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Original article

Medial meniscus extrusion correlates with disease duration of the sudden symptomatic medial meniscus posterior root tear

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ABSTRACT

Introduction: Medial meniscus posterior root tear (MMPRT) leads to abnormal biomechanics of the knee by inducing the medial meniscus extrusion (MME). However, a time-dependent increase of the MME is not fully elucidated in patients suffering from the acute MMPRT. The aim of this study was to investigate the relationships among disease duration of the MMPRT and severity of the MME. We hypothesized that MME measurement correlates with disease duration after a sudden onset of the minor traumatic MMPRT during the short-term follow-up period.

Materials and methods: Forty-six patients who had an accurate episode of the posteromedial painful popping were investigated. All the patients were diagnosed having a symptomatic MMPRT with magnetic resonance imaging (MRI) examinations. Absolute MME was measured using MRI scans within 12 months after painful popping events. A correlation coefficient between duration from injury to MRI examination and absolute MME was evaluated.

Results: Mean absolute MME was 4.5 ± 1.6 mm (range, 1.1 – 8.8 mm) on MRI measurements. A good correlation was observed between MME measurement and duration from injury to MRI examination ($R^2 = 0.612$). The best-fit equation for predicting each value was: $MME = 0.014 \times \text{disease duration} + 3.288$ mm.

Discussion: This study demonstrated that absolute MME increases progressively within the short duration after the onset of symptomatic MMPRT. Our results suggest that preoperative MME assessment may be important in determining disease duration and treatment strategy of the MMPRT.

Level of evidence: Retrospective cohort study level IV.

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1. Introduction

Medial meniscus posterior root tear (MMPRT) can occur especially in middle-aged or older female patients who have a single event of posteromedial painful popping sensation during light activities such as using stairs and squatting [1,2]. Deep flexion of the knee leads to repetitive impingement of the medial meniscus (MM) posterior root, resulting in subsequent degenerative changes and MMPRT. A single event of painful popping has a high positive predictive value (96.5%) in identifying a minor traumatic onset of MMPRT [2]. The MM posterior root can serve as an anchor to regulate the meniscal shift during the knee motion and load bearing [3–5]. Injuries of the MM posterior root, including complete radial and/or oblique tears adjacent to the ligamentous insertion and

posterior horn, lead to accelerated degeneration of the knee joint articular cartilage by disrupting meniscal functions [3]. In addition, the MMPRT leads to abnormal biomechanics of the tibiofemoral joint and the inability to convert axial loads into hoop stresses by inducing radial displacement of the MM, also called the MM extrusion (MME) [4,5]. MME is a frequent finding on magnetic resonance imaging (MRI) of patients having the MMPRT [6,7]. Severity of the MME is associated with a loss of medial compartment cartilage volume [8], medial joint space narrowing [9], severity of osteoarthritis as reflected by radiographic Kellgren–Lawrence (KL) grade [10,11], degenerative knee abnormalities [12], knee joint pain [13], increase in subchondral bone lesions and tibial plateau expansion [14] in patients with osteoarthritic knees. MME of ≥ 3 mm is more frequent in painful osteoarthritic knees than in contralateral painless knees and more frequent in osteoarthritic knees that have a higher radiographic grade (KL grade: 3) [13]. Radially displaced MM forms a bulged (or swelled) meniscal shape on a coronal MR image during the progression of osteoarthritic knees [15].

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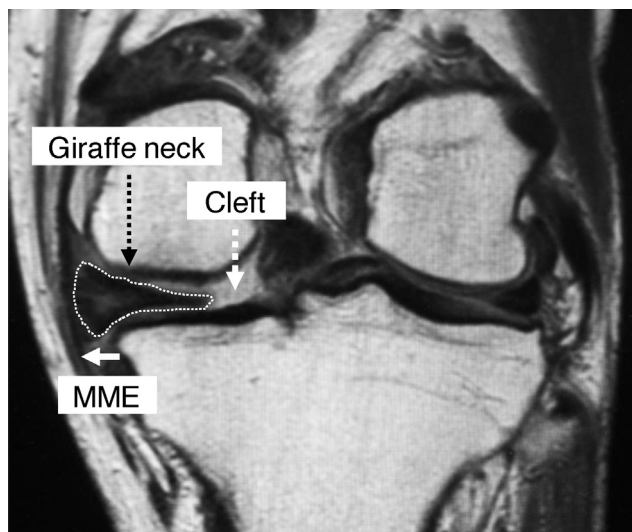


Fig. 1. Characteristic signs of the MMPRT on MR images. A 60-year-old woman (the left knee). Giraffe neck sign of the MM posterior segment (dotted area and dotted black arrow). Cleft sign (dotted white arrow). Medial extrusion of the MM (MME, arrow).

