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RESEARCH

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Association between anatomical risk factors and medial meniscus posterior root tears: a retrospective study

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Abstract

Background The purpose of this study was (a) to investigate the association between the potential anatomical risk factors and medial meniscus posterior root tears (MMPRTs), and (b) to determine the optimal cutoff values of risk factors for discriminating MMPRTs.

Methods A retrospective study was conducted, from January 2018 to January 2020, 86 patients with MMPRTs identified by an experienced musculoskeletal radiologist using 3-T magnetic resonance imaging (MRI), and also confirmed during arthroscopic surgery were included in this study. Moreover, MMPRTs patients were matched with 128 patients with other types of medial meniscal tear knees at the same period according to patients' demographics. We categorized the two patient groups into subgroups based on the causes of meniscus root tears. A subgroup analysis was performed to evaluate the parameter differences between traumatic and degenerative MMPRT in these groups. The associations between clinical and anatomic factors and MMPRTs were analyzed. Additionally, a logistic regression analysis was performed to detect risk factors correlated with MMPRTs.

Results Based on the analysis, binary logistic regression models analysis indicated that medial posterior tibial slope (MTS) (odds ratio (OR) = 1.212, $P = 0.005$), hip knee ankle (HKA) (OR = 1.657, $P < 0.001$) and medial femoral condyle length/medial tibial plateau length (MFCL/MTPL) (OR = 16.597, $P = 0.019$) were the risk factors correlated with MMPRTs. A subgroup analysis revealed that the MTS, HKA, and MFCL/MTPL were risk factors associated with traumatic MMPRTs. Additionally, age, MTS, HKA, and MFCL/MTPL were identified as risk factors linked to degenerative MMPRTs. Additionally, the receiver operating characteristic (ROC) curves demonstrated these factors had comparable accuracy at predicting MMPRTs (under the curve were 0.635, 0.700 and 0.627, respectively). The cutoff values of those factors were 7.4º, 2.4º, and 1.2, respectively.

Conclusions Based on results from the current study, we identified MTS > 7.4º, HKA > 2.4º and MFCL/MTPL > 1.2 were the risk factors correlated with MMPRTs.

Keywords Medial meniscus posterior root tears, Risk factors, Medial posterior tibial slope, Medial femoral condyle, Medial tibial plateau

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Background

Root tears of the meniscus make up around 20% of all meniscal tears, presenting a substantial component of meniscus pathologies [1]. Degenerative posterior root tears of the medial meniscus are the most frequently seen type among meniscus tears [2]. Responsible for bearing 40–80% of the load in the knee joint, meniscal root tears lessen the ability to withstand hoop stresses, akin to having undergone a full meniscectomy [3]. These injuries can lead to diminished meniscal function, decreased knee stability, and are closely associated with knee osteoarthritis [4]. Compared to partial meniscectomy, there is greater evidence suggesting that various surgical repair strategies not only restore the hoop tension of the medial meniscus but also prevent the progression of knee degeneration [5–8].

Risk factors for meniscal tears fall into extrinsic and intrinsic categories. Extrinsic factors include neuromuscular forces, mechanisms of injury, delays in surgery, unmanaged ligament injuries, and biomechanics during movements [9, 10]. Intrinsic risk factors involve age, gender, alignment of the lower limbs, increased body mass index (BMI), and the shape of the tibial plateau [11, 12]. Nevertheless, the specific impact of these factors on medial meniscus posterior root tears (MMPRTs) has not been thoroughly investigated. Past studies offer conflicting findings regarding the connection between certain variables and MMPRTs [13–16]. These tears commonly arise from their involvement in transmitting shear and compressive forces and are crucial for stabilizing the knee [17]. Given that a larger contact area of the medial tibiofemoral joint may further increase hoop stresses, it appears reasonable to suggest that an increased medial femoral condyle length/medial tibial plateau length (MFCL/MTPL) could contribute to the development of MMPRTs [18]. Consequently, recognizing these anatomical factors may aid orthopedic surgeons in identifying MMPRTs risk factors in vulnerable individuals.

The aim of this study was twofold: firstly, it sought to explore the link between possible anatomical risk factors and MMPRTs. Secondly, it aimed to establish the optimal threshold values of these risk factors for distinguishing between individuals with MMPRTs and those in the control group. The underlying hypothesis proposed that significant anatomical risk factors exist for MMPRTs.

