RESEARCH ARTICLE

Slope of the Medial Tibial Plateau and the Incidence of a Medial Meniscal Tear

Alireza Askari, MD; Seyed Farzam Mirkamali, MD; Mohammad Taher Ghaderi, MD; Peyman Arasteh, MD, MPH; Mehdi Mohammadpour, MD

Research performed at Shafa Orthopedic Hospital, Iran University of Medical Sciences, Tehran, Iran

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Abstract

Objectives: Previous studies of the association between tibial slope and meniscal tear have led to contradictory results. In this regard, the present study aimed to examine the effect of medial tibial plateau slope on the incidence of isolated medial meniscal tear.

Methods: This study was performed on 75 patients with a posterior horn medial meniscal tear and 150 matched control subjects. Two different observers evaluated the slope of the medial tibial plateau on the lateral radiographs. Reliability of radiographic evaluation was investigated in a pilot study using the intraclass correlation coefficient (ICC) test.

Results: Intra-observer reliability for the slope of the medial tibial plateau was high, with ICC values of 0.961 and 0.957 for the first and second observers, respectively. The interobserver reliability was 0.947. The mean slope was 10.2±3.7° in the case group and 10.1±4.4° in the control group (P=0.97). Moreover, the mean slopes of the medial tibial plateau were 10.3±4.1° and 10.1±4.2° in participants with tibial bone varus angles of (TBVA) < 4° and ≥ 4.2 (P=0.77). The slope was not statistically correlated with age (r=0.074, 95% CI: -0.05−0.20, P=0.26), gender (r=0.07, P=0.29), BMI (r=0.02, 95% CI: -0.10−0.15, P=0.74), level of joint degeneration (r=-0.023, 95% CI: -0.11−0.15, P=0.73), and TBVA (r=-0.010, 95% CI: -0.14−0.12; P=0.12).

Conclusion: No significant difference was found between patients with and without an isolated meniscal tear in terms of the medial tibial plateau slope. These results suggest that the tibial slope may not affect the incidence of isolated medial meniscal tears.

Level of evidence: III

Keywords: Meniscal tear, Posterior tibial slope, Tibial plateau

Introduction

The meniscus is a C-shaped fibrocartilaginous structure, which acts as a secondary stabilizing mechanism within the joint through load transmission and shock absorption.[1] Incidence rate of a meniscal tear is reported to be 0.61 per 1,000 people in the general population and 8.7 per 1,000 people in the active duty military population.[2-4] Considering the significant negative impact of the meniscal tear on the quality of life of patients,[5-7] identifying risk factors of this injury is of critical value for preventive purposes.

To date, several risk factors have been proposed for meniscal tear, including age, male gender, body mass index, anterior cruciate ligament injury, reconstructive surgery, kneeling and squatting, climbing stairs, and playing sports, such as soccer and rugby.[8] Recently, geometric characteristics of the meniscus and its adjacent structure have also been suggested as risk factors of meniscal tears, including the larger size of the cross-sectional meniscal area[9] and length of the femoral condyle relative to the tibial plateau.[10]

Impact of the tibial slope as a geometric risk factor for anterior cruciate ligament (ACL) injury has been reported in several studies. In this respect, a larger tibial slope has been attributed to a larger anterior tibial translation,

Corresponding Author: Mehdi Mohammadpour, 1. Bone and Joint Reconstruction Research Center, Department of Orthopedics, School of Medicine, Iran University of Medical Sciences, Tehran, Iran. 2. Clinical Research Development Unit, Taleghani Educational Hospital, Abadan University of Medical Sciences, Abadan, Iran

Email: hassaninalkaduhimi@gmail.com

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thereby, increasing the risk of ACL stretch and ruptures.[11-13]

Increased tibial slope also imposes greater forces on the meniscus, particularly in the medial portion, and could be regarded as a risk factor for meniscal tear.[14] However, the association of tibial slope with meniscal tear has been investigated in a small number of studies.[14,15] In this study, it was hypothesized that the medial tibial slope increased the risk of medial meniscal tear in the knee joint.

Accordingly, this study aimed to compare the tibial slope of the medial tibial plateau of patients with and without meniscal tears to find the relationship between this slope and the incidence of an isolated medial meniscal tear.

