Traumatic Patellar Dislocation and Cartilage Injury – A Follow-Up Study of Long-Term Cartilage Deterioration

Salonen EE[1] M.D., Magga T[2] M.D., Sillanpää PJ[3] M.D. Ph.D., Kiekara T[2] M.D., Ph.D., Mäenpää H[1] Adj. Prof, Mattila VM[1] Prof

[1]Department of Orthopedics, Unit of Musculoskeletal Surgery, Tampere University Hospital, Finland

[2] Medical Imaging Centre, Tampere University Hospital, Finland

[3]Dextra Hospital, Tampere, Finland

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Abstract

Background: Patellofemoral cartilage deterioration and osteoarthritis are reported to be associated with recurrent patellar dislocation. However, association between first-time traumatic patellar dislocation and cartilage deterioration is unknown.

Purpose: The aim of this study was to assess long-term cartilage deterioration in the patellofemoral and tibiofemoral joint after conservatively treated traumatic lateral patellar dislocation.

Study Design: Case series.

Methods: 20 patients (mean age 25 years) who sustained first-time traumatic lateral patellar dislocation with no previous patellofemoral instability symptoms were initially scanned with 1.5 Tesla magnetic resonance imaging. A follow-up 3 Tesla magnetic resonance imaging was conducted on average 8 years after first-time lateral patellar dislocation. Subjective instability symptoms and Knee Injury and Osteoarthritis Outcome Score were also assessed.

Results: In the primary magnetic resonance imaging, patellofemoral cartilage injury was seen in 14 of 20 patients (70%). Most (14/15) of the injuries were seen in the patellar cartilage, especially at the medial facet. In the follow-up magnetic resonance imaging, patellofemoral cartilage deterioration was visible in all patients. The central patella (p=0.005) seemed especially prone to cartilage deterioration during the follow-up. Half of the patients (10/20) had grade III-IV cartilage lesions in patellofemoral joint in follow-up magnetic resonance imaging. In the primary MRI only one patient exhibited TF joint cartilage lesions, whereas at the time of follow-up 10 of 20 patients exhibited TF cartilage lesions. The majority of these lesions were considered clinically non-significant (ICRS = 1) and were seen in the lateral compartment (6/10, 60%). Of the 14 patients (36%) with injury to the patellar cartilage, 5 reported subsequent instability of the patellofemoral joint, but this was not associated with more significant cartilage deterioration in the follow-up magnetic resonance imaging compared to patients without re-dislocation.

Conclusion: While recurrent lateral patellar dislocation is known to lead to degenerative process, also a single first-time or infrequently repeated traumatic lateral patellar dislocation seems to be associated with gradual cartilage deterioration. Traumatic lateral patellar dislocation might initiate gradual degeneration of the cartilage in the patellofemoral joint and can lead to the development of generalized knee osteoarthritis. Instability symptoms of the patellofemoral joint however were not related to the severity of the deterioration.

Key terms: lateral patellar dislocation, cartilage deterioration, patellofemoral osteoarthritis, knee osteoarthritis, patellofemoral instability

What is known about the subject: While the long-term prognosis of cartilage deterioration after conservatively treated traumatic lateral patellar dislocation has not been studied, anterior cruciate ligament tear causes cartilage deterioration over the long-term in both conservatively- and surgically-treated patients.

What this study adds to existing knowledge: Cartilage deterioration tends to progress over time after single or infrequently repeated traumatic patellar dislocation. Some patients also develop magnetic resonance -based osteoarthritic changes in compartments other than the patellofemoral joint in the knee. Instability symptoms of the patellofemoral joint are not related to the severity of deterioration.

Introduction

Traumatic lateral patellar dislocation (LPD) is a common injury in young, physically active adults [16, 19, 23]. It is the second most common cause of hemarthrosis of the knee. Diagnosis of traumatic LPD is based on clinical examination and magnetic resonance imaging (MRI). Bone bruise in the medial patellar facet and lateral femoral condyle, and medial patellofemoral ligament (MPFL) tear confirm the diagnosis of traumatic LPD [5, 12, 22]. Concomitant cartilage injury in the patellofemoral (PF) joint after traumatic LPD occurs in 71% to 95% of patients [5, 10, 19, 22, 24]. Osteochondral fractures of the PF joint are seen in 25% of LPD patients [19].