Materials and methods

Patient selection

Data from January 2018 to January 2020 was analyzed to review patients who underwent arthroscopic meniscectomy or meniscal repair for the medial meniscus tears and received knee radiographs and magnetic resonance imaging (MRI) scans. The study focused on 86 patients with MMPRTs identified by an experienced musculoskeletal radiologist using 3-T MRI, which was later confirmed during arthroscopic surgery. The patient enrollment flowchart of this study is shown in Fig. 1. The inclusion criteria required patients have isolated MMPRTs as seen

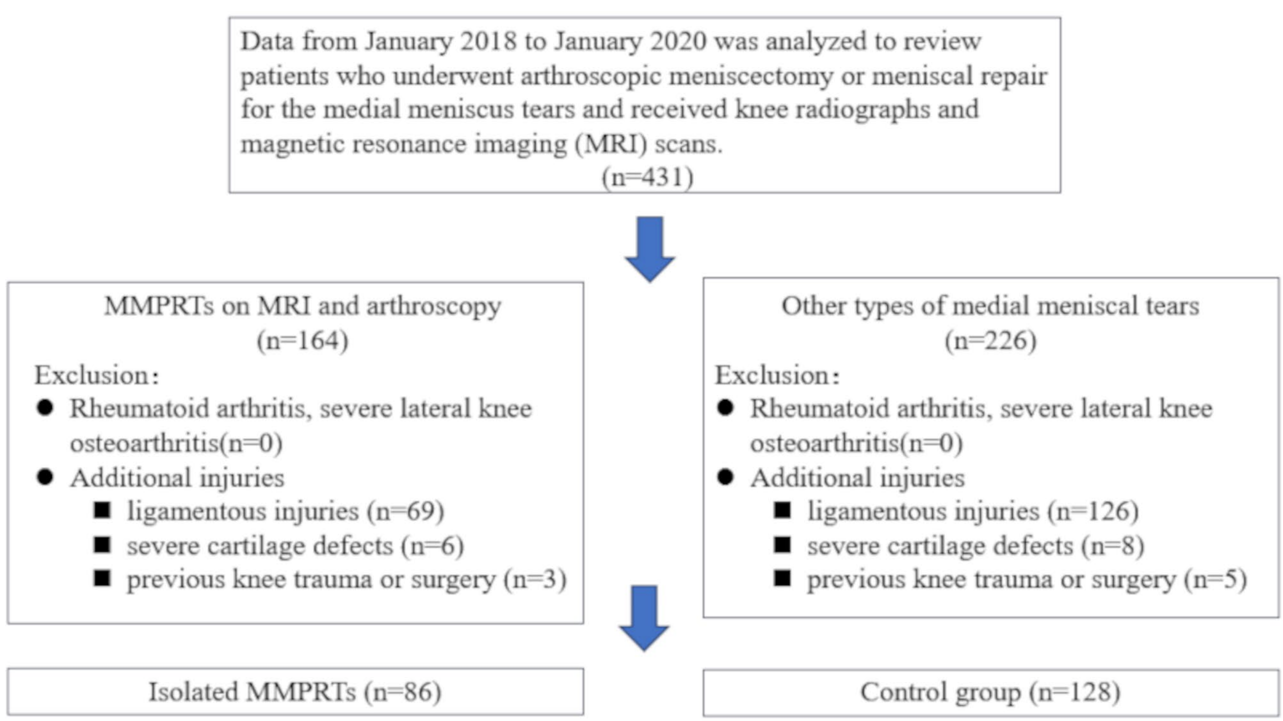

Fig. 1 Flowchart illustrating the enrollment of patients for this study

on MRI and arthroscopy, and have high-quality knee radiographs and MRI scans. Patients with rheumatoid arthritis, severe lateral knee osteoarthritis and additional injuries (such as ligamentous injuries, severe cartilage defects) or previous knee trauma or surgery affecting the knee joint anatomy were excluded from the study. Furthermore, the MMPRTs patients were matched with a control group composed of 128 cases of other types of isolated medial meniscus tears in the same period. These included 36 cases of horizontal tears, 52 cases of radial tears, 4 cases of bucket handle tears and 36 cases of complex tears. These cases were identified through knee MRI scans and confirmed during arthroscopic surgery. Patients with rheumatoid arthritis, severe lateral knee osteoarthritis and additional injuries (such as ligamentous injuries, severe cartilage defects) or previous knee trauma or surgery affecting the knee joint anatomy were excluded from the study.

