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# Effect of Meniscal and Focal Cartilage Lesions on Patient-Reported Outcome After Anterior Cruciate Ligament Reconstruction

## A Nationwide Cohort Study From Norway and Sweden of 8476 Patients With 2-Year Follow-up

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**Background:** The effect of concomitant intra-articular injury on patient-reported outcome after anterior cruciate ligament (ACL) reconstruction is debated.

**Purpose:** To evaluate the effect of meniscal and articular cartilage lesions on patient-reported outcome 2 years after ACL reconstruction.

**Study Design:** Cohort study (prognosis); Level of evidence, 2.

**Methods:** The study included all patients with primary, unilateral ACL reconstruction registered in the Norwegian and the Swedish National Knee Ligament Registry from 2005 through 2008 who had completed the Knee Injury and Osteoarthritis Outcome Score (KOOS) Knee-Related Quality of Life subscale at a 2-year follow-up (mean  $\pm$  SD, 2.1  $\pm$  0.2 years) after surgery (n = 8476). Multiple linear regression analyses were used to evaluate the associations between each KOOS subscale (Pain, Other Symptoms, Activities of Daily Living, Sport and Recreation Function, Knee-Related Quality of Life) as the measure for patient-reported outcome and meniscal and cartilage lesions.

**Results:** A total of 3674 (43%) patients had meniscal lesion(s), 1671 (20%) had partial-thickness (International Cartilage Repair Society [ICRS] grades 1-2) cartilage lesion(s), and 551 (7%) had full-thickness (ICRS grades 3-4) cartilage lesion(s). Multiple linear regression analyses detected no significant associations between meniscal lesions or partial-thickness cartilage lesions and the scores in any of the KOOS subscales at the 2-year follow-up. Full-thickness cartilage lesions were significantly associated with decreased scores in all of the KOOS subscales.

**Conclusion:** Patients with concomitant full-thickness cartilage lesions reported worse outcome in all of the KOOS subscales compared with patients without cartilage lesions 2 years after ACL reconstruction. Meniscal lesions and partial-thickness cartilage lesions did not impair patient-reported outcome 2 years after ACL reconstruction.

**Keywords:** registry; anterior cruciate ligament (ACL); reconstruction; cartilage lesions; meniscal lesions; KOOS; outcome

Anterior cruciate ligament (ACL) injuries are often combined with other intra-articular injuries to the knee such as meniscal and cartilage lesions. The reported incidences of meniscal lesions are 35% to 61%<sup>7,16</sup> and of cartilage lesions, 16% to 46%<sup>3,16</sup> at the time of ACL reconstruction.

Both concomitant meniscal and cartilage lesions have been found to increase the risk of later osteoarthritis (OA) after ACL reconstruction.<sup>10,15,18,21</sup> However, it is recommended that patient-reported outcome measures should be emphasized in outcome evaluations.<sup>12,19</sup> Knowledge of

the concomitant meniscal and cartilage lesions' effects on patient-reported outcome is important both regarding the information to the patients and the choice of treatment of these lesions. There are conflicting reports in the literature, however, concerning the effect of meniscal and articular cartilage lesions on patient-reported outcome after ACL reconstruction. Previous studies have tried to assess this issue.<sup>13,28-32,34</sup> However, no consensus exists on how intra-articular injuries affect patient-reported outcome after ACL reconstruction.

The aim of the present study was to evaluate the effect of meniscal lesions, partial-thickness (International Cartilage Repair Society [ICRS] grades 1-2)<sup>2,9</sup> cartilage lesions, and full-thickness (ICRS grades 3-4)<sup>2,9</sup> cartilage lesions on patient-reported outcome after ACL reconstruction in

a prospective nationwide population-based study. The hypothesis of the present study was that ACL-injured patients with concomitant meniscal lesions, partial-thickness cartilage lesions, and full-thickness cartilage lesions report equal outcome compared with patients without such lesions as measured by Knee Injury and Osteoarthritis Outcome Score (KOOS) at 2-year follow-up after ACL reconstruction.

## MATERIALS AND METHODS

### The Norwegian and Swedish National Knee Ligament Registries

The Norwegian National Knee Ligament Registry and the Swedish National Knee Ligament Registry were established in June 2004 and January 2005, respectively, with the main objective to prospectively register all surgical procedures of the knee ligaments and monitor the outcome on a nationwide scale. The development and design of the Norwegian registry has been thoroughly described in a previous study.<sup>6</sup> To facilitate collaboration, the Swedish registry was designed to obtain basically the same parameters as the Norwegian registry. Before the surgical procedure, the patients complete the KOOS questionnaire, and postoperatively the surgeons complete a form that includes specific baseline variables for the knee and surgical procedure. The surgeons' compliance rates of reporting primary ACL reconstructions are more than 85% for both registries.<sup>33,36</sup> At 1 (Sweden only), 2, 5, and 10 years postoperatively, the patients receive a postal or electronic request from the registries to complete the KOOS questionnaires. The completed questionnaires are returned to the registries by postal mail, e-mail, or through a web portal.

