Knee Surg Sports Traumatol Arthrosc (2010) 18:298–303
DOI 10.1007/s00167-009-0894-x

KNEE

Full-thickness cartilage lesion do not affect knee function in patients with ACL injury

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Received: 16 December 2008 / Accepted: 1 August 2009 / Published online: 4 September 2009

Abstract There is debate in the literature regarding the impact of full-thickness cartilage lesion on knee function in patients with ACL injury. The hypothesis of the current study is that a full-thickness cartilage lesion at the time of ACL reconstruction does not influence knee function as measured by the Knee injury and Osteoarthritis Outcome Score (KOOS) in patients with ACL injury. Of the 4,849 primary ACL surgery cases in the Norwegian National Knee Ligament Registry as of 12 December 2007, 30 patients met the following inclusion criteria: a full-thickness cartilage lesion (International Cartilage Repair Society [ICRS] grades 3 and 4), age less than 40 years, no associated pathology or meniscus injury, and less than 1 year between knee injury and ACL reconstruction. Each of the 30 patients in this study group was matched with two control participants without cartilage lesions. Preoperatively, the patients completed the KOOS, and the surgeon recorded the location and size of the cartilage lesion and graded the cartilage injury according to ICRS standards. There were no significant differences between the case and control groups for any of the five subscales of the KOOS. A cartilage lesion was located in the medial compartment in 67% of the cases, in the lateral compartment in 20% of the cases, and in the patellofemoral joint in 13% of the cases. In conclusion, the combination of a full-thickness cartilage lesion and an ACL rupture did not result in inferior knee function at the time of the ACL reconstruction as measured by the KOOS.

Keywords ACL · Cartilage injuries · Knee function · Cross-sectional study

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Introduction

The incidence of cartilage lesions in patients with ACL injuries is estimated to vary from 18 to 42% [3]. The range of cartilage lesions varies from superficial fibrillation and flossing to full-thickness injury (International Cartilage Repair Society [ICRS] grades 1–4, ICRS Cartilage Injury Evaluation Package [www.cartilage.org]). There is some controversy regarding the importance of the presence of a full-thickness cartilage lesion (ICRS grades 3 and 4). Some studies state that full-thickness cartilage injuries at the time of the ACL reconstruction do not affect clinical outcome, even in a long-term perspective [19, 20]. However, some orthopedic surgeons routinely surgically treat full-thickness cartilage lesions simultaneously with ACL reconstruction to prevent or delay degenerative changes, while others have used disabling knee pain at the time of ACL reconstruction as an argument for simultaneously surgically treating the

cartilage injury [1, 14]. The current hypothesis is that the presence of a full-thickness cartilage lesion will not affect knee function in patients scheduled for ACL reconstruction. This is of particular importance for orthopedic surgeons facing the clinical decision of whether to perform a cartilage-repair procedure simultaneously with ACL reconstruction. The purpose of this study was to compare knee function in patients with a combined ACL injury and full-thickness cartilage lesion with knee functions in patients with an ACL injury but no cartilage lesion at the time of the ACL reconstruction.

Materials and methods

In this cross-sectional study, we extracted data from the Norwegian National Knee Ligament Registry (NKLR). The NKLR was established in June 2004 as the first national cruciate ligament registry, and prospectively collects information regarding all cruciate ligament reconstruction surgery in Norway [11]. The registry uses the Knee injury and Osteoarthritis Outcome Score (KOOS) as the knee outcome score; there are no other knee outcome scores available from the registry data. All Norwegian hospitals in which cruciate ligaments are reconstructed provide data for the registry. NKLR data compliance is considered to be satisfactory (96%) [11].

