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Original Research Article

The role of lateral and medial posterior tibial slope in anterior cruciate ligament injuries: a case-control study

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ABSTRACT

Background: The anterior cruciate ligament (ACL) is one of the major stabilisers of the knee and is the most frequently involved ligament in knee injuries and related functional instability. The objective of the study was to compare the lateral posterior tibial slope (LPTS) and medial posterior tibial slope (MPTS) among those with ACL injury and those with the intact ligament.
Methods: MRI of 65 (male-43, female-22) ACL injured and 65 (male-58, female-7) ACL intact knees were studied. Using RadiAnt DICOM viewer software, the slopes of both medial and LPTS s were measured. The statistical analysis was performed by IBM SPSS 25. Associations between various factors were assessed using the Chi square test for categorical variables and independent t test were done for quantitative variables. P<0.05 had been considered statistically significant.
Results: Among cases the mean LPTS was $10.23^0 \pm 3.93^0$ and mean MPTS was $6.61^0 \pm 3.49^0$. Among controls, mean LPTS was $8.46^0 \pm 3.63^0$, mean MPTS was $5.51^0 \pm 2.91^0$. Case had a statistically significant (p=0.009) steeper LPTS than control population. MPTS of cases were steeper than the control population with no statistical significance (p=0.055).
Conclusions: In this study, the LPTS was significantly increased among patients with ACL injury as compared with ligament-intact controls. LPTS measurements should be considered as a significant independent modifiable risk factor for ACL injury.

Keywords: ACL injury, LPTS, MPTS

INTRODUCTION

The ACL is one of the major stabilisers of the knee joint and is the knee ligament which is most frequently involved in injuries and related functional instability. In the knee joint, the structure which acts as the primary restraint to anterior tibial translation is the ACL. The ligament accounts for approximately 85% of the resistance to the anterior drawer test when the knee is at 90 degrees of flexion and neutral rotation.[1] There are several structural risk factors proposed for ACL injury. The posterior tibial slope is defined as the angle between a line parallel to the posterior tibial inclination (of medial or lateral condyle) and a line that bisects the diaphysis of the tibia. Patients with an increased posterior tibial slope have a higher risk for enlarged anterior tibial translation. A higher posterior tibial slope may increase risk for valgus and external rotation of leg, and possibly will increase the shear stress and impingement risk of ACL. The purpose of this study was to compare the LPTS and MPTS among those with ACL injury and those with intact ligament.

METHODS

This was a case-control study, conducted among patients visiting the orthopaedic department of Rajagiri hospital, Aluva, Kochi, Kerala, during December 2020 and June 2021. Cases were patients between 15 to 55 years of age with MRI evidence of complete primary ACL tears. Control groups included patients between the same age group with complaints related to the knee, but with MRI evidence of an intact ACL.

Exclusion criteria

The exclusion criteria were age less than 15 years and older than 55 years, ACL reconstruction graft failure, knees with osteoarthritis features, patients with a history of fractures around the knee, patients with previous major ligament injuries of the knee (PCL, MCL, LCL), knees with fixed deformity, prior surgery around the knee, multi-ligamentous injury of knee and tumours of proximal tibia.

The 65 (male-58, female-7) patients with MRI-proven ACL injury were included as cases and 65 (male-43, female-22) patients with intact ACL on MRI were included as controls. Consecutive sampling methods were used for selecting cases and controls.

MRI knees were taken using Philips Ingenia 3.0-T machine. All patients underwent MRI according to the standard protocol. All MRI scans had 3-mm slice thicknesses and were conducted with the patient in a supine position and the knee extended. Measurements were done in proton density with fat depression (PD with SPAIR) images using a RadiAnt DICOM viewer (64-bit, product version- 2020.1.1.38146).