Participation in the 2 national registries is voluntary for surgeons and patients. In Norway, patients are asked preoperatively to participate in the registry. If the patient accepts, he or she signs a written informed consent allowing the data assembly and later use of their registry data for follow-ups at 2, 5, and 10 years postoperatively. The Norwegian registry has been approved by the Norwegian Data Inspectorate as a national health registry. In Sweden, no written consent is necessary for national clinical databases. The storage and processing of the data is protected by the Personal Data Act of Sweden. All data extracted from both the Norwegian and Swedish registry are anonymous to ensure that the researchers only have access to nonidentifiable data.

### Knee Injury and Osteoarthritis Outcome Score

The KOOS is a valid, reliable, and responsive self-administered questionnaire for patients with several types of knee injury and knee OA.<sup>23</sup> It has been validated for ACL, meniscal, and cartilage injury, as well as other knee injuries,<sup>1,24</sup> and age- and sex-specific population-based reference data of the KOOS have been established.<sup>22</sup> The KOOS consists of 42 questions distributed between 5 subscales: Pain (9 questions), Other Symptoms (Symptoms) (7 questions), Activities of Daily Living (ADL) (17 questions), Sport and Recreation Function (Sport/Rec) (5 questions), and Knee-Related Quality of Life (QoL) (4 questions). Each subscale ranges from 0 (worst) to 100 (best), and it is recommended to use each subscale independently in outcome evaluations.<sup>24</sup> Calculation of the score of each subscale and treatment of missing data were done according to the guidelines given by Roos et al.<sup>24</sup>

### Patients

A total of 15,783 patients were registered with unilateral primary ACL reconstruction between January 1, 2005, and December 31, 2008, in the Norwegian and the Swedish National Knee Ligament Registry. This patient cohort and its baseline data have been described in a previous study on incidence and risk factors for full-thickness cartilage lesions in ACL-injured knees.<sup>26</sup> In the present study, all patients from this cohort who had completed the KOOS QoL subscale at the 2-year follow-up were included.

At a mean  $\pm$  standard deviation (SD) follow-up of  $2.1 \pm 0.2$  years and mean  $\pm$  SD patient age of  $30.4 \pm 10.6$  years, KOOS data were received from 8476 (54%) of the 15,783 patients. Of these, 3805 (45%) patients were from the Norwegian registry and 4671 (55%) from the Swedish registry. Baseline characteristics at the time of ACL reconstruction for the patients included in the study cohort and those lost to follow-up are shown in Table 1. During the follow-up, 126 (1.5%) patients had their primary ACL graft revised.

Cartilage lesions are classified in the registries' databases according to the ICRS grading system,<sup>2,9</sup> in which grade 0 = normal, grade 1 = nearly normal (superficial lesions, soft indentation, and/or superficial fissures and cracks), grade 2 = abnormal (lesions extending down to <50% of cartilage depth), grade 3 = severely abnormal (cartilage lesions extending down >50% of cartilage depth as well as down to calcified layer), and grade 4 = severely abnormal (osteochondral lesions extending just through

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TABLE 1  
Baseline Characteristics at the Time of ACL Reconstruction of the Patients  
Included in the Study Cohort and the Patients Lost to Follow-up<sup>a</sup>

