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A Smaller Posterior Tibial Slope May Be Associated with an Increased Risk of Tears in the Anterior Horn of the Lateral Meniscus

Min-Hwan Huh, MD, Min Jung, MD[*,†], Kwangho Chung, MD[*,‡], Hyun-Soo Moon, MD[*,§], Se-Han Jung, MD[*,†], Sungjun Kim, MD[‖], Sung-Hwan Kim, MD[*,†]

Graduate School, Yonsei University College of Medicine, Seoul,
[*]Arthroscopy and Joint Research Institute, Yonsei University College of Medicine, Seoul,
[†]Department of Orthopedic Surgery, Severance Hospital, Yonsei University College of Medicine, Seoul,
[‡]Department of Orthopedic Surgery, Yongin Severance Hospital, Yonsei University College of Medicine, Yongin,
[§]Department of Orthopedic Surgery, Gangnam Severance Hospital, Yonsei University College of Medicine, Seoul,
[‖]Department of Radiology, Gangnam Severance Hospital, Yonsei University College of Medicine, Seoul, Korea

Background: While lateral meniscus anterior horn (LMAH) tears can increase peak contact pressure in the knee joint, limited research has explored the correlation between LMAH tears and posterior tibial slope (PTS), closely associated with knee joint kinematics. This study aimed to investigate the association between PTS and LMAH tears. It was hypothesized that patients with LMAH tears would exhibit lower PTS values compared to those without such tears.

Methods: This study retrospectively included 35 patients with isolated LMAH tears and 83 patients with no pathological findings on magnetic resonance imaging (MRI) between January 2010 and October 2023. PTS was measured using the medial tibial plateau on lateral radiographs, while both the medial and lateral slopes were separately evaluated on MRI. Group comparisons and multivariable logistic regression were performed, with inverse probability of treatment weighting (IPTW) applied to adjust baseline differences. Receiver operating characteristic (ROC) analysis was conducted to determine a threshold value. Tear types and treatment methods were also analyzed.

Results: The mean PTS was significantly smaller in the LMAH tear group (LMAH tear group, 4.70° ± 2.16°; control group, 6.58° ± 2.95°, $p < 0.001$), while MRI-based medial PTS (LMAH tear group, 4.62° ± 2.43°; control group, 4.81° ± 2.35°; $p = 0.702$) and lateral PTS (LMAH tear group, 4.02° ± 2.24°; control group, 4.78° ± 2.39°; $p = 0.115$) showed no significant differences. In multivariable logistic regression, the adjusted odds ratio of PTS in the LMAH tear group was 0.76, indicating that for each 1° decrease in PTS, the odds of an LMAH tear increased approximately 1.32 times (95% CI, 0.62–0.93; $p = 0.009$). After IPTW matching, mean PTS remained significantly smaller in the LMAH tear group ($p = 0.006$). The ROC curve analysis identified a PTS cutoff value of 4.49° for distinguishing LMAH tear from controls, and PTS < 4.49° was significantly associated with LMAH tear (odds ratio, 0.25; 95% CI, 0.11–0.60; $p = 0.001$). Tear types showed no significant differences in PTS, but treatment methods varied significantly, with repair more frequent in simple tears and meniscectomy in degenerative or complex tears.

Conclusions: A smaller PTS may be associated with an increased risk of LMAH tears.

Keywords: *Tibial slope, Tibial menisci, Meniscal tear*

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Correspondence to: Sung-Hwan Kim, MD
Department of Orthopedic Surgery, Severance Hospital, Yonsei University College of Medicine, 50-1 Yonsei-ro, Seodaemun-gu, Seoul 03722, Korea
Tel: +82-2-2228-2180, Fax: +82-2-393-1139, E-mail: orthohwan@gmail.com

The posterior tibial slope (PTS) is defined as the posterior slope of the proximal tibia in the sagittal plane and is assessed as the angle between the line indicating the posterior slope of the tibial plateau and a line perpendicular to the center of the tibial diaphysis.[1,2] The kinematics of the knee joint are closely influenced by PTS.[3] Increased PTS can influence anteroposterior knee instability by increasing anterior tibial translation.[1] Due to these characteristics, numerous studies have investigated the association between an anterior cruciate ligament deficiency and increased PTS.[4]