Measurement of the medial and LPTS of the tibia with magnetic resonance imaging

The centre of the tibia was identified from the corresponding views on coronal and sagittal images. In the coronal image, the centre was taken at the midpoint of the intercondylar eminence. In the corresponding sagittal image, the mid-axial points of the tibial shaft were identified by drawing perfectly aligned two circles in the proximal shaft of the tibia. The circles were drawn in such a way that the circumference of the circle was perfectly aligned with the cortical margin of the tibial shaft. The centres of each circle were identified by drawing their diagonals. Cobb angle tool used for measurements of angles. The vertical limb of the Cobb angle tool was aligned along the previously identified centres of circles (Figure 1). The Cobb angle tool then copied and pasted to the required sagittal images of the medial and lateral tibial plateau. The required mid-sagittal planes for both plateaus were selected using the linked sagittal and coronal images. The centre point of the lateral or medial tibial plateau was then identified on the coronal series, which was used to determine the corresponding sagittal image in the mid-condylar plane to measure the LPTS or MPTS. The horizontal limb of the Cobb angle tool was aligned along the subchondral bone of the lateral and medial tibial plateau line of the selected sagittal images and then it showed the slopes, the MPTS and the LPTS (Figure 2 and 3).

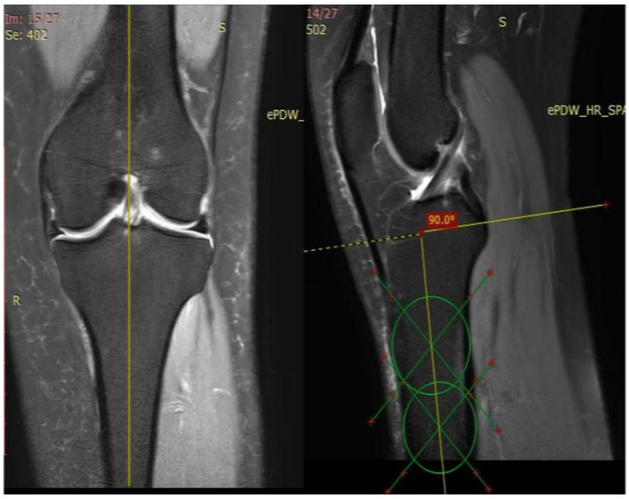

Figure 1: Marking the axis of the tibia by drawing circles.

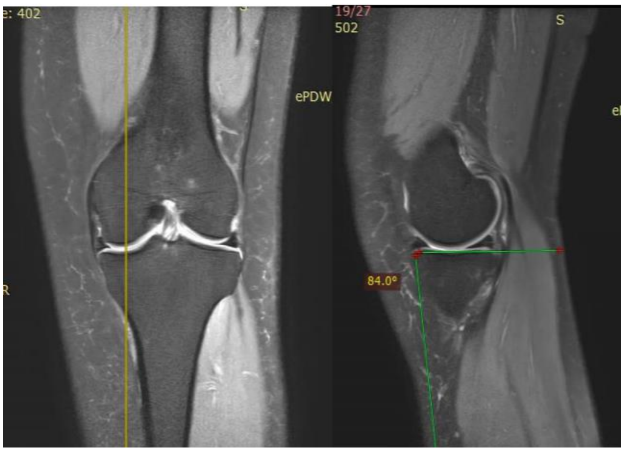

Figure 2: Align the vertical limb along the centre and horizontal limb of the Cobb angle tool along the subchondral bone of the MPTS.

Figure 3: Align the vertical limb along the centre and horizontal limb of the Cobb angle tool along the subchondral bone of the LPTS.

Studies commenced after getting clearance from scientific committee and ethical committee. All measurements and examinations were done by a single observer. The data was entered in MS excel. Statistical analysis performed by IBM SPSS 25. Qualitative variables are expressed as frequency and percentages and quantitative variables as mean and SD. Associations between various factors were assessed using the chi-square test for categorical variables and independent t test done for quantitative variables. P<0.05 considered statistically significant.

RESULTS

Total of 130 subjects were taken in study. Of 130 subjects, 65 (male-43, female-22) were ACL intact controls, the other 65 (male-58, female-7) were ACL-injured cases. The mean age of the cases were 30.18 years (30.18±9.34), (range: 16-51 years). The mean age of the controls were 31.37 years (31.37±8.54 years), (range: 15-54 years). The difference in mean age was -1.185±1.569 (95% CI: -4.290 to 1.921). There was no statistically significant difference in age distribution between the two groups (p=0.452). Considering the age, the two groups, that is, cases and controls, were comparable. The demographic details were included in Table 1 and Figure 4.