	Study Cohort (N <sub>1</sub> )	Lost to Follow-Up (N <sub>2</sub> )
Age at surgery, <sup>b</sup> y (N <sub>1</sub> = 8476; N <sub>2</sub> = 7301)	26 (9-69)	25 (8-64)
Time from injury to surgery, <sup>b</sup> mo (N <sub>1</sub> = 8170; N <sub>2</sub> = 7089)	9 (0-521)	9 (0-429)
Female patients <sup>c</sup> (N <sub>1</sub> = 8476; N <sub>2</sub> = 7307)	4088 (48)	2611 (36)
Previous ipsilateral knee surgery <sup>c</sup> (N <sub>1</sub> = 8476; N <sub>2</sub> = 7307)	2198 (26)	1948 (27)
Concomitant ligament injury <sup>c,d</sup> (N <sub>1</sub> = 8476; N <sub>2</sub> = 7307)	627 (7)	487 (7)
Concomitant meniscal lesion(s) <sup>c</sup> (N <sub>1</sub> = 8476; N <sub>2</sub> = 7307)	3674 (43)	3170 (43)
Concomitant cartilage lesion(s) <sup>c</sup> (N <sub>1</sub> = 8476; N <sub>2</sub> = 7307)	2247 (27)	1945 (27)
ACL graft <sup>c</sup> (N <sub>1</sub> = 8476; N <sub>2</sub> = 7307)		
Hamstring tendons	6476 (76)	5759 (79)
Bone–patellar tendon–bone	1836 (22)	1380 (19)
Other/unknown	164 (2)	168 (2)
KOOS, preoperative <sup>e</sup>		
Pain (N <sub>1</sub> = 6140; N <sub>2</sub> = 4807)	74.8 ± 17.5	73.7 ± 18.1
Symptoms (N <sub>1</sub> = 6163; N <sub>2</sub> = 4819)	71.5 ± 17.8	70.0 ± 18.2
ADL (N <sub>1</sub> = 6132; N <sub>2</sub> = 4796)	83.9 ± 17.2	82.7 ± 17.8
Sport/recreation (N <sub>1</sub> = 6108; N <sub>2</sub> = 4787)	42.3 ± 27.0	41.8 ± 27.1
QoL (N <sub>1</sub> = 6141; N <sub>2</sub> = 4804)	34.2 ± 18.1	33.5 ± 18.3

<sup>a</sup>ACL, anterior cruciate ligament; ADL, Activities of Daily Living; KOOS, Knee Injury and Osteoarthritis Outcome Score; QoL, Quality of Life.

<sup>b</sup>Data expressed as median (range).

<sup>c</sup>Data expressed as No. (%).

<sup>d</sup>Medial collateral ligament, lateral collateral ligament, posterior cruciate ligament, posterolateral corner.

<sup>e</sup>Data expressed as mean ± standard deviation.

the subchondral bone plate, or deeper lesions down into trabecular bone). In the present study, patients with cartilage lesions were grouped into having partial-thickness lesions (ICRS grades 1-2) or full-thickness lesions (ICRS grades 3-4). Patients with more than 1 cartilage lesion were grouped according to the deepest lesion (highest ICRS grade). The size of the cartilage lesions is reported to the registries as area <2 cm<sup>2</sup> or ≥2 cm<sup>2</sup>. When stratifying for area of the cartilage lesions in the present study, patients with more than 1 cartilage lesion were grouped according to the largest lesion.

## Statistics

Statistical analyses were performed using SPSS software, version 19 (SPSS, Inc, an IBM Company, Chicago, Illinois).

At first, crude mean KOOS scores were estimated for patients with meniscal lesions, partial-thickness cartilage lesions, and full-thickness cartilage lesions. In addition, the crude mean KOOS scores were stratified by the location of meniscal lesions, as well as by the location and the area of cartilage lesions.

The study's primary objective was to evaluate the effect of concomitant meniscal lesions, partial-thickness cartilage lesions, and full-thickness cartilage lesions on patient-reported outcome, measured by KOOS, after ACL reconstruction. The factors of interest (ie, meniscal lesions, partial-thickness cartilage lesions, and full-thickness cartilage lesions) were first included in linear regression analyses as independent variables with each of the KOOS

subscales as the dependent variable. Based on current literature and clinical assumption, the variables sex, age (continuous variable), previous ipsilateral knee surgery, time from injury to surgery (continuous variable), concomitant ligament injury, and type of ACL graft were considered as possible confounders and predictors for patient-reported outcome. These factors were included in the multiple linear regression analyses together with the factors of interest as independent variables and each of the KOOS subscales as the dependent variable. Preoperative KOOS was not included as an independent variable in the multiple regression analyses for 2 reasons. First, the preoperative KOOS was considered a variable on the causal pathway between the exposure of interest (meniscal and cartilage lesions) and the outcome (KOOS at 2-year follow-up), and controlling for preoperative KOOS would then have led to an underestimation of the effect of meniscal and cartilage lesions.<sup>11</sup> Second, controlling for preoperative KOOS would bring focus more on the effect of the ACL reconstruction on patient-reported outcome, rather than the effect of the concomitant intra-articular injuries.

Differences were considered statistically significant for *P* values <.05. All crude mean KOOS scores, regression coefficient estimates (βs), and odds ratios (ORs) are presented with 95% confidence intervals (CIs).

