

# Characteristic location and rapid progression of medial femoral condylar chondral lesions accompanying medial meniscus posterior root tear

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## ABSTRACT

**Background:** This study aimed to demonstrate the characteristics of the chondral lesion at the medial femoral condyle (MFC) in patients with medial meniscal posterior root tear (MMPRT), and to compare the progression rate of accompanying chondral disease in MMPRT with that in degenerative non-radial tear.

**Methods:** Thirty-one patients who underwent arthroscopic surgery for MMPRT and 31 controls who underwent arthroscopic surgery for degenerative medial meniscus posterior horn horizontal tear (MMPHT) were included. Accompanying chondral lesions in the MFC were evaluated by magnetic resonance imaging (MRI) at initial diagnosis and from video taken at arthroscopic surgery using the International Cartilage Repair Society (ICRS) classification system. The difference in severity and extent of the chondral lesion between initial diagnosis and surgery was measured.

**Results:** Twenty-five patients with MMPRT (80.6%) and 29 patients (93.5%) with MMPHT had ICRS grade  $\geq 2$  chondral injuries at MFC. In the MMPRT and MMPHT groups, the most severely injured areas of the MFC were the far medial compartment (52%) and central compartment (51%), respectively. Comparing MRI and arthroscopy, 12 patients (39%) in the MMPRT group showed progression of chondral disease after a mean of 3.5 months, whereas only three patients (10%) in the MMPHT group showed progression after a mean of 3.1 months.

**Conclusions:** MFC lesions accompanying MMPRT were located more medially and progressed faster than those with non-root horizontal tear. Earlier intervention such as repair of MMPRT or high tibial osteotomy, if malalignment is present, may be considered in order to prevent the progression of chondral lesion.

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## 1. Introduction

The medial meniscus posterior horn endures most of the stresses applied to the medial compartment [1]. Because the posterior horn region has limited mobility due to strong attachment to the tibia, it is vulnerable to injury leading to its degeneration and tear [2–4]. Medial meniscus posterior root tear (MMPRT) causes loss of hoop tension and functional load distribution [5]. In a cadaveric study, MMPRT was associated with a 25% increase in peak contact pressure in the medial compartment compared with an intact meniscus [3]. A high prevalence of chondral lesions of the medial femoral condyle (MFC) of the distal femur has been reported in several studies [6,7]. The loss of hoop tension would lead to the extrusion of the medial meniscus, far-medial edge loading between the medial femoral condyle and the medial tibial plateau, and an increase in contact pressure of the medial compartment. However, the geographical analysis of the chondral lesion within the MFC has never been studied compared to other degenerative meniscus tears. Information on the effect of MMPRT on cartilage loss in the same compartment is limited.

Furthermore, MMPRT has been associated with progressive medial tibiofemoral cartilage damage [6]. The increase in contact pressure would increase the speed of the progression of the chondral damage. The higher risk of progression of tibiofemoral damage in MMPRT compared to other meniscal tears has been studied using magnetic resonance imaging (MRI) [6]. However, this study was based on entirely radiographic findings. Thus, no definitive presence of root tear or severity of cartilage damage has been confirmed with arthroscopy in previous studies.

This study aimed to demonstrate chondral lesion characteristics at the MFC in MMPRT patients and to compare the progression rate of the accompanying chondral lesions in MMPRT with that in degenerative non-radial tear. Our hypothesis was that accompanying chondral lesion in MMPRT was located more medially than non-root degenerative medial meniscus horizontal tears, and chondral lesion progression was faster in MMPRT patients.

## 2. Material and methods

### 2.1. Study design and study population

For this retrospective comparative study, 92 patients who had MMPRT without severe degeneration and 112 patients who had medial meniscus posterior horn horizontal tear (MMPHT) treated from August 2014 to June 2017 were reviewed. Patients who had previous knee surgery or concomitant ligament injury on the same side of the knee and those who had advanced osteoarthritis (Kellgren–Lawrence grade 3 or 4 in radiography) were excluded.

Patients who were diagnosed with chronic MMPRT on MRI were treated with conservative therapy for three months initially. MMPRT was defined on MRI as a radial tear within five millimeters of the posterior bony attachment of the medial meniscus [8]. Conservative therapy consisted of activity modification that included prohibiting patients from squatting or climbing stairs, applying an ice pack, taking anti-inflammatory drugs or analgesics, and controlling weight. No intra-articular injections were given to the patients. If pain and functional disability decreased after three months of conservative treatment, the patient was consistently followed up without surgery. However, if the patient's pain persisted with increased functional disability after three months of conservative treatment, patients received arthroscopic meniscectomy or meniscus repair according to the reparability of the meniscus. Fifty-four MMPRT patients showed positive responses to conservative treatment. The remaining 31 patients who failed conservative treatment and received arthroscopic surgery were finally included in the present study (Figure 1).

