International Journal of Orthopaedics Sciences

E-ISSN: 2395-1958
P-ISSN: 2706-6630
IJOS 2020; 6(1): 1145-1148

www.orthopaper.com
Received: 13-11-2019
Accepted: 17-12-2019

Abhijeet Salunkhe
Junior Resident, Department of Orthopaedics, Sri Devaraj Urs Medical College, SDUAHER, Kolar, Karnataka, India

Dr. Prabhu Ethiraj
Associate Professor, Department of Orthopaedics, Sri Devaraj Urs Medical College, SDUAHER, Kolar, Karnataka, India

Arun HS
Professor and Head, Department of Orthopaedics, Sri Devaraj Urs Medical College, SDUAHER, Kolar, Karnataka, India

Corresponding Author:
Dr. Prabhu Ethiraj
Associate Professor, Department of Orthopaedics, Sri Devaraj Urs Medical College, SDUAHER, Kolar, Karnataka, India

The relationship between anterior cruciate ligament injuries and posterior tibial slope

Abhijeet Salunkhe, Dr. Prabhu Ethiraj and Arun HS

DOI: https://doi.org/10.22271/ortho.2020.v6.i1o.1973

Abstract
Background: An injury to the anterior cruciate ligament (ACL) is a multifactorial injury and is influenced by intrinsic and extrinsic risk factors. Recently, study of variable anatomy of the proximal tibia has come up as a possible risk factor for an ACL injury. Increased posterior tibial slope (PTS) has been identified as a potential risk factor for anterior cruciate ligament (ACL) injury, but studies which have examined this relationship are inconclusive and sometimes results are contradictory.
Methodology: In this study sample size of total 72 patients was included, in which 38 patients had non-contact ACL injury and rest 34 constituted as a control group, who has same demographic characteristics as patients in ACL injury group. This study was conducted in period of April 2017 – Feb 2019 at tertiary care hospital, R.L. Jalappa Hospital, Sduaher, Tamaka, Kolar. All patients included in the study were above 18 years of age and also were willing to participate in the study. Patients with open injury of ipsilateral knee and with previous history of surgery over knee were excluded from the study.
The posterior tibial slope was measured from a lateral knee radiograph in all the 72 cases. The data was analyzed for the association between an increased posterior tibial slope and the incidence of ACL injury.
Results: In injured group of 38 patients, 15 patients were female and 23 were male. The average age of the patients in this group was 26.7 years (±6.3 years). The control group consisted of 34 patients, in which 24 were men and10 were women. The average age of the control group was 26.2 years (±6.5 years).
An ANOVA revealed significant differences in tibial slope angle between the 2 groups. Subjects in the noncontact ACL group had significantly greater tibial slope angles (8.81° ± 2.58°) when compared with control subjects (6.9° ± 2.67°). The trend toward greater tibial slope angles in the noncontact ACL group was also observed when each gender was examined independently; however, the difference was only statistically significant for women between the injury and control groups (8.9° ± 2.6° vs 7.2° ± 2.4°).
Conclusion: Our results concluded that, in patients who had non contact ACL injury, had increased posterior tibial slope. But despite of these findings, the clinical significance of an increased tibial slope as an isolated risk factor for ACL injury still remains unanswered. The question also remains as to what degree of increased tibial slope should raise concerns about the increased risk for subsequent injury. Limitations of this study were less number of cases and the study included only non contact ACL injuries. Thus, a study with more number of subjects and also comprising of contact ACL injuries, probably give a better conclusion.
Level of evidence: Case-control retrospective study; Level III.

Keywords: Anterior cruciate, posterior tibial slope, ACL

Introduction
There are several risk factors described in literature which make patients prone for anterior cruciate ligament injuries. These risk factors have been divided into 4 types as: anatomical hormonal environmental and neuromuscular [1]. While anatomic risk factors are typically the hardest to modify, their identification remains important for further advancement of preventative measures and treatment of these injuries. Tibial slope may also be an identifiable risk factor for ACL injuries. In the consensus statement from a recent research conference on ACL injuries, variations in tibial slope, among other anatomical and structural factors, were noted as important knowledge gaps related to the risk of ACL injury [2]. Tibial slope is defined as the angle formed at the intersection of a line parallel to the posterior tibial inclination and a line that bisects the diaphysis of the tibia.
The relationship between posterior tibial slope (PTS) and increased anterior tibial translation

was measured by Dejour and Bonnin [3], who noted that for every 10-degree increase in PTS there was an associated increase in tibial translation. This was true for both ACL-deficient and ACL intact knees using monopodal stance [3].

