

Investigation for Lesional Onset Site and Patellofemoral Joint Anatomy in Juvenile Femoral Trochlear Osteochondritis Dissecans : A Case Control Study

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Abstract

Background: Femoral trochlear osteochondritis dissecans is an uncommon disease, and its cause remains unknown. We investigated the site of osteochondritis dissecans lesions and the patellofemoral joint anatomy of femoral trochlear osteochondritis dissecans in 15 knees, and assessed the clinical outcomes of the surgical treatments.

Methods: We conducted a retrospective study of 15 knees in 14 patients who underwent surgery. The mean age was 13.2 ± 1.0 years at the time of surgery. All patients played athletic sports and experienced no traumatic events. We determined the site of osteochondritis dissecans lesions using the modified Cahill and Berg classification on magnetic resonance imaging scans. We also evaluated the patellofemoral structures with sulcus angle, facet ratio, patellar tilt, patellar height, and tibial tubercle-trochlear groove distance.

Results: We performed osteochondral autograft transplantation surgery in nine knees, internal fixation in four knees, and drilling in two knees. The mean follow-up period was 34.5 ± 14.0 months, and the period of return to sports was 6.1 ± 1 months. At the final follow-up, the mean Tegner activity scale was 7.2 ± 1.4 (preoperative score was 7.7 ± 1.0), and the Lysholm knee score was 98.5 (range, 89-100). The area of most preponderance was in the medial portion of the lateral femoral condyle in the frontal view, and in the segment superior two-thirds of the anterior region in the lateral view. There were no anatomical abnormalities in the patellofemoral structures.

Conclusions: Femoral trochlear osteochondritis dissecans lesions occurred in virtually identical sites, and there were no anatomical abnormalities. This disease seemed to be related to the repetitive and persistent loading from the patella at slight knee flexion. In almost all cases, satisfactory postoperative results were obtained for osteochondritis dissecans regardless of the stage or surgical method.

Introduction

Osteochondritis dissecans (OCD) is a limited subchondral bone necrosis lesion, which progresses slowly toward separation of necrotic osteocartilaginous fragments that then move freely in the joint space. OCD rarely occurs before the age of six years, most frequently presenting at ages 13 to 21 years [1]. The incidence of OCD of the knee is associated with age, sex, and race of the patient. Kessler et al. demonstrated that the incidence of OCD rose from 6.8/100,000 in those aged 6–11 years to 11.2/100,000 in those aged 12–16 years [1]. Males seem to have a higher incidence of OCD than females (ratio, 2:1) [2] [3]. The recently noted increase in incidence rates and the decrease in the male to female ratio have been attributed to the growing popularity of youth sports among both sexes [4]. In terms of race, Kessler et al. also showed that non-Hispanic blacks had the highest incidence of OCD (31.6/100,000), with the lowest incidence observed among Asians (4.7/100,000) [1].

OCD most often involves the medial femoral condyle (85%), followed by the lateral femoral condyle (13%) and the trochlea (2%) [5]. Most previous studies on adolescents with OCD of the knee focused on lesions involving femoral condyles. Femoral trochlear OCD is an uncommon disease, and its cause remains unknown. No studies have examined the onset site of the lesion and the associated anatomical features in detail in this disease. We hypothesized that femoral trochlear OCD is caused by abnormalities in the patellofemoral joint and

is more likely to occur on the outer side, which comes into contact with the patella as the knee flexes. In this study, we examined young patients who underwent surgical treatment for OCD lesions of the femoral trochlear groove. The primary purpose of this study was to investigate the site at which OCD lesions are commonly found, and the anatomical features of the patellofemoral joint of the femoral trochlear disease. The secondary aim was to assess the clinical outcomes of surgical treatments.

