

The Effect of Abnormal Tibial Slope on Medial Meniscus Tear

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Abstract: Objective: To study the relationship between tibial plateau retroversion and medial meniscus injury, and further discuss and explore the abnormal anatomical factors. Methods: 36 patients who underwent knee surgery in overseas Chinese hospital from 2011 to 2022 were randomly selected and divided into groups A and B. Group A (28 cases) had definite medial meniscus injury, while group B (8 cases) had no medial meniscus injury and underwent other operations. All medial meniscus injuries met the diagnostic criteria and could be observed under arthroscopy. The tibial plateau caster angle (PTS) was measured on MRI, and the statistical significance was determined by two independent sample t-test and chi square test. The variables with statistical significance were analyzed by binary logistic regression. Finally, the independent risk factors of medial meniscus injury were determined, and the Or value was calculated. P value <0.05 was considered statistically significant. Results: there were 28 knees in group A and 8 knees in group B. There was no significant difference in age, sex and BMI between the two groups (p>0.05). The main tear sites of medial meniscus were posterior horn tear (57.14%) and body tear (14.28%), and the tear types were complex tear (32.1%) and horizontal tear (21.4%). The average PTS of group A (8.69 °) was significantly higher than that of group B (6.22 °) (p<0.01). The results of binary logistic regression analysis showed that PTS was statistically significant (p<0.005), so we believed that the increase of PTS (OR=1.62, 95%CI, 1.086~2.403) was an independent risk factor for medial meniscus injury. Conclusion: PTS is higher in patients with medial meniscus injury. The abnormal anatomical structure of increasing retroversion is a risk factor for medial meniscus injury.

Keywords: Medial meniscus tear, Posterior tibial slope, Medial proximal tibial angle, PTS, Knee.

1. Introduction

Abnormal caster angle can affect joint flexion angle, joint stability and femoral roll back[1, 2, 3]. Some special types of meniscus injuries, such as the posterior corner edge tear of the medial meniscus, ramp injury, and layered tear, are all closely related to anterior cruciate ligament injury[4,7].However, no study has taken into account the factors related to meniscus injury and anatomy, such as whether the increase of caster angle is an anatomical high-risk factor for medial meniscus tear.

Abnormal force line and tibial deformity are also some high-risk anatomical factors. Some studies have revealed that there is a close relationship between posterior root tear of medial meniscus, varus deformity, force line deviation and body mass index [6,7].Many related studies believe that medial meniscus tear is closely related to severe osteoarthritis and varus force line, large caster angle and anterior cruciate ligament injury [8].

The abnormal morphology of bone tissue is very important for the influence of meniscus. Both the increased caster angle and the deep depression of the medial platform can lead to the tearing of the posterior root of the medial meniscus [9].however, there are few studies on the relationship between the abnormal caster angle and the force line of the lower limbs and the injury of the medial meniscus.

Our assumption in this study is that there is a correlation between medial meniscus injury and tibial retroversion.

2. Materials and Methods

2.1. Research Object

The researchers retrospectively selected 50 cases from the preoperative and intraoperative data of arthroscopic surgery in Guangzhou Overseas Chinese hospital from 2020 to 2021. After exclusion, there were 38 cases (38 patients), including 15 males and 23 females. (mean age 52.36 ± 17.25 , age range 18~80 years) these cases underwent arthroscopic debridement, medial and lateral meniscus repair, and patellofemoral ligament reconstruction. The age and sex of all cases were counted.

Exclusion criteria:

- (1) Progressive osteoarthritis;
- (2) Tibial fracture;
- (3) Congenital limb deformity or unequal length of lower limbs;
- (4) Patients who cannot cooperate with imaging examination.

2.2. Research Method

2.2.1. Mri Image Acquisition

The patient lies on the examination table (1.5T, Siemens symphony, Germany: T1 sequence, 1mm thick, 160x160 mm2 window) of the MRI equipment, straightens the knee joint of the affected side, the patella of the affected side is upward, and maintains the upward position of the knee joint. After the patient is placed in a good position, fill the gap between the knee joint of the patient and the MRI coil with a filler to prevent the patient from involuntary activities during

the examination. The scanning direction is perpendicular to the transcondylar axis of the femoral condyle in the axial position, and parallel to the tibial mechanical axis in the sagittal position.

2.2.2. Measurement of Tibial Retroversion Angle

We measured the retroversion angle of the medial tibial plateau on MRI images. For the measurement of tibial retroversion angle, we refer to the method first proposed by hudek [10].