Giffin *et al* [4] reported that as the tibial inclination was increased, there was an associated anterior translation of the tibia relative to the femur. Although they did not find any increase in the in situ forces of the cruciate ligaments, they suggested that altering the tibial slope may be beneficial for ACL-deficient or posterior cruciate ligament-deficient knees to improve resting position and joint congruity [4].

Using plain radiographs to characterize PTS, some studies have found no correlation with ACL injury while others have demonstrated statistically significant variations in women only [5, 6, 7, 8, 9]

Furthermore, studies that have used magnetic resonance imaging (MRI) to more thoroughly characterize tibial geometry have found that PTS on the lateral tibial plateau, but not on the medial tibial plateau, may be correlated with ACL injury. A recent meta-analysis showed that both medial and lateral PTS are associated with ACL injury regardless of sex [10].

The purpose of this study was to determine if there is a difference in PTS angle between patients with a history of noncontact ACL injury and a control group with no history of ACL injury in patients presenting to R.L.JALAPPA HOSPITAL, SDUAHER, TAMAKA, KOLAR.

The null hypothesis is that there is no difference in the PTS angle between patients with a history of noncontact ACL injury and a control group without history of ACL injury.

Materials and Methods

A retrospective review of all ACL reconstructions performed at our institution from June 2017 – Feb 2019 was conducted. All subjects were available for follow-up. If a noncontact mechanism of injury was established, a radiographic review was performed. Following inclusion and exclusion criteria were used.

Inclusion criteria

1. Patients of age group > 18 years.
2. All patients with closed non contact ACL injury

Exclusion criteria

1. Open injury.
2. History of ligamentous instability
3. History of prior surgery on knee.

A control cohort of 34 patients was established from subjects who reported to orthopaedic outpatient department at our hospital with a diagnosis of anterior knee pain, patella-femoral syndrome, or knee contusion superficial bruised knee/ abrasion that had radiographic evaluation that included a lateral knee radiograph.

All patients in the control group underwent a detailed physical evaluation of the knee. Detailed physical examination also included details to rule out any history of ligamentous instability or prior surgery for the affected knee. Subjects with any history of instability or prior surgery were excluded from the control group. Subjects were also excluded if they had any abnormal radiographic findings or physical examination findings consistent with ligamentous instability. All patients had a minimum of 2 radiographic views of the knee, AP and lateral. Evaluation of the lateral knee radiographs to establish the PTS was done for all subjects, using the method described by Dejour and Bonnin [6] to measure the slope of the medial tibial plateau (Figure 1).

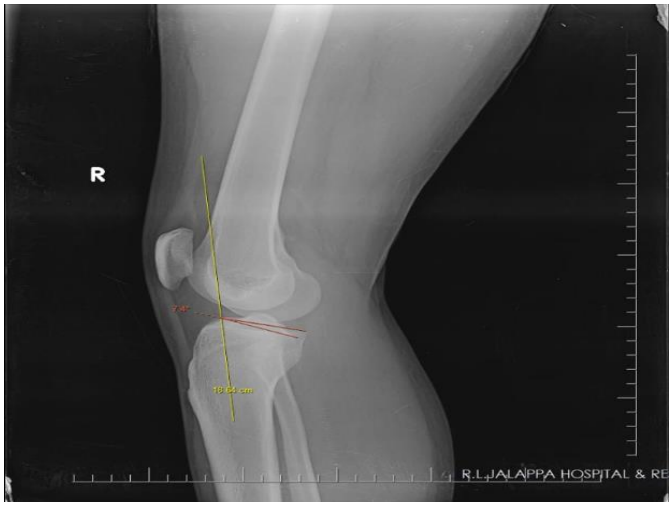

Fig 1: Showing method to calculate posterior tibial slope

The PTS angles were measured using the IMPAX system and the digital software measurement package of the computer. Analysis of variance (ANOVA) tests were performed to analyze the data. Differences in PTS between the 2 groups and by gender within each group were examined.

The dependent variable in our analysis was PTS angle, and the 2 independent variables were group and gender, each consisting of 2 levels. The 2 levels of the group variable consisted of those subjects with noncontact ACL injuries and an uninjured control group. Within each group, the data were further examined to identify gender differences.

Interobserver reliability was assessed by calculating the intraclass correlation coefficient, along with 95% confidence intervals as a measure of precision, between the 2 raters for PTS measures.

Results

A total of 72 patients were included in the study and out of which 38 were diagnosed as ACL injury on MRI and other 34 patients consisted of control group who did not had ACL injury but had similar demographic characteristics as injured group were included in study. In injured group of 38 patients, 15 patients were female and 23 were male. The average age of the patients in this group was 26.7 years (±6.3 years). The control group consisted of 34 patients, in which 24 were men and10 were women. The average age of the control group was 26.2 years (±6.5 years).