The meniscus is an important structure in the knee with primary functions that include joint stabilization, shock absorption, and load transmission.[5,6] Previous studies reported that degenerative meniscus tear was a risk factor for knee osteoarthritis.[7-10] Tibial translation due to PTS is one of several causes of meniscus tears.[11,12] Increased PTS is associated with lateral meniscus posterior horn tears and medial meniscus posterior horn tears.[13,14] Nevertheless, few studies have explored the connection between PTS and meniscus anterior horn tears. Shepard et al.[15] reported that the proportion of meniscus anterior horn tears was small compared to other types of meniscus tear, and mainly involved the lateral meniscus. For this reason, lateral meniscus anterior horn (LMAH) tears are often overlooked in clinical practice. However, LMAH tears could also lead to increased peak contact pressure in the knee tibiofemoral joint.[16] Identifying risk factors may help in early detection and management of LMAH tears. In previous studies, smaller PTS was found to increase stress on anterior subchondral bone and to be associated with higher remaining posterior tibial translation.[3,17] Logically combining these factors, it is predicted that there will be an association between PTS and LMAH tears. However, few studies have evaluated PTS and LMAH tears. This study aimed to investigate the association between PTS and LMAH tears. It was hypothesized that patients with LMAH tears would exhibit lower PTS values compared to those without such tears.

METHODS

The Institutional Review Board of Gangnam Severance Hospital, Yonsei University College of Medicine approved this study (IRB No. 3-2024-0252). Due to the retrospective design of the research, the Board waived the requirement for informed consent.

Patient Enrollment

To maintain consistent diagnostic criteria of arthroscopic findings, data were retrospectively gathered from patients who underwent arthroscopic knee surgery performed by a single surgeon (SHK) between January 2010 and October 2023. Patients with isolated LMAH tears who underwent treatment through arthroscopic meniscectomy and/or repair were included in the study. Patients who fulfilled the following criteria were excluded: (1) discoid lateral meniscus, (2) combined osteotomy, ligament, or cartilage surgery, (3) lateral meniscus tear with medial meniscus tear, (4) previous surgical history of the affected knee, (5) combined meniscal allograft surgery, or (6) septic arthritis or inflammatory arthritis. In addition, patients with lateral meniscus posterior horn tears, body tears, or entire degenerative tears were excluded (Fig. 1). The control group

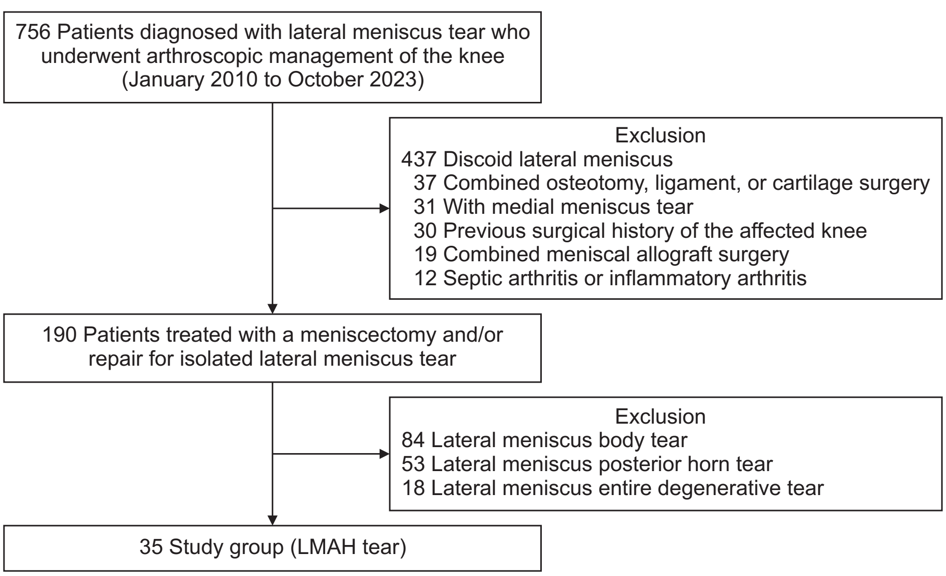

Fig. 1. Flowchart of selection of patients with lateral meniscus anterior horn (LMAH) tears. Each exclusion criterion was applied based on the principal diagnosis and lesion site, and no patient was counted more than once.

originally consisted of patients diagnosed in the outpatient clinic with “internal derangement of knee, unspecified meniscus or ligament” (International Classification of Diseases, 10th Revision code: M23.99) and presenting knee pain during the same period. To improve comparison validity, only patients with no pathological findings on magnetic resonance imaging (MRI) were selected, ensuring that control groups did not have meniscus tears or other confounding conditions (Fig. 2).

