Cureus

Review began 09/19/2023 Review ended 10/03/2023 Published 10/08/2023

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Association Between Posterior Tibial Slope and Clinical Outcomes After Isolated Anterior Cruciate Ligament Reconstructions

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Abstract

Background

Increased posterior tibial slope (PTS) is an important risk factor for non-traumatic graft failure and revision surgery after anterior cruciate ligament reconstruction. If a tibial posterior slope is an important factor for graft failure after anterior cruciate ligament reconstruction, does it affect clinical outcomes? This study aimed to evaluate the association between PTS and clinical outcomes after anterior cruciate ligament reconstruction.

Material and methods

Patients undergoing arthroscopic anterior cruciate ligament reconstruction with hamstring tendons in the clinic were evaluated retrospectively. Inclusion criteria were: patients with at least an 18-month follow-up period who were evaluated with the Tegner Lysholm scoring system, aged between 18 and 40 years, with only an anterior cruciate ligament rupture. PTSs were measured from the lateral radiographs of the knees. The patients were divided into two groups with a PTS of 10° or less.

Results

The mean Tegner Lysholm score was 86.8 ± 8.9 . The mean PTS was $9.7^{\circ} \pm 1.5^{\circ}$. In total, 14 and 15 patients had a PTS of above 10° and below 10°, respectively. The mean age and follow-up time of patients were 28.5 ± 5.3 years and 24.6 ± 7.2 months in the group with a PTS of above 10° and 30.2 ± 5.3 years and 24.2 ± 5.18 months in the group with a PTS of below 10°, respectively. Tegner Lysholm scores were 88.2 ± 8.8 and 85.6 ± 9.1 in the group with values above 10° and below 10°, respectively. Statistically, there was no significant difference between the clinical outcomes of both groups.

Conclusion

PTS does not affect the clinical outcomes of patients who underwent arthroscopic anterior cruciate ligament reconstruction in the early period.

Categories: Orthopedics

Keywords: tegner lysholm knee scoring system, arthroscopy knee, anterior cruciate ligament (acl) reconstruction, posterior tibial slope, anterior cruciate ligament tear

Introduction

Arthroscopic anterior cruciate ligament (ACL) reconstruction is one of the most common orthopedic surgical procedures. There are defined reasons for revision surgery after ACL reconstruction. Age, sex, body mass index, joint laxity, inability to open the tunnels in the appropriate position, graft thickness, inadequacy of the materials used in graft fixation, and tibial posterior slope are some of these [1,2].

Recent studies have reported that increased posterior tibial slope (PTS) is an important risk factor for nontraumatic graft failure and revision surgery after ACL reconstruction [3,4]. Increased PTS causes anterior translation of the tibia during walking [5]. According to the results of the previous studies, a 1° increase in the medial tibial slope causes a 1.24-fold increase in graft failure, a 1° increase in the lateral tibial slope causes a 1.17-fold increase in graft failure, and the risk of graft failure is higher in patients with a lateral tibial slope of 10 degrees or more [6,7]. Thus, if the tibial posterior slope is an important factor for graft failure after ACL reconstruction, does it affect clinical outcomes?

The purpose of this study was to evaluate the association between PTS and clinical outcomes after ACL reconstruction. The PTS of the patients was determined according to the preoperative lateral knee radiographs, and the clinical outcomes of both groups were compared by dividing them into two groups:

How to cite this article

Kasman U, Surucu S, Korkmaz O (October 08, 2023) Association Between Posterior Tibial Slope and Clinical Outcomes After Isolated Anterior Cruciate Ligament Reconstructions. Cureus 15(10): e46679. DOI 10.7759/cureus.46679

those below and above 10°.