Mean LPTS of study population was $9.34^0\pm3.87^0$ (0.2^0 to 23.3^0). The mean MPTS of study population $6.06^0\pm3.25^0$. (0.2^0 to 14.8^0). The mean LPTS of total study population was higher than MPTS. Figure 5 and 6 shows the distribution of LPTS and MPTS among the study populations.

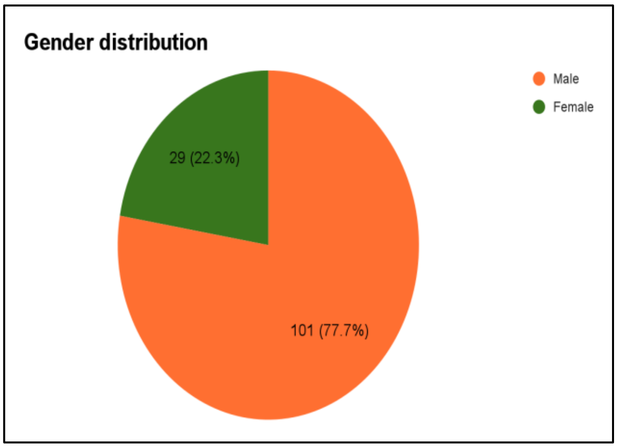

Figure 4: Gender distribution of study population.

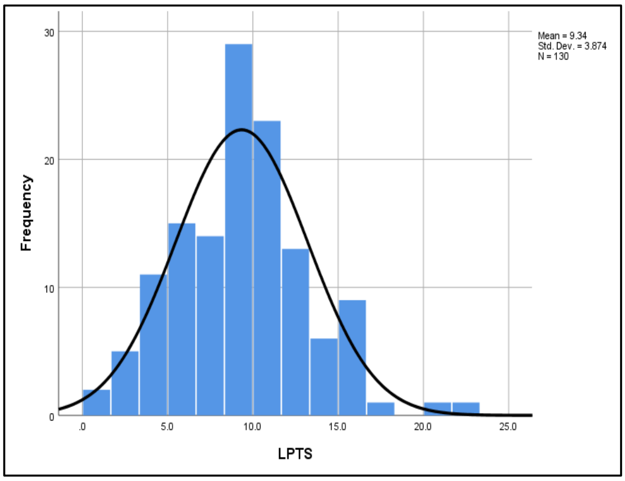

Figure 5: Distribution of LPTS among the study population.

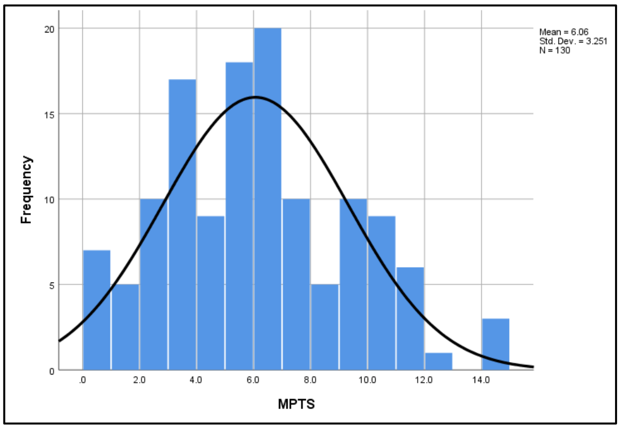

Figure 6: Distribution of MPTS among the study population.

When considering the entire study population, the mean LPTS of males were $9.64^0\pm3.90^0$ and of females were $8.29^0\pm3.65^0$, with a mean difference of 1.34±0.81 (95% CI: -0.26 to 2.94), (Table 4). This difference in mean was found to be not statistically significant between the two gender groups (p=0.10). Similarly, the mean MPTS of males were $6.11^0\pm3.27^0$ and of females were $5.90^0\pm3.22^0$, with mean difference of 0.20±0.68 (95% CI: -1.15 to 1.56), (Table 5). This difference in mean was found to be not statistically significant between the two gender groups (p=0.76). That means there was no significant difference in LPTS or MPTS between males and females.

Table 1: Age, weight, height and BMI of study population.

