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Risk Factors for Medial Meniscus Posterior Root Tear

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Background: Medial meniscus posterior root tears (MMPRT) have a different clinical effect from other types of meniscal tears. These tears are very common among Asian people and may be related to the frequent use of postures such as the lotus position or squatting.

Purpose: The present study was designed to identify the risk factors for MMPRT among an Asian sample.

Study Design: Cohort study; Level of evidence, 3.

Methods: An observational study was performed of 476 consecutive patients undergoing an arthroscopic procedure on their medial meniscus from January 2010 to December 2010. One hundred four patients had MMPRT (group 1), and the other patients had other types of medial meniscal tears (group 2). Demographic characteristics (age, sex, body mass index [BMI]), radiographic features (mechanical axis angle, tibia vara angle, tibial slope angle, Kellgren-Lawrence grade [KLG]), and environmental factors (occupation, trauma history, sports activity level, table use or not, bed use or not—variables that are representative of the oriental lifestyle of lotus position and squatting) were surveyed. We assessed the relation of these risk factors to the type of meniscal tear (group 1 or 2).

Results: In group 1, there were 7 male and 97 female patients, with an average age of 58.2 years (range, 39-78 years) and BMI of 26.7 ± 3.4 kg/m^2. In group 2, there were 136 male and 236 female patients ($P < .01$ compared with group 1), with an average age of 54.3 years (range, 17-77 years; $P < .01$) and a BMI of 24.9 ± 3.1 kg/m^2 ($P < .01$). With regard to radiographic features, the mechanical axis angle demonstrated a significantly increased varus alignment in group 1 (4.5° ± 3.4°) compared with group 2 (2.4° ± 2.7°; $P < .01$), and the KLG was 1.4 ± 0.8 in group 1 and 0.9 ± 0.6 in group 2 ($P < .01$). Environmental factors showed no differences in occupation, table use or not, and bed use or not, except sports activity level. There were 41 patients (42.7%) in group 1 and 77 patients (20.6%) in group 2 who did not participate in any recreational activity ($P < .01$). Multiple logistic regression analysis showed that female sex was associated with a 5.9-fold increase in risk (95% confidence interval [CI], 2.138-16.575), a varus mechanical axis angle with a 3.3-fold increase (95% CI, 1.492-7.153), a BMI more than 30 kg/m^2 with a 4.9-fold increase (95% CI, 1.160-20.955), and lower sports activity level with a 2.7-fold increase (95% CI, 1.011-7.163) for MMPRT.

Conclusion: Persons with MMPRT had significantly increased age, female sex predominance, higher BMI, increased KLG, greater varus mechanical axis angle, and lower sports activity level compared with persons with other types of meniscal tear. After adjusting for other factors, sex, BMI, mechanical axis angle, and lower sports activity level remained strong determinants of MMPRT. Interestingly, oriental postural positions including the lotus position and squatting showed no contribution to increased risk of MMPRT. This suggests that intrinsic risk factors (similar to those that predispose to osteoarthritis) predispose to MMPRT.

Keywords: medial meniscus; root tear; risk factor

Meniscal damage is very common in the general community[3] and is an important risk factor predisposing to the development of osteoarthritis.[8] Despite knowledge that meniscal tears can predispose to osteoarthritis, we know little about what predisposes to meniscal tears. Efforts to identify modifiable risk factors for disease should focus on risk factors early in disease genesis.

The most frequent location of meniscal damage is the posterior horn of the medial meniscus,[3] and radial tears of the posterior horn of the medial meniscus are very common among Asian people.[4,18] Medial meniscus posterior root tear (MMPRT) results in 2 separate pieces of menisci with attachment to the tibia at only one end. This permits the meniscus to be displaced peripherally, to lose hoop stress and functional load distribution,[19] which may predispose to development of osteoarthritis due to altered joint contact stress.[15] This type of tear is more common than previously considered, with rates of 10.1% to 10.5% of all meniscal tears in prior studies.[4,18]

Several risk factors for MMPRT have been proposed, including age, body mass index (BMI), sex, injury, and cultural environment.[9,12] However, the relative importance of these risk factors has not been systematically investigated,