Considering the distinct underlying pathologies of traumatic and degenerative meniscus root tears, we categorized the two patient groups into subgroups based on the causes of meniscus root tears. A subgroup analysis was performed to evaluate the parameter differences between traumatic and degenerative MMPRT in these groups.

Fig. 2 MFCW (red line) is calculated on the coronal plane image by measuring the distance between the innermost and outermost articular cartilage. Similarly, MTPW (yellow line) is determined by measuring from the medial intercondylar spine of the tibia to the most lateral point of the plateau, representing the distance between the inner edges

Data collection

The consultant surgeon either performed or supervised the arthroscopic surgery. Detailed information on patients' demographics and clinical attributes such as age, gender, injury side, comorbidities (e.g. diabetes mellitus, hypertension), cause of meniscal tears (traumatic MMPRTs are characterized by patients who have a documented history of knee trauma), hip knee ankle (HKA) angles (a positive value signified varus alignment), Kellgren-Lawrence (K-L), medial tibial slope (MTS), medial femoral condyle width (MFCW), medial tibial plateau width (MTPW), medial femoral condyle length (MFCL), and medial tibial plateau length (MTPL) were meticulously documented.

Measurements in X-rays and MRI

HKA angle is defined as the angle formed by the mechanical axis of the femur and tibia as measured on whole leg X-rays (standing, both legs in a standing position) while ensuring the unification of lower extremity rotation.

Images were obtained using a 3.0-T MRI (slice thickness of 4 mm with 0- mm gap) scanner (Siemens) equipped with a knee coil for transmit and receive functions. The standard knee imaging protocols were utilized with proton-density, fast spin-echo proton-density with fat saturation and T2- weighted fat-saturated images. Two orthopedic surgeons and radiologist were blinded to the patient's information, all qualified professionals from our institution, independently reviewed the knee MRIs. In cases of disagreement, consensus was reached through discussion between the two reviewers. Diagnosis of patients with MMPRTs relied on specific MRI features like cleft, giraffe neck, and ghost signs [19], which were further validated during arthroscopic surgery.

Measurements of MFCW and MTPW followed the technique outlined by Kwak [20](Fig. 2), while MFCL and MTPL measurements adhered to the methodology described by Musahl [21] (Fig. 3). The measurement of MTS was conducted based on the approach proposed by Hudek [22] (Fig. 4).

Statistical analyses

Mean values ± standard deviation was used to present quantitative variables. Continuous data were examined for normality with the Shapiro–Wilk test,

and group comparison was done using the student's t-test. Count variables were reported as numbers and percentages and analyzed with the Chi-square test. Binary logistic regression analysis model was utilized to identify independent risk factors associated with MMPRTs. Sensitivity and specificity were determined using optimal cut-off scores, and accuracy was evaluated through the area under the curve (AUC) from Receiver Operating Characteristic (ROC) curves. Statistical

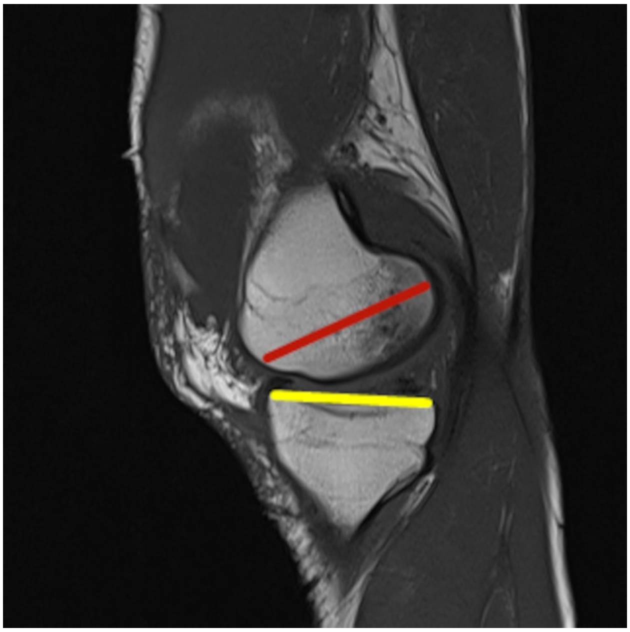

Fig. 3 MFCL (red line) is measured as the maximum distance from the junction of the trochlea and the medial anterior femoral condyle to the center of the posterior articular condyle. MTPL (yellow line) is measured as the maximum anteroposterior diameter of the medial tibial plateau in this case

