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Meniscal and articular cartilage lesions in the anterior cruciate ligament-deficient knee: correlation between time from injury and knee scores

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Abstract

Purpose Anterior cruciate ligament (ACL) rupture is associated with meniscal tears and/or articular cartilage damage. The aim of this study was twofold: (a) to report and correlate the incidence of meniscal and cartilage lesions in ACL-deficient knees with time from injury and (b) to correlate lesions of menisci and cartilage with widely used knee scores.

Methods Data were analysed from 109 consecutive patients with ACL rupture. Meniscal and articular cartilage lesions were documented during the arthroscopic reconstruction of the ACL. Patients were distributed into 3 groups according to time from injury; group A: 0–3 months (35 patients), group B: 3–12 months (39 patients) and group C: more than 12 months (35 patients). Lysholm, KOOS and IKDC rating scales were recorded preoperatively. Logistic regression analyses were applied to correlate the concomitant intra-articular pathologies with the time from injury and knee-rating scales.

Results Of 109 patients, 32 (29 %) had a medial meniscus tear, 20 (19 %) had a lateral meniscus tear, 17 (15 %) had both menisci torn and 40 (37 %) had no meniscal tear. Analysis revealed that time from injury was not a significant factor for the presence of a meniscal lesion. The odds of development of a high-grade cartilage lesion in an ACL-deficient knee reconstructed more than 12 months from time from injury are 5.5 and 12.5 times higher when compared with knees that underwent ACL reconstruction less than 3 months and between 3 and 12 months after knee injury, respectively. No association was found between intra-articular pathology and the KOOS and Lysholm scores. A positive correlation between the IKDC score and patients without any intra-articular pathology was found.

Conclusions The presence of high-grade cartilage lesions is significantly increased in an ACL-deficient knee when reconstruction is performed more than 12 months after injury. However, the incidence of meniscal tears is not increased significantly. Correlation of intra-articular pathology in ACL-deficient knees with knee-rating scales is weak.

Level of evidence Diagnostic study, Level II.

Keywords Anterior cruciate ligament · Meniscal tears · Cartilage lesions · Time from injury · Knee scores

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Introduction

The anterior cruciate ligament (ACL) rupture is commonly associated with meniscal tears and/or articular cartilage damage as a result of either the initial trauma or the following repetitive shear and rotational forces that are exerted upon a chronically unstable knee. The incidence of meniscal tears varies from 3.5 to 81 % depending on several factors such as age, time from injury and type and difficulty level of sports [8, 14, 19, 27–30, 35]. There is overall agreement that the incidence of meniscal tears rises as the time from injury (TFI) increases.

Similarly, the literature consistently supports an increasing incidence of cartilage injury with increasing TFI [6, 14,

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20, 23, 24, 32, 37]. Data from a cohort study of 3,475 patients gathered according to the design of the Norwegian National Knee Ligament Registry demonstrate that the possibility for a cartilage lesion to be present in the adult knee increased by nearly 1 % for each month that elapsed from the injury date up to the surgery date [14]. Considering that ACL injury affects young and active populations, those patients could be characterized as "young patients with old knees" [23, 24].

The border between "acute" and "chronic" ACL injuries and their classification, accordingly, into TFI groups varies in the literature [6, 7, 9, 13, 19, 30, 35]. However, there has been general consensus on the suggestion that ACL rupture should be managed in an early setting (at less than 3 months) rather than in a late phase, in order that the risk of meniscal tears is minimized [6, 9, 13, 18, 20, 30, 35]. Furthermore, the correlation of the reconstruction outcomes with the inhibition of the osteoarthritic changes is even more controversial [5, 8, 9, 11, 21–23, 25, 31].

The current literature does not point out whether the presence of additional intra-articular pathology in the ACL-deficient knee is always accompanied by low knee scores; the clinical significance of lesions can often be difficult to ascertain as the relationship between clinical symptoms, and the articular cartilage status is not always predictable [3, 16].

The aim of this study was twofold: (a) to report and correlate the incidence of meniscal and cartilage lesions in ACL-deficient knees with longer TFI and (b) to correlate lesions of menisci and cartilage with widely used knee scores. It has been primarily hypothesized that the rate of meniscal and cartilage lesions would be increased with longer TFI. Secondarily, it has been hypothesized that meniscal and cartilage lesions would correlate with knee scores.