Radiographic Assessment

PTS was assessed using true lateral knee radiographs. They were obtained with medial and lateral femoral condyles superimposed at 30° of knee flexion. Among the available radiographs for each patient, the one where the femoral condyles were best superimposed was selected to maintain consistency and minimize measurement errors. The line of posterior cortex was chosen as the reference due to its demonstrated high reliability and minimized error in manual measurement procedures.[18] The PTS was determined by measuring the angle between the proximal extension of the line perpendicular to the posterior tibial cortex line at the metaphyseal level, which is extended proximally, and a line representing the medial tibial plateau (Fig. 3). The medial tibial plateau was used for measurements in true lateral knee radiographs because the medial tibial plateau is the major load-bearing compartment of the knee and its relatively flat, slightly concave shape provides consistent landmarks for manual measurement.[1,19] The hip-knee-ankle angle (HKAA), medial proximal tibial angle (MPTA), and lateral distal femoral angle (LDFA) were also measured on whole leg radiographs, and the joint line convergence angle (JCA) was measured on knee anteroposterior radiographs to assess their potential confounding effects. HKAA values were positive for varus alignment and negative for valgus alignment. Likewise, positive values of JCA indicated that the medial gap of the knee joint was tighter than the lateral gap, while negative values of JCA indicated that the lateral gap of the knee joint was tighter than the medial gap. All radiographs were measured in a blinded manner at 4-week intervals using a picture archiving and communication system. To assess interobserver reliability, a second surgeon (SHJ) independently measured the radiographs, also in a blinded state.

Medial and Lateral PTS Measurement on MRI

PTS measurements of the medial and lateral tibial plateaus were obtained on sagittal MRI images by method of Hudek et al.[20] First, the sagittal slice displaying the intercondylar eminence, the tibial attachment of the posterior cruciate ligament, and the anterior and posterior tibial cortex that appeared in a concave shape was selected. On this

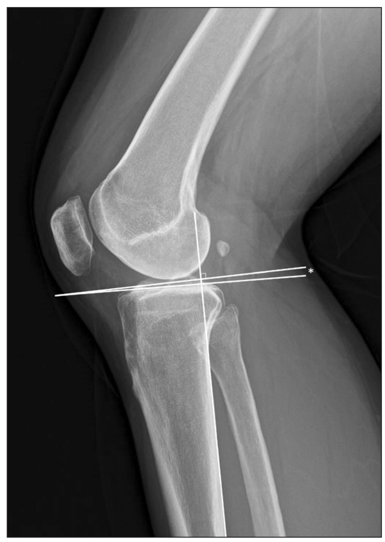

Fig. 3. Posterior tibial slope is measured by the angle (asterisk) between the line drawn along the tibial plateau connecting its highest anterior and posterior bony ridges and a line perpendicular to the posterior tibial cortex line at the metaphyseal level, which is extended proximally.

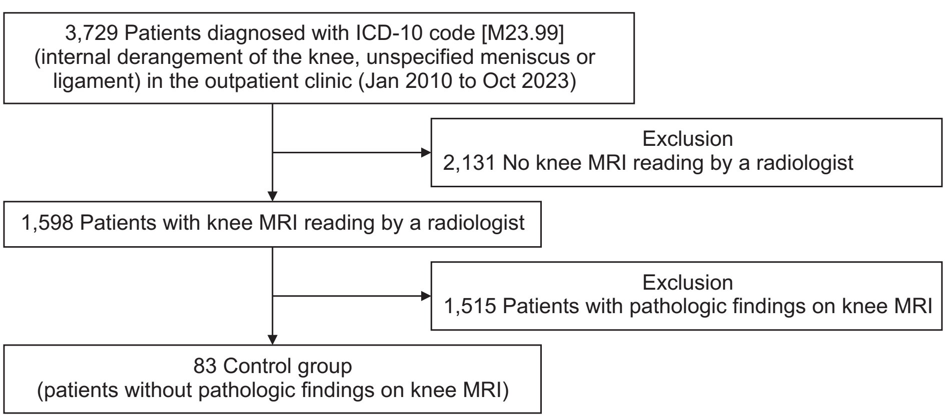

Fig. 2. Flowchart of selection of patients without pathologic findings on knee magnetic resonance imaging (MRI). ICD-10: International Classification of Diseases, 10th Revision.

