

Does Posterior Tibial Slope Affect Graft Rupture Following ACL Reconstruction?

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Purpose: The purpose of this study was to evaluate the association between posterior tibial slope (PTS) and anterior cruciate ligament (ACL) graft rupture in patients who have undergone ACL reconstruction by comparing results in patients who experienced graft rupture and a matched control group. **Methods:** The study included 64 knees of 64 patients (58 men and 6 women), of mean age 31 years (range, 18-60 years) who underwent revision ACL reconstruction for ACL graft rupture, as well as a control group without ACL graft rupture matched for age, sex, body mass index (BMI), and left or right side. The mean time to failure in study group was 48.5 months, and after revision surgeries, the mean follow-up period was 37.7 months. The graft used for the primary surgery was autograft in 3 patients (4.7%) and allograft in 49 patients (76.6%). The type of graft could not be confirmed in the remaining 12 patients (18.7%). PTS was measured on plain radiographs and compared in the 2 groups. **Results:** Mean PTS was significantly higher in patients with ($13.2^\circ \pm 2.5^\circ$; range, 8.5° - 18.2°) than without ($10.9^\circ \pm 3.1^\circ$; range, 4.9° - 13.6°) rerupture ($P < .01$). When mean PTS was compared in the 37 patients who underwent primary surgery by the same surgeon, it was significantly higher in patients with ($13.5^\circ \pm 2.5^\circ$; range, 8.5° - 18.2°) than without ($11.1^\circ \pm 2.9^\circ$; range, 5.1° - 13.6°) rerupture ($P < .01$). PTS in patients with rerupture was not significantly associated with age, gender, BMI, and right or left side. The odds ratio of ACL graft rupture in knees with $PTS \geq 12^\circ$ was 4.52 ($P < .001$). **Conclusions:** This study showed that mean PTS was significantly greater in patients with than without noncontact ACL graft rerupture (13.2° vs 10.9° , $P < .01$). The failure of ACL reconstruction appears to be associated with increased PTS, with $PTS \geq 12^\circ$ a risk factor for the failure of ACL reconstruction. **Level of Evidence:** Level III, retrospective comparative study.

Anatomic characteristics of a knee joint have been associated with injury to the anterior cruciate ligament (ACL).¹ These include a narrow intercondylar notch, steep posterior tibial slope (PTS), generalized joint laxity, and increased Q-angle.¹⁻⁵ Among those, increased PTS can cause anterior displacement of the tibia, affecting the biomechanics of the ACL.⁶⁻⁸ Eventually, this may increase the risk of ACL rupture.

Moreover, increased PTS may predispose to ACL injuries.^{2,9-14}

Increases in the numbers of persons participating in sports activities have increased the risks of ACL injury, as well as rupture of an ACL graft. Salmon et al.¹⁵ reported that after reconstruction, repeat ACL injury occurred in 6% of patients over 5 years. The revision rate in a Swedish registry was 3.3%, and in a Danish registry it was 4.1%.^{16,17} However, the relationship between the risk of ACL graft rupture and PTS remains unclear.¹⁸⁻²⁰ The purpose of this study was to evaluate the association between PTS and ACL graft rupture in patients who had undergone ACL reconstruction by comparing results in patients who experienced graft rupture and a matched control group. We hypothesized that PTS would be greater in patients with ACL graft rupture.

Methods

The study included 64 knees of 64 patients who underwent revision ACL reconstruction for ACL graft rupture by a noncontact mechanism from April 2005 to October 2014. Noncontact ACL injury occurs without direct physical contact with other people or objects at

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The authors report that they have no conflicts of interest in the authorship and publication of this article. Full ICMJE author disclosure forms are available for this article online, as [supplementary material](#).

Received August 8, 2017; accepted January 30, 2018.

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0749-8063/17961/\$36.00

<https://doi.org/10.1016/j.arthro.2018.01.058>

Table 1. Preoperative Demographics

	Study Group	Control Group
Patients (knees)	64 (64)	64 (64)
Age, mean	31	31
Gender, male:female	58:6	58:6
BMI, kg/m ² , mean	25.2	25.5
Time to failure, mos, mean	48.5	
Follow-up period, mos, mean		59.7

NOTE. There were no significant differences between comparisons.

the time of injury. The study population consisted of 58 men and 6 women, of mean age 31 years (range, 18-60 years; [Table 1](#)). Of the 64 patients, 31 underwent operation on the right knee and 33 on the left knee; 37 underwent index surgery by one surgeon at our hospital and 27 by 11 surgeons at other hospitals. The mean time to failure in the study group was 48.5 months (range, 10-139 months), and after revision surgeries, the mean follow-up period was 37.7 months (range, 12-126 months). The graft used for the primary surgery was autograft in 3 patients (4.7%) and allograft in 49 patients (76.6%). The type of graft could not be confirmed in the remaining 12 patients (18.7%). The transtibial technique was used for the index reconstructions at our institution. This study was approved by our institutional review board.