PF cartilage deterioration and PF osteoarthritis are observed in patients with recurrent patellar dislocation [8, 9, 18]. No published data exists about cartilage deterioration after a single fist-time traumatic patellar dislocation episode. It is unclear whether cartilage is worn over time due to recurrent episodic dislocations or to the initial trauma of the primary LPD. It has been suggested that acute bone bruise causes traumatic changes and affects chondrocyte metabolism, resulting in the development of local cartilage deterioration and osteoarthritis [3, 12, 24]. The clinical significance of cartilage changes is controversial, but it is assumed that these changes cause symptoms and lead to decreased physical activity [1, 6, 7, 17].

While the association between LPD and cartilage injury has not yet been thoroughly studied, another common knee injury, anterior cruciate ligament (ACL) tear, causes cartilage deterioration over the long-term. Within 5 to 15 years after ACL tear, 40% to 90% of patients exhibit osteoarthritic changes in the injured knee [4, 13]. ACL reconstruction does not seem to prevent deterioration of the cartilage [11]. It is unclear whether similar changes occur in the cartilage after traumatic LPD.

To our knowledge, there are no studies assessing the long-term prognosis of cartilage deterioration after traumatic conservatively treated LPD. The role of primary injury in the progression of local PF

cartilage deterioration is unknown. We hypothesized that a single first-time or infrequently repeated traumatic LPD initiate degeneration of the cartilage in the PF joint and may lead to the development of generalized knee osteoarthritis, similar to ACL injury.

The aim of this study was to assess long-term cartilage deterioration in the PF and TF joints after conservatively treated a single first-time or infrequently recurrent traumatic LPD. We examined the progression in the depth and size of local cartilage defects and whether some patients exhibit osteoarthritic changes in all three compartments of the knee. We also examined the association between cartilage deterioration and clinical symptoms.

Materials and Methods

During the years 2005-2007 at the study hospital, patients with a single first-time traumatic LPD were recruited to the study to evaluate bone bruise and cartilage injury in the PF joint (23 patients). To be included in the study, patients had to be skeletally mature and without previous PF joint instability symptoms. Patients with significant knee injury other than MPFL tear or previous knee surgery were excluded. Primary MRI (1.5T) was performed within 70 days after LPD to confirm the clinically suspected diagnosis. For a diagnosis of traumatic LPD, a MPFL tear and bone bruise on the medial patellar and lateral femoral condyle had to be identified in MRI. The MPFL tear was categorized as patellar insertion, femoral insertion or at midsubstance region based on injury location. The first-year MRI results of bone bruises have been published previously [12].

The patient cohort was followed for an average of 8 years after LPD. One patient in the primary cohort underwent ACL reconstruction during the follow-up and two declined to continue in the study. Thus a total of 20 patients underwent follow-up MRI (mean age 25 years, range 19-45 and mean body mass index 26, range 21-38). Physical activity before the injury and after 8-year follow-up was assessed. All patients were young and healthy and were considered not to have any significant predisposing anatomic abnormalities that are well-known risk factors for patellar dislocation (e.g., patella alta, high-grade trochlear dysplasia, or increased tibial tubercle-trochlear groove distance over 20 mm).

After the single first-time LPD, all patients were treated conservatively. Knee brace with non-restricted range of motion was advised to use up to four weeks for a patient comfort. Full weight bearing as tolerated was allowed immediately and patients were advised to perform knee extension exercises. An appointment with a physiotherapist was conducted at four weeks after the trauma and gradual quadriceps muscle strengthening exercises and light running was allowed. Participation in contact sports was allowed to start at three months. The patients were clinically examined by an

orthopedic surgeon at four weeks and at three months after first-time LPD to evaluate the initial recovering period and time to safely return to play.

MR imaging

The primary MRI scans were performed with a 1.5T Signa Excite HD imager (GE Healthcare, Milwaukee, WI) between June 2005 and May 2007, and previously published by Paakkala et al [12].

The follow-up MRI scans were performed between November 2013 and December 2014 using a 3T MRI scanner (Siemens Magnetom Skyra 3T XQ -grad, Siemens Healthcare, Erlangen, Germany). The images were acquired with a 15-channel receiver/transmitter extremity coil except for one patient who was scanned with a body coil due to excessive knee girth. The 3T MRI sequences and their parameters are shown in Table 1.