slice, 2 best-fitting circles were drawn within the proximal tibial metaphysis: the proximal circle fitted to the anterior, posterior, and cranial tibial cortex bone and the distal circle fitted to the anterior and posterior cortex bone. A straight line connecting the centers of these 2 circles was defined as the tibial longitudinal axis. The medial posterior tibial slope (MPTS) and lateral posterior tibial slope (LPTS) were measured on the central sagittal slices where the centers of the respective tibial plateaus were visible, maintaining the previously established longitudinal axis for consistency. The slope of each tibial plateau was then determined as the acute angle between a line tangential to the medial and lateral plateaus surfaces and a line perpendicular to the tibial longitudinal axis (Fig. 4).

Statistical Analysis

Statistical analyses were conducted using version 9.4 of SAS software (SAS Institute). PTS and other known risk factors of meniscus tears were compared.[11,12] Student *t*-test was applied to analyze numerical variables (i.e., age, body mass index [BMI], HKAA, MPTA, LDFA, JCA, and PTS), which were presented as means and standard deviations. For categorical variables (i.e., sex and radiographic osteoarthritis grade according to the Kellgren-Lawrence grade [KL grade]), Pearson chi-square test or Fisher's exact test was used. Multivariable logistic regression was used to assess the impact of each factor, with the results expressed as odds ratios. In addition, meniscal tear types were categorized as simple (single-plane patterns), complex (combined patterns), or degenerative, and treatment methods (meniscectomy or repair) were analyzed for their association with tear type.

Baseline characteristics were probable risk factors for meniscus tears, so these factors could be adjusted during comparisons of PTS.[11] However, selection bias could not be fully avoided in this case-control study. Furthermore, the incidence of LMAH tears was relatively low compared with other types of meniscus tears.[15] Therefore, to address potential biases and the small number of patients in the study group, an inverse probability of treatment weighting (IPTW) analysis was also conducted. This method generates pseudo-datasets by weighting participants according to the inverse of their treatment probability, ensuring balanced baseline characteristics across groups.[21] In this way, the differences in baseline characteristics including valgus alignment between the 2 groups were no longer significant. By making clinical covariates similar, the IPTW matching method could effectively minimize selection bias. Because radiographic and MRI-based slope measurements are not directly interchangeable, these analyses were conducted separately.[22]

The receiver operating characteristic (ROC) curve analysis was conducted to establish the PTS threshold that differentiates patients with LMAH tears from the control group. The area under the curve (AUC) reflects the discriminative ability of the threshold, and the optimal cutoff point was identified to balance sensitivity and specificity effectively.

The intraobserver and interobserver reliabilities of PTS measurements were assessed using the intraclass correlation coefficient (ICC), calculated with a 95% CI based on mixed 2-way models and absolute agreement. The ICC values between 0.75 and 0.90 indicate good reliability, and values above 0.90 indicate excellent reliability.[23] Statistical significance was set at $p < 0.05$. A post hoc power analysis was also conducted using G*Power version 3.1 (Heinrich-