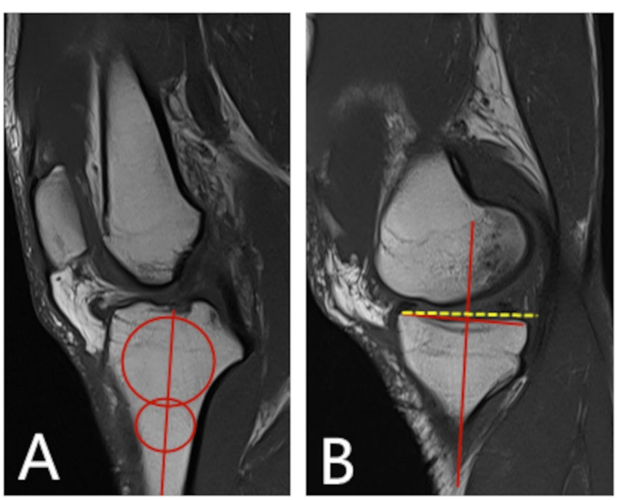

Fig. 4 The central image of the sagittal tibial MRI is identified, highlighting the attachment point of the posterior cruciate ligament, the intercondylar eminence, and the plane that delineates the anterior and posterior cortex of the proximal tibia (**A**). Software is utilized to draw two circles within the image: the first circle should touch the proximal end of the tibia and the anterior and posterior cortex, while the second circle, positioned below the first, should also be tangent to the anterior and posterior tibia. The centers of the circles should align, establishing the anatomical axes of the tibia. To determine the posterior inclination of the medial tibial plateau, locate the central slice of the medial tibia on a sagittal T1-weighted knee MRI. Connect the most anterior and posterior points of the medial tibial platform with a straight line, and calculate the angle between the anatomical axis of the tibia and the tangent to the medial tibial plateau, subtracting 90°(**B**)

significance was considered for *P* values below 0.05. Data analysis was conducted using SPSS Version 22 (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp).

Results

Patients' demographics

The study included a cohort of 86 patients, aged 16 to 63, who underwent arthroscopic treatment for MMPRTs. A control group comprised 128 individuals, aged 21 to 73. As detailed in Table 1, there were no significant differences were observed in demographic characteristics or K-L grading. However, a subgroup analysis shows age in the degenerative MMPRTs group were significantly higher comparing with those in control group. Among the 86 patients diagnosed with MMPRTs, 35 were classified as type 2, 16 as type 3, 18 as type 4, and 17 as type 5 according to the 'LaPrade' classification.

Radiologic outcomes between the groups

There were no substantial differences observed in MFCW, MTPW, MFCW/MTPW, MFCL, and MTPL between the groups. However, the MMPRTs group exhibited significantly higher values in MTS, HKA, and MFCL/MTPL in comparison to the control group ($p < 0.001$ for all, see Table 2). Additionally, a subgroup analysis shows MTS, HKA, and MFCL/MTPL in the both degenerative MMPRTs and traumatic MMPRTs group were significantly higher comparing with those in control group.

Determining the risk factors for MMPRTs

Binary logistic regression analysis was performed to pinpoint the independent risk factors associated with MMPRTs (Table 3). The analysis revealed that MTS (OR = 1.212, $P = 0.005$), HKA (OR = 1.657, $P < 0.001$), and MFCL/MTPL (OR = 16.597, $P = 0.019$) were significant independent risk factors for MMPRTs. A subgroup analysis revealed that the MTS, HKA, and MFCL/MTPL were risk factors associated with traumatic MMPRTs. Additionally, age, MTS, HKA, and MFCL/MTPL were identified as risk factors linked to degenerative MMPRTs.

Evaluating the predictive value of risk factors for MMPRTs

Figure 5; Table 4 depict the ROC curves for MTS, HKA, and MFCL/MTPL in predicting MMPRTs risk. These indicators showed similar accuracy in forecasting MMPRTs (with AUC values of 0.635, 0.700, and 0.627, respectively). The cutoff values for these parameters were determined to be 7.4°, 2.4°, and 1.2, respectively. Among the three factors, MFCL/MTPL demonstrated the highest specificity (86.0%), while HKA showed the highest sensitivity (79.7%). Additionally, combined these