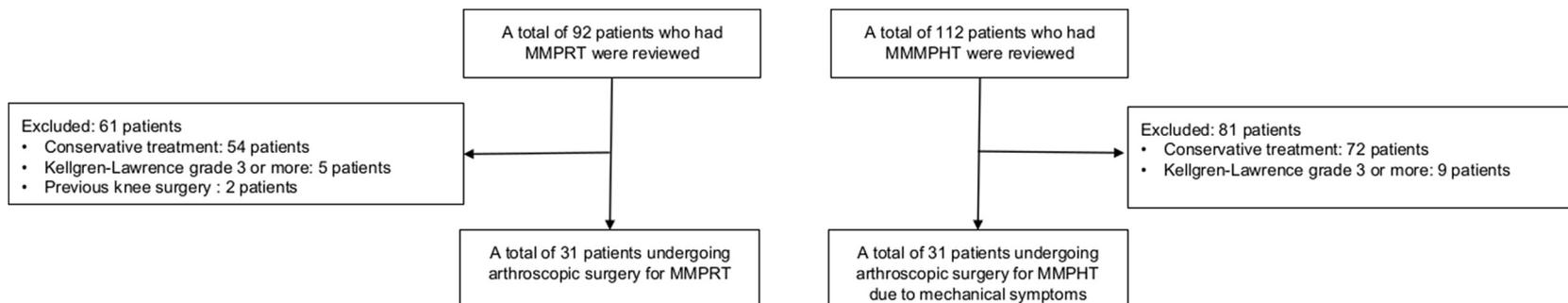
Patients diagnosed with degenerative MMPHT on MRI were treated with conservative therapy unless mechanical symptoms such as clicking, catching, or locking during motion of the knee joint were present. Thirty-one patients who had mechanical symptoms and received arthroscopic surgery were included in the present study.

Due to the advanced conservative treatment protocol, there was a difference between the time of MRI examination and arthroscopic surgery. This time difference was recorded. Radiologic evaluation included coronal mechanical alignment (hip–knee–ankle angle) [9] at the whole lower extremity in standing anterior–posterior radiograph. Using coronal and sagittal T2 images of MRI, the hyaline cartilage surfaces of MFC were evaluated. Evaluation of the cartilage and its documentation were performed by the severity grade and location of the lesion based on the International Cartilage Repair Society (ICRS) articular cartilage lesion classification system, where lesion depth is graded from 0 to 4, and ICRS knee cartilage lesion mapping system, where the cartilage surface is subdivided into nine further locations (each approximating 1.3 cm<sup>2</sup>) [10] (Figure 2).

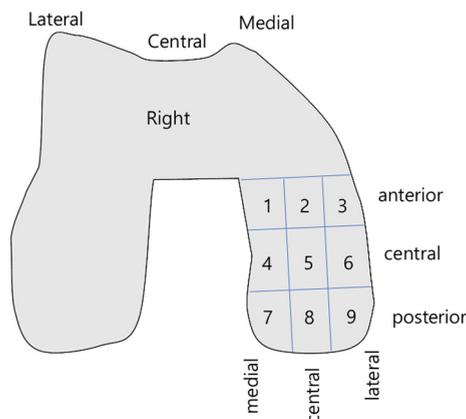
Arthroscopic assessment of the cartilage lesions was performed using arthroscopic images and video. Evaluation of the cartilage and its documentation were carried out using the same ICRS articular cartilage lesion classification system and ICRS knee cartilage lesion mapping system.

### 2.2. Statistical analysis

Independent *t*-test was used to compare continuous variables such as mechanical alignment and time difference. Chi-squared test was used to compare categorical variables such as Kellgren–Lawrence grade and number of cartilage lesions. Radiographic parameters were measured twice by one independent observer with a four-week interval between measurements. The intra-observer measurement reliabilities were assessed using the intra-class correlation coefficient (ICC). Statistical significance was considered when  $P < 0.05$ . Statistical Package for the Social Sciences (SPSS) for Windows (version 20.0; SPSS Inc., Chicago, IL, USA) was used for statistical analysis.