Table 1. 3T MRI sequences and parameters for long-term evaluation of cartilage injury. Sag sagittal, Cor coronal, Ax axial, TSE turbo spin echo, SE spin echo, FS fat saturation, TR time to repeat, TE time to echo, NEX number of excitations, FOV field of view

	TR (ms)	TE (ms)	NEX	Slice Thickness / gap (mm/mm)	Matrix	FOV (cm)
Sag PD TSE	3030	19	1	2.5 / 0.25	404 x 448	15
Sag PD TSE FS	4110	54	1	3.0 / 0.6	346 x 384	15
Cor PD TSE FS	3590	28	2	3.0 / 0.3	404 x 448	16
Cor T1 SE	750	12	2	2.5 / 0.25	358 x 448	14
Ax PD TSE FS	4990	41	1	3.5 / 0.35	384 x 384	15

MRI evaluation

The primary and follow-up MR images were evaluated on a PACS workstation (Carestream VuePacs v11.14) by two musculoskeletal radiologists both with 7 years of experience in knee MRI. The radiologists were blinded to the clinical data. The data was evaluated independently and in case

of disagreement consensus was reached. The cartilage of the patella and trochlear groove were dived into three subregions as previously described [25] (Figures 1 and 2). The TF joint cartilage was divided into eight subregions: the anterior medial femoral condyle, central medial femoral condyle, posterior medial femoral condyle, anterior lateral femoral condyle, central lateral femoral condyle, posterior lateral femoral condyle, medial tibial condyle, and lateral tibial condyle (Figure 3). The patellofemoral and tibiofemoral articular cartilages were assessed for defects according to Brittberg and Winalski [2] (modified ICRS classification) in consensus by the two radiologists.

Figure 1. Left knee. Axial proton density-weighted 3T MR image with fat saturation (PD fat sat) showing patellar cartilage divided into three subregions: medial facet (1), central patella (2), and lateral facet (3).

Figure 2. Right knee. Axial PD fat sat image at the level of the trochlear cartilage. Cartilage is divided into three subregions: medial third (1), central third (2), and lateral third (3).

Figure 3. Sagittal plane PD fat sat image of the lateral compartment of the tibiofemoral joint. The joint surfaces are divided into four subregions with two lines parallel to the anterior and posterior border of the meniscus.

Clinical assessment and follow-up

Clinical symptoms of the patients were assessed using the Knee injury and Osteoarthritis Outcome Score (KOOS) questionnaire [14, 15] at the time of 8-year follow-up. Before first-time LDP patients were non-symptomatic of any kind of knee complaints. Patients were invited to sign an agreement for clinical follow-up and 14 of the 20 patients responded and completed the KOOS questionnaire. In addition, the 14 patients were interviewed by telephone between April and May 2015. The interview included an assessment of PF joint instability symptoms, re-dislocations, and level of physical activity before first-time LPD and after 8-year follow-up using Tegner classification [20]. Results of the KOOS were analyzed as described elsewhere by Roos et al [14, 15].

Statistical analysis

The Wilcoxon test was used to evaluate differences in nonparametric ordinal data between the groups, and an independent-samples t test was used to assess differences in the continuous normally distributed data between the groups. Differences in the two-way tables were determined with Pearson's chi-square test or Fisher's exact test when the expected cell count was less than five. A p value of 0.05 was considered statistically significant. SPSS 22.0 for Windows software (SPSS, Chicago, Illinois) was used for the statistical analysis.

The study was approved by the Human Ethics Committee of the local research institute (D.nr. 05024) and conducted according to the Declaration of Helsinki.

Results

During the recruiting period, a total of 23 patients met the inclusion criteria and were enrolled to the study. 20 patients (7 males, 13 females) underwent follow-up MRI between September 2013 and May 2014. Mean patient age was 25 years (range 19-45 years) at the time of injury and 34 years (range 26-53 years) at the follow-up. Mean body mass index at the time of a single first-time LPD was 26 (range 21-38). Physical activity of the patients was assessed by using Tegner classification. Mean Tegner level (scale 0 to 10) was on average 6 before primary LPD (range 4-7) and 5 after 8-year follow-up (range 2-7). The primary MRI in years 2005-2007 was performed on average 24 days (range 10-69 days) after a single first-time LPD while the follow-up MRI was performed on average 8 years (range 7 years 6 months - 9 years 2 months) after the initial LPD.

