Morphology of the Popliteomeniscal Fascicles around the Popliteal Hiatus Using 7-tesla Magnetic Resonance Imaging and 3-dimensional Images: A Cadaveric Study.

Hiroki Kaneko[1], Goro Tajima[1], Moritaka Maruyama[1], Atsushi Sugawara[1], Shinya Oikawa[1], Ryunosuke Oikawa[1], Ken Hayashi[1], Minoru Doita[1]
[1] Iwate Medical University, Yahaba, Iwate, Japan

Disclosures: The authors have no conflicts of interest directly relevant to the content of this study.

INTRODUCTION:

Hypermobile meniscus is known as one of the causes of knee pain and locking or limitation of the range of motion during knee flexion, even when it is difficult to diagnose meniscus tear on magnetic resonance imaging. Most such cases show excessive hypermobility of the posterior part of the lateral meniscus (LM) on arthroscopy. The cause of hypermobility in the posterior part of the LM was thought to be posttraumatic disruption of the popliteomeniscal fascicles (PMF)[1], which consisted a distinctive structure located between the popliteal tendon and the LM[2].

The number of PMF is described to consist of three fascicles, anteroinferior (AI-PMF), posterosuperior (PS-PMF), posteroinferior (PI-PMF) , however, a variety of percentages for the presence of the PMF in the knees has been reported in dissection studies[2]. The location and length[3], thickness[1], kinematic[4] of the PMFs were studied, and the function of the PMF is reported to restrict the motion of LM, nevertheless, the detailed structural attachment of the PMF has not yet been clarified. Recent studies have shown favorable outcomes in meniscus stabilization with outside-in technique or all inside technique with a suture device for hypermobile LM[1]; however, little has been mentioned about the optimal insertion point or safety zone around the popliteal tendon. To appropriately treat for hypermobile LM and other LM injuries around the popliteal hiatus, it is necessary to define the characteristic features of the PMF and its relationship with the LM and the popliteal tendon.

The purpose of this study is to make clear the anatomical feature of the PMF around the popliteal hiatus by using 7-tesla magnetic resonance imaging (7T-MRI) and 3-dimensional (3D) images. The hypothesis was that characteristic features of the PMF and its relationship of the LM and the popliteal tendon can be identified, and that they are consistent.

METHODS:

Four knees were used from human cadavers fixed by thiel method. The mean age at the time of death was 85±15 years (range,70-91 years). Specimens were cut left thigh, and poured 50 mL of a solution mixed 1 mL of Omniscan32% with 200 mL of saline solution into left knee joint. All knees were scanned using a dedicated knee coil on a 7T-MRI scanner. MR arthrography images were obtained and saved as Digital Imaging and Communications in Medicine data. All data were uploaded to dedicated software, and reconstructed as 3D images including such structures bone, muscle, menisci, cruciate ligaments, PMFs, joint capsule. These images were used to analyze the morphology of the structural attachment of the PMF and lengths, angles of the AI-PMF and PS-PMF.

RESULTS:

In the 7T-MRI and 3D images observations, the AI-PMF and PS-PMF were discernible in all knees (Fig.1). The PI-PMF could only be identified in one knee. The AI-PMF extended in an inferior-posterior direction from its point of attachment at the lateral aspect of the LM and merged with meniscofibular ligament (MFL). The PS-PMF extended in a superior-lateral direction from its point of attachment at the posterior aspect of the LM. The courses of meniscal insertion of the AI-PMF and PS-PMF are oblique, and do not interfere the popliteal tendon. The average attachment lengths of the AI-PMF and PS-PMF to the LM were 20.53 ± 4.9 mm and 6.69 ± 2.01 mm, respectively (Fig.2). The AI-PMF and PS-PMF demonstrated a gradual attenuation in thickness from their attachments of the LM to the edge of PMFs. The average angles of sweep of the AI-PMF and PS-PMF were 22.95 ± 7.05° and 35.99 ± 11.06°, respectively (Fig.3).

DISCUSSION:

The morphology of the PMFs were clarified by 7T-MRI. Based on this study, the characteristic structure of the AI-PMF and PS-PMF is proved in detail, and the lengths and angles of attachment of the PMF at the LM.

SIGNIFICANCE/ CLINICAL RELEVANCE:

This study may be useful information to repair hypermobile meniscus successfully.

REFERENCES:

1: Toyooka S, et al., Diagnostics (Basel) (2021). 2: Peduto AJ, et al., Am J Roentgenol (2008). 3: Aman ZS, et al., Am J Sports Med (2019). 4: Simonian PT, et al., Am J Sports Med (1997).

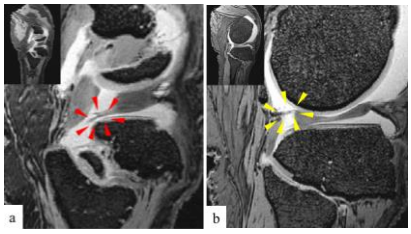

Fig.1 7T-MR arthrography findings (sagital view) of the left knee. **a** AI-PMF extend in an inferior-posterior direction from attachment at lateral meniscus (red triangles). **b** PS-PMF extend in a superior-lateral direction from attachment at lateral meniscus (yellow triangles).

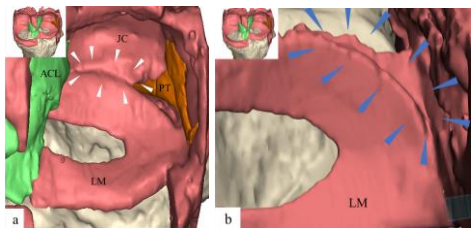

Fig.2 3D model of the PS-PMF and AI-PMF attachments to the LM. **a** There is the PS-PMF on top of the PT (white triangles). **b** After cutting the PS-PMF, there is the AI-PMF under the PT (blue triangles). LM; Lateral meniscus, PT; Popliteus tendon, JC; Joint capsule, ACL; Anterior cruciate ligament

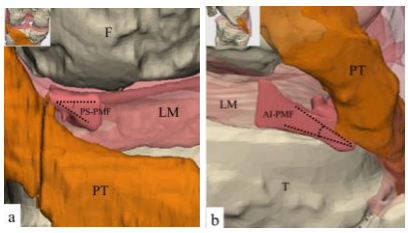

Fig.3 3D model of the PS-PMF and AI-PMF. PMFs become thinner from attachment of LM to edges. **a** 3D model (posterior view) is cut the posterior joint capsule, and the angle of PS-PMF. **b** 3D model (lateral view) is cut the lateral joint capsule, and the angle of AI-PMF. LM; Lateral meniscus, F; Femur, T; Tibia, PT; Popliteal Tendon, JC; Joint capsule