Material And Methods

Study design and participants

In this retrospective study, written informed consent was obtained from all patients included in this study. This study design was reviewed and approved by Kanazawa University Medical Ethics Review Committee (approval No. 1842). The study complied with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

This study's aim was to investigate the site at which OCD lesions are commonly found, and the anatomical features of the patellofemoral joint of the femoral trochlear disease. The secondary aim was to assess the clinical outcomes of surgical treatments. We conducted a retrospective study of 15 knees that underwent surgery (14 patients: 13 males, 1 female; 1 patient underwent bilateral knee surgery) from May 2010 to October 2019. The mean age was 13.2 ± 1.0 years at the time of surgery. All patients played athletic sports (7 soccer, 2 basketball, 2 volleyball, 1 handball, 1 baseball, and 1 kendo) and had experienced no traumatic events (Table 1).

Table 1
Characteristics of the patients

No.	Age at surgery (years)	Sex	Sports	Location of lesions	ICRS grade	Surgical Treatment	Tegner activity score, pre/post operation		Lysholm knee score	Time to return to sports (months)
							pre	post		
1	13	M	Basketball	4-A2	I	Internal fixation	7	7	100	5.5
2	12	M	Soccer	4-A2	I	Drilling	9	9	100	5
3	11	M	Basketball	4-A1	I	Drilling	7	7	95	3
4	12	M	Soccer	4-A2	I	Internal fixation	9	9	100	10
5	13	M	Soccer	4-A2	I	Internal fixation	7	7	100	6
6	13	M	Soccer	4-A2	I	Internal fixation	7	7	100	6
7	13	M	Soccer	4-A2	I	OATS	9	4	100	none
	14			4-A2	I	OATS			89	
8	13	M	Soccer	4-A1	I	OATS	9	9	100	6
9	14	M	Soccer	4-A3	I	OATS	9	9	100	6
10	13	M	Kendo	3-A2	I	OATS	7	7	100	7
11	15	M	Handball	4-A2	I	OATS	7	7	100	6
12	13	M	Volleyball	2-A2	I	OATS	7	7	100	5
13	15	F	Volleyball	4-A2	I	OATS	7	6	94	8
14	14	M	Baseball	4-A2	I	OATS	7	7	100	6

Abbreviations: M: male; F: female; ICRS: International Cartilage Repair Society; OATS: osteochondral autograft transplantation surgery

Using T2-weighted fat-suppressed coronal magnetic resonance imaging (MRI), all patients who had an epiphyseal line > 1.5 mm on the central part of the femoral condyle were considered to have skeletally immature knees [6]. We determined the site of OCD lesions using the modified Cahill and Berg classification on MRI scans. Based on the original radiographic classification, the femoral condyle is divided into five parts in the frontal view and three parts in the lateral view (Fig. 1a, b) [7]. We then added three subsegments in the frontal part of the lateral view and denoted them as A1, A2, and A3, in order from the top (Fig. 1c).

The International Cartilage Repair Society (ICRS) classification was used to determine the disease stage, and surgical treatments were considered according to the stability and size of the OCD lesion. The Tegner activity scale and Lysholm knee score were used for clinical evaluation. We conducted postoperative follow-up for at least 1 (mean: 5, range: 1–10) year and also investigated the period required to return to sports for each patient.

Evaluation of patellofemoral structures

We evaluated the patellofemoral (PF) structures as follows (Fig. 2). The sulcus angle consists of intersection of the tangents of medial and lateral condyle on computed tomography or MRI [8]. The facet ratio was expressed as a percentage of the medial to the lateral facet length measured about 3 cm above the femorotibial joint space [9]. The patella tilt is the angle between the line through the transverse axis of the patella and the posterior tangential line of the femoral condyle [10]. The patellar height was assessed using the Caton-Deschamps index, which was defined as the ratio of the articular facet length of the patella to the distance between the articular facet of patella and the anterior corner of the superior tibial epiphysis. The index is a pertinent and reliable ratio to evaluate patellar height even in children and adolescents [11]. Tibial tubercle lateralization was estimated by measuring the tibial tubercle-trochlear groove (TT-TG) distance referenced off the posterior femoral condyle, as previously described [12, 13]. These data were compared with those of the control group, which comprised 15 age- and sex-matched preoperative patients with anterior cruciate ligament injury.