Table 1 Patient demographics

Factors	Case group (86)			Control group (128)			*P* value
	Overall	Traumatic (43)	Degenerative (43)	Overall	Traumatic (59)	Degenerative (69)	
Gender: male n(%)	38(44.2%)	21(48.8%)	17(39.5%)	44(34.4%)	19(32.2%)	25(36.2%)	0.359
Side, right (%)	48(55.8%)	23(53.5%)	24(55.8%)	68(53.1%)	29(49.2%)	39(56.5%)	0.907
Age (yr)	42.9 ± 10.8	41.9 ± 11.0	43.9 ± 10.7 [a]	40.0 ± 14.0	41.4 ± 14.3	38.9 ± 13.8	0.112
Height	161.4 ± 8.2	163.0 ± 8.4	159.8 ± 7.8	161.0 ± 8.6	160.6 ± 8.8	161.3 ± 8.4	0.755
BMI (kg/m^2)	23.5 ± 2.96	23.0 ± 2.6	24.0 ± 3.2	23.3 ± 2.8	22.9 ± 2.7	23.7 ± 2.9	0.689
Duration of symptoms (m)	6.8 ± 11.7	5.9 ± 13.2	7.8 ± 10.1	8.0 ± 10.5	9.2 ± 11.1	7.0 ± 9.9	0.440
K-L							0.234
0	52(60.5%)	27(62.8%)	25(58.1%)	85(66.4%)	37(62.7%)	48(69.6%)	
1	32(37.2%)	15(34.9%)	17(39.6%)	36(28.1%)	17(28.8%)	19(27.5%)	
2	2(2.3%)	1(2.3%)	1(2.3%)	7(5.5%)	5(8.5%)	2(2.9%)	
Comorbidities							
Diabetes mellitus	1 (0.9%)	1(2.34.7%)	0(0%)	1 (%) (0.5%)	0(0%)	1(1.4%)	0.859
High blood pressure	4 (3.7%)	2(4.7%)	2(4.7%)	6 (2.7%)	2(3.4%)	4(5.8%)	0.772

BMI: body mass index; K-L: Kellgren-Lawrence

[a] is the statistical value of comparing the subgroups parameter between case group and control group

* *P* value is the statistical value of comparing the overall parameter between case group and control group

Table 2 Radiologic outcomes between the groups

Anatomical factors	Case group (86)			Control group (128)			*P* value
	Overall	Traumatic (43)	Degenerative (43)	Overall	Traumatic (59)	Degenerative (69)	
MTS (º)	7.0 ± 2.6	6.9 ± 0.4 [a]	7.0 ± 2.6 [a]	5.7 ± 2.1	5.9 ± 2.1	5.5 ± 2.0	**< 0.001**
HKA (º)	2.8 ± 1.6	2.7 ± 1.6 [a]	2.9 ± 1.7 [a]	1.7 ± 1.1	1.6 ± 1.0	1.8 ± 1.1	**< 0.001**
MFCW (mm)	24.5 ± 7.7	24.4 ± 7.4	24.6 ± 8.2	23.8 ± 5.3	22.9 ± 2.7	23.8 ± 5.6	0.494
MTPW (mm)	27.8 ± 6.4	27.4 ± 6.3	28.3 ± 6.5	26.8 ± 4.4	26.8 ± 4.3	26.7 ± 4.4	0.137
MFCW/MTPW	0.9 ± 0.3	0.9 ± 0.2	0.9 ± 0.3	0.9 ± 0.2	0.9 ± 0.2	0.9 ± 0.2	0.764
MFCL (mm)	45.5 ± 5.0	46.1 ± 5.2	44.9 ± 4.9	44.9 ± 6.3	45.6 ± 6.4	44.2 ± 6.2	0.412
MTPL (mm)	34.7 ± 4.9	35.2 ± 5.6	34.1 ± 4.0	35.9 ± 4.8	36.3 ± 4.5	35.4 ± 5.0	0.08
MFCL/MTPL	1.3 ± 0.1	1.3 ± 0.1 [a]	1.3 ± 0.1 [a]	1.3 ± 0.1	1.3 ± 0.2	1.3 ± 0.1	**< 0.001**

MTS: medial posterior tibial slope; HKA: hip knee ankle; MFCW: medial femoral condyle width; MTPW: medial tibial plateau width; MFCL: medial femoral condyle length, and MTPL: medial tibial plateau length

[a] is the statistical value of comparing the subgroups parameter between case group and control group

* *P* value is the statistical value of comparing the overall parameter between case group and control group