On MRI, measurement can be divided into the following steps:

A: (1)Find the central image of the tibia in the sagittal position: that is, the attachment point of the posterior cruciate ligament on the tibia.(2)Find the intercondylar ridge.(3)Determine the anterior and posterior cortex of the proximal tibia;

B: The application software draws two circles inside the

tibia in the image of step A. the first circle is required to be tangent to the tibial plateau and the posterior tibial cortex. The second circle is below the first circle, and its center is located on the circumference of the first circle and tangent to the anterior and posterior cortex of the tibia (Figure 1);

C: The line connecting the centers of the above two circles is the tibial anatomical axis la;

D: Determine the sagittal plane where the medial tibial plateau is located (that is, the sunken plane in the center of the medial tibial plateau), and draw the line between the anterior and posterior edges of the tibial plateau on this plane, so that I can get the tangent of the medial tibial plateau;

E. The included angle formed by the tangent of the medial tibial plateau and the vertical line of the anatomical axis in the sagittal position is the required tibial plateau caster PTS ° (Figure 2). In order to reduce the error, we asked two researchers to measure the average value of the results obtained three times for each patient's MRI image caster.

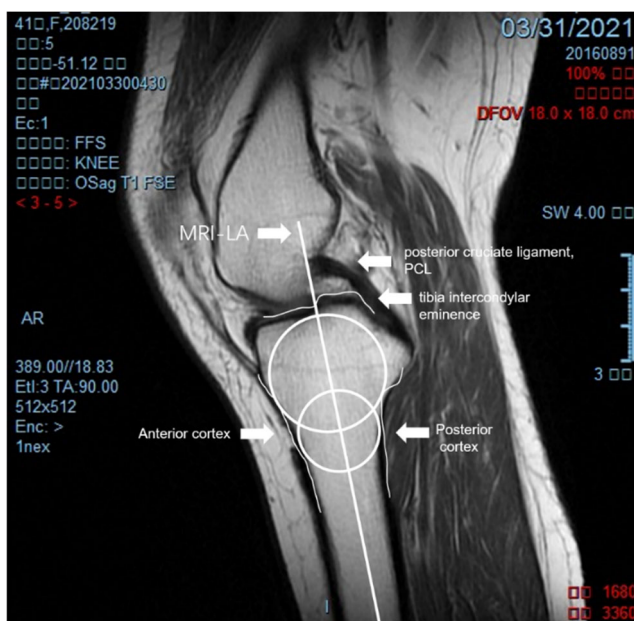


Figure 1. The MRI-LA in the figure is the tibial anatomical axis we need.

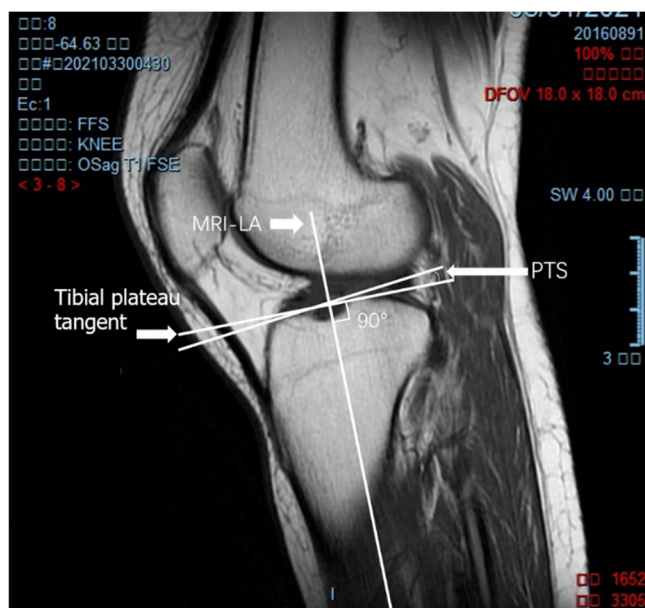


Figure 2. The included angle between the perpendicular line of the tibial anatomical axis MRI-LA and the tangent line of the medial tibial plateau is PTS.

Table 1. Comparison of English full name and abbreviation in the text

Abbreviation	Full name
PTS	posterior tibial slope
MM	medial meniscus
MRI	magnetic resonance images
OR	odds ratio
CI	confidence interval

2.2.3. Statistical Analysis

SPSS 21.0 software was used for statistical analysis, and the statistical description included the mean, standard deviation, maximum and minimum values of each group. Chi

square test, t-test and binary logistic regression analysis were used in statistical analysis, and $p < 0.05$ was considered to be statistically significant.

3. Result

Table 2. General information of patients.