All of the patients in the study completed the KOOS form preoperatively. Immediately after ACL reconstruction, the surgeons completed another form describing specific variables for the ACL-deficient knee (Fig. 1). The KOOS is validated for degenerative changes in the knee [17]. The Norwegian version of the KOOS was translated according to international guidelines [11]. The reasons for choosing the KOOS over alternative knee function scores to provide data for the NKLR were outlined by Granan et al. [11]. The KOOS form is patient-based to allow for nonbiased outcome data. It is self-explanatory, takes less than 10 min to fill in to ensure good compliance at follow-up visits, and was previously validated for cruciate ligament surgery [11]. In May and December 2007, the primary author (VH) performed a search of the NKLR database. Of the 4,849 primary ACL-surgery cases in the NKLR at the time of inclusion, approximately 20% also had a full-thickness cartilage injury. Of these cases, 30 patients met the following inclusion criteria: a full-thickness chondral defect (ICRS grade 3) or an osteochondral defect (ICRS grade 4), age less than 40 years, no associated pathology or meniscus injury, and less than 1 year between the incident that caused ACL rupture and reconstruction surgery The likelihood of additional injury to the knee joint is assumed to increase when the period from the ACL injury to the ACL reconstruction is prolonged [10]. Patients older than 40 years are often subject to injuries to joint cartilage due to reasons other than trauma, and were excluded. To obtain comparable groups, all patients with meniscus injuries and other additional injuries or surgery in their knees were excluded. For each of the patients in the study group, two control subjects with an isolated ACL rupture, no other knee injuries, and no cartilage lesions were matched from the NKLR according to age, gender, and days from injury to reconstruction and graft choice. Thus, the only factor distinguishing the study group from the control group was the cartilage lesion.

The surgical protocol and the preoperative KOOS form were checked manually to assure that the data from the surgeons and patients were consistent with the data found in the electronic file in the NKLR. The data were extracted from the registry according to the previously mentioned inclusion criteria for the two groups.

Missing data from the KOOS form were treated according to the guidelines provided by the original author of the KOOS score [17]. One of the patients included in the control group was excluded during the statistical analysis because of an incomplete KOOS score. Thus, one of the patients in the study group had only one matched control.