**Figure 1.** Study subjects inclusion/exclusion flowchart. MMPHT, medial meniscus posterior horn tear; MMPRT, medial meniscus posterior root tear.



**Figure 2.** International Cartilage Repair Society knee cartilage lesion mapping system.

### 3. Results

The demographic characteristics and preoperative data did not show any difference between the two groups (Table 1). Average preoperative hip–knee–ankle angle was 3.0° varus and 2.7° varus in the MMPRT and MMPHT groups, respectively. Twenty-five of 31 MMPRT patients (80.6%) had ICRS grade  $\geq 2$  chondral lesions at MFC, and 29 of 31 patients (93.5%) in the control group had grade  $\geq 2$  chondral lesions in MRI images.

The most severely injured area of MFC in the MMPRT group was the central–lateral (far medial) compartment, which was 52% of the total cartilage lesion. In the MMPHT group, however, the most severely injured area of MFC was the central–central compartment, which was 51% of the total cartilage lesion (Figure 3). This injury pattern showed statistically significant differences between the two groups at the central–lateral compartment ( $P < 0.001$ ), central–central compartment ( $P = 0.030$ ), and central–medial compartment ( $P < 0.001$ ). Only six percent of chondral lesions were present in the central–lateral compartment in the MMPHT group.

Comparing the preoperative MRI and arthroscopic findings, 12 MMPRT patients (39%) showed progression of chondral disease after a mean of 3.5 months, whereas only three MMPHT patients (10%) showed progression after a mean of 3.1 months ( $P = 0.005$ ). In the MMPRT group, eight of 12 progressed chondral lesions were at the central–lateral compartment of the MFC, whereas in the MMPHT group, no progression of chondral lesions was found at the central–lateral compartment of the MFC ( $P = 0.027$ ) (Table 2). Four chondral lesions at the central–central compartment in the MMPRT group and two chondral lesions in the MMPHT group showed progression.

### 4. Discussion

The most important finding of the present study was that the chondral lesions associated with MMPRT were located far medially and progressed faster than those lesions associated with MMPHT.

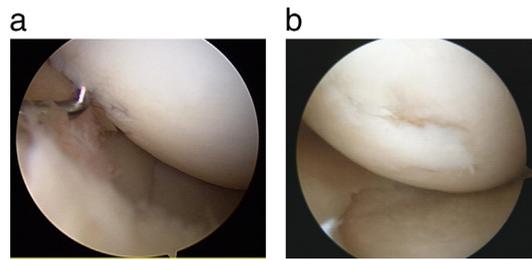
Degenerative posterior horn meniscal tears have been associated with the presence of chondral disease of Outerbridge II in more than 85% of cases in previous studies [11]. Likewise, patients with complex meniscus tears were significantly more likely to have Outerbridge III or IV chondral disease [12]. These findings correspond to our results where 93.5% of the control group had chondral lesions.

Previous studies also reported that malposition of the medial meniscus significantly increased the risk for focal cartilage loss. In a prospective MRI study, meniscus subluxation was associated with less meniscal coverage and reduced meniscal height. Less

**Table 1**  
Baseline characteristics of the study groups.

Clinical characteristics	MMPRT (n = 31)		MMPHT (n = 31)		P
	Mean	SD (range)	Mean	SD (range)	
Age (years)	55.5	4.9 (39–64)	57.6	4.3 (48–66)	n.s.
Male/female	5/26		9/22		n.s.
BMI	26.1	3.2 (20.3–32.7)	27.3	2.6 (20.5–31.9)	n.s.
Right/left knee	12/19		18/13		n.s.
Hip–knee–ankle angle (°)	3.0	1.8 (0.5–4.6)	2.7	1.9 (–0.2 to 5.3)	n.s.
Time from MRI examination to surgery (months)	3.5	0.6 (2.9–5.7)	3.1	1.7 (1.1–6.8)	n.s.
Presence of medial femoral chondral lesions in MRI (n)	25 (80.6%)		29 (93.5%)		n.s.

BMI, body mass index; MMPHT, medial meniscus posterior horn horizontal tear; MMPRT, medial meniscus posterior root tear; MRI, magnetic resonance imaging; n.s., not significant; SD, standard deviation.