Variables	Total number of study population	Minimum	Maximum	Mean	Std. deviation
Age (years)	130	15	54	30.78	8.93
Weight (kg)	130	47.4	114.2	73.74	13.08
Height (cm)	130	150	188	170.85	9.29
BMI (kg/m^2)	130	16.9	39.7	25.33	4.30

Table 2: Comparison of the study groups based on LPTS.

Variables	Groups	Frequency	Mean	S. D	Mean difference	Std. error	95% CI	T value	P value
LPTS	Case	65	10.23^0	3.93^0	1.77	0.66	0.45 to 3.08	2.665	0.009
	Control	65	8.46^0	3.63^0					

Table 3: Comparison of the study subjects' groups based on the MPTS.

Variables	Groups	Frequency	Mean	S. D	Mean difference	Std. error	95% CI	T value	P value
MPTS	Case	65	6.61^0	3.49^0	1.09	0.56	-0.24 to 2.20	1.93	0.055
	Control	65	5.51^0	2.91^0					

Table 4: Distribution of the lateral tibial slopes based on gender.

Variables	Groups	Frequency	Mean	S. D.	Mean difference	Std. error	95% CI	T value	P value
LPTS	Male	101	9.64^0	3.90^0	1.34	0.81	-0.26 to 2.94	1.65	0.10
	Female	29	8.29^0	3.65^0					

Table 5: Distribution of medial tibial slopes based on gender.

Variables	Groups	Frequency	Mean	S. D.	Mean difference	Std. error	95% CI	T value	P value
MPTS	Male	101	6.11^0	3.27^0	0.20	0.68	-1.15 to 1.56	0.30	0.76
	Female	29	5.90^0	3.22^0					

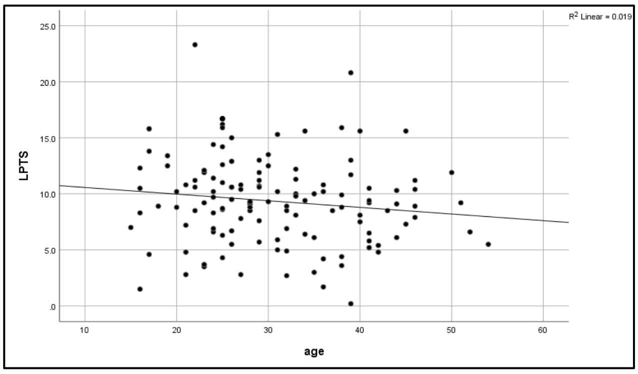

Figure 7: Scatter diagram showing the distribution of LPTS with age.

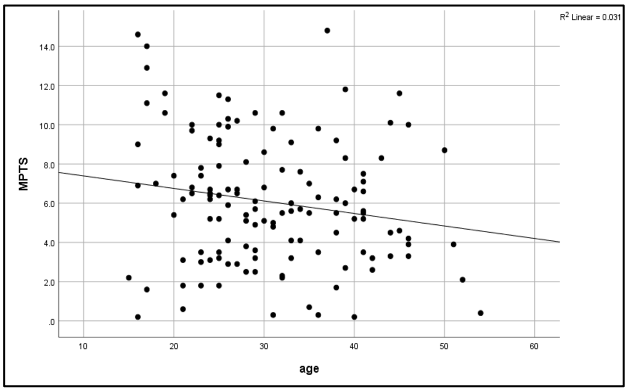

Figure 8: Scatter diagram showing the distribution of MPTS with age.

In the current study, no significant correlation was found between age and LPTS (p=0.122 and Pearson correlation coefficient value: -1.36), (Figure 7). The MPTS is found to be decreasing with advancing age (p=0.046 and Pearson correlation coefficient value: -0.175), (Figure 8).

DISCUSSION

The most important finding of this study is that the LPTS were significantly higher in the ACL-injured group compared to the control group. The mean LPTS of the total study population was higher than the MPTS. The LPTS was higher than MPTS among both cases and controls, and was statistically significant among ACL injured groups. The results of the study support previous studies suggesting that increased lateral posterior tibial slope is associated with an increased risk of primary ACL injury.[2,3] LPTS was significantly increased among patients with ACL tears as compared with controls. Kumar Panigrahi et al have studied 100 cases of ACL injured knees and 100 controls with an intact knee.[4] In their study, the ACL injured population had a mean MPTS of 6.41^0 with SD 2.66^0, and mean LPTS of 8.12^0 with SD 3.65^0. They got a statistically significant difference in LPTS (p<0.001) of cases and controls, but not with MPTS (p=0.27).

