Age and Shallower Medial Tibial Plateau Depth as Risk Factors for Medial Meniscus Posterior Root Tear : A multivariate Analysis of Coronal and Sagittal Planes

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Disclosures: The authors have no conflict of interest.

Introduction: Several risk factors for medial meniscus (MM) posterior root tear (PRT) have been reported, including advanced age, increased body mass index (BMI), varus alignment of the lower limb [1], daily activities such as kneeling and squatting [2], steep medial tibial posterior slope (MTPS), shallow medial tibial plateau depth (MTPD) [3], and contralateral MMPRT [4]. In clinical practice, however, MMPRT is also observed in patients with valgus alignment, in younger individuals with a low BMI, or in those with a gentle MTPS. To the best of our knowledge, no previous study has simultaneously evaluated coronal and sagittal plane parameters as risk factors for MMPRT. Therefore, the purpose of this study was to investigate the risk factors for MMPRT by combining osseous morphology parameters from the coronal and sagittal planes.

Methods: This study was approved by our Institutional Review Board, and informed consent was obtained from all patients. We retrospectively analyzed 100 knees with MMPRT (Group M: 21 men, 81 women) and 67 knees that underwent synovectomy, MM or lateral meniscus (LM) surgeries, or osteotomy around the knee (OAK) between 2016 and 2025 (Group O: 29 men, 38 women). The inclusion criteria were Kellgren–Lawrence grade ≦2 in both groups and acute MMPRTs with clearly defined onset in Group M. The exclusion criteria were Kellgren–Lawrence grade ≥3, chronic MMPRTs with unknown onset and a history of anterior cruciate ligament (ACL) injury, lower extremity fracture or other ipsilateral knee surgeries. The following parameters were evaluated: age, sex, BMI, coronal plane parameters (hip–knee–ankle angle [HKAA], mechanical lateral distal femoral angle [mLDFA], medial proximal tibial angle [MPTA], joint line convergence angle [JLCA]), and sagittal plane parameters (MTPS and MTPD). MTPS was defined on lateral radiographs as the angle between a line perpendicular to the tibial proximal anatomical axis and medial tibial plateau, as previously described [5]. The tibial proximal anatomical axis was defined as the line connecting the midpoints of the anterior and posterior cortical lines at just distal to the tibial tubercle and at a point 10 cm distal. MTPD was measured on MRI at the slice showing the deepest medial tibial plateau, as the perpendicular distance from a line connecting the anterior and posterior subchondral bone margins (excluding cartilage) to the deepest point of the concavity [6] (Figures. 1 and 2). Sex (categorical variable) was analyzed using chi-square tests, whereas continuous variables were analyzed using t-tests or Mann–Whitney U tests with GraphPad Prism 6 software (GraphPad Software, Inc.). Multivariate logistic regression analysis with a stepwise selection method was performed to identify preoperative prognostic factors for MMPRT and to calculate their odds ratios (ORs) using EZR software (Saitama Medical Center, Jichi Medical University).

Results: Patients' demographics and radiological characteristics are presented in Table 1. Group M was significantly older than Group O ($P < 0.0001$) and included a significantly higher proportion of female patients ($P<0.01$). Group M also had a significantly shallower MTPD compared with Group O ($P < 0.0001$). No significant differences were observed between the groups in MTPS or in coronal plane parameters (HKAA, mLDFA, MPTA, JLCA). In the multivariate logistic regression analysis, age and MTPD were identified as significant risk factors for MMPRT (Table 2).

Discussion: The most important finding of this study was that patients with MMPRT (Group M) had a significantly higher age and shallower MTPD compared with those without MMPRT (Group O). The multivariable analysis identified age and MTPD as the only significant factors associated with the occurrence of MMPRT. Among the osseous morphological parameters, no factors in the coronal plane were significant, and in the sagittal plane, only MTPD—not MTPS—remained significant. Although this study included a relatively large sample size, BMI, HKAA, and MTPS—previously reported as risk factors for MMPRT [1,3,4]—did not emerge as significant predictors. One possible explanation is that the control group in this study was not composed of healthy volunteers, but rather of patients with other MM or LM injuries and those who had undergone OAK, which may have reduced the intergroup differences. A shallow MTPD may allow greater posterior translation of the femur, destabilize the medial pivot center, leading to impingement of the MM posterior horn and increased stress on the MM posterior root, thereby predisposing patients to MMPRT [3]. The results of the present study suggest that the development of MMPRT is likely influenced by a multifactorial interaction among age, BMI, osseous morphology, and lower limb alignment. This study has several limitations. First, the control group did not consist of healthy volunteers. Second, radiological and clinical evaluation after surgery were not performed. Third, daily activities such as kneeling or squatting, which have been reported as risk factors for MMPRT [2], were not assessed. Further studies are warranted to better investigate the epidemiology of MMPRT.

Clinical relevance: The risk of MMPRT should be evaluated comprehensively, taking into account not only BMI, lower limb alignment, and MTPS, but also patient age and MTPD. Even among patients with a low BMI, valgus-neutral alignment, and a gentle MTPS, those with advanced age and a shallow MTPD should receive patient education, such as avoiding squatting and undertaking weight reduction, to decrease mechanical stress on the MM posterior root and to reduce the risk of MMPRT.

References: 1. Hwang BY et al. OMID: 22582224; 2. Kawada K et al. PMID: 40390861; 3. Okazaki Y et al. PMID: 31243503; 4. Hiranaka T et al. PMID: 32488369; 5. Brandon ML et al. PMID: 16904590; 6. Hashemi J et al. PMID: 19846692.

Acknowledgements: We thank our collaborative researchers for their cooperation.

Figures:

Figure 1
(a). MRI of the knee in Group M.
Medial tibial plateau depth (0.3 mm).
(b). MRI of the knee in Group O.
Medial tibial plateau depth (2.3 mm).

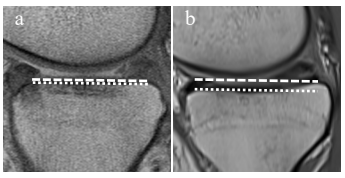

Table 1. Patients' characteristics

	Group M (n=102)	Group O (n=67)	*P* value
Age (years)	64.2 ± 9.8	49.9 ± 16.1	<0.0001
Sex (male / female)	21 / 81	29 / 38	<0.01
BMI (kg/m^2)	25.8 ± 4.1	25.0 ± 4.6	0.25
HKA (°)	2.7 ± 2.6	2.8 ± 3.2	0.26
mLDFA (°)	87.5 ± 1.6	87.4 ± 2.0	0.78
MPTA (°)	86.1 ± 2.2	85.9 ± 2.2	0.75
JLCA (°)	1.2 ± 1.2	1.3 ± 1.4	0.63
MTPS (°)	9.5 ± 3.0	8.7 ± 2.9	0.073
MTPD (mm)	1.4 ± 0.6	1.9 ± 0.7	<0.0001

Data are presented as mean ± standard deviation.

Table 2. Result of multivariate logistic regression analysis

Dependent variables	Significant variables	Odds ratio	*P* value	95% CI
Subjects with or without MMPRT n = 169	Age (years)	1.14	<0.00001	1.08-1.20
	Sex (male / female)		0.20	
	BMI (kg/m^2)		0.056	
	HKA (°)		0.064	
	MTPS (°)		0.11	
	MTPD (mm)	0.23	<0.001	0.98-1.30