Materials And Methods

This study was conducted at Bahcesehir University, VM Medicalpark Pendik Hospital. This study was approved by the ethics committee of the local institute (Decision No. 2021-12/06). All patients provided informed consent. In this study, 62 patients who underwent arthroscopic ACL reconstruction with hamstring tendons in the clinic were evaluated retrospectively between 2016-2018. The inclusion criteria were as follows: patients with at least an 18-month follow-up period who were evaluated with the Tegner Lysholm scoring system at the last control, aged between 18 and 40 years, with only ACL rupture, and who underwent lateral knee X-ray before surgery. Patients with a follow-up period of less than 18 months who were not evaluated with the Tegner Lysholm scoring system, aged under 18 years and over 40 years, with chondral and meniscal tears with ACL tears, and who did not undergo a lateral knee X-ray in the preoperative period were excluded from this study. Twenty-nine patients who met the inclusion criteria were included in this study. PTSs were measured from the lateral radiographs of the knees obtained preoperatively. The patients were divided into two groups with a PTS of 10° reless.

Surgical technique

All ACL reconstructions were performed using hamstring tendons as autografts. After diagnostic arthroscopy, the semitendinosus and gracilis tendons were harvested. Tendons were prepared in a fourstrand style. The femoral tunnel was prepared using the anteromedial portal approach. The tibial tunnel was prepared using the arthroscopic control technique. The prepared autograft was passed through tunnels; femoral side fixation was performed with an endobutton; and tibial side fixation was performed with a bioabsorbable screw and staple.

Post-operative follow-up and physical therapy

The patients used an angle knee brace for the first two weeks of the post-operative period. Up to 90° of flexion of the knee was allowed. After the first two-week period, the use of angle-adjustable knee braces was terminated, and a physical therapy program was started to strengthen the quadriceps and increase the knee joint's range of motion. The same physical therapy program was applied to all patients. Early and late complications among the patients were determined. Treatments for complications were arranged. Patients were evaluated with the Tegner Lysholm score of the final controls.

Measuring method of PTS

A line extending proximal to the tibial plateau was drawn at the posterior tibial cortex. The second line was drawn parallel to the medial tibial plateau. The angle between the two lines was measured. The measured angle was accepted as the posterior tibial slope [8] (Figure 1).



FIGURE 1: Measurement method of the posterior tibial slope

Statistical analysis

The suitability of the data for normal distribution was tested, and because they were not normally distributed, the non-parametric Mann-Whitney U test was used. A p-value <0.05 at the 95% confidence interval was considered statistically significant.

Results

A total of 62 patients underwent ACL reconstruction with the hamstring tendon technique. There were 12 male (80%) and 3 female (20%) patients in group 1, and 11 male (78.6%) and 3 female (21.4%) patients in group 2. The mean follow-up durations were 24.6 ± 7.2 and 24.2 ± 5.1 months for groups 1 and 2, respectively. The mean ages of the patients were 28.5 ± 5.3 and 30.2 ± 5.3 years in groups 1 and 2, respectively. The mean BMIs were 27.2 ± 3.6 and 26.3 ± 3.8 kg/m2 in groups 1 and 2, respectively. There was no significant difference in age, BMI, or follow-up duration between the two groups (p>0.05).

The mean age of the patients in the study was 29.4 ± 5.3 years. The mean follow-up period was 24.4 ± 6.1 months. The mean Tegner Lysholm score was 86.8 ± 8.9 . The mean PTS was $9.7^{\circ} \pm 1.5^{\circ}$. The lowest PTS was 7.8° , and the highest PTS was 12.5° . In total, 14 and 15 patients had a PTS of above 10° and below 10° , respectively. The mean tibial slope of the 1st group was $8.7^{\circ} \pm 0.9^{\circ}$ (7.8° - 9.1°), and that of the 2nd group was $11.1^{\circ} \pm 0.8^{\circ}$ (10.2° - 12.5°).

Tegner Lysholm scores were 88.2 ± 8.8 and 85.6 ± 9.1 in the group with a PTS above 10° and in the group with a PTS below 10° , respectively. Statistically, there was no significant difference between the clinical outcomes of both groups (p>0.48) (Table 1).

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	Number	The PTS (mean+SD)	Tegner Lysholm score	P-value
All patients	29	9.7° ± 1.5°	86.8 ± 8.9	
Patients with PTS above 10°	14	8.7° ± 0.9°	88.2 ± 8.8	p>0.48
Patients with PTS below 10°	15	11.1° ± 0.8	85.6 ± 9.1	

TABLE 1: Comparison of clinical outcomes of two groups

Mean values of all patients included in the study and both groups.