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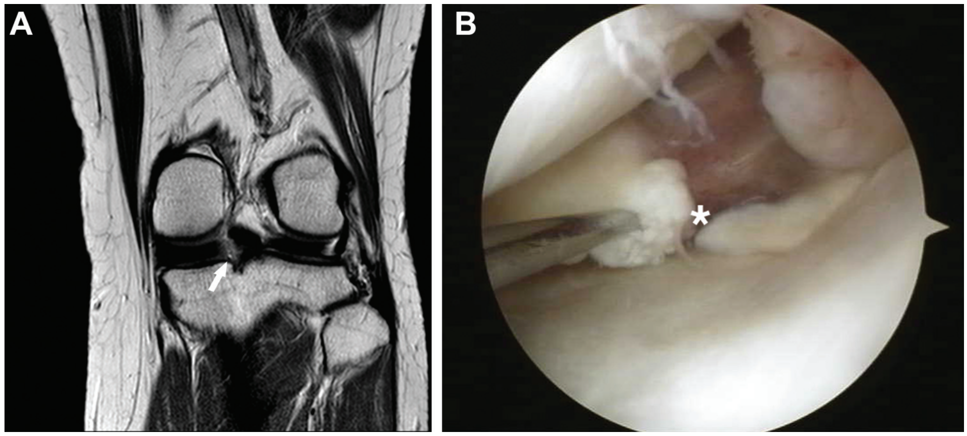

Figure 1. (A) Coronal fat-saturated T2-weighted image showing a root tear of the medial meniscus (arrow) and (B) arthroscopic view showing the posterior root tear of the medial meniscus (asterisk).

although there are several previous reports that together present somewhat confusing evidence for apparent relationships between selected variables and MMPRT.[4,18]

The purpose of this retrospective observational study was to contribute to the epidemiologic understanding of risk factors (demographic, anatomic [or radiographic], and environmental factors) for MMPRT.

MATERIALS AND METHOD

Patients

We retrospectively reviewed the records of 564 patients who underwent arthroscopic meniscectomy or meniscal repair for tears of the medial meniscus between January 2010 and December 2010, excluding those with ligament laxity, lateral meniscal tear, systemic arthritis, osteonecrosis, or other combined ligament injury. The final group included 121 patients with MMPRT and 443 patients with other types of medial meniscal tear identified by an experienced musculoskeletal radiologist using 1.5-T magnetic resonance imaging (MRI), and also confirmed during arthroscopic surgery (Figure 1). The sensitivity of MRI in diagnosing MMPRT was 73%. Of these patients, it was possible to review all pertinent information and obtain informed consent in 104 patients (86%) with MMPRT (group 1) and 372 patients (84%) with other types of meniscal tear (group 2) from their medical records, phone, or clinic visit. Hospital Ethic Committee approval was obtained. The surgical indication was persistent medial joint area pain despite 3 months of nonoperative treatment.

Risk Factors

Demographic factors included in this study were age, sex, and BMI. Radiographic factors included mechanical axis angle, tibia vara angle, tibial slope angle, and Kellgren-Lawrence grade (KLG),[13] which was graded as 0 (normal), 1 (doubtful narrowing of joint space and possible osteophytic lipping), 2 (definite osteophytes and definite narrowing of joint space), 3 (moderate multiple osteophytes, definite narrowing of joint space, some sclerosis, and possible deformity of bone contour), or 4 (large osteophytes, marked narrowing of joint space, severe sclerosis, and definite deformity of bone contour). Environmental factors included occupation, trauma history, sports activity level, table use or not, and bed use or not. Variables about table use or not and bed use or not are representative of the oriental lifestyle of lotus position (knee flexed and internally rotated) and squatting. Table use implies use of a chair and hence not sitting in the lotus, and no bed use implies a sedentary lifestyle that includes lots of squatting and sitting in the lotus position in activities of daily living.