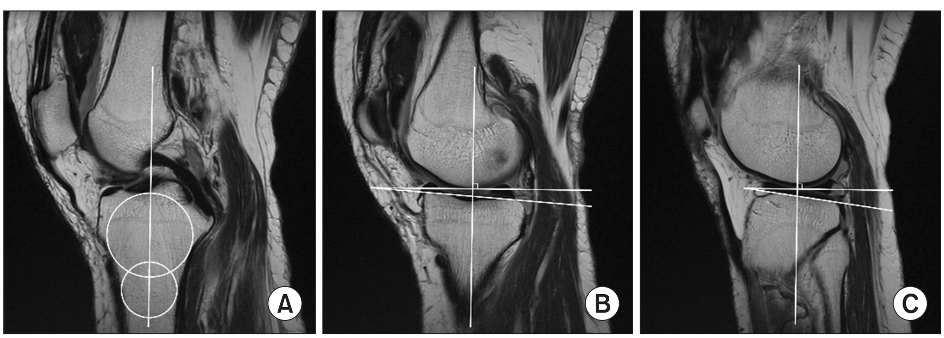

Fig. 4. (A) The tibial longitudinal axis was established by connecting the centers of 2 circles fitted to the anterior, posterior, and cranial cortices of the proximal and distal tibia. (B) The medial posterior tibial slope was measured using a tangent line connecting the most superior anterior and posterior points of the medial tibial plateau. The medial posterior tibial slope was defined as the angle between the tangent line of the medial tibial plateau and a line perpendicular to the tibial longitudinal axis. (C) The lateral posterior tibial slope was measured using a tangent line connecting the most superior anterior and posterior points of the lateral tibial plateau. The lateral posterior tibial slope was defined as the angle between the tangent line of the lateral tibial plateau and a line perpendicular to the tibial longitudinal axis.

Heine-Universität Düsseldorf) to assess the achieved power of this study. For the measurement of PTS, the intraobserver ICC was 0.949 (95% CI, 0.927–0.965) and the interobserver ICC was 0.935 (95% CI, 0.908–0.955). For LPTS, the intra- and interobserver ICCs were 0.915 (95% CI, 0.878–0.941) and 0.796 (95% CI, 0.718–0.854), respectively. For MPTS, the intra- and interobserver ICCs were 0.908 (95% CI, 0.867–0.936) and 0.707 (95% CI, 0.604–0.787), respectively. A post hoc power analysis using G*Power (Heinrich-Heine-Universität Düsseldorf) confirmed that the power for detecting this difference was 0.92, sufficient for this comparison.

RESULTS

Comparison between LMAH Tear and Control Groups

This study included 35 patients in the LMAH tear group and 83 patients in the control group. There were no significant differences between the LMAH tear and control groups in baseline characteristics, including age, sex, and BMI. PTS was significantly smaller in the LMAH tear group (mean ± standard deviation: LMAH tear group, 4.70° ± 2.16°; control group, 6.58° ± 2.95°; $p < 0.001$). However, MRI-based measurements of MPTS (LMAH tear group, 4.62° ± 2.43°; control group, 4.81° ± 2.35°; $p = 0.702$) and LPTS (LMAH tear group, 4.02° ± 2.24°; control group, 4.78° ± 2.39°; $p = 0.115$) showed no statistically significant differences. Furthermore, HKAA in the LMAH tear group showed significantly more valgus alignment than in the control group (LMAH tear group, –0.42° ± 2.98°; control group, 1.64° ± 2.68°; $p < 0.001$). MPTA (LMAH tear group, 87.27° ± 2.20°; control group, 85.92° ± 2.41°; $p = 0.005$) and the ratio of KL grade 1 osteoarthritis (LMAH tear group, 48.57%; control group, 27.71%; $p = 0.029$) was significantly greater in the LMAH tear group. However, LDFA and JCA showed no significant differences (Table 1). There were no significant differences in PTS among tear types. However, treatment methods demonstrated a significant association with tear type: repair was more frequently performed for simple tears, while meniscectomy was predominantly chosen for degenerative and complex tears (Table 2).

In univariable logistic regression, the odds ratios of HKAA (0.77; 95% CI, 0.66–0.90; $p = 0.001$), MPTA (1.28; 95% CI, 1.07–1.53; $p = 0.008$), osteoarthritis (KL grade 1) (2.46; 95% CI, 1.09–5.59; $p = 0.031$), and PTS (0.74; 95% CI, 0.61–0.89; $p = 0.002$) demonstrated a statistically significant correlation with LMAH tears. After multivariable logistic regression of those factors, the adjusted odds ratio of PTS was 0.76, indicating that for each 1° decrease in PTS, the odds of an LMAH tear increased by approximately 1.32 times (95% CI, 0.62–0.93; $p = 0.009$) (Table 3).