In the primary MRI, all the patients exhibited MPFL injury in at least two of the three locations (patellar insertion, femoral insertion or midsubstance area). Of the 20 patients, 6 had totally disrupted MPFL and rest 14 had multiple partial disruptions. There were 18 injuries of the patellar MPFL insertion, 18 injuries of the midsubstance MPFL, and 19 injuries of the femoral MPFL insertion.

In the primary MRI, cartilage injury of the PF joint was seen in 14 of 20 patients (70%). Most (14/15) of the injuries were seen in the patellar cartilage and especially the medial facet (Table 2, Figure 4A). As the requirement to be included in the study was a MPFL tear, all the patients had MPFL injuries in various locations, indicating acutely sustained traumatic LPD. No other concomitant ligamentous injury was observed among the included patients.

Table 2. Patellar cartilage injury in initial and follow-up MRI. Patellofemoral joint is divided into six subregions [25] and articular cartilages were assessed for defects according to the ICRS classification in consensus by the two radiologists.

	Primary MRI (N=20)		**Follow-up MRI (N=20)**		**p-values**
Patellofemoral cartilage subregion	**Cartilage injury, number of patients**	**Median ICRS (range 0-4)**	**Cartilage Injury, number of patients**	**Median ICRS (range 0-4)**	
Patella lateral facet	6/20 (30%)	0	16/20 (80%)	1	0.003
Central patella	10/20 (50%)	1	20/20 (100%)	3	0.005
Patella medial facet	12/20 (60%)	1	16/20 (80%)	3	0.163
Trochlea lateral	0/20 (0%)	0	6/20 (30%)	0	0.026
Trochlea central	1(20) (0,5%)	0	5/20 (25%)	0	0.167
Trochlea medial	1/20 (0,5%)	0	4/20 (20%)	0	0.109