## RESULTS

There were 3674 (43%) patients with 1 or more meniscal lesions at the time of ACL reconstruction: 1661 (20%)

TABLE 2

Location, Area, and Treatment of the Partial-Thickness (ICRS Grades 1-2) and Full-Thickness (ICRS Grades 3-4) Cartilage Lesions at the Time of ACL Reconstruction<sup>a</sup>

	Partial-Thickness Cartilage Lesions (n = 3291)	Full-Thickness Cartilage Lesions (n = 657)
Location		
Patella	617 (19)	71 (11)
Trochlea	171 (5)	42 (6)
Medial femoral condyle	1131 (34)	337 (51)
Lateral femoral condyle	404 (12)	83 (13)
Medial tibial plateau	475 (14)	67 (10)
Lateral tibial plateau	493 (15)	57 (9)
Area		
<2 cm <sup>2</sup>	1926 (59)	312 (48)
≥2 cm <sup>2</sup>	1181 (36)	330 (50)
Not reported	184 (6)	15 (2)
Treatment		
No	2411 (73)	321 (49)
Surgical procedure	254 (8)	254 (39)
Not reported	626 (19)	82 (12)

<sup>a</sup>Data expressed as No. (%). ACL, anterior cruciate ligament; ICRS, International Cartilage Repair Society.

patients had a medial meniscal lesion, 1219 (14%) had a lateral meniscal lesion, 657 (8%) had both a lateral and a medial meniscal lesion, and in 137 (2%) patients, the location of the lesion was unknown. There were 4331 meniscal lesions, of which 736 (17%) lesions were left untreated at the time of ACL reconstruction, 2749 (64%) were resected, 671 (16%) were repaired, and for 175 (4%) lesions the treatment was either classified as "other" or not reported.

A total of 2247 (27%) of the patients had 1 or more cartilage lesions at the time of ACL reconstruction. Of these, 1671 (20%) patients had 1 or more partial-thickness cartilage lesions (ICRS grades 1-2), 551 (7%) had 1 or more full-thickness cartilage lesions (ICRS grades 3-4), and in 25 patients, the grading of the cartilage lesions was not reported. The total numbers of cartilage lesions were 3291 partial-thickness lesions and 657 full-thickness cartilage lesions. The location, area, and treatment of the cartilage lesions are shown in Table 2.

### Meniscal Lesions and Crude Mean KOOS Scores

The crude mean KOOS scores at 2-year follow-up for patients with meniscal lesions and patients without meniscal lesions (ie, all other patients) are shown in Table 3. The KOOS scores reported by patients with and without meniscal lesions were similar.

The crude mean KOOS scores at 2-year follow-up for the patients with medial meniscal lesions and lateral meniscal lesions are shown in Table 4. Even though the differences were quite small, there was a trend toward lower scores among the patients with medial meniscal lesions in all subscales.

### Cartilage Lesions and Crude Mean KOOS Scores

The crude mean KOOS scores at 2-year follow-up for patients with partial-thickness cartilage lesions, full-thickness cartilage lesions, and patients without cartilage lesions (ie, all other patients) are shown in Table 5. The KOOS scores reported by patients with partial-thickness cartilage lesions and without cartilage lesions were similar. However, patients with full-thickness cartilage lesions reported lower crude mean values for all of the KOOS subscales compared with those patients without cartilage lesions at 2-year follow-up.

Table 6 shows the crude mean KOOS scores at 2-year follow-up for the patients with full-thickness cartilage lesions by location of the cartilage lesions. There were no significant differences in KOOS scores between the patients with various locations of the full-thickness cartilage lesions.

As shown in Table 7, there was a trend toward lower crude mean KOOS scores at 2-year follow-up among the patients with cartilage lesions with an area ≥2 cm<sup>2</sup> compared with the patients with cartilage lesions <2 cm<sup>2</sup>. However, these differences were small, and none of them were significant.

### Effects of Meniscal and Cartilage Lesions on KOOS

Table 8 shows the results for the unadjusted and adjusted regression analyses of the associations between each KOOS subscale and partial-thickness cartilage lesions (vs no cartilage lesions), full-thickness cartilage lesion (vs no cartilage lesions), and meniscal lesions (vs no meniscal lesions). No significant associations were detected in the unadjusted or adjusted analyses between meniscal lesions and the KOOS scores in any of the subscales. Partial-thickness cartilage lesions showed no significant associations with the KOOS scores, except for decreased scores in the unadjusted analyses of the subscales ADL and Sport/Rec. Full-thickness cartilage lesions were significantly associated with decreased KOOS scores in all subscales, both in the unadjusted and the adjusted analyses.

The differences in mean KOOS between patients without cartilage lesions and patients with full-thickness cartilage were all in favor of those without cartilage lesions and varied from 3.6 to 7.6 preoperatively and from 3.3 to 8.3 at 2-year follow-up (Figure 1). The differences decreased from preoperative to follow-up for the subscales Pain, Symptoms, and ADL and increased for the subscales Sport/Rec and QoL.