Table 3 Determining the risk factors for MMPRTs

Classification	Risk factor	Odds ratio	95% confidence interval	*P* value
Overall	MTS (º)	0.825	0.720–0.945	**0.005**
	HKA (º)	0.604	0.480–0.759	**< 0.001**
	MFCL/MTPL	0.050	0.006–0.633	**0.019**
Traumatic	MTS (º)	1.198	1.008–1.423	**0.040**
	HKA (º)	1.846	1.325–2.574	**< 0.001**
	MFCL/MTPL	19.594	1.147-334.708	**0.040**
Degenerative	Age	1.032	1.000-1.064	**0.047**
	MTS (º)	1.329	1.108–1.593	**0.002**
	HKA (º)	1.746	1.297–2.352	**< 0.001**
	MFCL/MTPL	79.719	3.065-2073.336	**0.008**

MMPRTs: medial meniscus posterior root tears; MTS: medial posterior tibial slope; HKA: hip knee ankle; MFCL: medial femoral condyle length, and MTPL: medial tibial plateau length

parameters had higher specificities compared to one single factor.

Discussion

The main finding of this study was that the MTS, HKA, and MFCL/MTPL were identified as risk factors associated with MMPRTs. To select the appropriate MMPRTs patients, the cutoff values of risk factors were determined. Previous research involving knee MRI scans from over 300 patients with ACL deficient and ACL intact knees revealed a correlation between higher MTS and lateral posterior tibial slope (LTS) and noncontact ACL tears [23]. This connection is believed to stem from biomechanical alterations and increased shear force on the tibial plateau, especially in cases where there is a steep tibial slope. The inclination of the tibial slope is a critical anatomical factor that impacts the movement patterns of the tibiofemoral joint [24]. Changes in the posterior tibial slope can result in modifications to tibiofemoral