Preoperative standing hip-knee-ankle radiographs were taken, and mechanical axis angle was measured. Mechanical axis angle is the angle between a line from the center of the femoral head running distally to the midcondylar point between the cruciate ligaments (femoral mechanical axis) and a line from the center of the tibial plateau extending distally to the center of the tibial plafond (tibial mechanical axis) in radiographs of the entire lower limb.[6] Tibia vara angle is the angle between the tibial plateau tangent and the tibial mechanical axis (a line from the center of the tibial plateau extending distally to the center of the tibial plafond). On lateral radiographs, the tibial slope angle is measured as the

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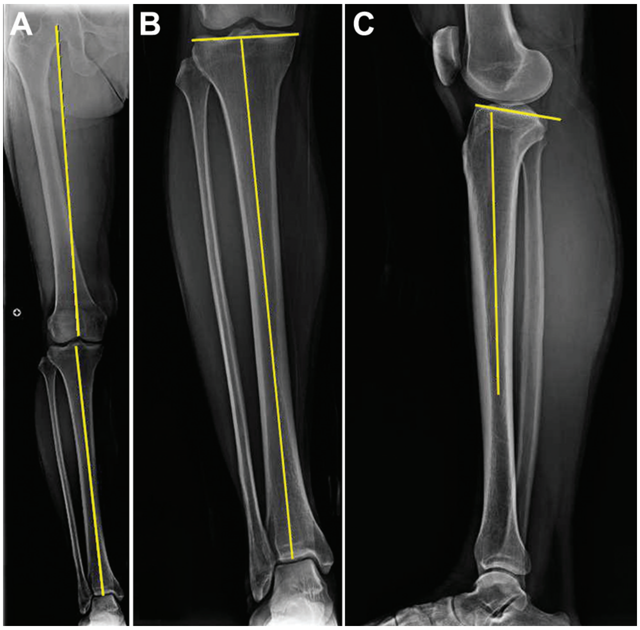

Figure 2. (A) The mechanical axis angle is the angle between a line from the center of the femoral head to the midcondylar point between the cruciate ligaments and a line from the center of the tibial plateau to the center of the tibial plafond. (B) The tibia vara angle is the angle between the tibial plateau tangent and a line from the center of the tibial plateau to the center of the tibial plafond. (C) The tibial slope angle is the angle between a line from the center of the cortex between 5 cm distal to the tibial tubercle and 15 cm distal to the proximal joint facet and the line tangential to the proximal joint facet of tibia.

angle between the posterior tibial anatomic axis (a line from the center of the cortex between 5 cm distal to the tibial tubercle and 15 cm distal to proximal joint facet) and the line tangential to the proximal joint facet of tibia[22] (Figure 2). The KLG was measured on extension weightbearing views. Type of occupation was categorized as white/blue collar. Trauma history was categorized as present/none. Sport activity level was categorized as lower or higher (participation more than 2-3 times per week).

To assess the reliability of radiographic assessment, each evaluation (KLG, mechanical axis angle, tibia vara angle, and tibial slope angle) was measured on the PACS system (INFINITT PACS, INFINITT Healthcare Co Ltd, Seoul, Korea) by 2 experienced raters (B.-Y.H., H.-E.L.) under supervision of K.A.-J., who has 10 years of musculoskeletal radiology experience. All raters were blinded to the information of the patients. The average of the 2 individual mean values was used. Overall ratings were determined by consensus when necessary.

Statistical Analysis

The principal analysis was to compare risk factors between the 2 groups of meniscal tears. For continuous data, a paired sample t test was used to compare the 2 groups. A chi-square test was employed to compare the categorical ordinal data of the 2 groups. Multiple logistic regression analysis was performed on variables thought to be associated with root tear according to the bivariate analyses (entry criterion, $P < .05$). Odds ratios (ORs) and confidence intervals (CIs) were reported for variables significantly associated with the outcome as defined by the Wald test. The interobserver reliability in measuring KLG, mechanical axis angle, tibia vara angle, and tibial slope was evaluated using the intraclass correlation set at a 95% CI. A level of significance was set at <.05. Statistical analyses were performed using SPSS version 12.0 (SPSS Inc, Chicago, Illinois).