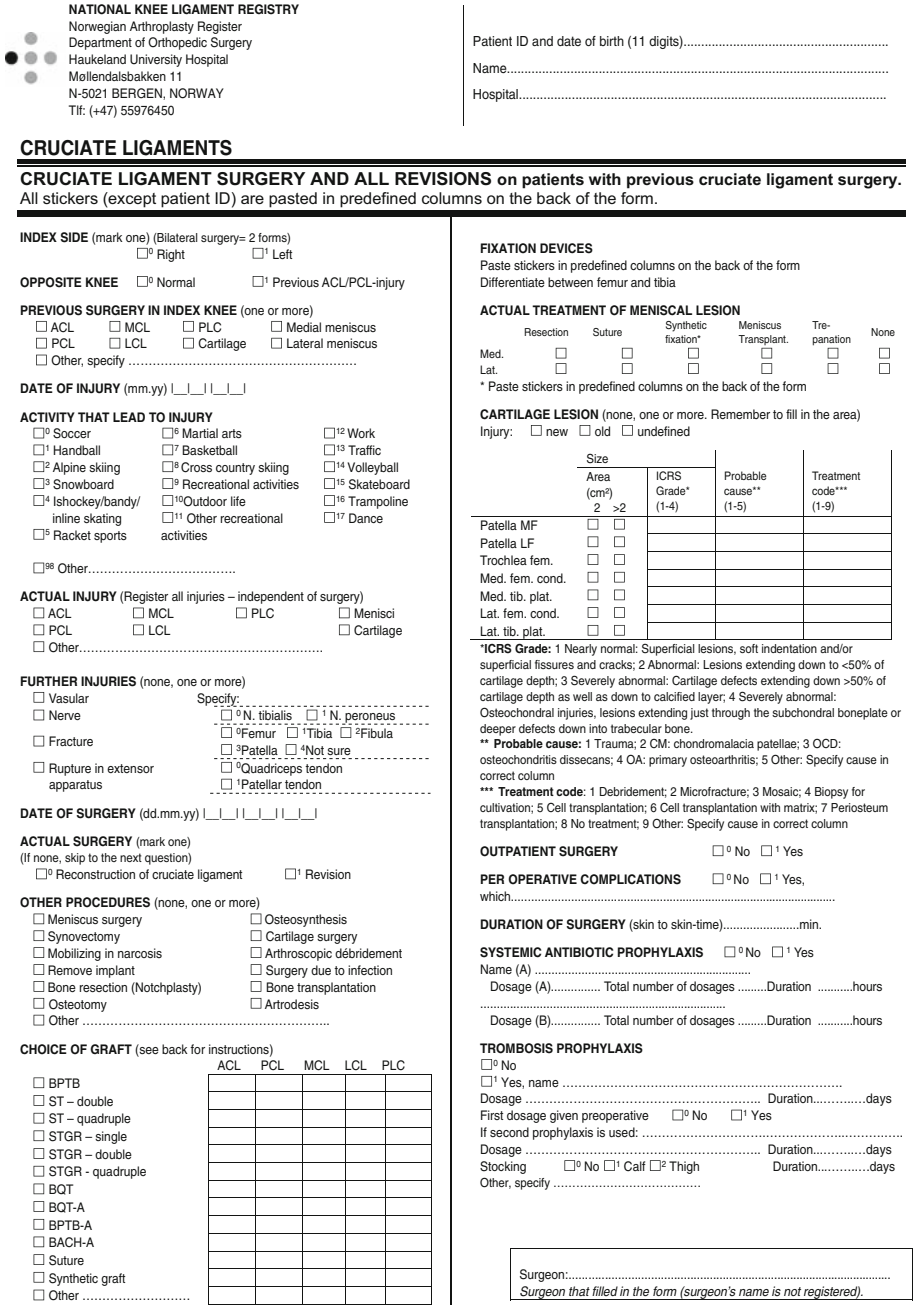
Statistical analysis

The information was gathered electronically and analyzed using the Statistical Package of Social Sciences (SPSS) version 14. The Mann–Whitney U test for nonparametric data was used to compare subjects with and without a full-thickness cartilage lesion. The significance level was defined as $P \leq 0.05$. Power analyses revealed that 22 patients had to be included in the study group to test the hypothesis with a power of 0.80, a significance level of 0.05, and a standard deviation of difference of less than 25% in the KOOS quality-of-life subscale. This subscale is considered to be the most sensitive for this group of patients [17].

Results

The study group consisted of 30 patients; after exclusion of one patient due to a missing KOOS value, the control group was reduced from 60 to 59 patients. The groups were comparable preoperatively (Table 1). There were no statistically significant differences between the groups for any of the five KOOS subscales (Fig. 2). A cartilage lesion was located in the medial compartment in 20 cases (67%), in the lateral compartment in six cases (20%), and in the patellofemoral joint in four cases (13%) (Table 2). Six of the patients in the study group had more than one cartilage injury. These were minor changes in the other compartments of the knee, and only one of the lesions was a

Fig. 1 Preoperative registry form for ACL surgery. Reproduced with permission from NKLR



NATIONAL KNEE LIGAMENT REGISTRY
Norwegian Arthroplasty Register
Department of Orthopedic Surgery
Haukeland University Hospital
Møllendalsbakken 11
N-5021 BERGEN, NORWAY
Tlf: (+47) 55976450

Patient ID and date of birth (11 digits).....
Name.....
Hospital.....

CRUCIATE LIGAMENTS

CRUCIATE LIGAMENT SURGERY AND ALL REVISIONS on patients with previous cruciate ligament surgery.
All stickers (except patient ID) are pasted in predefined columns on the back of the form.

INDEX SIDE (mark one) (Bilateral surgery= 2 forms)
☐0 Right ☐1 Left

OPPOSITE KNEE ☐0 Normal ☐1 Previous ACL/PCL-injury

PREVIOUS SURGERY IN INDEX KNEE (one or more)
☐ ACL ☐ MCL ☐ PLC ☐ Medial meniscus
☐ PCL ☐ LCL ☐ Cartilage ☐ Lateral meniscus
☐ Other, specify .....