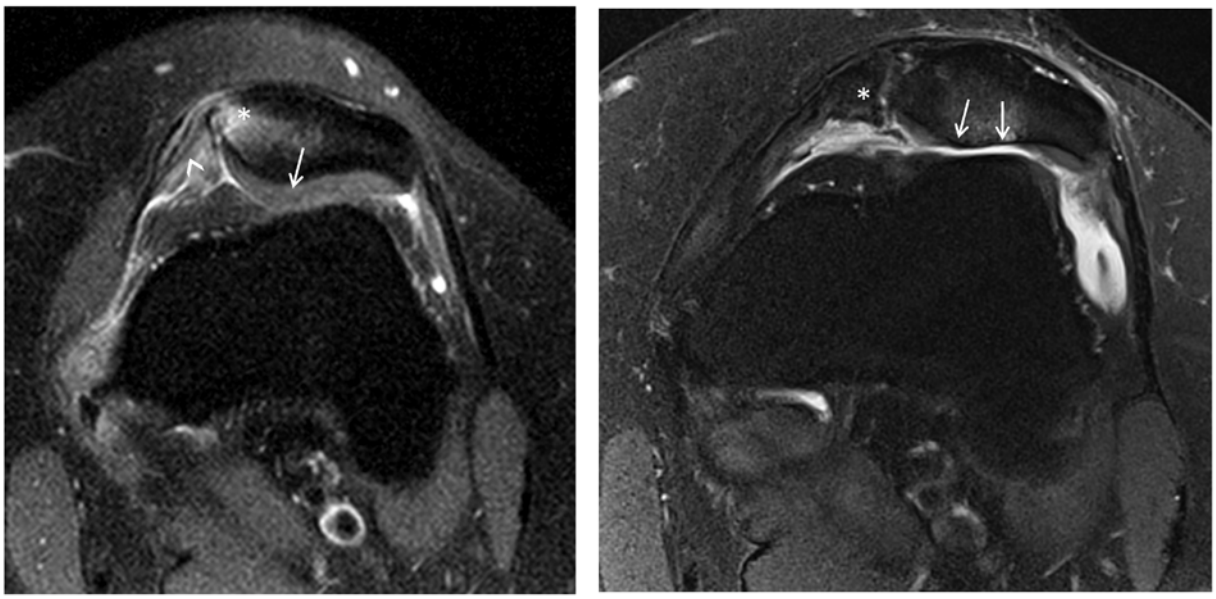

Figure 4 A-B. 26-y-old female with acute traumatic LPD. Axial PD fat sat image. On primary MRI (A,above), bone bruise is visualized in the medial patella (asterisk) along with partial disruption of the patellar insertion of the MPFL (arrowhead), confirming traumatic LPD. The patellar cartilage appears normal (thin arrow). Follow-up MRI (B, below) showing severe cartilage deterioration at the central patella and lateral facet with subchondral bone edema (thin arrows). Ossification is observed at the patellar insertion of the MPFL (asterisk).

In the follow-up MRI, all the primary PF cartilage injuries were still evident. In addition, those patients without cartilage injury at the primary MRI had all developed varying degrees of cartilage damage in the PF joint (Figure 4B). In the follow-up MRI, PF cartilage deterioration was visible in all 20 patients (100%). The central patella ($p = 0.005$) and lateral patellar facet ($p = 0.003$) were especially prone to cartilage deterioration during the follow-up. Of 20 patients, 12 (60%) had ICRS III-IV cartilage lesions in at least one section of the PF joint in the follow-up MRI. Of these 12 patients, 6 had local full-thickness cartilage damage with bone edema underneath the deteriorated surface (ICRS IV). The most severe injuries were all located at the patellar cartilage. Of 20 patients, 3 (15 %) had grade III deterioration in the cartilage of the lateral femoral condyle.

Concerning the TF joint, in the primary MRI only one patient exhibited mild TF joint cartilage lesions, whereas at the time of follow-up 10 of 20 patients exhibited TF cartilage lesions. The majority of these lesions were considered clinically non-significant (ICRS = 1) and were seen in the lateral compartment (6/10, 60%).

One male patient, aged 30 years exhibited severe TF and PF changes at the time of follow-up MRI, but not at the time of primary MRI, indicating progression of osteoarthritic disease of the whole knee joint (Figure 5 and 6, Table 3). Prior to the first-time traumatic LPD, the patient was recreational soccer and floorball player (Tegner 7). At the 8–year follow-up he was visiting gym every now and then, but knee pain prevented him to run more than one kilometer continuously (Tegner 3). After 8-year follow-up his KOOS was 69.6 out of 100.