Materials and Methods

Study design

Medical records of patients who were consecutively referred to our university hospital with the diagnosis of an isolated medial meniscus injury between January 2011 and May 2020 were reviewed, and eligible patients were included as the case group. Patients were included only if the injury was located in the posterior horn of the medial meniscus. The exclusion criteria were a history of ligamentous surgery, osteotomy, or cartilage surgery; lateral meniscus lesions identified during arthroscopic evaluation; incomplete data, such as missing lateral radiography; advanced knee joint degeneration (Kellgren-Lawrence grade III or IV),[16] a history of knee fractures or previous knee surgeries; inflammatory joint disorders or connective tissue disorders; noticeable knee deformity; and a body mass index (BMI) of ≥ 30 kg/m^2. Meniscal injury was diagnosed using preoperative MRI and confirmed through arthroscopy.

The control group consisted of individuals who had normal knee magnetic resonance imaging performed for reasons unrelated to meniscal tears, with a case-to-control ratio of 1:2. These individuals were matched with the case group regarding age, gender, and BMI. The control group was subjected to the same exclusion criteria as the case group.

The tibial bone varus angle (TBVA) was measured on anteroposterior radiographs as the angle between the mechanical axis of the tibia and the proximal tibial epiphyseal axis [Figure 1]. Characteristic features of the case and control groups are demonstrated in [Table 1].

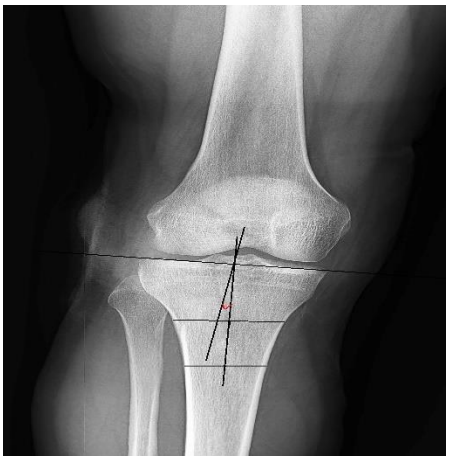

Figure 1. Calculation of the tibial bone varus angle on the anteroposterior radiograph

Table 1. Characteristic features of the patients with and without meniscus tear

Variable*	Case group (n=75)	Control group (n=150)	P-value
Age (years)	37±9.9	37.5±12.6	0.71
Gender - no. (%)			0.1
Male	43 (57.3%)	103 (68.7%)	
Female	32 (42.7%)	47 (31.3%)	
Body mass index (kg/m2)	24.3±2	24.5±2.4	0.57
Joint degeneration- no. (%)			0.3
None	57 (76%)	96 (64%)	
Grade 1	13 (17.3%)	38 (25.3%)	
Grade 2	5 (6.7%)	16 (10.7%)	
Type of meniscal tear- no. (%)			
Horizontal or flap tear	36 (48%)	-	
Vertical longitudinal tear	18 (24%)	-	
Complex tear	15 (20%)	-	
Root tear	6 (8%)	-	
TBVA (º)	5.1±3.5	4.7±3.3	0.54

TBVA: tibial bone varus angle

*All plus-minus values are means ± SD

On the lateral radiography of the proximal tibia, the slope of the medial tibial plateau was assessed as follows: a reference line (15 cm proximal tibia) was drawn tangential and parallel to the posterior cortex. Subsequently, a line was drawn perpendicular to the reference line, and the angle between this vertical line and the tangent line of the medial

tibial plateau was calculated with the picture archiving and communication system [Figure 2]. Radiographic evaluations were performed by two senior orthopedic surgeons.

Statistical analysis

Statistical analyses were performed in SPSS software for Windows (version 16). The intra- and inter-observer reliabilities of the radiographic measurements were tested in a pilot study using the intraclass correlation coefficient (ICC). The descriptive data were presented as mean±standard deviation for quantitative variables and numbers with percentages for categorical variables. Comparison of mean values between the case and control groups was made using an independent t-test or its nonparametric counterpart (Mann-Whitney U test). The chi-squared test was used to compare the categorical variables. Pearson's or Spearman's correlation coefficient was used to evaluate the potential correlation between the variables. The median split approach was used to categorize the numerical variables, such as age and BMI. A $P<0.05$ was considered statistically significant.