### DISCUSSION

The main finding of the present study is that patients with concomitant full-thickness cartilage lesions reported significantly worse outcome measured by the KOOS at 2-year follow-up after ACL reconstruction compared with patients without such lesions. This is to our knowledge the most comprehensive study demonstrating this and also the first to do this in a nationwide population-based

TABLE 3

Crude Mean KOOS Scores for Patients With and Without Meniscal Lesions at 2-Year Follow-up After ACL Reconstruction<sup>a</sup>

KOOS Subscale	Patients Without Meniscal Lesions (n = 4790-4802)		Patients With Meniscal Lesions (n = 3657-3674)	
	Mean	95% CI	Mean	95% CI
Pain	84.7	84.2-85.1	84.9	84.3-85.4
Symptoms	78.1	77.6-78.6	78.1	77.5-78.7
ADL	91.0	90.6-91.4	91.3	90.9-91.8
Sport/recreation	65.3	64.5-66.1	65.5	64.6-66.4
QoL	63.6	62.9-64.3	63.0	62.2-63.7

<sup>a</sup>ACL, anterior cruciate ligament; ADL, Activities of Daily Living; CI, confidence interval; KOOS, Knee Injury and Osteoarthritis Outcome Score; QoL, Quality of Life.

TABLE 4

Crude Mean KOOS Scores for Patients With Meniscal Lesions by Location at 2-Year Follow-up After ACL Reconstruction<sup>a</sup>

KOOS Subscale	Medial Meniscal Lesions (n = 1651-1661)		Lateral Meniscal Lesions (n = 1217-1219)	
	Mean	95% CI	Mean	95% CI
Pain	83.8	82.9-84.6	86.0	85.1-86.8
Symptoms	77.3	76.4-78.1	79.1	78.1-80.0
ADL	90.2	89.5-90.9	92.3	91.6-93.0
Sport/recreation	64.1	62.8-65.5	66.7	65.2-68.2
QoL	61.4	60.2-62.6	64.2	62.8-65.5

<sup>a</sup>ACL, anterior cruciate ligament; ADL, Activities of Daily Living; CI, confidence interval; KOOS, Knee Injury and Osteoarthritis Outcome Score; QoL, Quality of Life.

TABLE 5

Crude Mean KOOS Scores for Patients Without Cartilage Lesions and Patients With Partial-Thickness (ICRS Grades 1-2) and Full-Thickness (ICRS Grades 3-4) Cartilage Lesions at 2-Year Follow-up After ACL Reconstruction<sup>a</sup>

KOOS Subscale	Patients Without Cartilage Lesions (n = 6206-6229)		Patients With Partial-Thickness Cartilage Lesions (n = 1666-1671)		Patients With Full-Thickness Cartilage Lesions (n = 550-551)	
	Mean	95% CI	Mean	95% CI	Mean	95% CI
Pain	85.1	84.7-85.5	84.5	83.8-85.3	81.3	79.7-82.9
Symptoms	78.3	77.9-78.7	78.5	77.6-79.3	75.0	73.4-76.6
ADL	91.6	91.2-91.9	90.5	89.8-91.2	87.7	86.3-89.1
Sport/recreation	66.4	65.7-67.0	64.1	62.7-65.5	58.1	55.6-60.6
QoL	63.9	63.3-64.5	62.7	61.6-63.9	58.2	56.1-60.2

<sup>a</sup>ACL, anterior cruciate ligament; ADL, Activities of Daily Living; CI, confidence interval; ICRS, International Cartilage Repair Society; KOOS, Knee Injury and Osteoarthritis Outcome Score; QoL, Quality of Life.

manner. Additional findings of the present study were that concomitant partial-thickness cartilage lesions and meniscal lesions were not associated with decreased patient-reported outcome 2 years after ACL reconstruction. Data from the present study also indicate that the depth (ICRS grading) of the cartilage lesion is a more important factor for the prognosis in terms of patient-reported outcome than the size and location of the lesion.

The worse reported outcome by the patients with full-thickness cartilage lesions compared with those without cartilage lesions could be explained by an already decreased KOOS score before surgery and/or by less

benefit from ACL reconstruction. The observed similarity in the differences in mean KOOS between patients without cartilage lesions and patients with full-thickness cartilage lesions preoperatively and at follow-up indicates that decreased KOOS scores before surgery are the most important factor. This is, to some degree, in contrast to a previous report from the current research group, in which no differences were found in preoperative KOOS scores between patients with and without full-thickness cartilage lesions.<sup>8</sup> In the previous study, however, a subpopulation (n = 89) of patients with ACL-reconstructed knees with and without full-thickness cartilage lesions was included, which is not

**TABLE 6**  
Crude Mean KOOS Scores for Patients With Full-Thickness Cartilage Lesions (ICRS Grades 3-4) by Location at 2-Year Follow-up After ACL Reconstruction<sup>a</sup>