DATE OF INJURY (mm.yy) |__|__| |__|__|

ACTIVITY THAT LEAD TO INJURY
☐0 Soccer ☐6 Martial arts ☐12 Work
☐1 Handball ☐7 Basketball ☐13 Traffic
☐2 Alpine skiing ☐8 Cross country skiing ☐14 Volleyball
☐3 Snowboard ☐9 Recreational activities ☐15 Skateboard
☐4 Ishockey/bandy/ inline skating ☐10 Outdoor life ☐16 Trampoline
☐5 Racket sports ☐11 Other recreational activities ☐17 Dance
☐98 Other.....

ACTUAL INJURY (Register all injuries – independent of surgery)
☐ ACL ☐ MCL ☐ PLC ☐ Menisci
☐ PCL ☐ LCL ☐ Cartilage
☐ Other.....

FURTHER INJURIES (none, one or more)
☐ Vasular
☐ Nerve — Specify: ☐0 N. tibialis ☐1 N. peroneus
☐ Fracture — ☐0 Femur ☐1 Tibia ☐2 Fibula ☐3 Patella ☐4 Not sure
☐ Rupture in extensor apparatus — ☐0 Quadriceps tendon ☐1 Patellar tendon

DATE OF SURGERY (dd.mm.yy) |__|__| |__|__| |__|__|

ACTUAL SURGERY (mark one)
(If none, skip to the next question)
☐0 Reconstruction of cruciate ligament ☐1 Revision

OTHER PROCEDURES (none, one or more)
☐ Meniscus surgery ☐ Osteosynthesis
☐ Synovectomy ☐ Cartilage surgery
☐ Mobilizing in narcosis ☐ Arthroscopic débridement
☐ Remove implant ☐ Surgery due to infection
☐ Bone resection (Notchplasty) ☐ Bone transplantation
☐ Osteotomy ☐ Artrodesis
☐ Other .....

CHOICE OF GRAFT (see back for instructions)

	ACL	PCL	MCL	LCL	PLC
☐ BPTB					
☐ ST – double					
☐ ST – quadruple					
☐ STGR – single					
☐ STGR – double					
☐ STGR - quadruple					
☐ BQT					
☐ BQT-A					
☐ BPTB-A					
☐ BACH-A					
☐ Suture					
☐ Synthetic graft					
☐ Other					

FIXATION DEVICES
Paste stickers in predefined columns on the back of the form
Differentiate between femur and tibia

ACTUAL TREATMENT OF MENISCAL LESION

	Resection	Suture	Synthetic fixation*	Meniscus Transplant.	Tre-panation	None
Med.	☐	☐	☐	☐	☐	☐
Lat.	☐	☐	☐	☐	☐	☐

* Paste stickers in predefined columns on the back of the form

CARTILAGE LESION (none, one or more. Remember to fill in the area)
Injury: ☐ new ☐ old ☐ undefined

	Size Area (cm^2) 2	>2	ICRS Grade* (1-4)	Probable cause** (1-5)	Treatment code*** (1-9)
Patella MF	☐	☐			
Patella LF	☐	☐			
Trochlea fem.	☐	☐			
Med. fem. cond.	☐	☐			
Med. tib. plat.	☐	☐			
Lat. fem. cond.	☐	☐			
Lat. tib. plat.	☐	☐			

***ICRS Grade:** 1 Nearly normal: Superficial lesions, soft indentation and/or superficial fissures and cracks; 2 Abnormal: Lesions extending down to <50% of cartilage depth; 3 Severely abnormal: Cartilage defects extending down >50% of cartilage depth as well as down to calcified layer; 4 Severely abnormal: Osteochondral injuries, lesions extending just through the subchondral boneplate or deeper defects down into trabecular bone.
**** Probable cause:** 1 Trauma; 2 CM: chondromalacia patellae; 3 OCD: osteochondritis dissecans; 4 OA: primary osteoarthritis; 5 Other: Specify cause in correct column
***** Treatment code**: 1 Debridement; 2 Microfracture; 3 Mosaic; 4 Biopsy for cultivation; 5 Cell transplantation; 6 Cell transplantation with matrix; 7 Periosteum transplantation; 8 No treatment; 9 Other: Specify cause in correct column