Figure 2. Calculation of the slope of the medial tibial plateau on the lateral radiography of the proximal tibia

Results

Mean ages of the case and control groups were 37±9.9 and 37.5±12.6 years, respectively (P=0.71). The two groups had no difference regarding baseline characteristics as shown in [Table 1].

Inter- and intra-observer reliability

The intra-observer reliability for determining the slope of the medial tibial plateau was 0.961 for the first observer and 0.957 for the second observer. The inter-observer reliability was 0.947.

Medial tibial plateau in different sub-groups

Mean slope values of the medial tibial plateau were 10.3 ± 4.1º and 10.1 ± 4.2º in participants with TBVAs of < 4º and ≥ 4.2º, respectively (P=0.77). Furthermore, mean slope values of the medial tibial plateau were 10 ± 4.1º and 10.4 ± 4.2º in participants aged < 36 and ≥ 36 years old, respectively (P=0.54). In addition, mean slope values of the medial tibial plateau were 10.1 ± 4.2º and 10.3 ± 4.1º in participants with BMI values of < 24.5 kg/m^2 and ≥ 24.5 kg/m^2, respectively (P=0.57). Moreover, mean slope values of the medial tibial plateau were 10 ± 4º and 10.6 ± 4.3º in males and females, respectively (P=0.3). Mean slope of the medial tibial plateau was not significantly different in patients with different levels of joint degeneration. Tibial slope of the medial tibial plateau in different subgroups of patients is summarized in [Table 2].

Correlations

Mean slope values of the medial tibial plateau were 10.2 ± 3.7º and 10.1 ± 4.4º in the case and control groups, respectively (P=0.97). The slope was not statistically correlated with age (r=0.074, 95% CI: -0.05–0.20, P=0.26), gender (r=0.07, P=0.29), BMI (r=0.02, 95% CI: -0.10–0.15, P=0.74), level of joint degeneration (r=-0.023, 95% CI: -0.11–0.15, P=0.73), and TBVA (r=-0.010, 95% CI: -0.14–0.12, P=0.12).

Table 2. Slopes of the medial tibial plateaus in different subgroups of patients

Variable*	Slope of medial tibial plateau (º)	P-value
Age (years)		
<36	10±4.1	0.54
≥36	10.4±4.2	---
Gender		
Male	10±4	0.3
Female	10.6±4.3	---
Body mass index (kg/m2)		
<24.5	10.1±4.2	0.57
≥24.5	10.3±4.1	---
Joint degeneration		
None	10.1±4.2	0.89
Grade 1	10.4±4.1	---
Grade 2	10.3±4.3	---

Table 2. Continued		
TBVA (º)		
<4	10.3±4.1	0.77
≥4	10.1±4.2	---

TBVA: tibial bone varus angle
*All plus-minus values are means ± SD

Discussion

In this study, the differences between the slopes of the medial tibial plateaus of patients with and without isolated meniscus tears were evaluated. This research also evaluated the association of this slope with the characteristic features of patients, such as age, gender, BMI, and TBVA. According to the results, no significant difference was observed between the slopes of the medial tibial plateaus of patients with and without an isolated meniscal tear. In addition, this slope was not related to other measured clinical characteristics of the patients.

Lee et al. reviewed the influence of posterior tibial slope (PTS) on medial meniscal tears in 174 patients who underwent ACL reconstruction for chronic ACL tears. Incidence of a medial meniscus tear in their patients was 44%. Mean PTS was significantly higher in patients with a meniscal tear in comparison to patients without a meniscal tear (11.4º vs. 9.8º). They concluded that PTS ≥ 13º is associated with an increased risk of secondary medial meniscal tears in ACL-deficient patients and suggested considering this association in the evaluation of patients requiring early ACL reconstruction to reduce the rate of secondary medial meniscal tears.[15]

Samuelsen et al. performed a cadaveric study to evaluate the association between tibial slope, ACL graft forces, and meniscal tear. Based on their investigations, medial meniscus tears magnified the effect of increased PTS on ACL graft forces. They suggested performing a slope-changing osteotomy at slopes of > 12º before ACL reconstruction combined with meniscal repair.[17] Association between the PTS, medial meniscal tear, and ACL deficiency has also been demonstrated in other studies.[18-21] However, the effect of PTS on the incidence of isolated medial meniscal tears has been investigated in a small number of studies.