KOOS Subscale	Patella (n = 71)		Trochlea (n = 42)		Medial Femur (n = 337)		Lateral Femur (n = 83)		Medial Tibia (n = 67)		Lateral Tibia (n = 57)	
	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI
Pain	82.8	78.8-86.8	82.2	76.4-88.0	81.8	79.9-83.7	79.7	75.5-83.8	79.1	73.7-84.4	79.8	73.9-85.8
Symptoms	74.7	70.4-78.9	75.8	70.0-81.6	75.4	73.4-77.4	74.2	70.3-78.1	75.0	70.2-79.8	74.8	69.5-80.1
ADL	88.9	85.6-92.2	86.2	80.9-91.5	87.8	86.0-89.5	88.7	85.3-92.0	85.0	80.0-89.0	86.6	81.6-91.6
Sport/recreation	61.6	54.6-68.5	55.6	46.1-65.1	57.8	54.6-61.0	60.1	54.2-66.1	57.4	49.7-65.1	57.1	48.9-65.4
QoL	62.2	56.0-68.3	57.6	49.6-65.6	58.2	55.6-60.8	59.6	54.4-64.7	59.1	52.6-65.7	58.4	50.9-66.0

<sup>a</sup>ACL, anterior cruciate ligament; ADL, Activities of Daily Living; CI, confidence interval; ICRS, International Cartilage Repair Society; KOOS, Knee Injury and Osteoarthritis Outcome Score; QoL, Quality of Life.

**TABLE 7**  
Crude Mean KOOS Scores for Patients With Cartilage Lesions (ICRS Grades 1-4) by Area at 2-Year Follow-up After ACL Reconstruction<sup>a</sup>

KOOS Subscale	Cartilage Lesions <2 cm <sup>2</sup> (n = 1278-1282)		Cartilage Lesions ≥2 cm <sup>2</sup> (n = 900-902)	
	Mean	95% CI	Mean	95% CI
Pain	84.3	83.4-85.2	82.9	81.7-84.1
Symptoms	78.1	77.1-79.0	76.9	75.7-78.1
ADL	90.4	89.6-91.2	88.8	87.7-89.8
Sport/recreation	63.7	62.2-65.3	60.9	59.0-62.8
QoL	61.4	60.1-62.8	61.4	59.7-62.3

<sup>a</sup>ACL, anterior cruciate ligament; ADL, Activities of Daily Living; CI, confidence interval; ICRS, International Cartilage Repair Society; KOOS, Knee Injury and Osteoarthritis Outcome Score; QoL, Quality of Life.

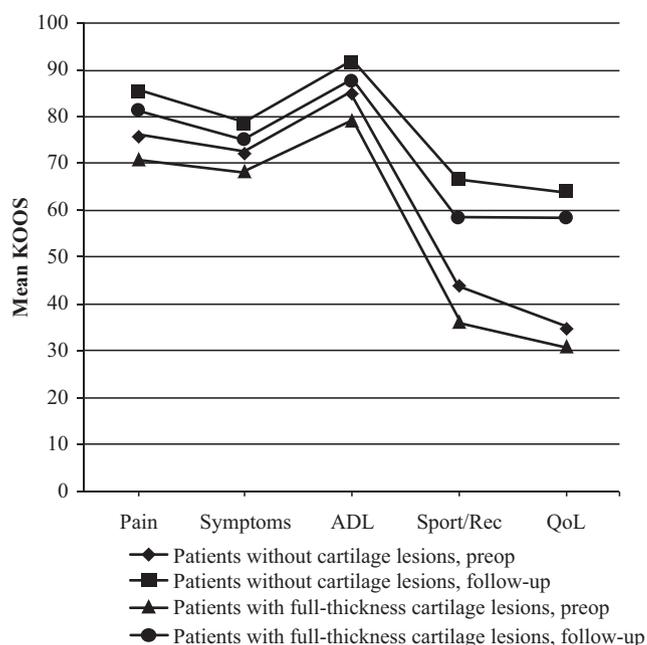
**TABLE 8**  
Unadjusted and Adjusted Regression Analyses of the Associations Between the KOOS Subscales and Meniscal Lesions, Partial-Thickness Cartilage Lesions (ICRS Grades 1-2), and Full-Thickness Cartilage Lesions (ICRS Grades 3-4) at 2-Year Follow-up After ACL Reconstruction<sup>a</sup>