Statistical analysis

The measurements for the PF structures were compared between the femoral trochlear OCD group and the control group using the two-sample t-test. All analyses were performed using the Statistical Package for the Social Sciences for Windows (version 23.0; SPSS Inc., Chicago, IL, USA). The level of significance was set at $p = 0.05$.

Results

In many cases, the OCD lesions spanned multiple regions. Therefore, the region that contained the most lesions was selected. The area of most preponderance was in segment 4 (medial portion of the lateral femoral condyle) in the frontal view and in segment A2 (superior two-thirds of the anterior region) in the lateral view (Table 1). Only one patient showed OCD lesions in the medial femoral trochlear groove.

On application of the ICRS classification, two, eight, and five knees showed stage I, II, and III disease, respectively. We performed osteochondral autograft transplantation surgery(OATS)for nine knees, which involved internal fixation using a poly-L-lactide (PLLA) pin and via drilling in four and two patients, respectively. The mean follow-up period was 34.5 ± 14.0 months. At the final follow-up, the mean Tegner activity scale was 7.2 ± 1.4 (preoperative score: 7.7 ± 1.0), and the Lysholm knee score was 98.5 (range, 89–100). The period of return to sports was 6.1 ± 1 months, and one patient who injured both knees, could not return due to pain during exercise.

On evaluating the anatomical parameters of PF structures in the femoral trochlear OCD group, we calculated the sulcus angle, facet ratio, patellar tilt, patellar height, and TT-TG as $137.1 \pm 6.4^\circ$, $62.6 \pm 12.3\%$, $10.3 \pm 3.5^\circ$, 1.07 ± 0.08 , and 10.3 ± 2.3 mm, with associated p-values of 0.79, 0.48, 0.88, 0.13, and 0.91, respectively. There were no significant differences in the PF structural measurements between the femoral trochlear OCD group and the control group (Table 2).

Table 2
Anatomical findings compared between both groups

Parameters	OCD (N= 15)	Control (N= 30)	p-value
Age (years)	13.2 ± 1.1	13.3 ± 0.7	0.84
Sulcus angle (°)	137.08 ± 6.4	135.5 ± 4.3	0.79
Facet ratio (%)	62.6 ± 12.3	65.3 ± 7.5	0.48
Patella tilt(°)	10.3 ± 3.5	9.3 ± 2.9	0.88
Patella height	1.07 ± 0.08	1.01 ± 0.12	0.13
TT-TG (mm)	10.3 ± 2.3	10.4 ± 2.4	0.91

Abbreviations: OCD, osteochondritis dissecans, TT-TG, tibial tubercle-trochlear groove distance

One case is shown in Fig. 3, which corresponds to No. 1 in Table 1. The lesion was determined to be 4-A2 on MRI, and internal fixation using PLLA pin was performed. The patient was able to return to full sports activities 5.5 months after the surgery.

Discussion

The most important finding of this study was that femoral trochlear OCD lesions occurred in virtually identical sites. To the best of our knowledge, this is the first study to conduct an investigation in detail on the sites where femoral trochlear OCD lesions are most commonly found.

The etiology of OCD is unknown, and numerous hypotheses have been proposed, including ischemia, repetitive microtraumas, genetic factors, inflammation, and ossification disorders [14, 15]. A previous study reported that malalignment of PF structures with associated elevated TT-TG distance or occurrence of repetitive microtrauma along with tightness of the lateral retinaculum might be associated with onset of femoral trochlear OCD [16, 17]. In another study, the disease was thought to be caused by repeated shear force transmitted by the patella to the convex surface during extension of the weightbearing knee from a flexed position, which was different from that causing chondral fracture due to sudden trauma [18]. Considering PF biomechanics, as the knee gets close to full extension, the site of femoral trochlea in contact with the patella, moves in a more laterally and superiorly direction [19]. Therefore, the lateral trochlea may be more easily impinged upon by the patella than by the medial trochlea, which makes OCD lesions more likely to occur on the lateral trochlea.

In our study, we did not find any anatomical abnormalities of the PF structure in the femoral trochlear OCD group as compared to that in the control group, and all applicable measurements in the control group were within the normal ranges reported in the literature [8–12]. Furthermore, none of the patients had experienced a traumatic event. Almost all femoral trochlear OCD lesions were located in the notch and in the lateral region in the frontal view and in the superior two-thirds of the anterior region in the lateral view. These regions included areas contacting the patella at slight knee flexion (25°–30°).