OUTPATIENT SURGERY ☐0 No ☐1 Yes

PER OPERATIVE COMPLICATIONS ☐0 No ☐1 Yes,
which.....

DURATION OF SURGERY (skin to skin-time).....min.

SYSTEMIC ANTIBIOTIC PROPHYLAXIS ☐0 No ☐1 Yes
Name (A) .....
Dosage (A)..... Total number of dosages .....Duration .....hours
.....
Dosage (B)..... Total number of dosages .....Duration .....hours

TROMBOSIS PROPHYLAXIS
☐0 No
☐1 Yes, name .....
Dosage ..... Duration.....days
First dosage given preoperative ☐0 No ☐1 Yes
If second prophylaxis is used: .....
Dosage ..... Duration.....days
Stocking ☐0 No ☐1 Calf ☐2 Thigh Duration.....days
Other, specify .....

Surgeon:.....
Surgeon that filled in the form (surgeon's name is not registered).

Table 1 Demographic information reported as mean values for age and median values for months

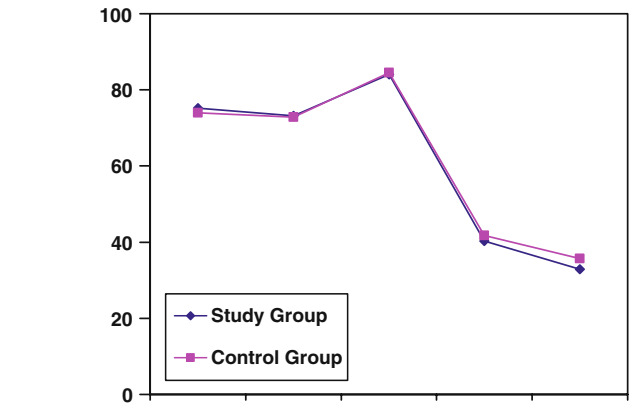
	Study group	Control group
Age	27.2 (15–38)	27.4 (16–39)
Gender	21 M, 9 F	42 M, 17 F
Months between injury and operation	5 (1–10)	5 (1–11)

full-thickness injury (ICRS grade 3 or 4). The majority of the lesions were less than 2 cm^2 in the study group.

Seven of the 20 cases with cartilage lesions located in the medial compartment were treated surgically simultaneously with ACL reconstruction. Four of these underwent stabilization with the removal of chondral flaps, and three underwent a microfracture procedure. None of the patients with cartilage injuries in the lateral compartment or the patellofemoral joint underwent surgical interventions.

Discussion

The most important finding of the present study was that a full-thickness cartilage injury does not lead to reduced knee



	Pain	Symptom	Function	Sport	QoL
Study Group	75,2	73,2	84,1	40,3	32,9
Control Group	74	72,8	84,5	41,8	35,7

Fig. 2 Mean KOOS score of study and control groups

Table 2 Location and incidence of cartilage injuries and incidence of simultaneous operative treatment of cartilage injuries

Location	Incidence	Operated	Debridement	Microfracture
Medial compartment	20 (67%)	7	4	3
Lateral compartment	6 (20%)	0	0	0
Patellofemoral joint	4 (13%)	2	2	0

function in ACL-deficient knees preoperatively, as evaluated by the KOOS. The KOOS has been shown to be both reliable and valid when evaluating cartilage defects in ACL-injured knees. Consequently, it should be valid for testing our hypothesis [5]. To our knowledge, knee function in patients with full-thickness cartilage lesions and rupture of the ACL has not been studied previously at the time of ACL reconstruction, probably because of the large amount of ACL-injured subjects required to obtain sufficient numbers with cartilage lesions. In the current study, we applied strict inclusion to study patients with ACL rupture with a cartilage lesion as the only additional injury. Furthermore, to rule out the possibility that the cartilage injury could represent a degenerative change, subjects with knees that had been injured more than 1 year preoperatively were excluded.