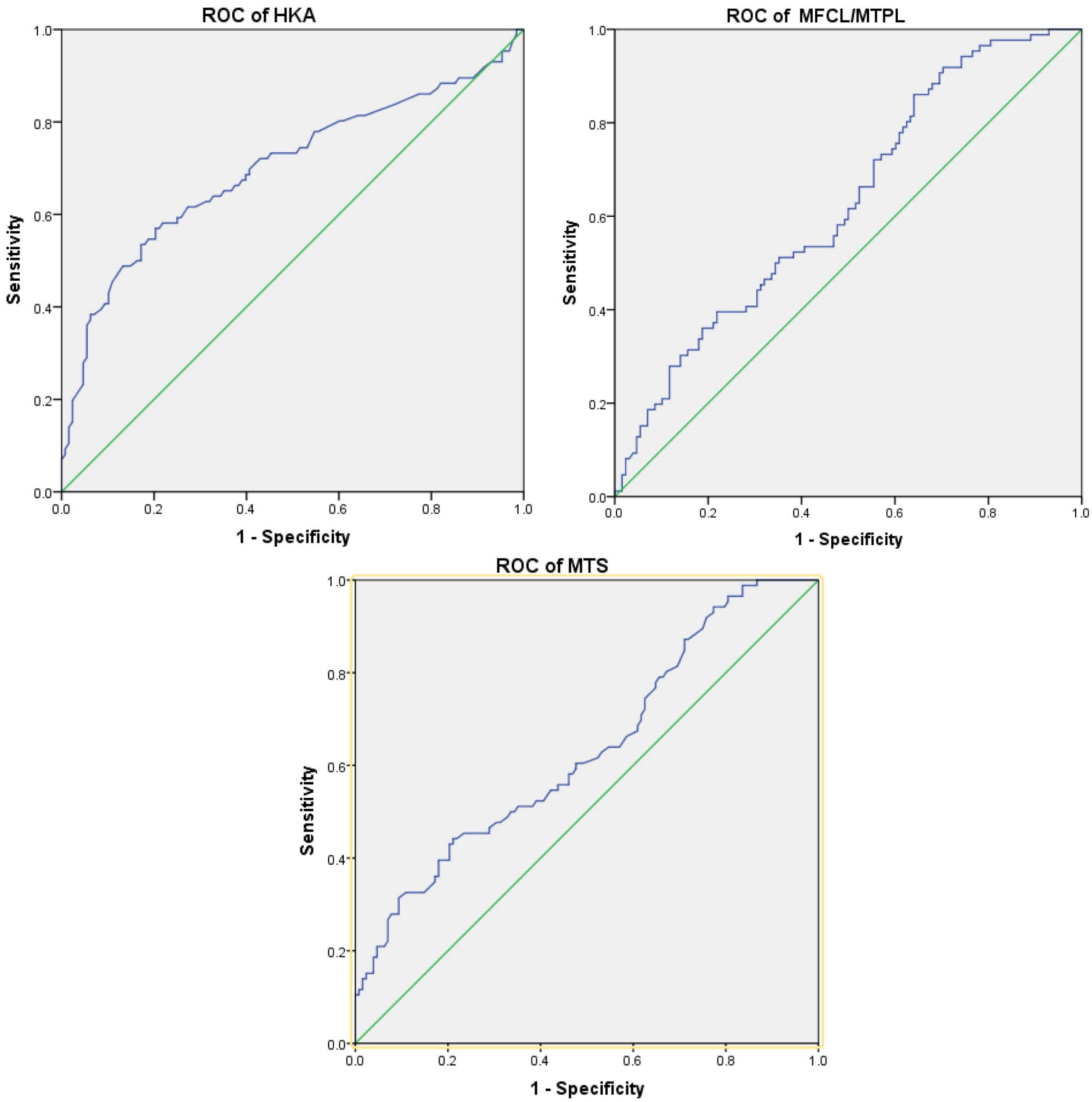

Fig. 5 The receiver operating characteristic (ROC) curves of risk factors for predicting MMPRTs. MTS: ROC curve of MTS; HKA: ROC curve of HKA; MFCL/MTPL: ROC curve of MFCL/MTPLI

Table 4 Evaluating the predictive value of risk factors for MMPRTs

Risk factors	Cut-off value	Sensitivity	Specificity	AUC	*P* value
MTS (º)	7.4	44.2%	78.9%	0.635	**0.001**
HKA (º)	2.4	57.0%	79.7%	0.700	**< 0.001**
MFCL/MTPL	1.2	86.0%	35.9%	0.627	**0.002**

MMPRTs: medial meniscus posterior root tears; AUC: under the curve; MTS: medial posterior tibial slope; HKA: hip knee ankle; MFCL: medial femoral condyle length, and MTPL: medial tibial plateau length

contact force, leading to elevated anterior tibial translation and potential contact between the medial femoral condyle and the MMPRTs, resulting in compression and posterior shear forces being transferred to the root [11]. Therefore, a steep tibial slope, which contributes to greater anterior tibial translation, may increase the likelihood of MMPRTs. Additionally, research on cadaveric models demonstrated that heightened posterior tibial slope can enhance compression and anterior shear force at the MMPRTs when the knee is under compression and internal rotation, respectively. Furthermore, an increased flexion angle was associated with elevated medial shear force and tension at the MMPRTs under similar loading conditions [25]. Indeed, numerous articles have reported that the steep posterior slope of the medial tibial plateau contributes to posterior root tears of the medial meniscus [26, 27]. In contrast to earlier findings, it was observed that MMPRTs patients exhibited higher MTS measurements, which were established as an risk factor for MMPRTs. The identified cutoff value for MTS was determined to be 7.4º, indicating that a measurement exceeding this threshold is indicative of a heightened risk for MMPRTs. Numerous methods for measuring MTS have been reported in the literature. Given the considerable variability in MTS values depending on the measurement technique employed, it is essential to increase sample sizes in future studies to validate the accuracy of the results.

Recent biomechanical research has demonstrated that the root tear led to a 25% surge in peak contact pressure, but repair procedures were able to rectify the peak contact pressure back to normal levels [28]. Varus alignment has been linked to heightened medial meniscus extrusion and peak contact pressure, as highlighted in a biomechanical exploration [29]. Our previous retrospective study investigated 129 patients who received arthroscopically assisted tendon graft fixation of the MMPRTs between January 2018 and September 2021, and identified age > 37.5 years, BMI > 24.5 kg/m2, preoperative meniscus extrusion > 2.7 mm and HKA > 3.3° as independent risk factors correlated with incomplete meniscus root healing status [23]. Furthermore, an observational investigation was conducted involving 476 consecutive patients who underwent arthroscopic intervention for their medial meniscus between January 2010 and December 2010. Hwang et al. revealed that individuals with MMPRTs exhibited a significantly higher varus mechanical axis angle compared to those with other types of meniscal tears [15]. In accordance with previous studies, we determined that the HKA was a risk factor for MMPRTs, with corresponding cutoff values at 2.4°.