MME in osteoarthritic knees (KL grade: 2/3) shows more extrusion (2.64 mm) than that in reference subjects (0.53 mm, KL grade: 0) [15]. MME in asymptomatic knees (KL grade: 0/1) shows a minor extrusion value (1.64 mm). There is a slight increase in MME over 4 years (0.04 mm/year) [16]. On the other hand, MME associated with the MMPRT reaches a mean of 4.1–4.2 mm (KL grade: 0–4) during the short-term symptomatic period [17,18]. In addition, a degree of the MME can affect postoperative clinical outcome of the MMPRT pullout repair. Pullout-repaired patients with decreased MME have more favorable clinical scores and radiographic findings than those with increased MME [19]. Several authors describe that MME is not completely reduced by MMPRT repair [20,21]. Based on these findings, MME following the MMPRT may progress more rapidly than that in osteoarthritic knees with intact MM posterior roots. Therefore, it may be important to assess preoperative MME for determining surgical indication and timing of the MMPRT repair. However, a time-dependent increase of the MME in patients suffering from the symptomatic MMPRT remains unclear. The aim of this study was to investigate the correlation between severity of the MME and disease duration after a painful popping event defined as the sudden onset of symptomatic MMPRT. We hypothesized that measurement value of the MME would associate with symptomatic duration from the onset of MMPRT to the MRI examination.

2. Methods

This study received the approval of our Institutional Review Board and written informed consent was obtained from all patients. Fifty-five patients were diagnosed having the true MMPRT at the posterior root ligament with MRI examinations between September 2012 and August 2016. The presence of the MMPRT was defined according to characteristic MRI findings (radial tear/cleft/truncation sign of the MM posterior root within 9 mm from the attachment, giraffe neck sign, white meniscus/ghost sign, and/or MME) within 12 months after painful popping events (Fig. 1) [6,7]. Posterior horn tear and posterior segment tear of the MM were excluded. Forty-six patients (42 women and 4 men) who had an accurate episode of the posteromedial painful popping involved in a minor traumatic onset during daily activities were included (Table 1). Patients who had the MMPRT without a mem-

Table 1
Demographics and clinical characteristics.

		Range
Number of patients	46	
Gender, men/women	4/42	
Age (years)	64.7 ± 9.3	48–76
Height (m)	1.55 ± 0.06	1.44–1.69
Body weight (kg)	63.3 ± 13.4	44–88
Body mass index (kg/m ²)	26.4 ± 5.0	19.0–36.6
Duration from injury to MRI examination (days)	93.1 ± 83.9	1–289
Absolute MME (mm)	4.5 ± 1.6	1.1–8.8

Data of age, height, body weight, body mass index and duration are displayed as a mean ± standard deviation.

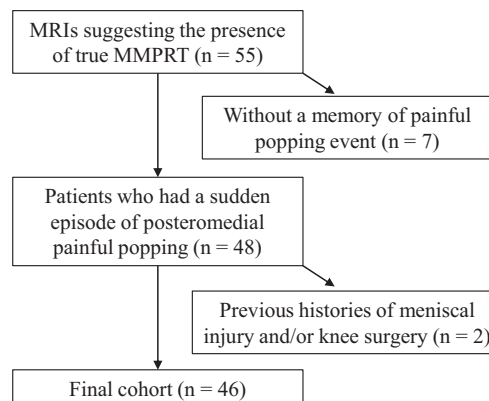


Fig. 2. Patient exclusions and final cohort.

ory of painful popping (n = 7, 12.7%) and the MMPRT with previous meniscal injury and/or knee surgery (n = 2) were excluded (Fig. 2). Mean age of the patients was 64.7 years (range, 48–76 years) at the diagnosis of the MMPRT with a sudden onset. Patient demographics were shown in Table 1. No patient was lost during the follow-up.

2.1. MRI-based measurements

MRI evaluation was performed using an Achieva 1.5 T (Philips, Amsterdam, The Netherlands) with a knee coil. Standard sequences of the Achieva included sagittal [repetition time (TR)/echo time (TE) 742/18], coronal (TR/TE 637/18), and axial (TR/TE 499/18) T2-weighted fast-field echo with a 20° flip angle (FA). Slice thickness was 3 mm with a 0.6-mm gap. Field of view (FOV) was 16 cm with an acquisition matrix size of 205 × 256 [22–24]. Absolute MME was measured from the medial margin of the tibial plateau to the outer border of the MM on the coronal MR image that crossed the midpoint of the anteroposterior length of the MM [22,24]. Two orthopaedic surgeons (Y.K. and Y.O.) independently measured the MME in a blinded manner. Each observer performed each measurement twice, at least 2 weeks apart. The reliability of the measurements was assessed by examining the interobserver and intraobserver reliabilities with the intraclass correlation coefficient (ICC). An ICC > 0.80 was considered to represent a reliable measurement.

2.2. Statistical analysis

Data were presented as means ± standard deviations. Linear regression analysis was used to assess the correlation between absolute MME and duration from injury to MRI examination. A good correlation was represented by R² ≥ 0.60, fair correlation by R² ≥ 0.50 and poor correlation by R² < 0.50. Statistical analyses were

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