PTS: posterior tibial slope

During the duration of the follow-up, revision surgery was not required at any time. In the early period, superficial cellulitis was found in two individuals, and antibiotic therapy was administered to those patients. No complications, including deep vein thrombosis and septic arthritis, were found during this examination.

Discussion

The relationship between posterior tibial slope (PTS) and anterior cruciate ligament (ACL) injuries has garnered attention in recent studies, as PTS is believed to be a potential contributing factor to ACL injury risk. PTS is measured as the posterior inclinations of the medial and lateral tibial plateau, with typical values being 7° for the medial plateau and 5° for the lateral plateau [9]. It's hypothesized that an increased PTS can lead to greater knee rotatory flexibility, potentially increasing the risk of anterior tibial translation and, subsequently, ACL injury [10].

Several studies have explored the connection between PTS and ACL injuries. A meta-analysis reported an association between both medial and lateral PTS and ACL injuries [11]. However, another study found a statistically significant association only between lateral PTS and ACL injuries, not medial PTS [12]. Additionally, one study suggested that individuals with a PTS above 8° were at an increased risk of ACL injury [13]. Notably, while ACL injury has been associated with lateral posterior tibial inclination, a meta-analysis suggests that both medial and lateral posterior tibial inclination are linked to ACL injuries [11,14]. Moreover, patients with increased medial (>5.6°) and lateral (>3.8°) PTS have shown higher failure rates after primary ACL reconstruction using hamstring autografts in long-term follow-ups [15]. The measurement of the posterior tibial cortex is considered the most reliable method for analyzing PTS on lateral knee radiographs in patients undergoing ACL revision reconstruction [16]. However, in some studies, measurements of medial and lateral posterior tibial inclination were unavailable, making it challenging to assess their effects on clinical outcomes. In this study, medial and lateral posterior tibial inclination measurements could not be measured, so the effect of medial and lateral PTS on clinical outcomes could not be determined.

Various studies in the literature have reported different angle values as risk factors for ACL injury and the need for revision surgery after ACL reconstruction. For instance, some studies suggest that a PTS above 12° is associated with a higher risk of ACL injury and reconstruction failure [4,17,18]. Another study identified a PTS of $\geq 17^{\circ}$ and anterior tibial translation of ≥ 6 mm as predictive risk factors for primary ACL reconstruction failure [19]. Additionally, a PTS above 10° is considered a risk factor for significant anterior tibial subluxation in the lateral compartment following non-contact ACL injuries [20].

The reasons for inadequacies after ACL reconstruction are multifactorial, including surgical technical errors, re-injury, and biological deficiencies [21]. High lateral tibial posterior slope can potentially lead to tunnel enlargement during ACL surgery [22], but osteotomies to reduce PTS in revision surgery have shown positive clinical outcomes [23,24]. Additionally, reducing the tibial posterior slope by more than 5° preoperatively has been reported to benefit the reconstructed ACL graft [25]. Correcting varus and posterior tibial tilt has led to decreased anterior tibial translation and reduced forces on the reconstructed ACL graft, supporting the goal of aligning the tibial plateau vertically, especially in ACL reconstruction surgery [26]. Based on Park et al.'s study, patients with ACL rupture who had successful group and 10.2° in the unsuccessful group) compared to those who failed conservative treatment. They have reported that the failure of conservative treatment after an ACL tear is associated with increased PTS [27].

This study is limited by the absence of a conservatively treated control group and the small number of participants.