RESULTS

Bivariate analysis of variables is provided in Table 1. With regard to demographic factors, there were 7 male and 97 female patients in group 1 and 136 male and 236 female patients in group 2 ($P < .01$). The average age at the time of surgery was 58.2 years (range, 39-78 years) in group 1 and 54.3 years (range, 17-77 years) in group 2 ($P < .01$). Body mass index was 26.7 ± 3.4 in group 1 and 24.9 ± 3.1 in group 2 ($P < .01$). With regard to radiographic factors, only mechanical axis angle showed significantly increased varus alignment in group 1 (4.5° ± 3.4°) from group 2 (2.4° ± 2.7°; $P < .01$; the intraclass correlation coefficient for intertester reliability was 0.833). The KLG was 1.4 ± 0.8 in group 1 and 0.9 ± 0.6 in group 2 ($P < .01$). Environmental factors showed no differences in occupation, trauma history, table use or not, and bed use or not. There were 41 patients (42.7%) in group 1 and 77 patients (20.6%) in group 2 who had a lower level of sports activity ($P < .01$).

The multiple logistic regression model provided estimates of the magnitude of association for risk factors of interest (Table 2). Female sex was associated with a 5.9-fold increase in risk (95% CI, 2.138-16.575), a varus mechanical axis angle with a 3.3-fold increase (95% CI, 1.492-7.153), a BMI more than 30 kg/m^2 with a 4.9-fold increase (95% CI, 1.160-20.955), and lower sports activity level with a 2.7-fold increase (95% CI, 1.011-7.163). However, advancing age was not associated with any increase in risk between MMPRT and other type of medial meniscal tear.

DISCUSSION

In this study, we confirmed that female sex is an important risk factor for MMPRT. Higher BMI, radiographic factors (varus mechanical axis angle, increased KLG), and decreased sports activity level also contributed as risk factors for MMPRT. Radiographic factors representing regional knee geometry, such as tibia vara angle and tibial slope angle, revealed no differences between the 2 groups. However, overall lower limb geometry, such as mechanical axis angle, did contribute to the development of MMPRT.

Thus, the predominant risk factors for MMPRT (female sex, older age, and higher BMI) are consistent with those

TABLE 1
Demographics[a]

	Group 1 (n = 104)	Group 2 (n = 372)	P Value
Mean age (range), y	58.2 (39-78)	54.3 (17 to 77)	<.01
Sex, M/F	7/97	136/236	<.01
Body mass index, kg/m^2	26.7 ± 3.4	24.9 ± 3.1	<.01
Kellgren-Lawrence grade	1.4 ± 0.8	0.9 ± 0.6	<.01
Mechanical axis angle, deg	4.5 ± 3.4	2.4 ± 2.7	<.01
Tibia vara angle, deg	4.9 ± 2.3	4.2 ± 2.5	.07
Tibial slope angle, deg	10.4 ± 3.0	9.8 ± 3.7	.25
Bed use	49/96 (51.0%)	198/372 (53.2%)	.74
Table use	41/96 (42.7%)	156/372 (41.9%)	.43
Occupation, blue-collar/total	33/96 (34.4%)	101/372 (27.2%)	.87
Sports activity level, lower/total	41/96 (42.7%)	77/372 (20.6%)	<.01

[a]Group 1, medial meniscus posterior root tear; group 2, other type of medial meniscus tear.

TABLE 2
Logistic Regression Model of the Potential Risk Factors for Medial Meniscus Posterior Root Tear[a]

	Adjusted Odds Ratio	Lower 95% Confidence Interval	Upper 95% Confidence Interval	P Value
Age, y				
<50	Reference (1.0)			
50-60	2.172	0.688	6.849	.186
60-70	2.767	0.821	9.321	.101
≥70	1.818	0.381	8.681	.454
Female sex	5.953	2.138	16.575	.001
Body mass index, kg/m^2				
<25	Reference (1.0)			
25-30	1.746	0.821	3.713	.148
≥30	4.929	1.160	20.955	.031
Mechanical axis angle				
Neutral (0-2)	Reference (1.0)			
Varus (<0)	3.267	1.492	7.153	.003
Valgus (≥2)	2.174	0.445	10.615	.337
Sports activity level				
Higher	Reference (1.0)			
Lower	2.691	1.011	7.163	.048

[a]Group 1, medial meniscus posterior root tear; group 2, other type of medial meniscus tear.

for development of osteoarthritis.[9,12] The posterior horn of the medial meniscus endures most of the stress applied to the medial compartment.[1] The posterior horn region has little mobility because of its strong attachment to the tibia at the meniscal root. Hence, the medial meniscus posterior horn is particularly vulnerable to injury, including microinjury, which can lead to degeneration and tearing.[7,23] Ford et al[10] demonstrated a significant association between increasing BMI and meniscal tears leading to surgery. Moreover, our study demonstrated that MMPRT was more positively associated with higher BMI than other types of medial meniscal tear. Also, increased KLG and varus mechanical axis angle have the same effect on MMPRT as high BMI does.