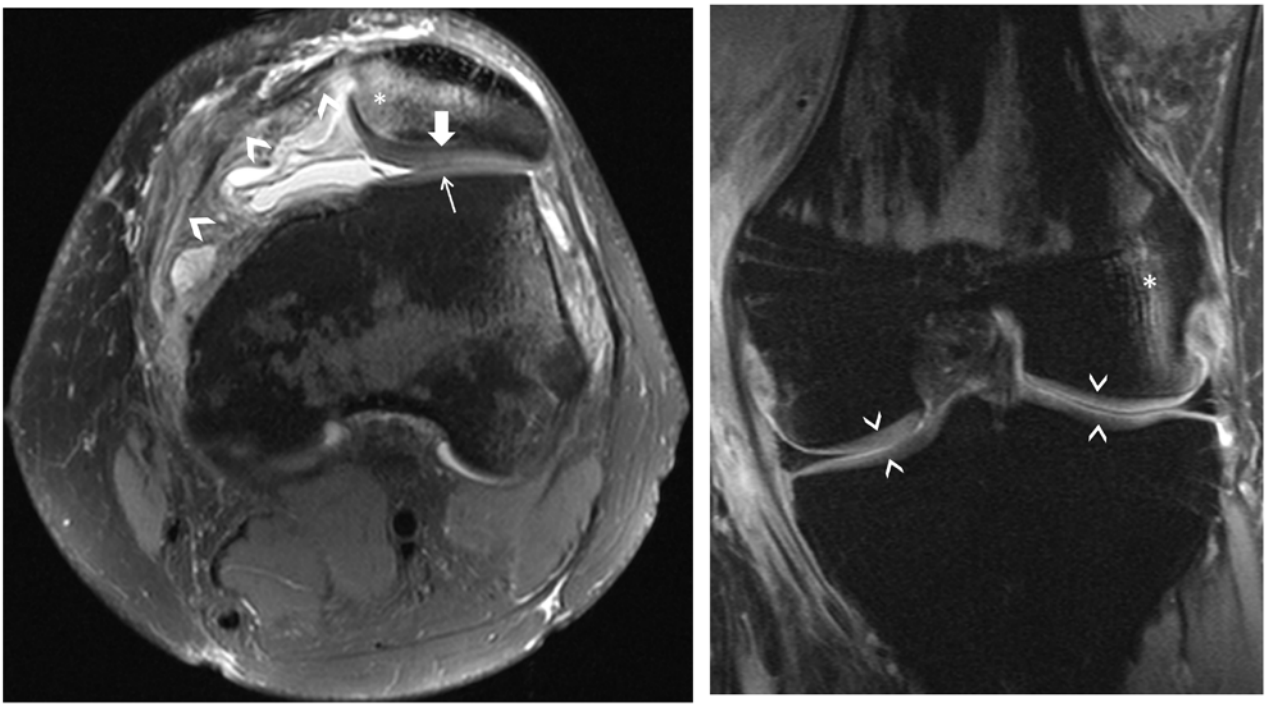

Figure 5 A-B. 21-y-old male with acute traumatic LPD. Primary 1.5T images (PD fat sat) of the left knee in the axial (A, above) and coronal (B, below) plane. Bone bruises (asterisks) visible on the medial side of the patella and the lateral femoral condyle indicate recent patellar dislocation. There is also disruption of the patellar insertion and midsubstance of the MPFL (arrowheads). No traumatic changes in the patellar cartilage (thick arrow) or the trochlear cartilage (thin arrow) are detected. In B, the tibiofemoral cartilage (arrowheads) seems to be intact.