Conclusions

In conclusion, the posterior tibial slope has no effect on the clinical outcomes of patients who underwent arthroscopic anterior cruciate ligament reconstruction in the early treatment period. In the future, we anticipate that studies with longer follow-up periods and larger sample numbers will contribute to the existing body of literature.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: Ozgur Korkmaz, Ugur Kasman

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Disclosures

Human subjects: Consent was obtained or waived by all participants in this study. Animal subjects: All authors have confirmed that this study did not involve animal subjects or tissue. Conflicts of interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following: Payment/services info: All authors have declared that no financial support was received from any organization for the submitted work. Financial relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. Other relationships: All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

References

- Wiggins AJ, Grandhi RK, Schneider DK, Stanfield D, Webster KE, Myer GD: Risk of secondary injury in younger athletes after anterior cruciate ligament reconstruction: a systematic review and meta-analysis. Am J Sports Med. 2016, 44:1861-76. 10.1177/0363546515621554
- Kamath GV, Redfern JC, Greis PE, Burks RT: Revision anterior cruciate ligament reconstruction. Am J Sports Med. 2011, 39:199-217. 10.1177/0363546510370929
- Christensen JJ, Krych AJ, Engasser WM, Vanhees MK, Collins MS, Dahm DL: Lateral tibial posterior slope is increased in patients with early graft failure after anterior cruciate ligament reconstruction. Am J Sports Med. 2015, 43:2510-4. 10.1177/0363546515597664
- Webb JM, Salmon LJ, Leclerc E, Pinczewski LA, Roe JP: Posterior tibial slope and further anterior cruciate ligament injuries in the anterior cruciate ligament-reconstructed patient. Am J Sports Med. 2013, 41:2800-4. 10.1177/0363546513503288
- Marouane H, Shirazi-Adl A, Adouni M, Hashemi J: Steeper posterior tibial slope markedly increases ACL force in both active gait and passive knee joint under compression. J Biomech. 2014, 47:1353-9. 10.1016/j.jbiomech.2014.01.055
- Jaecker V, Drouven S, Naendrup JH, Kanakamedala AC, Pfeiffer T, Shafizadeh S: Increased medial and lateral tibial posterior slopes are independent risk factors for graft failure following ACL reconstruction. Arch Orthop Trauma Surg. 2018, 138:1423-31. 10.1007/s00402-018-2968-z
- Ahmed I, Salmon L, Roe J, Pinczewski L: The long-term clinical and radiological outcomes in patients who suffer recurrent injuries to the anterior cruciate ligament after reconstruction. Bone Joint J. 2017, 99-B:337-43. 10.1302/0301-620X.99B3.37863
- Hohmann E, Bryant A, Reaburn P, Tetsworth K: Does posterior tibial slope influence knee functionality in the anterior cruciate ligament-deficient and anterior cruciate ligament-reconstructed knee?. Arthroscopy. 2010, 26:1496-502. 10.1016/j.arthro.2010.02.024
- Weinberg DS, Williamson DF, Gebhart JJ, Knapik DM, Voos JE: Differences in medial and lateral posterior tibial slope: an osteological review of 1090 tibiae comparing age, sex, and race. Am J Sports Med. 2017, 45:106-13. 10.1177/0363546516662449
- Giffin JR, Vogrin TM, Zantop T, Woo SL, Harner CD: Effects of increasing tibial slope on the biomechanics of the knee. Am J Sports Med. 2004, 32:376-82. 10.1177/0363546503258880
- Zeng C, Cheng L, Wei J, et al.: The influence of the tibial plateau slopes on injury of the anterior cruciate ligament: a meta-analysis. Knee Surg Sports Traumatol Arthrosc. 2014, 22:53-65. 10.1007/s00167-012-2277y
- Waiwaiole A, Gurbani A, Motamedi K, Seeger L, Sim MS, Nwajuaku P, Hame SL: Relationship of ACL injury and posterior tibial slope with patient age, sex, and race. Orthop J Sports Med. 2016, 4:2325967116672852. 10.1177/2325967116672852
- de Sousa Filho PG, Marques AC, Pereira LS, Pigozzo BA, Albuquerque RS: Analysis of posterior tibial slope as risk factor to anterior cruciate ligament tear. Rev Bras Ortop (Sao Paulo). 2021, 56:47-52. 10.1055/s-0040-1712495