Analysis by KOOS Subscale	No. of Patients	Meniscal Lesions <sup>b</sup>			Partial-Thickness Cartilage Lesions <sup>c</sup>			Full-Thickness Cartilage Lesions <sup>c</sup>				
		β	95% CI	P Value	No. of Patients	β	95% CI	P Value	No. of Patients	β	95% CI	P Value
Pain												
Unadjusted	8447	0.2	-0.5 to 0.9	.643	8422	-0.6	-1.5 to 0.3	.192	8422	-3.8	-5.2 to -2.4	<.001
Adjusted	8067	0.1	-0.7 to 0.8	.866	8067	-0.2	-1.1 to 0.8	.727	8067	-3.3	-4.8 to -1.8	<.001
Symptoms												
Unadjusted	8474	-0.1	-0.8 to 0.7	.874	8449	0.2	-0.8 to 1.1	.733	8449	-3.3	-4.9 to -1.7	<.001
Adjusted	8094	-0.1	-0.9 to 0.6	.723	8094	-0.3	-1.3 to 0.7	.541	8094	-4.8	-6.5 to -3.1	<.001
ADL												
Unadjusted	8448	0.3	-0.3 to 0.9	.285	8423	-1.1	-1.8 to -0.3	.005	8423	-3.9	-5.1 to -2.7	<.001
Adjusted	8068	0.3	-0.3 to 0.9	.327	8068	-0.3	-1.0 to 0.5	.529	8068	-2.6	-3.9 to -1.3	<.001
Sport/recreation												
Unadjusted	8470	0.2	-1.0 to 1.4	.719	8445	-2.3	-3.7 to -0.8	.003	8445	-8.3	-10.6 to -5.9	<.001
Adjusted	8090	0.2	-1.0 to 1.4	.730	8090	-1.1	-2.6 to 0.5	.180	8090	-6.6	-9.2 to -4.1	<.001
QoL												
Unadjusted	8476	-0.7	-1.7 to 0.4	.211	8451	-1.2	-2.5 to 0.1	.070	8451	-5.8	-7.9 to -3.7	<.001
Adjusted	8096	-0.6	-1.7 to 0.4	.245	8096	-1.1	-2.5 to 0.2	.099	8096	-6.3	-8.6 to -4.1	<.001

<sup>a</sup>Regression analyses adjusted for sex, age, previous ipsilateral knee surgery, time from injury to surgery, concomitant ligament injury, and type of ACL graft. ACL, anterior cruciate ligament; ADL, Activities of Daily Living; β, regression coefficient; CI, confidence interval; ICRS, International Cartilage Repair Society; KOOS, Knee Injury and Osteoarthritis Outcome Score; QoL, Quality of Life.

<sup>b</sup>No meniscal lesion used as reference.

<sup>c</sup>No cartilage lesion used as reference.



**Figure 1.** Profiles of mean Knee Injury and Osteoarthritis Outcome Score (KOOS) results of patients without cartilage lesions and patients with full-thickness cartilage lesions (International Cartilage Repair Society [ICRS] grades 3-4) at preoperative and 2-year follow-up after anterior cruciate ligament reconstruction. ADL, Activities of Daily Living; QoL, Quality of Life; Sport/Rec, Sport and Recreation Function.

directly comparable with the wide and population-based patient cohort in the present study.

Even though the effects of the full-thickness cartilage lesions on KOOS were statistically significant, the level of clinical significance can be debated. Eight to 10 points on the KOOS are often used as a limit,<sup>23</sup> but for the minimal clinical important difference (MCID), this is not well founded.<sup>17</sup> Furthermore, in the present study, the adjusted effects of full-thickness cartilage lesions on the most responsive KOOS subscales, Sport/Rec and QoL, were  $-6.6$  and  $-5.8$ , respectively. Assuming that the effects were normally distributed and as a result of the large number of patients, a considerable number of patients with full-thickness lesions had even larger negative effects.

One possible explanation of why meniscal lesions did not influence the 2-year results is that the majority (almost 80%) of the lesions were treated at the time of ACL reconstruction, either by resection or repair, with good short-term prognosis. In addition, the majority of meniscal lesions left untreated most likely represented small and/or stable lesions, with limited potential to influence short-term patient-reported outcome. However, this is only based on assumption, as classification of meniscal lesion size is not included in the registries. Even though the rate of meniscal lesions treated with resection (64%) in the present study might be considered high, it is in accordance with the rates reported in the literature. A

recent meta-analysis including 19,531 patients with ACL reconstruction found an overall rate of 65% of the meniscal lesions treated with resection.<sup>20</sup> The rate of meniscal resections in the present study is, however, a cause for concern, as previous studies have shown that meniscus resection at the time of ACL reconstruction is associated with a high rate of later OA.<sup>4,15,27,35</sup> Thus, there might be a potential of the meniscal lesions to have negative effects on patient-reported outcome at later follow-ups.