According to multiple logistic regression, only PTS showed a significant correlation with LMAH tears. Therefore, IPTW matching was performed to balance all other

Table 1. Comparisons between the LMAH Tear and Control Groups

Variable	LMAH tear (n = 35)	Control (n = 83)	*p*-value
Age (yr)	42.17 ± 15.33	38.24 ± 13.07	0.159
Sex			0.292
Male	21 (60.00)	41 (49.40)	
Female	14 (40.00)	42 (50.60)	
BMI (kg/m^2)	24.56 ± 3.83	23.18 ± 3.39	0.055
HKA angle (°)	–0.42 ± 2.98	1.64 ± 2.68	< 0.001
MPTA (°)	87.27 ± 2.20	85.92 ± 2.41	0.005
LDFA (°)	85.74 ± 2.13	86.18 ± 1.98	0.289
JCA (°)	0.89 ± 1.83	1.28 ± 1.50	0.221
KL grade			0.029
0	18 (51.43)	60 (72.29)	
1	17 (48.57)	23 (27.71)	
PTS (x-ray) (°)	4.70 ± 2.16	6.58 ± 2.95	< 0.001
MPTS (MRI) (°)	4.62 ± 2.43	4.81 ± 2.35	0.702
LPTS (MRI) (°)	4.02 ± 2.24	4.78 ± 2.39	0.115

Values are presented as mean ± standard deviation or number (%).
LMAH: lateral meniscus anterior horn, BMI: body mass index, HKA: hip-knee-ankle, MPTA: medial proximal tibial angle, LDFA: lateral distal femoral angle, JCA: joint line convergence angle, KL: Kellgren-Lawrence, PTS: posterior tibial slope, MPTS: medial posterior tibial slope, MRI: magnetic resonance imaging, LPTS: lateral posterior tibial slope.

Table 2. Distribution of Tear Types, PTS, and Treatment Methods in Patients with LMAH Tears (n = 35)

Tear type	n	PTS (°)*	Meniscectomy†	Repair†
Simple tear	9	4.06 ± 1.90	4	5
Complex tear	12	5.13 ± 2.64	10	2
Degenerative tear	14	4.75 ± 1.89	13	1

Values are presented as mean ± standard deviation or number. Tear types were categorized as simple (single-plane patterns), complex (combined patterns), or degenerative. All patients underwent arthroscopic surgery, and treatment methods were therefore limited to meniscectomy or repair.
PTS: posterior tibial slope, LMAH: lateral meniscus anterior horn.
*No significant difference in PTS was observed among tear types (analysis of variance, $p > 0.05$). †The distribution of treatment methods (meniscectomy vs. repair) differed significantly among tear types (chi-square test, $p = 0.022$).

Table 3. Univariable and Multivariable Logistic Regressions between the LMAH Tear and Control Groups

	Univariable		Multivariable	
	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Age (yr)	1.02 (0.99–1.05)	0.160	-	-
Sex				
Male	Reference			
Female	0.65 (0.29–1.45)	0.294	-	-
BMI (kg/m^2)	1.11 (1.00–1.25)	0.059	-	-
HKA angle (°)	0.77 (0.66–0.90)	0.001	0.82 (0.67–1.00)	0.055
MPTA (°)	1.28 (1.07–1.53)	0.008	1.12 (0.89–1.41)	0.321
LDFA (°)	0.90 (0.74–1.10)	0.288	-	-
JCA (°)	0.86 (0.67–1.10)	0.222	-	-
KL grade				
0	Reference		Reference	
1	2.46 (1.09–5.59)	0.031	2.53 (0.99–6.51)	0.053
PTS (°)	0.74 (0.61–0.89)	0.002	0.76 (0.62–0.93)	0.009

LMAH: lateral meniscus anterior horn, OR: odds ratio, BMI: body mass index, HKA: hip-knee-ankle, MPTA: medial proximal tibial angle, LDFA: lateral distal femoral angle, JCA: joint line convergence angle, KL: Kellgren-Lawrence, PTS: posterior tibial slope.

Table 4. Comparison of PTS between the LMAH Tear and Control Groups after IPTW Matching

Variable	LMAH tear (n = 54.55)	Control (n = 92.71)	*p*-value
Age (yr)	38.89 ± 22.00	39.07 ± 14.77	0.960
Sex			0.757
Male	29.00 (56.89)	47.72 (53.15)	
Female	21.97 (43.11)	42.05 (46.85)	
BMI (kg/m^2)	23.81 ± 3.79	23.58 ± 4.36	0.742
HKA angle (°)	0.64 ± 3.14	1.19 ± 3.03	0.312
MPTA (°)	86.91 ± 2.49	86.26 ± 2.87	0.163
LDFA (°)	86.37 ± 3.53	86.19 ± 2.06	0.737
JCA (°)	1.03 ± 1.58	1.20 ± 1.60	0.548
KL grade			0.568
0	30.56 (59.95)	59.72 (66.53)	
1	20.41 (40.05)	30.05 (33.47)	
PTS (°)	4.83 ± 3.60	6.51 ± 3.01	0.006