- Stijak L, Herzog RF, Schai P: Is there an influence of the tibial slope of the lateral condyle on the ACL lesion? A case-control study. Knee Surg Sports Traumatol Arthrosc. 2008, 16:112-7. 10.1007/s00167-007-0438-1
- Yoon KH, Park SY, Park JY, Kim EJ, Kim SJ, Kwon YB, Kim SG: Influence of posterior tibial slope on clinical outcomes and survivorship after anterior cruciate ligament reconstruction using hamstring autografts: a minimum of 10-year follow-up. Arthroscopy. 2020, 36:2718-27. 10.1016/j.arthro.2020.06.011
- Gaj E, Monaco E, De Carli A, et al.: Measurement technique for posterior tibial slope on radiographs can affect its relationship to the risk of anterior cruciate ligament rupture. Int Orthop. 2021, 45:1469-75. 10.1007/s00264-020-04865-7
- Lee CC, Youm YS, Cho SD, Jung SH, Bae MH, Park SJ, Kim HW: Does posterior tibial slope affect graft rupture following anterior cruciate ligament reconstruction?. Arthroscopy. 2018, 34:2152-5. 10.1016/j.arthro.2018.01.058
- Salmon LJ, Heath E, Akrawi H, Roe JP, Linklater J, Pinczewski LA: 20-year outcomes of anterior cruciate ligament reconstruction with hamstring tendon autograft: the catastrophic effect of age and posterior tibial slope. Am J Sports Med. 2018, 46:531-43. 10.1177/0363546517741497
- Ni QK, Song GY, Zhang ZJ, et al.: Steep posterior tibial slope and excessive anterior tibial translation are predictive risk factors of primary anterior cruciate ligament reconstruction failure: a case-control study with prospectively collected data. Am J Sports Med. 2020, 48:2954-61. 10.1177/0363546520949212
- Song GY, Zhang H, Zhang J, Liu X, Xue Z, Qian Y, Feng H: Greater static anterior tibial subluxation of the lateral compartment after an acute anterior cruciate ligament injury is associated with an increased posterior tibial slope. Am J Sports Med. 2018, 46:1617-23. 10.1177/0363546518760580
- Wright RW, Gill CS, Chen L, Brophy RH, Matava MJ, Smith MV, Mall NA: Outcome of revision anterior cruciate ligament reconstruction: a systematic review. J Bone Joint Surg Am. 2012, 94:531-6.
 10.2106/IBIS.K.00733
- Sabzevari S, Rahnemai-Azar AA, Shaikh HS, Arner JW, Irrgang JJ, Fu FH: Increased lateral tibial posterior slope is related to tibial tunnel widening after primary ACL reconstruction. Knee Surg Sports Traumatol Arthrosc. 2017, 25:3906-13. 10.1007/s00167-017-4435-8
- Dejour D, Saffarini M, Demey G, Baverel L: Tibial slope correction combined with second revision ACL produces good knee stability and prevents graft rupture. Knee Surg Sports Traumatol Arthrosc. 2015, 23:2846-52. 10.1007/s00167-015-3758-6
- Sonnery-Cottet B, Mogos S, Thaunat M, et al.: Proximal tibial anterior closing wedge osteotomy in repeat revision of anterior cruciate ligament reconstruction. Am J Sports Med. 2014, 42:1873-80. 10.1177/0363546514534938
- Arun GR, Kumaraswamy V, Rajan D, et al.: Long-term follow up of single-stage anterior cruciate ligament reconstruction and high tibial osteotomy and its relation with posterior tibial slope. Arch Orthop Trauma Surg. 2016, 136:505-11. 10.1007/s00402-015-2385-5
- 26. Imhoff FB, Comer B, Obopilwe E, Beitzel K, Arciero RA, Mehl JT: Effect of slope and Varus correction high tibial osteotomy in the ACL-deficient and ACL-reconstructed knee on kinematics and ACL graft force: a biomechanical analysis. Am J Sports Med. 2021, 49:410-6. 10.1177/0363546520976147
- Park KB, Cho SD, Youm YS, Yang DG, Chung HY: Does posterior tibial slope affect the results of conservative treatment for anterior cruciate ligament tears?. Int Orthop. 2020, 44:1321-4. 10.1007/s00264-020-04649-z