Interestingly, in this study, most patients practiced soccer, followed by basketball. Price et al. evaluated the clinical characteristics between femoral trochlear OCD and participation in sporting activities that load the PF joint [20]. They conducted a retrospective study of 34 knees (30 patients) with femoral trochlear OCD and compared these to an age- and sex-matched control group with 102 femoral condyle lesions. According to the study, the odds of patients with femoral trochlear OCD lesions playing either basketball or soccer were 2.84 times higher than in those with femoral trochlear OCD lesions ($p = 0.017$). These two sports involve rapid deceleration before a change in direction or when landing from jumps, which are activities that increase loading of the patellofemoral joint and expose the trochlea to risk of injury.

In another study, Mc Elroy et al. examined relative characteristics of OCD knee lesions in baseball catchers as compared to those in basketball players who played in other positions [21]. They investigated 33 (29 patients) and 65 (49 patients) knees of catchers and non-catchers, respectively. They discovered that lesions in catchers were more posterior in location on the medial and lateral femoral condyles than those in non-catchers in the sagittal view ($p = 0.004$). This difference may occur because of repetitive and persistent hyperflexion of the knee in catchers as compared with the upright loading affecting knees of players in other positions. These two studies also revealed that repetitive and persistent loading of the knees may be risk factors for developing lesions in uncommon locations especially for young and active patients.

Management of juvenile OCD of the knee remains a controversial topic. The American Academy of Orthopaedic Surgeons clinical practice guidelines for OCD treatment do not address treatment of lesions in the trochlea [22]. The juvenile knee with a growth plate that is still open has a high potential for recovery, and therefore, conservative treatment should always be the first choice in stable OCD, as about 50% of lesions respond positively in a period of 10–18 months [4, 23]. Nonetheless, it is difficult to determine the time required to return to sports, and if the conservative treatment is ineffective, the treatment period becomes prolonged. Thus, even with early stage OCD, surgical treatment might be preferable to shorten the treatment period and allow return to sports especially in high activity athletes.

Various surgical methods have been proposed to treat OCD lesions and treatment decisions are influenced by clinical symptoms and characteristics of the lesion (location, size, and stability). The goals of treatment are to promote healing of the subchondral bone and to prevent subsequent osteochondral defects, cartilage collapse, and early degenerative changes. Drilling the subchondral bone with an aim to stimulate vascular ingrowth and subchondral bone healing is selected for stable lesions with intact articular cartilage. If the lesion is unstable, internal fixation is indicated. If fixation is impossible, there are some salvage techniques such as OATS, fresh osteochondral allograft, and autologous chondrocyte implantation (ACI) [24–26]. In addition to these common treatments for femoral trochlear OCD patients, some authors recommend releasing the lateral retinaculum in an attempt to centralize the patella in the trochlea to decrease the patellar contact pressures and enhance patellar tracking [17, 27, 28].

The Research in Osteochondritis of the Knee study group reported that two thirds (8/12) of operated femoral trochlear OCD patients show radiographic signs of healing and return to full activity without pain [29]. We achieved better postoperative outcomes than in that study regardless of the stage or the surgical method, and reoperation was not indicated in any patient. Since lateral patellar maltracking due to a tight lateral retinaculum was not observed intraoperatively, lateral release was not performed for any patient.

Our study has certain limitations. Firstly, the small sample size and retrospective nature of the study are important constraints. Secondly, we only focused on operatively treated OCD lesions and thus potentially missed a large proportion of trochlear lesions in our practice. The study does not include data on the percentage of the total trochlear OCD lesions representing operatively treated lesions. Thirdly, the femoral trochlear OCD lesion being in contact with the patella in slight knee flexion was considered in published literature but was not an intraoperative finding in our study. Finally, the contact pressure of the patellofemoral joint also depends on the quadriceps strength, which was not evaluated in this study. It is necessary to include a larger sample size and evaluate soft tissues. However, we have found that femoral trochlear OCD lesions occur in nearly similar locations in affected patients. The lesions are mostly detected on MRI but may easily be missed on radiographic imaging. Knowing the commonly involved location of the OCD lesions can prevent missed diagnoses of this uncommon condition.