Materials and methods

This prospective observational case series included 109 consecutive patients. All of them underwent ACL reconstruction between April 2009 and December 2010 at our department. All patients had a history of knee injury suggestive of an ACL tear and a positive Lachmann and/or pivot shift test. A 3.0-T MRI was performed preoperatively to all knees, and the presence of the ACL tear was confirmed during arthroscopy.

The inclusion criteria were as follows: (a) the presence of an ACL rupture in the affected knee established both clinically and through MRI imaging, (b) absence of previous knee surgery, (c) skeletal maturity and (d) absence of other ligamentous injury or lower limb malalignment. The exclusion criteria were as follows: (a) age more than 55 or less than 15 years, (b) body mass index (BMI) more than 30, (c) previous major injury in the lower extremities and (d) rheumatic diseases or psychosocial disorders.

Patients were divided into 3 groups according to TFI: group A: 0–3 months, group B: 3–12 months and group C: more than 12 months.

Evaluation forms

Self-reported questionnaires were filled in by the patients on the day prior to surgery.

The KOOS is a 42-item self-administered knee-specific questionnaire based on the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) [1, 12, 33]. It comprises 5 subscales (pain, symptoms, daily activities, sports and recreation activities and knee-related quality of life), each scoring from 0 to 100, with 100 representing the best result.

The Lysholm knee score index was also used to evaluate the knee function [36]. Individual scores were added up for locking, instability, pain, swelling, limp, walking aid or decreased ability to climb stairs and squat. The highest obtainable score is 100.

Lastly, the IKDC knee evaluation form [15] assessed symptoms, sports activities and function/activity of daily living, reserving a maximum of 100 points for the totally healthy knee (numerical). The addition of data from the clinical examination and radiography made a distinction among "normal", "nearly normal", "abnormal" or and "severely abnormal" knees (quantitative).

Surgical technique and documentation

Patients were operated on under general, spinal or regional anaesthesia. Standard arthroscopic portals including an anterolateral and an anteromedial portal were used in all of the cases. A thorough evaluation of the joint was performed in every case by using the anterolateral portal as a viewing portal and the anteromedial as a working portal (using a probe). Rupture of the ACL was assessed and confirmed arthroscopically using a probe. Both menisci were examined, and tears were classified as horizontal, vertical, bucket handle or complex. Similarly, articular cartilage lesions were graded (0–4) according to the ICRS classification [3]. The articular surfaces of the knee were divided into five regions: patellofemoral groove (PFG), medial femoral condyle (MFC), medial tibial condyle (MTC), lateral femoral condyle (LFC), lateral tibial condyle (LTC) and documented on a mapped grid after surgery. Multiple compartment involvement was recorded, and in the presence of more than one cartilage lesions, the one with the highest grade was used for the knee classification. Finally, after diagnostic arthroscopy, ACL reconstruction was performed using a semitendinosus/gracilis or a bone-tendon-bone patellar autograft. Peripheral meniscal tears (red–red or red–white zone) and longitudinal tears were treated with a meniscal repair. A partial meniscectomy was performed when a tear was present in the white–white zone area and in cases of degenerative and complex tears (Fig. 1). No treatment was provided for grade I and II cartilage lesions. Removal of degenerative chondral flaps and microfracture of the exposed subchondral bone was performed for grade III and IV lesions (Fig. 2). The majority of the operations were performed by the same surgeon.

Informed consent was obtained from all patients prior to surgery, and the study was approved by the institutional review board of the University Hospital Larisa.

Statistical analysis

Linear, logistic and multinomial logistic regression models were used in order to assess the significance of factors in the various models among the different groups of patients, the intra-articular pathology including meniscal tears and cartilage defects, the TFI, and multiple clinical questionnaires that assessed all patients preoperatively. Stepwise procedure was employed to find the best models describing the data at hand.