Medial meniscus posterior root tears have attracted renewed attention in recent years, mainly because of concerns of significant loss of primary biomechanical meniscus functions in preventing extrusion of the medial meniscus and preserving normal medial meniscal position and function, leading to a condition biomechanically similar to a total meniscectomy.[2,11,15] However, clinical features, characteristics, and risk factors have not been systematically investigated, although there are several previous reports focusing on surgical technique and clinical outcome.[5,17,20]

This study was conducted to investigate the epidemiologic characteristics of MMPRT and relevant risk factors. The incidence of MMPRT has not been thoroughly investigated. Several studies have suggested that up to 27.8% of all medial meniscal tears are MMPRT.[4,18] Our series demonstrated that 21.5% (121 of 564) of the patients who were treated for medial meniscal tear were diagnosed with MMPRT.

Consistent with our study, prior research indicates that MMPRT occurs in persons of older age and female predominance. Bin et al[4] reported that among their patients with MMPRT, 81 of 96 (84.4%) patients were female and 75 of 96 (78.1%) patients were older than 50 years. Ozkoc et al[18] reported that in their study, 47 of 67 (70.1%) patients were female, 54 of 67 (80.6%) patients were older than 50 years, and 54 of 67 (80.6%) patients were obese

(BMI of more than 30 kg/m^2). Despite no data to support the assertion, they postulated that the lifestyle of lotus position and squatting was responsible for the high incidence of MMPRT and explained that these postures lead to the high incidence of MMPRT in Asian people.

Inconsistent with other reports, we found that advancing age and oriental lifestyle with use of the lotus position and squatting (not using a bed or a table) showed no differences between the 2 groups. Bivariate analysis showed that 96 of 104 (92.3%) patients in group 1 and 271 of 372 (72.9%) patients in group 2 were older than 50 years ($P < .01$). However, advancing age did not have a weighted effect on MMPRT compared with other types of medial meniscal tear. We found that age has an even effect on medial meniscal tears regardless of location of the tear.

Interestingly, lifestyle showed no differences between the 2 groups. Bin et al[4] said that oriental lifestyle might lead to impingement of the posterior meniscal segment more often, and eventually the resultant degenerated posterior horn would be prone to tear, based on the kinematic analysis showing that menisci are dynamic structures that move anterior with extension and posterior with flexion.[21] Considering that Asian people adopt the lotus position and squatting in activities of daily living from a young age, knee structures (including musculature and ligament structure) may adapt to these circumstances.

We acknowledge that the present study has some limitations. First, enrolled patients in this study underwent an arthroscopic procedure, which may impose a selection bias. Therefore, it may be inappropriate to translate the present findings into asymptomatic or nonoperative managed meniscal tears and end-stage osteoarthritis patients associated with meniscal tears. Second, we did not subdivide the type of meniscal tear. Medial meniscus posterior root tear was defined as location (posterior horn) and type (radial tear) of medial meniscal tear. In this study, we focused only on the location, not on tear type. Interestingly, most MMPRTs are caused by a degenerative process,[14,16] although the tear type of MMPRT is radial tear (commonly, most radial tears of the body and posterior horn are caused by trauma). Third, because of this study's retrospective study design, missing patients were not included; therefore, this study included 84.4% of all included patients. However, there were no systematic differences between those patients who were included and those who were not.

CONCLUSION

This study demonstrates that advancing age, female sex, higher BMI, increased KLG, varus mechanical axis angle, and lower sports activity level are all associated with MMPRT. Of these, the most potent risk factors are sex, BMI, and mechanical axis angle. Interestingly, oriental-specific lifestyles such as the cross-legged position and kneeling show no contribution to increased MMPRT. This suggests that intrinsic risk factors (similar to those that predispose to osteoarthritis) predispose to MMPRT.

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