Wang et al. evaluated the effect of medial PTS on the locations of meniscal tears in 292 patients who underwent arthroscopic owing to knee osteoarthritis and meniscal lesions. The patients were categorized into two groups, namely patients with tears in the posterior horn and patients with tears in other sites. The mean medial PTS was significantly higher in patients with tears in the posterior horn (6.15º vs. 5.06º). They concluded that increased medial PTS might be considered a risk factor for the medial meniscal tear.[22] The present study only included patients with posterior horn meniscal tears and found no significant association between medial PTS and increased incidence of the meniscal tear. This result was not consistent with those of the study performed by Wang et al. This inconsistency could be attributed to the study design, which was case-control in the present study and cohort in the study conducted by Wang et al.

Alici et al. investigated the influence of the tibial slope on the incidence of medial and lateral meniscus lesions in 212 individuals with intact ACLs. In their study, participants were grouped into four categories, namely those with isolated medial meniscal tears (group 1), those with isolated lateral meniscal tears (group 2), those with both medial and lateral meniscal tears (group 3), and those with no meniscal tear (group 4). According to their results, the tibial slope on the medial tibial plateau was not significantly different between the four study groups. However, the tibial slope on the lateral tibial plateau was significantly larger in patients with an isolated lateral meniscal tear. They concluded that an increase in the lateral tibial slopes could increase the risk of lateral meniscal tear.[14]

In the present study, the association between lateral tibial slope and lateral meniscal tear was not evaluated. Similar to the study performed by Alici et al., the medial PTS was not significantly different between the patients with and without a medial meniscal tear in the present study.

Moon et al., in a case-control study, investigated the relationship between the PTS and isolated medial meniscal posterior horn tears in 159 and 60 patients with and without a meniscal tear, respectively. According to their results, the mean PTS was significantly greater in patients with an isolated medial meniscal posterior horn tear (7º vs. 5.2º), with a cutoff point of 6.6º between the two groups. They concluded that an increased PTS is strongly associated with an increased incidence of medial meniscal posterior horn tears and is less affected by the pattern of the meniscal tear. In contrast to the study of Moon et al., the current study failed to find a significant association between PTS and medial meniscal tear. This inconsistency creates the need for further evaluation of such associations in future studies.

The present study had some limitations. The main limitation of this study was its retrospective design, which could be associated with a significant risk of bias. In addition, the control group was selected from patients who were referred for knee pain with other pathologies, while a true control group would be regarded as individuals without knee pain. Finally, radiographs were used for the evaluation of PTS, while MRI could reflect the outlines of the medial tibial plateau more accurately.

Conclusion

No significant difference was found between the slope of the medial tibial plateau of the patients with and without an isolated medial meniscal tear. This result reveals that PTS might have no effect on the incidence of an isolated meniscal tear. However, owing to the inconsistent results

of available studies, further research is required to fully understand the association between meniscal injury and tibial slope.

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Authors Contribution:

Alireza Askari: Study design and supervision
Seyed Farzam Mirkamali: Data collection
Mohammad Taher Ghaderi: Data collection
Peyman Arasteh: Critically reviewing the manuscript
Mehdi Mohammadpour: Writing manuscript

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Declaration of Informed Consent: Patient selection was performed using convenience sampling, and all patients were required to provide written informed consent prior to enrollment.

Alireza Askari MD [1]
Seyed Farzam Mirkamali MD [1]
Mohammad Taher Ghaderi MD [1]
Peyman Arasteh MD, MPH [2]
Mehdi Mohammadpour MD [1,3]

1 Bone and Joint Reconstruction Research Center, Department of Orthopedics, School of Medicine, Iran University of Medical Sciences, Tehran, Iran
2 Shiraz University of Medical Sciences, Shiraz, Iran
3 Clinical Research Development Unit, Taleghani Educational Hospital, Abadan University of Medical Sciences, Abadan, Iran

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