Values are presented as mean ± standard deviation or number (%). Values of n represent weighted sample sizes after IPTW and may therefore appear as non-integer values. Adjustment for baseline characteristics: age, sex, BMI, HKA angle, MPTA, LDFA, JCA, KL grade.
PTS: posterior tibial slope, LMAH: lateral meniscus anterior horn, IPTW: inverse probability of treatment weighting, BMI: body mass index, HKA: hip-knee-ankle, MPTA: medial proximal tibial angle, LDFA: lateral distal femoral angle, JCA: joint line convergence angle, KL: Kellgren-Lawrence.

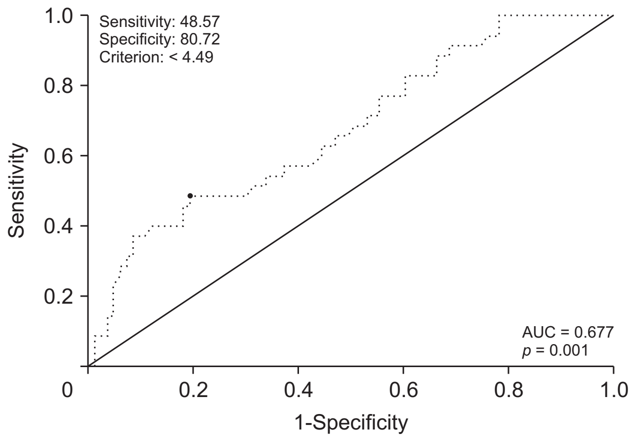

Fig. 5. Receiver operating characteristic curve of posterior tibial slope. AUC: area under the curve.

baseline characteristics except PTS. In a comparison after IPTW matching analysis, the mean PTS was significantly smaller in the LMAH tear group (LMAH tear group, 4.83° ± 3.60°; control group, 6.51° ± 3.01°; $p = 0.006$) (Table 4).

ROC Curve Analysis

ROC curves were drawn to obtain optimal cutoff points for PTS to discriminate between the LMAH tear and control groups. The cutoff point for PTS was 4.49° (sensitivity, 48.57%; specificity, 80.72%) and of the AUC was 0.677 (Fig. 5). The PTS < 4.49° was significantly associated with LMAH tear (odds ratio, 0.25; 95% CI, 0.11–0.60; $p = 0.001$).

DISCUSSION

The main outcome of this study was that PTS was significantly smaller in the LMAH tear group compared to the control group, whereas MRI-based LPTS did not demonstrate significant differences. Using ROC curve analysis, the PTS threshold for differentiating the study group from the control group was 4.49°. In subgroup analyses according to tear type, no significant differences in PTS were observed. However, treatment methods differed significantly, with repair being more frequently performed for simple tears and meniscectomy predominantly performed for degenerative and complex tears. These findings indicate that PTS may predispose to the occurrence of meniscal tears rather than determining their morphological patterns, and that treatment selection largely reflects tear complexity.

Meniscus tears are an important cause of osteoarthritis of the knee.[7,24] Several previous studies focused on meniscus posterior horn tears because the most frequent location of lesions in the meniscus is the posterior horn.[14,25] However, few studies have examined the causes of LMAH tears. LMAH tears can lead to increased peak contact pressure and impair the stability of the knee joint, which might have negative effects on the knee joint in the future.[16] Therefore, treatment of LMAH tears is important, and repair of LMAH tears can improve outcomes.[16] Two previous studies on the characteristics of LMAH tears reported that LMAH tears were frequently found in soccer players.[26,27] The repetitive kicking by soccer players could lead to hyperextension of the knee joint and recurrent impingement of the LMAH between the lateral femoral condyle and the lateral tibial plateau could result in degeneration of the LMAH.[26]

In this study, smaller PTS was a risk factor for LMAH tears. The main reason why PTS was smaller in the LMAH tear group was thought to be increased posterior tibial translation due to smaller PTS.[28] Previous studies of the posterior cruciate ligament reported that smaller PTS might result in increased posterior tibial translation.[17] Furthermore, smaller PTS could cause decreased internal rotation of the tibia during flexion of the knee.[28] These factors might result in increased impingement of the LMAH and lateral femoral condyle, increasing the likelihood of LMAH tears.

