# Significance of the Anterior Tibial Translocation Sign in Predicting the Presence of Anterior Cruciate Ligament Tears in Arthroscopically Proven Cases Derived From a Single Center Cohort

*Justeen Enrhico C. Rivera, MD and Mario T. Milo, MD*

## ABSTRACT

Anterior cruciate ligament (ACL) injury remains a common orthopedic case, especially in young adults with an active lifestyle. Activities of daily living and sports performance may be vastly compromised; thus, immediate diagnosis is essential. The researchers tested the diagnostic ability of the anterior tibial translocation sign (using the 5 mm cut-off) against the gold standard knee arthroscopy using cross-sectional study design. Analysis of the 23 magnetic resonance imaging (MRI) scans showed a sensitivity of 42.9% (true positives: 6 had ≥5 mm reading out of 14 positive arthroscopy findings), specificity of 77.8% (true negatives: 7 had <5 mm reading out of 9 negative arthroscopy findings) and positive predictive value (PPV) of 75.0% (6 out of 8 positive arthroscopy findings among ≥5 mm). In the sample data, 7 mm cut-off had the optimal trade-off between sensitivity and type I error, thus being the most predictive of ACL tear.

✉ Justeen Enrhico Rivera
rivera.justeenenrhico@gmail.com

Department of Radiological Sciences University of Santo Tomas Hospital

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## INTRODUCTION

The anterior cruciate ligament (ACL) is the most commonly disrupted ligament of the knee. The ACL injury is associated with knee anterolateral instability. Deficiency of the ACL allows the tibia to undergo anterior subluxation relative to the femur, thus producing the anterior tibial translocation sign. Knee arthroscopy still remains the gold standard for a definitive diagnosis of meniscal and cruciate ligament tears.[1] However, the degree of anterior subluxation of the tibia can be non-invasively measured directly on MR imaging.[2] This is analogous to the anterior drawer test elicited during physical examination, in which the tibia moves anteriorly as the leg is pulled forward.[3]

According to the study of Brandser, et al., the ACL runs obliquely in the knee; this, along with the knee position can lead to only a portion of the ligament being visualized on a given image.[4] On this note, the anterior tibial translocation sign can be valuable in this situation, which is seen on sagittal magnetic resonance (MR) images of the lateral femoral con-

dyle. This sign occurs when there is a 7-mm or greater anterior translocation of the tibia relative to the femur.[5] In the study conducted by Chan, et al.,[6] anterior translocation of 5 mm or more was shown to have a sensitivity of 86% and a specificity of 99% for ACL tear. According to Vahey, et al.,[5] in another study, when measured at the mid-sagittal plane of the lateral femoral condyle, anterior translocation of the tibia was a specific indicator of ACL tear. Subluxation of 5 mm or more had 58% sensitivity and 93% specificity for ACL tear.

The aim of this research study is to show the value of anterior tibial translocation (ATT) sign as a predictor of ACL tear. More intently, this research study seeks to prove the independent value of anterior tibial translocation sign for deciding ACL status independent of the primary sign; to increase the MRI diagnostic detection of ACL tears (in partial and complete ACL tears); and to correlate the degree of ATT with the degree of ACL tear.

## MATERIALS AND METHODS

This study is a retrospective chart review. A total of 154 University of Santo Tomas Hospital MRI patients (January 2012 to September 2016) diagnosed with ACL tear were used in this study.

MR imaging was done with a 1.5 T superconducting scanner (Intera Omni/Stellar, Philips) in all cases. Sagittal images were generated with a T1-weighted sequence (600-800/20), 3- to 4-mm thick sections with a 0.3 to 0.4 mm interslice gap, a 16-cm field of view, a 256 x 192 matrix and two excitations. The knee was placed in the anatomical position with a zero (0) degree of knee angulation.

All these selected MRI patients underwent subsequent knee arthroscopy performed by only one UST Orthopedic Surgery consultant, which would decrease inter-observer variability in the interpretation of arthroscopic findings. The total number of patients was divided into three groups, namely: control group (arthroscopy ACL tear negative group), partial tear group (arthroscopy partial ACL tear group) and complete tear group (arthroscopy complete ACL tear group). Then, the degree of ATT (in mm) shall be measured from the sagittal T1-weighted images of the complete and partial ACL tear group subjects. Sample findings are shown below (Figure 2). Finally, patients' measurement of the degree of ATT will be described in mean and standard deviation while the category of measurement such as tibial subluxation of ≥5 mm and tibial subluxation of ≤4 mm will be expressed in frequency and percentage. As for testing, the differences in the measurement of patients' ATT sign and their equivalent knee arthroscopy proven ACL tear findings with paired t-test will be used. Moreover, in comparing the measurements among the three groups, one-way analysis of vari-