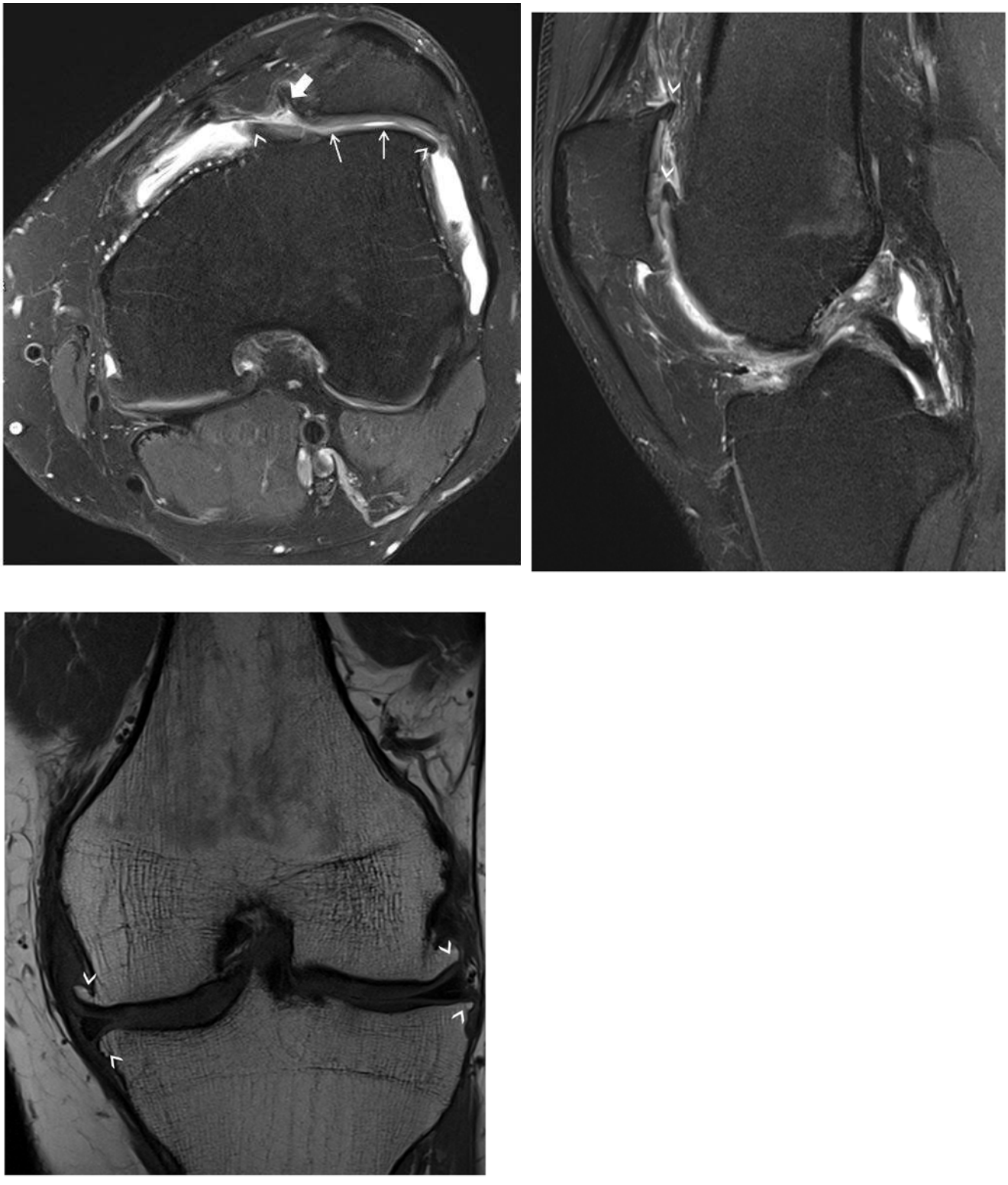

Figure 6 A-C. Same patient as in Fig. 5 after 8-year follow up. PD fat sat images in the axial (A, above) and sagittal (B, middle) plane, and a coronal T1 weighted image (C, below). In A, there is general thinning of the patellofemoral cartilage, especially in the medial facet of the patella (thick arrow) and at the center and lateral thirds of the trochlea (thin arrows), where grade III deterioration is observed. Osteophyte formation is observed along the patellofemoral joint margins (arrowheads). Generalized osteoarthritic changes with osteophytes (arrowheads) are also detected in the tibiofemoral joint (C).

Of the 20 patients scanned with follow-up MRI, 14 completed the KOOS questionnaire at the 8-year follow-up. The average KOOS score was 90 (range 70-100). Half of the patients (7/14) achieved at least 90 points (Table 3). Of 14 with ICRS III-IV cartilage defects of the PF joint in follow-up MRI, 8 had a mean KOOS score of 87 points while 6 of 14 patients with mild (ICRS $\leq$ II) changes had a mean KOOS score of 95 points (p = 0.091).

Table 3. ICRS of PF the joint, KOOS subscores and total KOOS scores. The total score is calculated as suggested previously [14]. Patient number 7 is the patient with tricompartmental osteoarthritic changes of the knee at 8-year follow-up after single traumatic lateral patellar dislocation.

	Cartilage damage (ICRS)	**KOOS SUBSCORES**					
Patient		**Symptoms**	**Pain**	**Daily function**	**Sports**	**Quality of life**	**Total**
1	4	89	97	100	85	63	86.8
2*	1	96	100	100	100	88	96.8
3*	3	96	100	100	100	94	98.0
4	2	100	100	100	90	94	96.8
5	2	100	100	100	100	94	98.8
6	1	82	92	99	85	81	87.8
7	3	68	78	82	45	75	69.6
8	3	100	100	100	100	100	100.0
9*	4	71	94	96	50	75	77.2
10*	4	68	92	96	85	75	83.2
11*	4	96	94	100	95	100	97.0
12	2	100	100	100	95	100	99.0
13	1	86	100	100	100	81	93.4
14	3	93	92	94	70	63	82.4

* Patients infrequent subsequent instability of the PF joint.