In a study by Zeng et al the patients with complete ACL rupture had statistically significantly (p<0.01) larger LPTS than the control group ($11.5^0 \pm 3.3^0$ and $9.4^0 \pm 2.6^0$, respectively).[5] Similar findings are also observed by Ristićet al where patients with ACL injury had statistically significant (p=0.06) steeper LPTS than controls (6.68^0vs

5.64^0).[6] However, there were no statistically significant differences for MPTS between the two groups. Todd et al also found a significantly greater posterior tibial slope angle ($9.39^0 \pm 2.58^0$) in ACL injured knees, when compared to control subjects ($8.50^0 \pm 2.67^0$) (p=0.003).[7]

There are reports that patients with increased LPTS (>12^o) are at a significantly higher risk for ACL reconstruction graft failure.[2,8] Webb et al found an increased risk of ACL graft failure or contralateral ACL injury associated with increased LPTS, which was most apparent when LPTS>12^o.[2] In our study, the mean LPTS of patients with ACL tears was 10.23^0, with 18 (27.7%) patients having a slope >12^o. Thus, theoretically, these patients may be at higher risk for ACL reconstruction graft failure; however, further longitudinal research is needed to determine risk stratification for graft failures in ACL reconstructed knees. According to Rahnemai-Azar et al, LPTS of 9^0 and greater predicts high-grade rotatory laxity (sensitivity 63%; specificity 72%).[9] In our study, the receiver operating characteristic analysis of LPTS revealed that an LPTS value of >12^0 was indicative of ACL rupture with a sensitivity of 27.7% and a specificity of 86.2% (Figure 9).

In this study, no significant correlation was found between age and LPTS (p=0.122 and Pearson correlation coefficient value: -1.36). The MPTS is found to be decreasing with advancing age (p=0.046 and Pearson correlation coefficient value: -0.175). According to some authors, neither LPTS nor MPTS changes with age.[10,11]

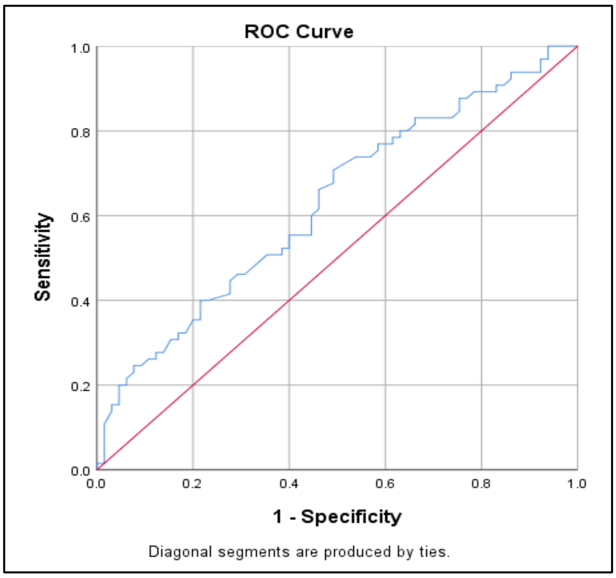

Figure 9: ROC curve.

CONCLUSION

There are several structural risk factors proposed for ACL injury. An understanding of the anatomical risk factors is important in cases of ACL injury and in ACL reconstruction failure. In our study, the LPTS was significantly increased among patients with ACL injury as compared with ligament-intact controls, which is consistent with the literature. This study is not without limitations. A single observer has taken all measurements. Studies with larger samples are essential. Additionally, patient outcomes were not analysed in the study, which may have provided insight regarding LPTS measurements, specifically for patients with ACL tears who had high LPTS (like>12^o). Lateral posterior tibial slope measurements should be considered as a significant independent modifiable risk factor for ACL injury.

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Conflict of interest: None declared
Ethical approval: The study was approved by the institutional ethics committee

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