoarthritis progression, and a larger number of total knee replacements at follow-up ranging from 8 to 40 years[2-4,20,21]; in addition, our study shows that a successful meniscus repair is not associated with an inferior subjective outcome compared with meniscus resection after ACLR at short-term follow-up. Surgeons should make every effort to repair the meniscus whenever possible. However, patients should be advised that there is a risk of reoperation after meniscus repair, which is lower for LM tears than for MM tears. The MM is more firmly attached to the tibial plateau,[22] and it resists anterior tibial translation in the ACL-reconstructed knee.[23,24] This may put the repaired MM under more stress, contributing to more failures.

The main strength of this study is the analysis of a large cohort (5,378 patients). Another strength is that all the patients received surgery and rehabilitation at the same institution. The treatment was, therefore, standardized. Finally, we performed a thorough analysis of patients who underwent subsequent meniscus resection at follow-up because of failure of the meniscus repair performed at the index ACLR. This characteristic makes this study different from previous studies that have investigated the effects, at short-term follow-up, of additional meniscus resection or repair in the setting of primary ACLR.[7,8]

Limitations

The lack of details regarding the extent and location of meniscus resection or repair is a limitation of this study. Our registry does not contain this information. It could be hypothesized that larger resections or repairs have a greater impact on the KOOS subscale scores at follow-up. Another limitation is the suboptimal follow-up. Although the follow-up rate was very high (93.8%) at 1 year postoperatively, only 45.9% of patients filled out the KOOS questionnaires at 2 years postoperatively. This 2-year follow-up rate is not ideal, but it is in line with previous cohort studies using large registries.[1,25] The patients lost to 2-year follow-up tended to be slightly younger, with a larger proportion of men than women. This phenomenon has previously been described in a nonresponse analysis of 2-year data in the Swedish national knee ligament registry.[26] However, all the other patient characteristics were comparable between the groups. A final limitation is the lack

of postoperative radiologic or magnetic resonance imaging. This would have been useful to confirm the condition of the menisci and articular cartilage, as well as assess the potential development of osteoarthritis. These factors could have potentially affected the results of this study.

Conclusions

Patients undergoing isolated ACLR and those undergoing ACLR with additional MM and/or LM resection or repair obtained equivalent results for each of the KOOS subscales at the 1- and 2-year postoperative follow-up assessments. Differences between the groups were only detectable preoperatively, with patients undergoing ACLR and MM plus LM repair showing the lowest scores for the KOOS Symptoms, Pain, ADL, and Sport/Rec subscales.

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