An ANOVA revealed significant differences in tibial slope angle between the 2 groups (Table 1). Subjects in the noncontact ACL group had significantly greater tibial slope angles (8.81° ± 2.58°) when compared with control subjects (6.9° ± 2.67°).

The trend toward greater tibial slope angles in the noncontact ACL group was also observed when each gender was examined independently; however, the difference was only statistically significant for women between the injury and control groups (8.9° ± 2.6° vs 7.2° ± 2.4°).

Table 1: Control group Injured group

	No. of subjects	Mean PTS	SD	No. of subjects	Mean PTS	SD
Women	10	7.2	2.4	15	8.9	2.62
Men	24	6.1	2.6	23	8.4	2.669
Total	34	6.9	2.58	38	8.81	2.67

Discussion

As concluded from above statistical analysis, our study shows that patients with ACL injury had greater medial PTS compared with the control group. Medial plateau slope was significantly different between our ACL injury and control groups. This finding is supported by multiple previous studies that have shown a higher lateral plateau PTS in patients with ACL deficiency [1, 6, 12]. Many of these studies found only statistically significantly greater slopes on the lateral and not medial tibial plateau. As independent, non-modifiable risk factors, the debate of the significance of notch width and PTS and their influence on ACL injuries appears to be unresolved [18]. Souryal and Freeman [19] have reported that a small intercondylar notch width index results in an increased risk for ACL injury. LaPrade and Burnett [13] found similar results when evaluating collegiate athletes.

The 2 previously published articles evaluating the association between PTS and noncontact ACL injuries have resulted in conflicting outcomes [5, 14]. Meister *et al* [14] compared 50 knees from 49 ACL-deficient patients (25 men) with 39 age-matched patients (17 men) with patellofemoral pain. Physical examination and arthroscopy were used to confirm the ACL injury in study group, and physical examination alone was used for the control group. A single examiner measured both groups. The average slope was 9.7° for the injured group versus 9.9° for the uninjured group. They concluded that PTS was not an identifiable risk factor for a noncontact ACL injury [14]. Brandon *et al* [5] performed a similar analysis using a larger cohort of patients (100 patients, 66 men) for evaluating the tibial slope and included a group and gender stratification. The injury cohort was determined by history, physical examination, and MRI.

In agreement with Brandon *et al*, [15] we found that there was a statistical difference between our control group and the injured group. However, when the groups were stratified on the basis of gender, we found that only the women showed a statistical difference (Table 1). No difference in PTS was noted between the injured and control groups for men when our analysis was stratified by gender, which suggests that the variability between women in the injured and control groups influenced the overall statistical model when male and female subjects were combined.

The degree of slope that would be clinically relevant is still open for debate, as we are discussing a few degrees of difference between groups. Also future studies are needed to evaluate the psychometric properties associated with different measurement techniques for assessing the PTS angle.

Finally, the measurement technique described by Dejour and Bonnin[6] relies on the use of the medial plateau for measurement because it is the most easily recognizable on plain radiography; however, evaluation of the lateral plateau may be more appropriate and warrants further investigation.

Stijak *et al*. [20] used MRI and plain radiography to evaluate the relationship between PTS and ACL injury. They found an increased PTS of the lateral plateau for their injury cohort versus the ACL-intact cohort. An increased lateral tibial plateau slope may influence the rotation of the knee and ultimately the pivot shift phenomenon.

A primary limitation of the current study is its retrospective nature. Prospective data collection and follow-up examining several anatomical and structural factors related to ACL injury would be preferential.

Furthermore, because MRI studies were not available for all subjects in the control group we had to rely on the information in the medical record to rule out ACL injury in that group. As a result, it is possible that patients with partial ACL injuries may have been missed, although we believe this possibility to be very less. The size of the injured female cohort, although larger than in the previous studies, is limited by the collection population at our institution, which may result in some selection bias.

The strengths of the study include the large number of measured patients for both the control and injured groups, thus eliminating the possibility of type II error. Although no study has specifically evaluated manual versus digital measurement of tibial slope, the use of digital radiographs and computer-assisted angle measurement software is supported in the literature for improved reliability, precision of measurement, and elimination of intrinsic error associated with manual techniques [7, 9, 16, 18].

Conclusion

Our results concluded that, in patients who had non contact ACL injury, had increased posterior tibial slope. But despite of these findings, the clinical significance of an increased tibial slope as an isolated risk factor for ACL injury still remains unanswered. The question also remains as to what degree of increased tibial slope should raise concerns about the increased risk for subsequent injury. Limitations of this study were less number of cases and the study included only non contact ACL injuries. Thus, a study with more number of subjects and also comprising of contact ACL injuries, probably give a better conclusion.