Conclusion

Femoral trochlear OCD lesions occurred in virtually identical sites that came into contact with the patella at 25–30° of knee flexion, and there were no anatomical abnormalities. Repetitive and persistent loading from the patella may be a risk factor for developing lesions in uncommon locations, particularly in young, active patients playing soccer and basketball. In almost all cases, satisfactory postoperative results were obtained for OCD regardless of the stage or surgical method used.

Abbreviations

ICRS: International Cartilage Repair Society

MRI: magnetic resonance imaging

OATS: osteochondral autograft transplantation surgery

OCD: osteochondritis dissecans

PF: patellofemoral

PLLA: poly-L-lactide

TT-TG: tubercle-trochlear groove distance

Declarations

Ethics approval and consent to participate

All patients in this retrospective study were under 18 years old and informed consent was obtained from their parents. This study design was reviewed and approved by Kanazawa University Medical Ethics Review Committee (approval No. 1842).

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests:

The authors declare that they have no competing interests.

Funding:

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Authors' contributions

Study design: JN, YO, KA, MK. Recruitment and data collection: YO, KA, MK

Data analysis and interpretation: KA, MK. First draft of paper: MK. Revision of paper: All authors.

The author(s) read and approved the final manuscript.

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Not applicable

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Figures

Fig. 1

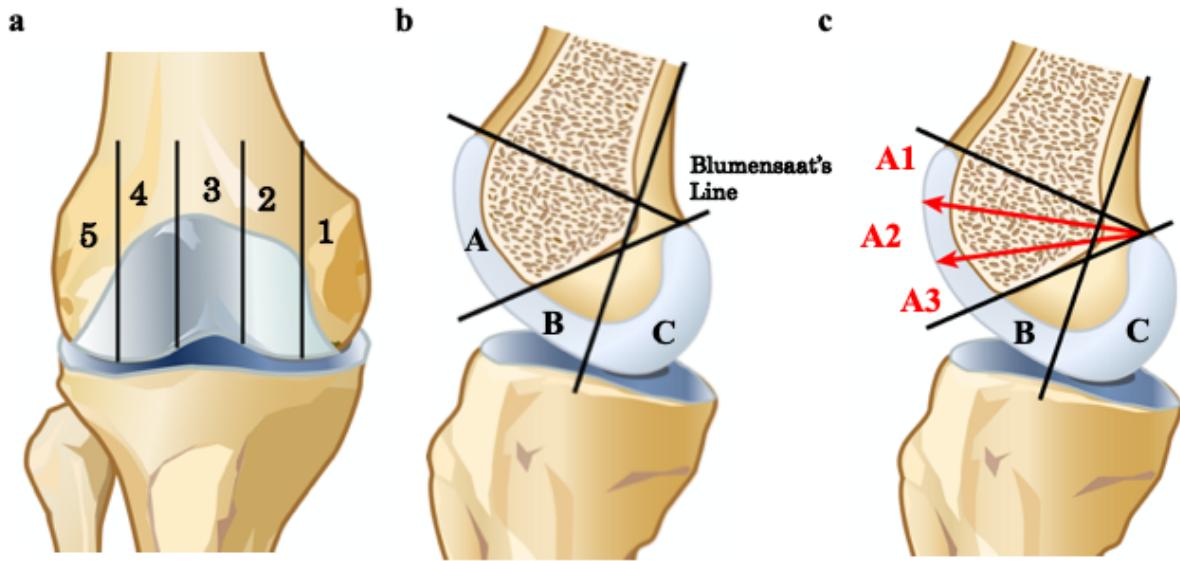


Figure 1

Cahill and Berg classification (a) Frontal view: the femoral condylar is divided into five parts. (b) Lateral view: the femoral condylar is divided into three parts using two borders: the anterior border formed by the Blumensaat's Line and the posterior border formed by the line projecting distally and parallel to the posterior femoral cortex. (c) Add the two lines in the frontal area and divide the three areas.