The femur's unique geometry necessitates corresponding changes in the meniscus's shape. As the knee moves from full extension to flexion, the meniscus shifts from a front-to-rear position to a more lateral orientation to align with the femoral condyle's contours. This adjustment allows the meniscus to smoothly slide against the tibia, adapting to the changing shapes and positions of the surrounding bones during movement [30]. Suganuma et al. [31] discovered that inconsistent posterior medial tibiofemoral joint in complete knee flexion contributed to simple medial meniscus tears. Harun et al. [32] conducted an investigation into the connection between MMPRTs and knee bone structure, and revealed that the tibiofemoral joint bone morphological disharmony is a risk factor for MMPRTs. Furthermore, Chung et al. [18] revealed that an increased medial femoral to tibial condylar dimension could contribute to the development of MMPRTs. Consistent with prior research, our study revealed a significant contrast in the MFCL/MTPL ratio between individuals with and without MMPRTs. We determined that the MFCL/MTPL ratio was a risk factor associated with MMPRTs, with a cutoff point of 1.2. These results suggest that an MFCL/MTPL ratio greater than 1.2 is a risk factor for developing MMPRTs. We found that the MFCL/MTPL ratio was higher in the medial meniscus posterior root tear group, suggesting that the tibiofemoral joint contact area in the MMPRTs group was smaller than that in the control group. This reduction in tibiofemoral joint contact area led to increased annular stress on the posterior meniscus root during the extrusion process, thereby heightening the risk of medial meniscus tears during repetitive movements such as knee flexion, extension, and rotation.

A systematic review found that the traumatic MMPRT group exhibits distinct patient characteristics, including a higher proportion of male and younger patients. This conclusion aligns with the patient cohort included in our study [33]. Previous research has identified age as a determining factor in the progression of osteoarthritis [34], correlating positively with the successful correction of MME in patients with repaired MMPRTs [8]. Through subgroup analysis, we discovered that, unlike trauma, age was identified as a risk factor associated with degenerative meniscus posterior root tears in the subgroup of degenerative MMPRTs.

Several limitations were identified in this study. Firstly, the inclusion of only patients who had undergone arthroscopic procedures resulted in a limited sample size and potential selection bias. Additionally, the demographic characteristics of MMPRT patients differ from those reported in previous studies. Secondly, certain factors like hormonal influences, quadriceps and hamstring strength, and other documented anatomical considerations were not taken into account, which could have enhanced the study. Nevertheless, the findings of this study possess clinical significance. The identified cutoff values for risk factors can assist surgeons in evaluating intrinsic anatomical risks associated with MMPRTs, despite the relatively small AUC values.

Conclusion

Based on results from the current study, we identified MTS > 7.4º, HKA > 2.4º and MFCL/MTPL > 1.2 were the risk factors correlated with MMPRTs.

Abbreviations

K-L	Kellgren-Lawrence
BMI	Body mass index

MMPRTs	Medial meniscus posterior root tears
MTS	Medial posterior tibial slope
HKA	Hip knee ankle
MFCW	Medial femoral condyle width
MTPW	Medial tibial plateau width
MFCL	Medial femoral condyle length
and MTPL	Medial tibial plateau length

Author contributions

The authors made the following contributions: Lan min made the conception for this research. Data collection and analysis were performed by Huang Jiayu and Nie Si. Li Hongbo and Gao Jingping analyzed the data and Nie Si and Lan Min drafted the article. Lan min and Nie Si reviewed/ edited the manuscript. All the authors critically revised the article for important intellectual content. The authors read and approved the final manuscript.

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No funding was obtained for this study.

Data availability

The datasets generated and/or analysed during the current study are not publicly available due [REASON WHY DATA ARE NOT PUBLIC] but are available from the corresponding author on reasonable request.

Declarations

Conflict of interest

No benefits in any form have been or will be received from any commercial party related directly and indirectly to the subject of this manuscript.

Levels of evidence

III, Case-control study retrospective comparative study.

Human ethics and consent to participate declarations

This study was approved by the ethics committee of the Jiangxi Provincial People's Hospital (The First Affiliated Hospital of Nanchang Medical College) (ID number 2024-63). All procedures performed in this study involving human participants were in accordance with the bioethical standards of the institutional and national research committees and with the 1964 Declaration of Helsinki and its later amendments. Which waived the requirement for informed consent from the patients given the retrospective nature of the study.

Clinical trial number

Not applicable.

Consent for publication

Not applicable.

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