The overall 2-year KOOS results from the present study cohort are lower than what is reported from another comprehensive cohort of patients with ACL-reconstructed knees in the United States, the Multicenter Orthopaedic Outcome Network (MOON) cohort.<sup>5,31</sup> However, these cohorts are difficult to compare directly, as the present study is based on 2 national registries gathering a broad cross section of surgeons and patients, whereas the MOON cohort recruited patients exclusively from surgeons at 7 different academic institutions in the United States. Magnussen et al<sup>14</sup> compared baseline characteristics from parts of the 2 cohorts and found numerous demographic and treatment differences with potential to influence outcome data.

In the current literature, the reported effects of concomitant intra-articular injury on patient-reported outcome after ACL reconstruction are divergent. Some studies have not found any associations between meniscus status and patient-reported outcome,<sup>13,32</sup> whereas others have shown significant associations.<sup>28,29,31</sup> Regarding cartilage lesions and ACL reconstruction, there have been reports on significant associations between cartilage status and patient-reported outcome,<sup>13,25,28,29</sup> whereas other studies have not reported such associations.<sup>30-32,34</sup> However, possible differences in the study populations, different follow-up periods, and the use of different patient-reported outcome measures make it difficult to compare the findings and might also explain the diversity in the reported results from the previous studies and the present study. The studies' recruitment of patients varied from including patients from single-surgeon practices, single-institution practices, multicenter registries, or nationwide registries. The number of patients included varied from 71 to 8476 in the present study, and the mean follow-up periods of the different studies ranged from 2.1 to 15.9 years. However, the main finding of the present study supports the view that concomitant full-thickness cartilage lesions in ACL-injured patients have negative effects on knee function and that ACL reconstruction in the short term does not restore knee function to the same level as in patients without full-thickness cartilage lesions.

The main strengths of the present study are the high number of patients included and the prospective nationwide population-based design, involving 2 countries with an estimated total population of 14 million. The study included all patients with unilateral primary ACL reconstruction and with completed KOOS subscale QoL at follow-up, without any further exclusion. The study cohort represented a wide range of patients regarding age, time from injury to surgery, previous knee surgery, and concomitant injuries. Thus, the results from the present study

should be applicable to comparable populations in which ACL injuries are treated with reconstruction.

As outlined by Maletis et al,<sup>16</sup> the use of registry data has possible limitations. However, the main limitation of the present study is the rate of loss to the 2-year follow-up (46%) with a potential of selection bias. However, with exception of the sex and age distribution, the baseline characteristics of the study cohort and those lost to follow-up were comparable for all reported variables (time from injury to surgery; previous ipsilateral knee surgery; concomitant meniscal, cartilage, and ligament injury; type of ACL graft; and preoperative KOOS scores). The patients lost to follow-up tended to be slightly younger and with a higher proportion of men than the patients in the study cohort, indicating that younger men had a lower compliance rate than overall regarding the KOOS questionnaire at 2-year follow-up. Future studies from the registries will need to focus on improving the compliance rates. During the current study period, the registries did not routinely send reminders to those patients who did not respond to the request for completed KOOS questionnaires at follow-ups. However, distribution of reminders is currently implemented as a routine for both registries, and it is hoped that this will contribute in reducing the rate of patients lost to follow-up in the future. The patients were not blinded by their meniscal and cartilage lesions at follow-up, which is a possible source of bias. However, patients with full-thickness lesions were the only ones to report lower scores, and it is not likely that the nonblinding only biased the results of these patients and not of the patients with meniscal and partial-thickness lesions. Another limitation is the use of KOOS as the only outcome measure, without any further clinical assessments. In a population-based nationwide study such as the current one, however, it would be both ethically difficult and resource consuming to include more outcome measures, especially if the outcome measures demand personal attendance and examination of this large number of patients. Furthermore, the reasons for choosing KOOS in the registries and its limitations are thoroughly outlined and discussed in previous studies.<sup>6,8</sup>

We suggest that the findings in the present study should be discussed when informing patients with concomitant intra-articular injury about the short-term prognosis after ACL reconstruction. The present study also proposes that there might be a potential of improving the short-term outcome after ACL reconstruction in patients with concomitant full-thickness cartilage lesions both by prevention and treatment of these lesions. In the current literature, however, there is little evidence on how to prevent or treat concomitant cartilage lesions in ACL-injured knees.<sup>3</sup> Thus, further research needs to focus both on prevention and optimized treatment of full-thickness cartilage lesions in ACL-injured knees.

## CONCLUSION

Patients with concomitant full-thickness cartilage lesions reported more pain and symptoms; impaired function in

activities of daily living, sports, and recreation; and reduced knee-related quality of life compared with patients without cartilage lesions 2 years after ACL reconstruction. Meniscal lesions and partial-thickness cartilage lesions did not impair patient-reported outcome compared with patients without such lesions 2 years after ACL reconstruction.

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