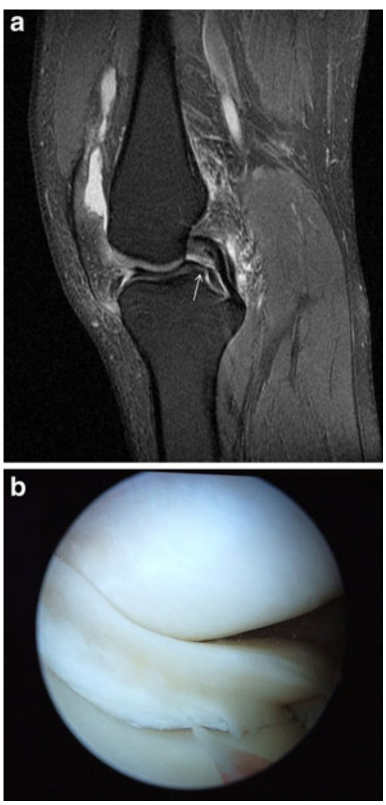

Fig. 1 **a** Sagittal intermediate-weighted MR image with fat suppression depicts displaced meniscal fragment (*arrow*) into the intercondylar notch from a bucket-handle tear of the medial meniscus forming a double PCL. **b** Corresponding arthroscopic image

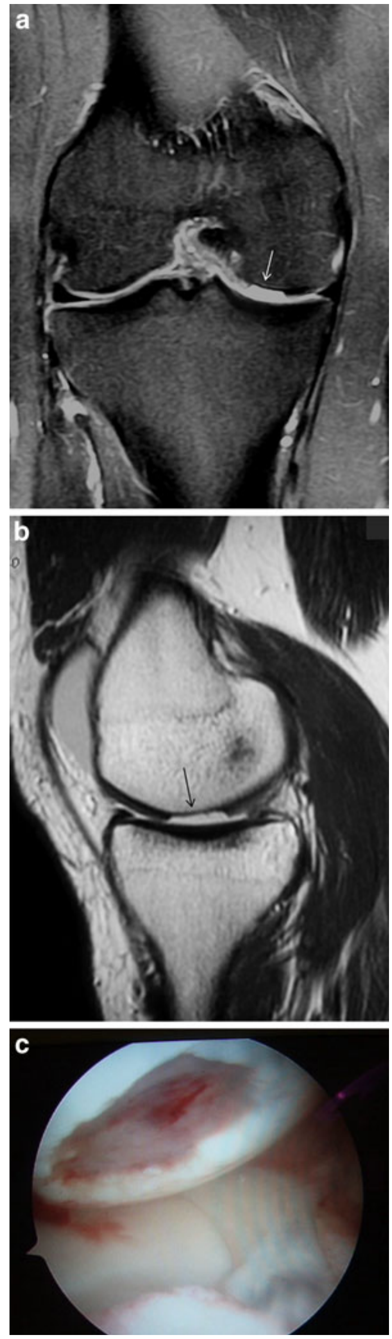

Fig. 2 **a** Coronal intermediate-weighted MR image with fat suppression and **b** sagittal T2-weighted image from the same patient show a full-thickness cartilage tear of the medial femoral condyle (*arrow*). **c** Corresponding arthroscopic image

Predictors with a value of $p < 0.05$ were considered to be statistically significant. Results were described using 95 % confidence intervals (CI), which depict an estimated accuracy of a statistical index. The R Project for statistical analysis software v.2.14.2 and its supplementary package MASS were used to compute all statistical indices.

Results

One hundred and nine patients were included in the study. Group A consisted of patients that underwent surgery within the first 3 months after injury ($n = 35$, months $= 1.95 \pm 0.8$), group B of patients that underwent surgery between the 4th and 12th months after injury ($n = 39$, months $= 6.9 \pm 2.4$) and group C patients had a surgery after the 12th month from injury ($n = 35$, months $= 59.4 \pm 63.8$). The cause of the ACL injury was a knee injury that occurred during soccer playing (50 %), basketball playing (17 %), a car/motorcycle accident (15 %), skiing (10 %) and domestic falls/other sports (8 %). The 3 groups were homogenous regarding distribution of male and female patients, side affected, age and BMI (Table 1).

Meniscal tears incidence and time from injury

Thirty-two out of 109 patients (29 %) had a medial meniscus tear, 20 (19 %) had a lateral meniscus tear, 17 (15 %) had both menisci torn, while 40 (37 %) had no meniscal tear. The distribution of meniscal lesions in each group is shown in Table 2. However, logistic regression analysis revealed that TFI was not a significant factor to account for the presence of a meniscal lesion (n.s). For the overall population of our study group, the estimated odds of having a meniscal tear at the medial meniscus seem to increase by 6 % (1.06, CI 1–1.13), while the odds of developing a meniscal tear at the lateral meniscus increase by merely 1 % (1.01, CI 0.95–1.08) for each year of increase. Also, the odds of having a bilateral meniscal tear increase by almost 10 % (1.09, CI 1.02–1.16) for each year of increase.