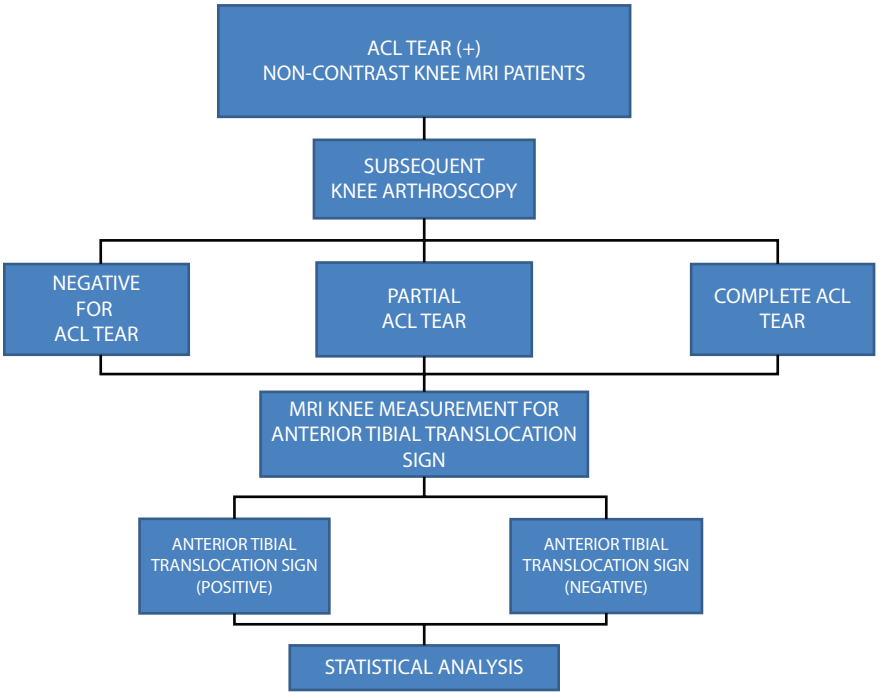


**Figure 1:** Study Framework.

**Figure 2.** Sample positive and negative anterior tibial translocation sign (T1-weighted sagittal MRI images)

ance (ANOVA) with post-hoc comparisons will be utilized. As for testing association among categorical variables, the Chi square test will be employed. Any associated p-values lesser than 0.05 alpha will be considered significant. The whole study procedure was summarized below (Figure 1).

Subjects for inclusion in the study were patients who underwent MRI of the knee from the period of January 2012 to September 2016 in the MRI section of the University of Santo Tomas Hospital who were subsequently followed by knee arthroscopy performed by one UST orthopedic surgeon consultant; interpretation of the official MRI result revealed a definite injury to the ACL, whether it is an acute or chronic process, which includes sprain, partial tear or complete tear as well as degenerative changes; and patients aged 18 years old and above.

Patients were excluded if they were aged 17 years old and under; patients with previous injury including that who have already undergone surgical intervention and patients who were not subsequently followed by knee arthroscopy by a specific UST orthopedic surgeon consultant.

After careful evaluation and screening of each patient, the final study population will only be composed of patients that have met all the criteria as specified above.

The sample size was calculated based on the data obtained by Chan, et al. (2014). According to the study, anterior translocation of 5 mm or more had a sensitivity of 86% and a specificity of 99% for ACL tear. At 5% level of significance and a chance of detecting of 80%, the total sample size needed was 107. Calculation was made using OpenEpi software using the Fleiss method.

The utility of MRI-derived anterior translocation measurements as a predictor of ACL tear would be quantified using sensitivity and specificity values. Moreover, the investigators would use receiver-operator characteristic curve to determine the best cut-off that was most predictive of ACL tear in the sample of patients.

**Sample Size: X-Sectional, Cohort, & Randomized Clinical Trials**

| | |
|---|---|
| Two-sided significance level (1-alpha): | 95 |
| Power (1-beta, % chance of detecting): | 90 |
| Ratio of sample size, Unexposed/Exposed: | 1 |
| Percent of Unexposed with Outcome: | 14 |
| Percent of Exposed with Outcome: | 86 |
| Odds Ratio: | 38 |
| Risk/Prevalence Ratio: | 6.1 |
| Risk/Prevalence difference: | 72 |

| | Kelsey | Fleiss | Fleiss with CC |
|---|---|---|---|
| Sample Size-Exposed | 11 | 8 | 11 |
| Sample Size-Nonexposed | 11 | 8 | 11 |
| Total sample size | 22 | 16 | 22 |

This present retrospective study conformed to the guidelines set forth in good clinical practice and ethical standards.

## RESULTS

The study design used was cross-sectional and aimed to determine whether anterior translocation sign can be used as a predictor of ACL tear.

Data showed that six subjects with MRI anterior translocation measurements of 5 mm or more had complete tears, while two had unremarkable results. In subjects with MRI measurements of less than five, eight had arthroscopically confirmed ACL tears, while seven had normal findings. Thus, using 5 mm cut-off to predict ACL tears, it had a sensitivity of 42.9%, specificity of 77.8%, and positive predictive value (PPV) of 75.0%.

There were approximately two-fold odds in having a positive ACL tear in the arthroscopy reading in patients with anterior translocation of 5 mm or more. However, this observed estimate was not statistically significant at 5% level of significance.