Fig. 2

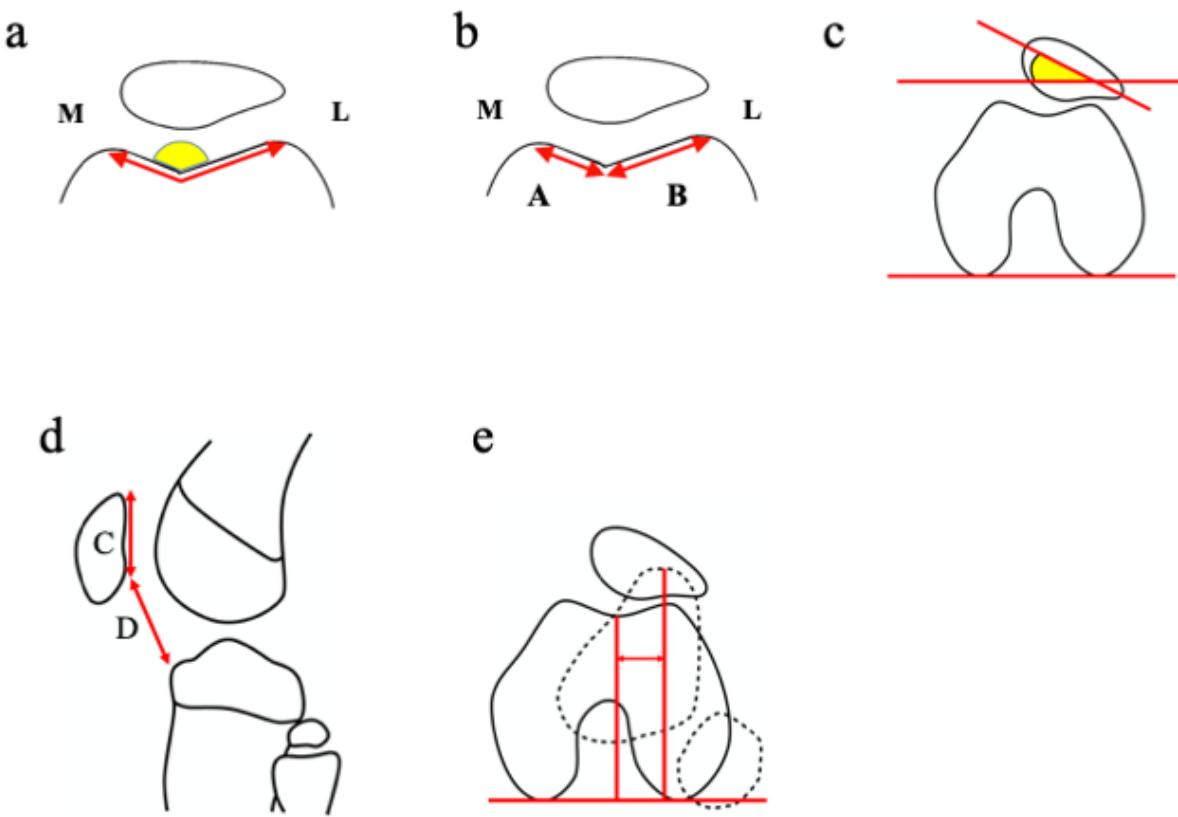


Figure 2

Anatomical evaluation of patellofemoral structures (a) Sulcus angle (indicated by the two arrows) M: medical, L: lateral (b) Facet ratio (A/B) (indicated by the two arrows) M: medical, L: lateral (c) Patellar tilt (indicated by two lines). (d) Patellar height as per Caton-Deschamps index (D/C) (indicated by the two arrows). (e) Tibial tubercle-trochlear groove (TT-TG) (indicated by the arrow between the parallel lines)