Articular cartilage lesions incidence and severity versus time from injury

The absence of cartilage lesion was higher in groups A and B (63 and 62 %, respectively), in comparison with group C (26 %), and this difference was statistically significant ($p < 0.05$). Remarkably, grade-IV lesions (cartilage destruction and exposure of the subchondral bone) were noticed only in group C patients (Table 3). For patients with grade III and IV cartilage defects, both TFI ($p < 0.01$) and patient age ($p < 0.01$) were found to be statistically significant factors. Our analysis showed that the odds of having a grade-III/IV lesion increase by 6 % (1.06, CI 1.02–1.14) for 1 year of increase in age. The odds of having a grade-III/IV lesion decrease by a factor of 0.46 from group A to group B, while the odds of having a grade-III/IV lesion increase by a notable factor of 5.52 from group A to group C. Finally, the estimated odds of developing a grade-III/IV lesion from group B to group C show an impressive 12-fold increase (12.5).

Regarding the topographic distribution of cartilage lesions, the medial and lateral femoral condyles were affected in the vast majority of the cases. Isolated medial tibial plateau and lateral tibial plateau lesions were not documented, while the presence of cartilage damage in more than one compartment was recorded for a total of 20 (18 %) patients (Table 4). Seventy-five per cent of patients with multi-compartmental lesions belonged to group C.

A logistic regression analysis was used to evaluate the relationship between patients with either mono- or multi-compartmental lesions and TFI. Our analysis indicates that there is a linear TFI incremental effect ($p < 0.001$). The odds of having multi- versus mono-compartmental lesions

Table 1 Demographic data of the patients

Time post-injury	Patients	Male	Female	Mean age	Mean BMI	R/L
0–3 months	35	31	4	26	26.4	22/13
3–12 months	39	34	5	24.1	24.6	26/13
>12 months	35	31	4	29.6	25.9	27/8
Total	109	96	13	26.4	25.6	75/34

Table 2 Distribution of meniscal tears according to time from injury

Meniscal tear	TFI (months)			Total
	Group A (0–3)	Group B (3–12)	Group C (>12)	
MM	10 (29 %)	9 (24 %)	13 (38 %)	32
LM	9 (26 %)	6 (15 %)	5 (13 %)	20
Both	3 (8 %)	6 (15 %)	8 (23 %)	17
No tear	13 (37 %)	18 (46 %)	9 (26 %)	40
Total	35	39	35	109

Table 3 Distribution of cartilage lesions according to time from injury

Grading	TFI (months)			Total
	Group A (0–3)	Group B (3–12)	Group C (>12)	
0	22 (63 %)	24 (62 %)	9 (26 %)	55
I + II	9 (26 %)	13 (33 %)	10 (28 %)	32
III + IV	4 (11 %)	2 (5 %)	16 (46 %)	22
Total	35	39	35	109

ICRS Classification System of cartilage lesions. Grade 0: normal, Grade I: intact surface but fibrillation and softening is present (1a) or superficial fissures and laceration are present (1b), Grade II: defects that involve <50 % of the cartilage thickness, Grade III: defects that extend through >50 % of the cartilage thickness, Grade IV: cartilage defects that extend into the subchondral bone increase by a factor of approximately 4.28 from group A to group C. The same holds when comparing group B to group C.

Preoperative scores and intra-articular pathology

The preoperative scores in the 3 main groups according to TFI are depicted in Table 5. ACL-deficient patients have been further divided into four dichotomous subgroups: patients with high-grade (grade-III and/or grade-IV) cartilage defects, patients with cartilage lesions (grade I–IV) and meniscal tears, patients with meniscal tears only and patients without intra-articular pathology, in order to find any possible correlation between the subgroups and the preoperative scores (Table 6).

Patients with ACL tear and high-grade cartilage defects (III–IV)

A multivariate logistic regression analysis revealed that the IKDC score had a small negative effect of 0.7 % on the odds ratio [OR = 0.991, CI (0.987, 0.999)] for this subgroup of patients.

The Lysholm and KOOS scores were not found to be statistically significant (n.s).

Patients with ACL tear, meniscal tears and cartilage lesions

Those meniscal tears and cartilage lesions (grade I–IV) appeared not to relate with any of the Lysholm, KOOS and IKDC scores (n.s).

Patients with ACL tear and meniscal tears

A multivariate logistic regression analysis revealed that Lysholm, KOOS and IKDC do not appear to be statistically related to meniscal tears (n.s).