**Figure 3.** Arthroscopic images of the chondral lesion of medial femoral condyle in a patient with medial meniscus posterior root tear (a) and with medial meniscus posterior horn horizontal tear (b).

coverage and reduced height also increased the risk of cartilage loss [13]. Meniscal subluxation has been frequently associated with MMPRT [14–17]. In a prospective study, root tears were associated with a higher incidence of chondral lesion than other meniscus tears [18]. In another retrospective study on meniscus root tear patients who underwent arthroscopic surgery, 74% had concomitant chondral defect of Outerbridge grade II or higher [19]. However, no previous studies have evaluated the geographical location of the chondral lesion compared to other meniscal tears. In a previous biomechanical study, posterior root tear significantly increased medial joint peak contract pressure and significantly decreased the contact area. Furthermore, when compared to the control knee, the loading pattern changed to a more posteromedial location [20]. The loss of hoop tension and thus the loss of the protective effect of the medial meniscus may explain such a loading pattern. Due to less coverage of the meniscus on the medial aspect of the MFC, the chondral lesion may occur more medially in MMPRT patients. The central–lateral compartment of the MFC is protected by medial meniscus coverage when meniscal hoop tension is preserved. These previous findings explain the geographical locations of the chondral lesions in the present study. This study showed that 52% of the chondral lesions in the MMPRT group were located at the central–lateral compartment compared to six percent in the MMPHT group.

Previous studies have reported more rapid progression of chondral disease after meniscectomy. An MRI study performed after partial meniscectomy revealed progression of chondral disease at the medial tibiofemoral compartment in as little as two years [21]. Other studies have supported the findings that local cartilage wear and subchondral changes are increased in the medial compartment where meniscectomy was carried out [21–23]. Furthermore, several studies have reported that MMPRTs are associated with early and rapid chondral degeneration of the knee similar to a meniscectomized knee [3,5,24,25]. A biomechanical analysis performed in a cadaveric study showed increased knee contact pressures in the medial compartment in an MMPRT model. Findings were similar to that of a total meniscectomized model. In addition, MMPRT caused a significant increase in varus alignment compared to intact knees [3]. This biomechanical study corresponds with the present study in that most chondral lesions were found in the far-medial compartment. In the present study, eight out of 24 chondral lesions at the central–lateral compartment and four out of 13 chondral lesions at the central–central compartment had chondral disease progression, which was significantly higher than the control group.

Poor healing rates have been a concern for repair in degenerative tears [26]. Various healing rates after pullout suture evaluated with second-look arthroscopy have been reported (0–69.7%) [27–29]. However, even though the reparability of the meniscus is lower in the age group of MMPRT, repairing the root tear has its role in restoring hoop tension and consequently preventing the progression of osteoarthritis [30].

This study has several limitations. First, this study has a retrospective design with a relatively small sample size. Second, applying the ICRS classification into an imaging evaluation has some limitations. The ICRS classification system was made to evaluate the cartilage defect of the knee joint on arthroscopy. The ICRS classification based on MRI has not been validated. The disadvantage of MRI is that it tends to underestimate the true size of the lesion [10]. However, ICRS grade >2 lesion is usually adequate to determine the chondral lesions in MRI images. The present study also focused more on the location of the lesion rather than its size. However, previous studies have reported the validity and reliability of MRI for quantification of cartilage abnormalities [31,32]. Third, the study was conducted in a tertiary referral hospital. Many of the patients underwent MRI at other hospitals. Therefore, the MRI protocols were not the same for all patients. Fourth, the inclusion and exclusion criteria

**Table 2**  
Number of progressed chondral lesions.

	MMPRT		MMPHT		P
	Progressed	Non-progressed	Progressed	Non-progressed	
Anterior-lateral	0	3	0	1	n.s.
Anterior-central	0	3	0	4	n.s.
Anterior-medial	0	1	0	3	n.s.
Central-lateral	8	16	0	3	0.027
Central-central	4	9	2	23	n.s.
Central-medial	0	0	1	11	n.s.

MMPHT, medial meniscus posterior horn tear; MMPRT, medial meniscus posterior root tear; n.s., not significant.

were different in the two groups. However, the baseline characteristics of the two groups were not statistically different. The degenerative nature of the meniscus pathology of the two groups makes the MMPHT group an ideal control group for comparison with the MMPRT group.

Medial femoral chondral lesions accompanied by MMPRT were located far medially compared with chondral lesions with MMPHT which were located centrally. Chondral lesions found with MMPRT progressed faster than those lesions in non-root degenerative horizontal tear. Earlier intervention, such as repair of MMPRT or high tibial osteotomy, if malalignment is present, may be considered in order to prevent the progression of chondral lesion.

### Conflict of interest

The authors certify that they have no commercial association that might pose a conflict of interest in connection with this article.

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