References

1. Allen MK, Glasoe WM. Metrecom measurement of navicular drop in subjects with anterior cruciate ligament injury. J Athl Train. 2000; 35(4):403-406.
2. Anderson AF, Anderson CN, Gorman TM, Cross MB, Spindler KP. Radiographic measurements of the intercondylar notch: are they accurate? Arthroscopy. 2007; 23(3):261-268.
3. Anderson AF, Dome DC, Gautam S, Awh MH, Rennirt GW. Correlation of anthropometric measurements, strength, anterior cruciate ligament size, and intercondylar notch characteristics to sex differences in anterior cruciate ligament tear rates. Am J Sports Med. 2001; 29(1):58-66.
4. Beynnon BD, Johnson RJ, Abate JA, Fleming BC, Nichols CE. Treatment of anterior cruciate ligament injuries, part I. Am J Sports Med. 2005; 33(10):1579-1602.
5. Brandon ML, Haynes PT, Bonamo JR, Flynn MI, Barrett GR, Sherman MF. The association between posterior-inferior tibial slope and anterior cruciate ligament insufficiency. Arthroscopy. 2006; 22(8):894-899.
6. Dejour H, Bonnin M. Tibial translation after anterior cruciate ligament rupture: two radiological tests

compared. J Bone Joint Surg Br. 1994; 76:745-749.
7. Farber DC, DeOrio JK, Steel MW. Goniometric versus computerized angle measurement in assessing hallux valgus. Foot Ankle Int. 2005; 26(3):234-238.
8. 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(2):376-382.
9. Grainger AJ, Duryea J, Elliott JM, Genant HK. The evaluation of a new digital semiautomated system for the radiological assessment of distal radius fractures. Skeletal Radiol. 2002; 31(8):457-463.
10. Griffin LY, Albohm MJ, Arendt EA, *et al*. Understanding and preventing noncontact anterior cruciate ligament injuries: a review of the Hunt Valley II meeting, January 2005. Am J Sports Med. 2006; 34(9):1512-1532.
11. Hewett TE, Myer GD, Ford KR, *et al*. Biomechanical measures of neuromuscular control and valgus loading of the knee predict anterior cruciate ligament injury risk in female athletes: a prospective study. Am J Sports Med. 2005; 33(4):492-501.
12. Hewett TE, Zazulak BT, Myer GD. Effects of the menstrual cycle on anterior cruciate ligament injury risk: a systematic review. Am J Sports Med. 2007; 35(4):659-668.
13. LaPrade RF, Burnett QM 2nd. Femoral intercondylar notch stenosis and correlation to anterior cruciate ligament injuries: a prospective study. Am J Sports Med. 1994; 22(2):198-202.
14. Meister K, Talley MC, Horodyski MB, Indelicato PA, Hartzel JS, Batts J. Caudal slope of the tibia and its relationship to noncontact injuries to the ACL. Am J Knee Surg. 1998; 11(4):217-219.
15. Myer GD, Ford KR, Paterno MV, Nick TG, Hewett TE. The effects of generalized joint laxity on risk of anterior cruciate ligament injury in young female athletes. Am J Sports Med. 2008; 36(6):1073-1080.
16. Shea KG, Stevens PM, Nelson M, Smith JT, Masters KS, Yandow S. A comparison of manual versus computer-assisted radiographic measurement: intraobserver measurement variability for Cobb angles. Spine. 1998; 23(5):551-555.
17. Shelbourne KD, Davis TJ, Klootwyk TE. The relationship between intercondylar notch width of the femur and the incidence of anterior cruciate ligament tears: a prospective study. Am J Sports Med. 1998; 26(3):402-408.
18. Shultz S, Schmitz RJ, Nguyen AD. Research Retreat IV: ACL injuries the gender bias: April 3-5, 2008 Greensboro, NC. J Athl Train. 2008; 43(5):530-531.
19. Souryal TO, Freeman TR. Intercondylar notch size and anterior cruciate ligament injuries in athletes: a prospective study. Am J Sports Med. 1993; 21(5):535-539.
20. 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(2):112-117.
21. Teitz CC, Lind BK, Sacks BM. Symmetry of the femoral notch width index. Am J Sports Med. 1997; 25(5):687-690.
22. Uhorchak JM, Scoville CR, Williams GN, Arciero RA, St Pierre P, Taylor DC. Risk factors associated with noncontact injury of the anterior cruciate ligament: a prospective four-year evaluation of 859 West Point cadets. Am J Sports Med. 2003; 31(6):831-842.
23. Woodford-Rogers B, Cyphert L, Denegar CR. Risk factors for anterior cruciate ligament injury in high school and college athletes. J Athl Train. 1994; 29(4):343-346.