Variable/Group	Age (years)	Gender Male/Female
Group A	43.38±18.96	10/18
Group B	54.93±16.18	5/3
P-value	0.095	0.175

There were 38 cases (15 males and 23 females) in this study. In group A (28 knees), there were 10 males and 18 females. In group B (8 knees), there were 5 males and 3 females. The average age at the time of surgery was 43.38 ± 18.96 years

(18-80) in group A and 54.93 ± 16.18 years (20-69) in group B. There was no statistical difference between the two groups in age and gender. (Table 2)

Table 3. Location and type of meniscus tear.

Group A (28 knees)		
Location of meniscus tear		
Anterior horn	7	(25.0%)
Body	4	(14.3%)
Posterior horn	16	(57.1%)
Multisite tear	1	(3.6%)
Type of meniscus tear		
Horizontal	6	(21.4%)
Radiation type	4	(14.3%)
Longitudinal tears	9	(32.1%)
complex tear	9	(32.1%)

Table 4. Comparison of PTS between two groups

Variable/Group	Group A(n=28)	Group B(n=8)	t	p
PTS	8.69±2.15	6.22±2.11	-2.868	0.007**

* $p < 0.05$ ** $p < 0.01$

There were definite medial meniscus injuries in group A, including anterior horn injury in 7 knees (25.0%), body injury in 4 knees (14.3%), posterior horn injury in 16 knees (57.1%), and multiple site injury in 1 knee (3.6%). There were 6 cases of horizontal tear (21.4%), 4 cases of radioactive tear (14.3%), 9 cases of longitudinal tear (32.1%), and 9 cases of complex tear (32.1%). Group B included 2 knees with synovitis, 3 knees with lateral meniscus injury, and 3 knees with patellar joint disease.

It can be seen from the above table that t-test (full name: independent sample t-test) is used to study the difference

between meniscus injury and PTS. From the above table, it can be seen that different meniscus injury samples are significant for PTS ($p < 0.05$), which means that different meniscus injury samples are different for PTS.

Specific analysis shows that: Meniscus injury showed a significant level of 0.01 for PTS ($t = -2.868$, $p = 0.007$), and the specific comparative differences showed that the average value of PTS in group B (6.22) would be significantly lower than the average value of group A (8.69). (Table 3) there was significant difference in PTS between the two groups ($p < 0.005$).

Table 5. Binary Logistic regression analysis of OR value, 95% confidence interval and P value

Summary of binary Logit regression analysis results							
Item	Regression coefficient	Standard Error	z value	Wald χ^2	p value	OR value	OR value 95% CI
PTS	0.480	0.203	2.367	5.604	0.018	1.615	1.086 ~ 2.403
Intercept	-2.375	1.524	-1.559	2.430	0.119	0.093	0.005 ~ 1.843

Dependent variable: meniscus injury
 McFadden *R* square: 0.183
 Cox & Snell *R* square: 0.176
 Nagelkerke *R* square: 0.269

It can be seen from the above table that taking PTS as the independent variable and meniscus injury as the dependent variable for binary logit regression analysis. It can be seen from the above table that PTS can explain the 0.18 change cause of meniscus injury. It can be seen from the above table that the model formula is: $\ln(p/1-p) = -2.375 + 0.480 \cdot pts$ (where p represents the probability of meniscus injury of 1, and $1-p$ represents the probability of meniscus injury of 0). The final specific analysis shows that the regression coefficient of PTS is 0.480, and shows a significant level of 0.05 ($z=2.367$, $p=0.018 < 0.05$), which means that PTS will have a significant positive impact on meniscus injury. And the odds ratio (or) is 1.615, which means that when PTS is increased by one unit, the change (increase) of meniscus injury is 1.615 times. Summary and analysis show that PTS will have a significant positive impact on meniscus injury. (Table 5)

4. Discussion and Conclusion

Meniscus injury is a common injury, especially the medial meniscus injury, which may be closely related to the abnormal function of force line and anterior cruciate ligament.

There is a close connection between the medial meniscus and the tibia, especially the posterior horn of the medial meniscus at [13]. This connection makes the medial meniscus as a stabilizing device, especially in cases of anterior cruciate ligament dysfunction, as a secondary stabilizing structure that resists tibial advancement [15,16]. The tibia moves forward after anterior cruciate ligament injury, and the medial meniscus is embedded into the femoral condyle to resist the tibial movement.

Studies have shown that in cases of chronic anterior cruciate ligament injury, the medial meniscus is damaged due to the wedging of the medial meniscus. On the other hand, the lateral meniscus with greater mobility is rarely damaged by this kind of injury [14].