In order to further set the best cut-off measurement that would predict ACL tears, the investigators constructed a receiver operating characteristic (ROC) curve. There were three cut-points: 5 mm, 6 mm and 7 mm. Based on the results, 7 mm cut-point had the highest area under the curve (AUC) and had the optimal trade-off between sensitivity and false positive

**Table 1.** Anterior translocation measurements versus arthroscopy findings

| Anterior translocation measurement | Arthroscopy findings | | Odds Ratio | P-value † |
|---|---|---|---|---|
| | (+) tear | (-) tear | | |
| ≥ 5mm | 6 | 2 | 1.90 | 0.400 |
| < 5mm | 8 | 7 | | |

† Fischer Exact test; p-value < 0.05 is statistically significant

**Table 2** ROC classification table

ROC Table

| *Index* | *Failure* | *Success* | *FPR* | *TPR* | *AUC* |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 1 | 1 | 0.392857 |
| 1 | 9 | 7 | 0.357143 | 0.222222 | 0.035714 |
| 2 | 12 | 8 | 0.142857 | 0.111111 | 0.003968 |
| 3 | 13 | 9 | 0.071429 | 0 | 0 |
| 4 | 14 | 9 | 0 | 0 | 0 |
| | | | | | 0.43254 |

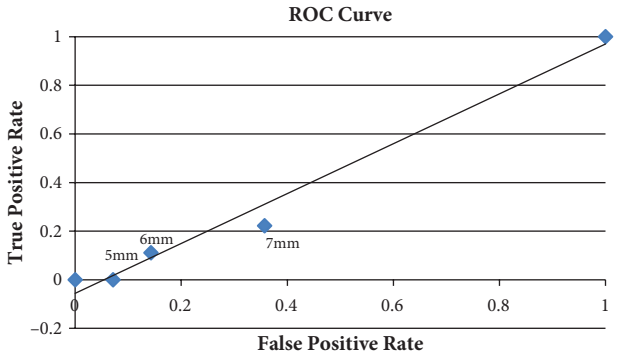


**Figure 3.** ROC curve

rate. Thus, anterior translocation of 7 mm or more was the best cut-off for predicting ACL tears (Table 1 and 2) (Figure 3).

## DISCUSSION

In ACLs, MRI is a valuable imaging tool prior to arthroscopic procedures. Aside from the direct sign of ACL tear, an indirect MRI sign, such as ATT sign is helpful in establishing an accurate MRI diagnosis (especially in equivocal cases). The aforementioned imaging sign mimics the anterior drawer test making it a clinically sound evaluation tool.

In this study, we were able to observe that measurements of 7 mm or more was the best cut-off to predict ACL tears. With this in mind, medical imaging specialists may incorporate this measurement during their interpretations.

However, we used a 5-mm cut-off for ATT in the sagittal knee MR images of patients who were diagnosed with partial or complete ACL tear and who subsequently underwent knee arthroscopy to predict the probability of ACL tears. The odds was almost two-fold, but, there was no enough evidence to conclude that MRI readings of 5 mm or more predict ACL tears approximately 200% of the time, at 5% level of significance.

## CONCLUSION

There is not enough evidence to conclude that MRI readings of 5 mm or more predict ACL tears. On the same sample of patients, the researchers were also able to observe that measurements of 7 mm or more was the best cut-off to predict ACL tears.

An important limitation of the study was its small sample size. More subjects should have been included to increase the power or chance of detecting a significant effect.

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## APPENDIX

**Table 1.** Data Collection Form

| PATIENT NO. | ANTERIOR TIBIAL SUBLUXATION | SUBSEQUENT KNEE ARTHROSCOPY FINDING | | | ANTERIOR TIBIAL TRANSLOCATION SIGN |
|---|---|---|---|---|---|
| | (IN MM) | NEGATIVE FOR ACL TEAR | PARTIAL ACL TEAR | COMPLETE ACL TEAR | (POSITIVE OR NEGATIVE) |
| 1 | 2.2 | X | | | NEGATIVE |
| 2 | 0 | X | | | NEGATIVE |
| 3 | 1 | X | | | NEGATIVE |
| 4 | 5.8 | X | | | POSITIVE |
| 5 | 0 | X | | | NEGATIVE |
| 6 | 4.9 | | | X | POSITIVE |
| 7 | 4.2 | | X | | NEGATIVE |
| 8 | 4.2 | X | | | NEGATIVE |
| 9 | 1.2 | X | | | NEGATIVE |
| 10 | 1.7 | X | | | NEGATIVE |
| 11 | 0 | | | X | NEGATIVE |
| 12 | 6.1 | X | | | POSITIVE |
| 13 | 2 | X | | | NEGATIVE |
| 14 | 4.2 | | | X | NEGATIVE |
| 15 | 8.1 | | | X | POSITIVE |
| 16 | 6.4 | | | X | POSITIVE |
| 17 | 5.7 | | | X | POSITIVE |
| 18 | 0.5 | | X | | NEGATIVE |
| 19 | 5.3 | | X | | POSITIVE |
| 20 | 2 | | | X | NEGATIVE |
| 21 | 2 | | X | | NEGATIVE |
| 22 | 5.8 | X | | | POSITIVE |
| 23 | 4.1 | | | X | NEGATIVE |