There is a divergence in the existing literature concerning the long-term consequences of full-thickness cartilage injuries in ACL-deficient knees. It is generally accepted that there is a high prevalence of symptomatic osteoarthritis among patients with an ACL injury, whether it was reconstructed or not [15, 22]. At the time of the ACL rupture, the blunt trauma or bone bruise may be sufficient to cause injury to the cartilage. It is estimated that this occurs in 15–40% of acute ACL tears [6, 8]. Whether this injury will progress to symptomatic osteoarthritis is not known. Researchers have reported significant deterioration in the status of the articular surface after second-look arthroscopy, an average of 15 months after ACL reconstruction [4]. However, there is disagreement among investigators regarding whether cartilage injuries diagnosed at the time of the reconstruction will actually cause pain and functional limitation (such as symptomatic knee osteoarthritis) in the long-term. Using the KOOS score, Spindler et al. [20] found that the status of the articular cartilage preoperatively did not affect the clinical outcome for a minimum of 5 years after ACL reconstruction. The same results were found based on the same cohort, when it was examined at a mean of 12.5 years after the ACL reconstruction [13]. Shelbourne et al. compared two groups of patients with ACL reconstruction. One group had a full-thickness cartilage lesion; the other did not have any cartilage lesions [13]. At a mean of 8.7 years after the ACL reconstruction, they found that the group without cartilage lesions had significantly higher subjective scores as measured by International Knee Documentation Committee (IKDC) criteria and the modified Noyes subjective questionnaire [19]. Drogset and Grontvedt [9] found a statistically significant relationship between preoperatively detected cartilage injury and osteoarthritis in ACL-deficient knees 8 years after ACL reconstruction. However, the mean time between injury and surgery in their study was 3.5 years, indicating that degenerative changes of the knee due to a long period of time between the rupture and the reconstruction might already be manifest preoperatively.

Several studies have validated the use of knee function questionnaires for patients with cartilage defects. For the current study, we used a score that has been evaluated and validated for anterior cruciate ligament injuries. Both the KOOS and IKDC 2000 forms have been shown to be valid questionnaires for examining knee function in patients with cartilage injuries. The NKLR included the KOOS form and not the IKDC 2000 because the KOOS form is considered to be more user-friendly from a patient's perspective [11]. It is possible, but unlikely, that the use of other functional knee scores might have yielded a different result. However, no consensus exists regarding how to best evaluate combined ACL injuries and full-thickness cartilage defects. Hambly and Griva [12] compared the use of IKDC criteria and the KOOS in postoperative articular cartilage-repair patients. They found that the IKDC criteria provided the best overall measure. However, this study measured the outcome after cartilage-repair surgery. However, in the current study, we did not compare any treatment effects; rather, we compared preoperative function in two groups, one with and one without a full-thickness chondral defect.

Swirtun and Renstrom [21] found that associated articular cartilage injuries or meniscus injuries did not affect the outcome after 5.6 years in any of the subscales of KOOS. But the study did not report treatment procedures for the articular cartilage defect. Furthermore, in that study, patients were excluded if they had an articular cartilage defect of grade 3 or higher according to the Outerbridge Classification. Additionally, Swirtun and Renstrøm [21] reported that ACL-injured subjects with additional knee trauma had significantly worse outcomes, as measured by KOOS, than did those without additional knee trauma. These patients were excluded in the current study because this could have biased the effect of the chondral lesion.