In this study, we excluded the cases of anterior cruciate ligament injury, and eliminated the secondary injury of anterior cruciate ligament injury to the medial meniscus. At the same time, the risk of anterior cruciate ligament injury will increase with the increase of caster angle, which can not accurately reflect the relationship between caster angle and medial meniscus injury.

Studies have reported that 27.8% of medial meniscus tears are radial tears of the posterior horn [17], and 32.5% of medial meniscus tears are posterior root tears, which is higher than that of lateral meniscus [18]. In our study, the posterior horn of the meniscus has the highest proportion of tears and body parts, the proportion of complex tears and radial tears is higher, and the proportion of posterior horn combined with complex tears is higher. The possible reason is that the posterior horn of the meniscus is under greater stress and

damage.

Arno et al. Believed that the change of tibiofemoral joint contact mechanics could lead to the degradation of knee cartilage with horizontal tear of meniscus, but did not lose the role of hoop 19. Another view is that the progression of osteoarthritis affects the integrity of the meniscus and eventually leads to degenerative tears. The formation of meniscus and osteoarthritis complement each other. Osteoarthritis of the medial platform begins in the center of the tibial plateau, accompanied by the convexity of the medial meniscus, and gradually develops from front to back. The destruction of this bone defect directly leads to the increase of varus angle and tibial plateau angle [20,21].

Many studies have shown that the presence of varus and proximal tibial deformity in the force line of the lower limb will affect the tearing mode of the medial meniscus [22, 23]. Some studies have shown that the varus angle of the lower limb is larger in cases of medial meniscus tear, and the varus angle of the tibial plateau is smaller than that of the control group.

The research shows that the varus force line directly leads to the medial posterior horn combined with radial tear. For the varus angle of the medial tibial plateau, the logistic regression analysis results show that it is not a risk factor for the injury of the medial meniscus, which may be because if the overall force line of the lower limbs is in the normal range, it can make up for the injury caused by the varus of the medial tibial plateau to a certain extent, And some studies also suggest that the varus angle has a greater impact on the meniscus than the varus angle of the tibial platform [24].

Caster refers to the angle 25 relative to the tibial plateau slope of the tibial longitudinal axis. Moore reported that the average caster of 50 Americans is 14° [23], the average caster of Japanese is 10° [26], and the average caster of Chinese is 14.7° [27]. Some studies have pointed out that the medial caster is 7.78° , while the lateral caster is 6.85° , and there is no obvious difference in age and sex [28].

Current research shows that PTS in cases of medial meniscus injury is larger than those without meniscus injury. It is obvious that there is a certain relationship between caster angle and medial meniscus tear. Although its injury mechanism has not been confirmed, we believe that the possible reason is that the increased shear stress caused the medial meniscus tear, which needs further research.

The anterior tibial displacement of the knee joint is aggravated, and the inclination of the tibia is increased, which will concentrate a lot of stress on the torn part of the medial meniscus, and may prevent the natural healing of the torn meniscus. Therefore, we believe that PTS is a secondary stable structure to prevent meniscus injury after anterior cruciate ligament reconstruction.

Tibial retroversion is a potential risk factor for anterior cruciate ligament injury. The biomechanical analysis of the

knee joint shows that the increase of caster angle can not only improve the movement of the knee joint, but also cause the anterior displacement of the knee joint, thereby increasing the load of the anterior cruciate ligament. This increase in load is also a predisposing factor for anterior cruciate ligament rupture [29].

There are some views that anatomical factors, including tibial plateau caster, are one of the risk factors for osteoarthritis[30,31,32]. Dehghan and Bahmani concluded that the caster in osteoarthritis cases is significantly greater than that in normal knee joints through the comparative study of the caster in osteoarthritis patients and normal knee joints.

Although the PTS of patients with medial meniscus tear is larger, because the difference in the mean value of PTS is relatively small, this may have no clinical significance. However, when we use different methods to analyze, the difference between the low group and the high group is significant. Tibial retroversion is an important factor in weight bearing and prosthesis design[34,35,36].

PTS was higher in patients with medial meniscus tear. These abnormal anatomical structures are one of the risk factors of medial meniscus injury.

The limitation of this study is that the tear mode is only determined by one researcher. The causal relationship between PTS and the type of medial meniscus tear has not been clarified in this study. The situation of lateral meniscus tear and its relationship with various angles have not been observed in this study. Cases of anterior cruciate ligament injury have been excluded in this study, while PTS is clearly related to anterior cruciate ligament injury, which may have a certain impact on the integrity of the data, The damage mechanism is not clear, which needs to be confirmed by further research.

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