Table 4 Topographic location of cartilage lesions

Location	TFI (months)			Total
	Group A (0–3)	Group B (3–12)	Group C (>12)	
MFC	7	5	7	19
LFC	4	3	4	11
MTP	0	0	0	0
LTP	0	0	0	0
PFG	0	4	0	4
Multiple	2	3	15	20

Patients with ACL tear and absence of intra-articular pathology

Patients without intra-articular pathology seem to be invariant to the Lysholm and KOOS scores (n.s). On the other hand, the IKDC preoperative score proved to be a good indicator ($p = 0.018$) as it had a positive effect of 3.9 % on the odds ratio [OR = 1.039, CI (1.007, 1.076)] for every unit of increase registered in the IKDC scale.

Discussion

The most important finding of the present study was that the incidence of intra-articular pathology, and particularly of high-grade cartilage lesions, increases with TFI, with 12 months being a critical landmark for the ACL reconstruction. The second important finding was that the preoperatively used knee evaluation scores do not seem to correlate with meniscal and cartilage lesions in an ACL-deficient knee.

More specifically, articular cartilage lesions were present in 49 % of the ACL-deficient knees and both number and (more importantly) grading of lesions increased with longer time from injury. Group C patients were found to have 5.5 times higher possibility to develop a high-grade cartilage lesion (grade III and grade IV) as compared with Group A patients, and 12.5 times higher when compared with Group B ones. Since high-grade cartilage lesions are indicative of irreversible knee degeneration, and they are strongly correlated with TFI, we believe that ACL reconstruction at no later than 12 months from injury is mandatory in order that we could prevent knee degeneration. Maffulli et al. [26] found 43 % prevalence of articular cartilage lesions in a case series study of 378 patients with ACL-deficient knees, while Granan et al. [14] reported a corresponding 26 % in a cohort study of 3,475 patients based on the Norwegian National Knee Ligament Registry. Even lower percentages (19 %) were reported in a retrospective multicenter study of 764 patients from Turkey [35]. A systematic review by Brophy et al. [4] which included 5 studies suggests that the incidence of severe articular cartilage injury in acute ACL tears ranges between 16 and 46 %. Flanigan et al. [10] evaluated the prevalence of chondral defects in athletes in a systematic review of 11 studies and found an overall prevalence of full-thickness defects of 36 % (range 2.4–75 % in all studies). Increase in number and grade of cartilage lesions with TFI is a consistent finding in many studies [4, 6, 14, 20, 23, 24, 26, 32, 37].

In addition, it has been noticed that approximately one-third of our patients in the chronic group had multi-compartmental lesions. According to our analysis, the odds of

Table 5 Preoperative knee scores in the 3 main groups of ACL-deficient patients

	Time from injury (in months)			Total
	Group A (0–3) ($n = 35$)	Group B (3–12) ($n = 40$)	Group C (>12) ($n = 35$)	110
Scores				
Lysholm	69.7	81.5	74.3	75.2
IKDC (numerical)	59.1	76.4	64.1	66.5
IKDC (qualitative)				
Normal	0	0	0	0
Nearly normal	3	17	6	26
Abnormal	21	20	21	62
Severely abnormal	11	3	8	22
KOOS	77.1	84.6	82.3	81.3

Table 6 Preoperative knee scores in the four subgroups of ACL-deficient patients

Scores	Group A ($n = 22$)	Group B ($n = 43$)	Group C ($n = 27$)	Group D ($n = 28$)
Lysholm	67	70	70	72
IKDC	57	61	59	66
KOOS	77	80	79	82

Group A: patients with high-grade (grade-III and/or grade-IV) cartilage defects

Group B: patients with cartilage lesions (grade I–IV) and meniscal tears

Group C: patients with meniscal tears only

Group D: patients without intra-articular pathology

having multi-compartmental lesions are approximately 4 times higher for the chronic group in comparison with acute and sub-chronic groups, which is in accordance with other studies [32, 37].