Fig. 3

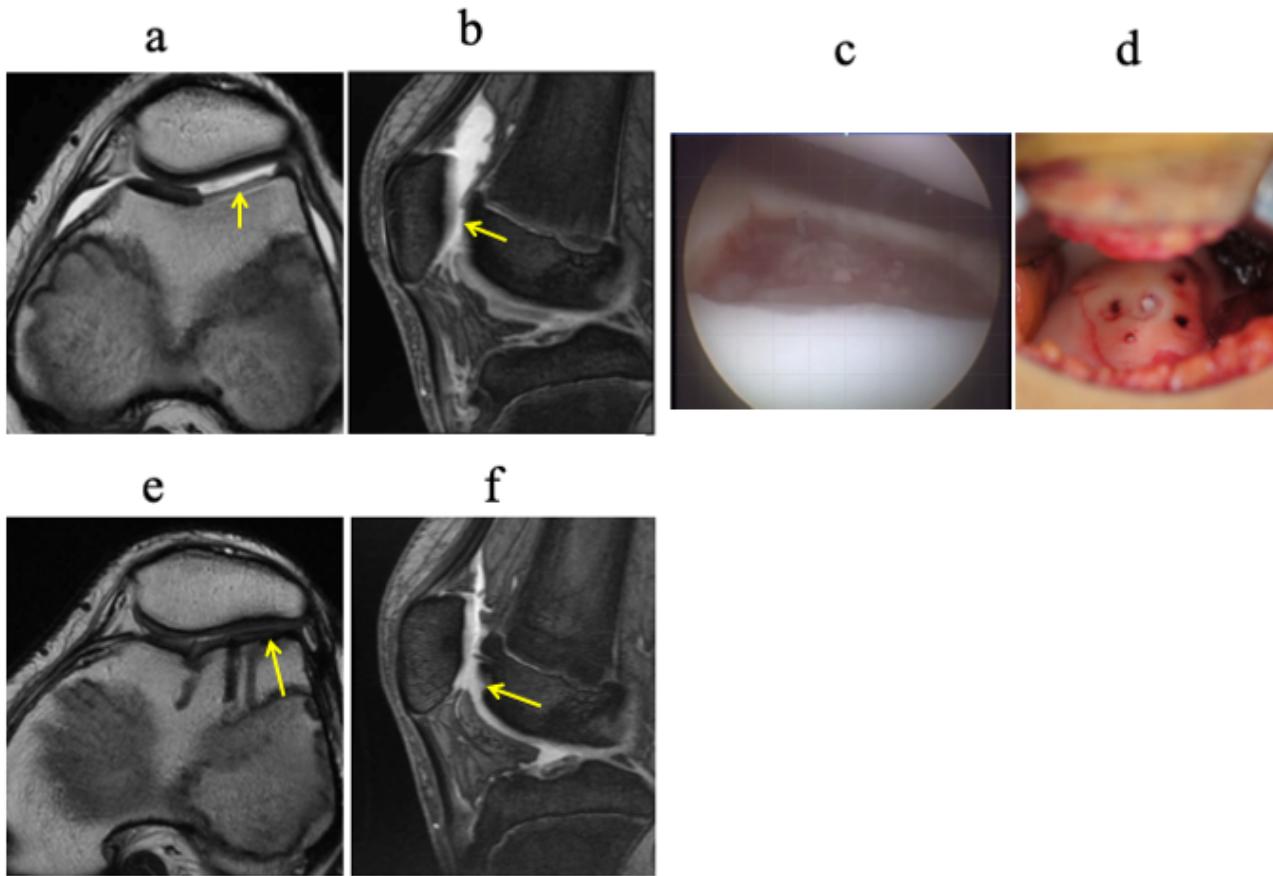


Figure 3

Case 1: a 13-year-old male (a) Preoperative T2-weighted axial magnetic resonance imaging (MRI). (b) Preoperative T2-weighted sagittal MRI scan. The lesion was determined to be 4-A2. (c) Intraoperative arthroscopic findings. Osteochondral defect is seen. (d) Internal fixation using a poly-L-lactide (PLLA) pin. (e) T2-weighted axial MRI scan one year after operation. (f) T2-weighted sagittal MRI scan one year after operation. The osteochondral lesions are repaired well and are associated with a good clinical outcome.