Based on our findings in the current study, we question the rationale of treating cartilage lesions at the time of ACL reconstruction. If there are no differences in function in ACL-injured subjects with or without a full-thickness chondral defect, treatment of the cartilage lesion must be based on the rationale that it will prevent later degenerative changes in these knees rather than on the belief that it will improve present knee function. On the other hand, the available documentation does not support the notion that ACL reconstruction will postpone the development of osteoarthritis [15]. Furthermore, surgical procedures for cartilage repair simultaneously with ACL reconstruction will negatively affect the type and progression of rehabilitation. No consensus is available regarding the best rehabilitation after cartilage-repair operations, but in general these procedures require a longer nonweight-bearing period. A longer nonweight-bearing period is not considered to be the best method for rehabilitating ACL-reconstructed knees.

Some authors have proposed that severe bone bruise is indicative of early degenerative changes in the cartilage [16]. Hanypsiak et al. [13] followed a cohort for 12 years and found no correlation between the occurrence of bone bruise at the time of trauma and functional outcome several years later. Most bone bruises in ACL-ruptured knees occur in the lateral compartment [16]. In our subjects, we found that two-thirds of the cartilage lesions were in the medial compartment. These lesions did not result in a significant increase in knee symptoms. The high incidence of cartilage lesions in the medial compartment may be due to the jerk mechanism in episodes of pivot shift in the unstable knee [2]. ACL reconstruction typically stabilizes the knee; therefore, further aggravation of the cartilage lesion in the medial compartment may be reduced. It may also reflect that cartilage lesions sustained in ACL-injured knees at different times in the posttraumatic period can have different causes.

Intraarticular bleeding caused by ACL rupture may lead to initial healing of the cartilage injury due to the effect of the stem cells in the blood. Likewise, ACL reconstruction may partially treat the cartilage lesion by releasing stem cells and growth factors from the bone marrow during surgery. This could explain why cartilage lesions are not associated with pain and decreased knee function in follow-up visits after ACL reconstruction [19, 20].

One weakness of the current study is that a high number of orthopedic surgeons with variable experience in cartilage surgery provide data to the NKLR. This may reduce the accuracy of cartilage lesion grading and, thus, the data input in the registry. However, the accuracy of arthroscopic grading was investigated by Cameron et al. [7] who demonstrated that experience in arthroscopic surgery did not affect the results significantly; they were able to accurately grade cartilage lesions using a similar arthroscopic classification system. Registry data do have weaknesses; however, in other study designs, it would be difficult to obtain sufficient numbers of cases to isolate the chondral lesion as the only parameter. Another possible weakness would be the use of the KOOS as the only outcome measure if it is not reliable, valid, and responsive to changes in conditions, such as the meniscus and other ligament injuries, cartilage injuries, and osteoarthritis that often accompany an ACL rupture. However, the KOOS has been validated for a number of knee-related conditions, including, recently, the treatment of focal cartilage lesions [5]. Other authors have advocated the use of other knee outcome scores as more valid for cartilage lesions; however, there has been letters to the editor about the use of the KOOS outcome score in this study that question the conclusions made in the study by Hambly et al. [12, 18]. In the existing literature, the KOOS outcome is currently the most validated and useful knee outcome score, although this could change in the future [5].

The current study contributes important information regarding preoperative knee function in patients with ACL injury and full-thickness cartilage lesions. However, the current study does not evaluate the long-term consequences of a cartilage lesion. Orthopedic surgeons should consider preoperative knee function when deciding the treatment of cartilage lesions simultaneously with ACL reconstruction and remember that no association between preoperative symptoms and the cartilage lesion is proven in the ACL-rupture knee.

Conclusion

The combination of a full-thickness cartilage lesion and an ACL rupture did not result in inferior knee function at the time of the ACL reconstruction, as measured by the KOOS.

Acknowledgments We would like to thank the National Knee Ligament Registry in Norway, especially Kjersti Steindal, for providing the data for the current study. We also thank the Oslo Sports

Trauma Research Center and Eckboe's grant for support while conducting the study.

Conflict of interest statement None.

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