The incidence of overall meniscal tears that has been documented in the present study was 63 % (29 % for medial meniscus, 19 % for lateral meniscus and 15 % for both menisci), which is consistent with data from other studies [8, 19, 28, 30, 35]. Although the total incidence of meniscal tears and the bilateral meniscal involvement were higher in knees reconstructed at more than 12 months from injury, these differences among the 3 subgroups were not statistically significant. The rate of meniscal tears in ACL-deficient knees varies from 3.5 to 81 % in the literature [9, 13, 14, 19, 28–30, 35]. Papastergiou et al. [30] reported an incidence of 55.7 % (25 % for medial meniscus, 17 % for lateral meniscus and 14 % for both menisci). This study divided patients into 6 groups, namely with reconstruction time at 1.5, 3, 6, 12 and 24 months from TFI. According to their findings, a significantly higher incidence of meniscal tears in patients undergoing ACL reconstruction at more than 3 months after the injury was observed, which is different from our findings. Similarly, Tandogan et al. [35] and Church and Keating [6] reported an increased incidence of meniscal tears in patients undergoing ACL reconstruction after 12 months as compared with those in the early group (at less than 12 months). Through this short review, it seems that a common landmark is set for 12 months post-injury. Adjusting our findings to this time-point, meniscal tear incidence for the "0–12 months" group is 55 %, and for the "more than 12 months" group, 74 %. These findings are in accordance with the results obtained in the aforementioned studies. In all periods of our study, we documented a higher incidence of medial meniscus tears than lateral meniscus, which coincides with the results of Tandogan et al. [35] but not with those of Cipolla et al. [7], who noticed that lateral meniscal tears were significantly more frequent than the medial meniscus tears in the acute phase. Finally, similarly to other studies, we found that patient age is a significant factor, which accounts for the incidence of medial and bilateral meniscal tears [36].

Three assessment tools have been selected for the present study based on the study by Garratt et al. [12]. This review of 16 knee-specific patient-assessed health instruments concludes that KOOS, the Lysholm knee score and the IKDC evaluation form present—along with other 4 instruments—good evidence of reliability, validity and responsiveness. As suggested by our analysis, the correlation of intra-articular pathology in ACL-deficient knees with widely used knee-rating scales is weak. In other words, preoperative prediction of intra-articular pathology (meniscal and cartilage lesions) in an ACL-deficient knee is not possible using the above-mentioned knee-rating scales. More specifically, no association was found between the KOOS and Lysholm scores among patients with meniscal lesions, high-grade cartilage lesions, meniscal and cartilage lesions, and patients without intra-articular pathology. Similarly, Hjermundrud et al. [16] found no differences between ACL-injured subjects with or without full-thickness chondral defects, who were assessed preoperatively by the KOOS. The IKDC rating scales were found to have a small negative effect of only 0.7 % in patients with high-grade cartilage lesions. However, no correlation was found between the IKDC, the patients with meniscal tears and the patients with meniscal and cartilage lesions. A positive correlation was recorded between the IKDC score and the patients without intra-articular pathology. As suggested from our results, the IKDC numerical subjective evaluation form could be more sensitive/indicative in detecting patients with high-grade cartilage lesions or patients without intra-articular pathology. Although these scores have been used to quantify the disability among patients which suffer mainly from ACL tears, the hypothesis of whether meniscal and cartilage lesions would correlate with knee scores has been tested. Similarly to other authors, we found that those knee scores are less reliable and valid when applied to evaluate other knee conditions except for ACL reconstruction outcomes [2, 17, 34].

The current study tries to provide additional information about the controversial issue of timing in ACL reconstruction and suggests that preoperatively knee evaluation forms should be a complementary rather than a diagnostic and predictive tool in the day by day clinical work.

The strong points of our study are that the majority of cases were operated by one experienced surgeon, and cartilage and meniscal lesions were recorded and graded ion a prospective basis during arthroscopy and not later by use of the video. The limitations on the other hand are the small number of patients, and like other similar studies, the fact that episodes of "giving way" or instability, especially in sub-acute and chronic groups, were not recorded, and therefore, it is difficult to determine whether meniscal and cartilage lesions in those group of patients were the result of the initial trauma or not.

Conclusions

It has been demonstrated in the present study that the odds of development of a high-grade cartilage lesion (grade III and IV) in an ACL-deficient knee reconstructed at more than 12 months from TFI are 5.5 and 12.5 times higher when compared with knees that underwent ACL reconstruction at less than 3 months and between 3 and 12 months after the knee injury, respectively. However, the incidence of meniscal tears was not statistically significant among the 3 subgroups. In addition, the KOOS and the Lysholm knee evaluation forms that have been used for the preoperative evaluation do not seem to provide the surgeon with the predictive information about any additional intra-articular pathology and the ideal time-point for ACL reconstruction.

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