Of 14 patients, 5 (36%) reported infrequent subsequent instability of the PF joint. Of these 5, 3 had apparent progression of cartilage deterioration in the follow-up MRI. Of 9 patients with stable PF

joints during the follow-up, 5 also had apparent progression of the cartilage deterioration. Patients with stable and unstable PF joints were analyzed in two groups; patients with only mild (ICRS $\leq$ II) cartilage defects (6/14 patients) and patients with ICRS III-IV defects (8/14 patients). There was no statistical difference in the grades of the cartilage defects or subjective PF joint instability symptoms ($p = 0.198$). Patients with stable PF joint (2/9) did not differ form patients with unstable PF joint (3/5) in regard to severity of cartilage defects ($p = 0.198$) The 30-year old male (see above) who had osteoarthritis in all three knee compartments in the follow-up MRI did not experienced any PF joint instability symptoms or re-dislocations after the initial single LPD.

Discussion

In this study, majority (14 (70%) of 20 patients) of the first-time LPD patients sustained cartilage injuries located in the PF joint and visible in primary MRI, which corresponds to the findings in previous studies [5, 10, 19, 22, 24]. At the time of the follow-up (mean 8 years), PF cartilage deterioration was visible in all 20 patients. The central patella and patellar lateral facet seemed especially prone to cartilage deterioration based on a comparison of the primary and follow-up MRI. One-third of the patients reported subsequent instability of the PF joint, but the subjective instability was not associated with the severity of cartilage lesions. Patients with more severe cartilage lesions seemed to have worse symptoms than patients with milder lesions at the time of follow-up.

To our knowledge there are no studies of the long-term prognosis of cartilage deterioration after conservatively treated single first-time or infrequently repeated traumatic LPD. Several reports have examined the primary cartilage lesion [5, 10, 19, 22, 24] after the injury, but only a few detected the development of local cartilage deterioration and subsequent osteoarthritis [9, 12, 24]. This is interesting as ACL tears are well known to cause cartilage deterioration over the long-term [4, 13], which might support our hypothesis.

It has been suggested that primary trauma causes metabolic changes in the whole joint leading to inflammation and further deterioration [3]. Previous studies demonstrated more cartilage deterioration in patients with multiple traumatic LPD [24]. On the other hand, studies of another type of common knee injury, ACL tears, have not demonstrated any benefit of ACL reconstruction or joint stabilizing for preventing cartilage deterioration [11]. In this study, one patient developed severe osteoarthritic changes in all three knee compartments. In that patient's primary MRI, only mild cartilage lesions were detected, while after the 8-year follow-up MRI local full-thickness cartilage deterioration, bone edema, and osteophyte formation in both the PF and TF joints were observed.

As we hypothesized, it was seen that even a single first-time LPD may initiate gradual degeneration of cartilage in a whole knee joint.

Limitations of the present study included the fact that primary MRI at the time of an injury was performed using a 1.5T MRI while in the follow-up MRI a 3T scanner was used. It is possible that some cartilage deterioration seen in the follow-up MRI was visible only with the 3T image quality. However, the cartilage changes observed in the follow-up MRI were considered to be severe enough to be detected also in 1.5T scanners, indicating that the reason for progressive deterioration had to be some other factor. In addition, it has been previously shown that the accuracy of cartilage lesion detection does not vary significantly between 1.5T and 3T MRI [21]. Another limitation is the relatively small number of patients and these findings warrant studies with larger samples.

A strength of this study was the on average 8-year follow-up period, which is, to our knowledge, the longest period studied. All patients were young and healthy and were considered not to have any significant predisposing anatomic abnormalities that are well-known risk factors for patellar dislocation (e.g., patella alta, high-grade trochlear dysplasia, or increased tibial tubercle-trochlear groove distance over 20 mm). The study sample included patients with only single or infrequently recurrent lateral patellar dislocation, which emphasizes the importance of the initial trauma in degenerative process.

The results of this study revealed significant PF joint cartilage deterioration 8 years after a single or infrequently repeated LPD. The changes were seen regardless of the subjective instability symptoms of the PF joint or patellar re-dislocations and it did not seem to directly affect the development of cartilage deterioration. In fact, a similar lack of association is seen after ACL tears, as it has been shown that ACL reconstruction (i.e., joint stabilization) does not prevent the development of osteoarthritis[11].

Conclusion

A single first-time or infrequently repeated traumatic patellar dislocation is associated with cartilage injury. In addition, deterioration tends to progress over time. Some patients also develop osteoarthritic changes in compartments other than the PF joint in the knee. Subjective instability symptoms of the patellofemoral joint or patellar re-dislocaitons, however, was not related to the severity of the deterioration.

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