Several studies have reported moderate to strong correlations between radiographic and MRI-based tibial slope measurements, indicating that these modalities tend to yield comparable results despite differences in measurement techniques.[29,30] However, in the present study, radiographic PTS was significantly smaller in the LMAH tear group compared with controls, whereas MRI-based LPTS did not reach statistical significance. This discrepancy may be explained by previous studies reporting that MRI measurements of PTS demonstrate greater variability and lower correlation with radiographs, and tend to yield smaller values than radiographic measurements.[20,22,31] Moreover, MRI measurements are more sensitive to MRI quality, slice selection, observer variability, and tibial morphology, all of which can attenuate group differences despite good intra- and interobserver reliability.[22] Therefore, these findings suggested that radiographic PTS may serve as a more reliable parameter for detecting clinically relevant differences in meniscal pathology, whereas MRI-based measurements should be interpreted as complementary but less consistent indicators.

In direct comparisons and univariable logistic regression, patients in the LMAH tear group had more valgus alignment than those in the control group, although there were no significant differences in multivariable logistic regression. The lateral meniscus is partially detached from the joint capsule and is linked to the popliteal hiatus through the popliteomeniscal fascicle.[32] Therefore, the lateral meniscus has greater tendency toward hypermobility than the medial meniscus.[33] However, in valgus alignment, the natural movement of the lateral meniscus is limited, which could increase strain on the lateral meniscus.[34] This might clarify why patients with LMAH tears exhibited a greater degree of valgus alignment compared to the control group. In the present study, although IPTW matching was applied to adjust for valgus alignment differences, a significant difference remained in the demographic table, suggesting a potential role of valgus alignment in LMAH tears. Future studies should further investigate this relationship.

This study has several limitations. First, the retrospective, single-surgeon design of this study inherently makes it susceptible to selection and measurement bias, and limits the generalizability of the findings to other clinical settings. Second, the sample size was relatively small for comparisons. Although IPTW analysis was applied to create a pseudo-population and reduce baseline differences, this limitation remains. Future studies using larger, multicenter cohorts are needed. Third, even though several risk factors were evaluated, there might be other factors that were not included, such as activity level which could have influenced the observed association between PTS and LMAH tears. Also, the control group may still have included patients with subclinical or functional abnormalities not detectable on imaging. Fourth, although the IPTW matching was performed to minimize baseline differences in valgus alignment, residual differences remained, as indicated in the demographic table. Moreover, as meniscal pathology is inherently multifactorial, the present study's focus on a single anatomical parameter may oversimplify the complex etiology. This limitation suggests the need for future research to explore the independent effects of valgus alignment on LMAH pathology.

To the best of our knowledge, there is limited evidence directly investigating the relationship between PTS and LMAH tears. While the statistical correlation between reduced PTS and LMAH tears was significant, the clinical applicability of the ROC-derived cutoff (4.49°) is limited by its low sensitivity (48.57%) and modest AUC (0.677). Although the ROC-derived cutoff showed only modest accuracy, recognizing smaller radiographic PTS as an independent risk factor for LMAH tears highlights its value as a practical and reproducible parameter that may assist clinicians in risk stratification, early diagnosis, patient counseling, and preventive strategies. The novelty of focusing on LMAH tears, rather than the more extensively studied posterior horn tears, strengthens the contribution of this study and provides new insights into the risk profile of meniscal injuries.

A smaller PTS may be associated with an increased risk of LMAH tears. In clinical practice, assessing PTS on radiographic imaging may facilitate risk assessment and inform clinical decision-making for early intervention in patients with recurrent knee symptoms.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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ORCID

Min-Hwan Huh https://orcid.org/0000-0002-4690-6997
Min Jung https://orcid.org/0000-0002-7527-4802
Kwangho Chung https://orcid.org/0000-0003-3097-3332
Hyun-Soo Moon https://orcid.org/0000-0001-8678-2960
Se-Han Jung https://orcid.org/0000-0001-8422-093X
Sungjun Kim https://orcid.org/0000-0002-7876-7901
Sung-Hwan Kim https://orcid.org/0000-0001-5743-6241

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