Among 81 patients who underwent revision ACL reconstruction for ACL graft rupture during same period, the study excluded 17 patients who had a history of contact ACL injuries (9 patients), had undergone rerevision ACL surgery (3 patients), had undergone index surgeries using synthetic ligaments (2 patients), had multiple ligament injuries (2 patients), or had combined fractures (one patient).

The control group included 64 patients who had undergone ACL reconstruction at our hospital by a single surgeon without ACL graft rupture and were matched with the rerupture group by age, sex, body mass index (BMI), and left or right side ([Table 1](#)). The mean follow-up period was 59.7 months.

Among 64 patients of the study group, the 37 patients who underwent primary surgery at our hospital by a single surgeon and experienced ACL graft rupture were matched with a control group of patients who underwent primary surgery at our hospital without rerupture for subgroup analysis.

PTS was measured on plain lateral radiographs. To measure the PTS, the diaphyseal axis of the tibia was drawn between 2 points equidistant from the anterior and posterior borders of the tibia: one just below the tibial tubercle and the other a further 10 cm below. A reference line was drawn perpendicular to that axis at the level of the tibiofemoral joint. The inclination of the tibia was drawn from the most superior points at the anterior and posterior edges of the medial tibial plateau (dished surface). The angle of this line to the reference

line was defined as the PTS ([Fig 1](#)). All parameters on radiographs were measured with a picture archiving communication system (Pi view STAR software; Infinitt, Seoul, South Korea). All measurements were performed 2 times by 2 individuals who were blinded to patient grouping, and mean values were used. The interobserver and intraobserver reliability (intraclass correlation coefficient) was calculated, and it was strong for both (0.901-0.984 and 0.919-0.995).

Statistical Analysis

Differences in PTS between groups with and without ACL graft rerupture were analyzed by paired *t*-tests. The associations between PTS and age, sex, BMI, and left or right side in the rerupture group were analyzed by independent *t*-tests and Pearson correlation tests. A logistic regression model was used to determine the probability of an ACL injury (odds ratio [OR]). All statistical analyses were performed using commercially available software (SPSS, Chicago, IL), with *P* values <.05 considered statistically significant. Post hoc power analysis showed that a sample size of 64 patients in each group provided sufficient power for static validation (effect size $d = 0.778$, $\alpha = 0.05$, $\text{power}[1-\beta] = 0.9969$).

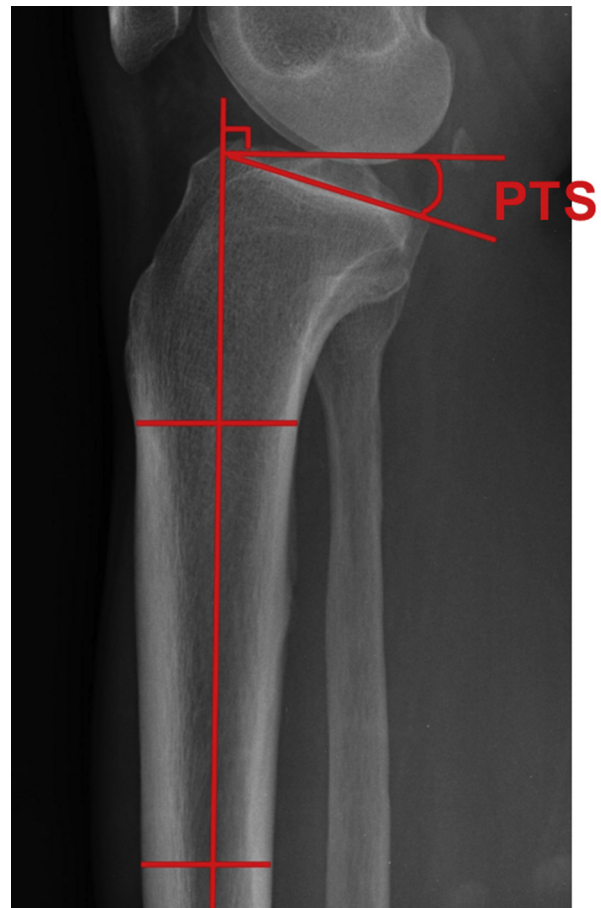


Fig 1. Measurement of posterior tibial slope on a plain lateral radiograph (right side).

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