

# **MRI Measurement Methods of Anterior Tibial Subluxation Compared for Predicting High-Grade Pivot Shift in ACL-Deficient Knees: A Multicenter Cohort Study**

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## **INTRODUCTION:**

Anterior cruciate ligament (ACL) injury leads to both anteroposterior and rotational instability of the knee. Rotational instability is typically evaluated using the pivot shift test, and high-grade pivot shift observed under anesthesia is associated with an increased risk of graft failure and residual instability after ACL reconstruction. However, conscious pivot shift testing performed in the outpatient setting is often unreliable due to muscle guarding and joint effusion.

MRI-based measurements of anterior tibial subluxation (ATS) have been investigated as predictors of rotational instability. ATS can be assessed using either the plateau method, which measures subluxation perpendicular to the tibial plateau, or the bone axis method, which measures it parallel to the tibial shaft axis. Additionally, separate evaluation of the lateral compartment (L\_ATS) and the difference between lateral and medial compartments (D\_ATS) has shown potential relevance. While previous studies have reported associations between L\_ATS or D\_ATS and pivot shift grade, it remains unclear which measurement method offers the strongest predictive power.

We hypothesized that D\_ATS measured with the bone axis method would be most strongly associated with intraoperative pivot shift. The aim of this study was to identify the MRI-based ATS measurement method most predictive of preoperative rotational instability in ACL-deficient knees.

## **METHODS:**

This was a retrospective multicenter cohort study of patients who underwent primary ACL reconstruction between October 2022 and December 2024. Data were prospectively collected across all participating institutions.

ATS was measured using both the plateau method and the bone axis method (Figure 1). For each method, L\_ATS and D\_ATS were recorded. Pivot shift grading was performed under anesthesia using the International Knee Documentation Committee classification. Patients with pivot shift grades A or B were categorized as having low-grade pivot shift (LG\_PS), while those with grades C or D were categorized as having high-grade pivot shift (HG\_PS).

Primary analyses compared ATS measurements between pivot shift groups. Receiver operating characteristic (ROC) curves and area under the curve (AUC) values were calculated for each ATS parameter, with HG\_PS defined as the positive outcome. In a secondary analysis, multivariate logistic regression was performed with HG\_PS as the outcome variable, incorporating demographic and clinical characteristics, with D\_ATS measured by the bone axis method as the explanatory variable.

## **RESULTS:**

A total of 291 patients were included in the final analysis after applying exclusion criteria to an initial cohort of 381 (Figure 2). Patient demographics and clinical characteristics are summarized in Table 1.

L\_ATS measured with the plateau method did not significantly differ between LG\_PS and HG\_PS. However, L\_ATS and D\_ATS measured with the bone axis method, and D\_ATS measured with the plateau method, were significantly greater in HG\_PS (Table 2).

The highest diagnostic accuracy was observed for D\_ATS measured with the bone axis method (AUC = 0.675), compared to D\_ATS with the plateau method (AUC = 0.611), L\_ATS with the bone axis method (AUC = 0.555), and L\_ATS with the plateau method (AUC = 0.512) (Figure 3).

Multivariate logistic regression identified female sex, contralateral knee hyperextension, medial meniscus tear, and D\_ATS measured with the bone axis method as independent predictors of HG\_PS (Table 3).

## **DISCUSSION AND CONCLUSION:**

D\_ATS measured with the bone axis method showed the strongest association with intraoperative rotational instability. Identifying this parameter, along with clinical factors such as female sex, contralateral hyperextension, and medial meniscus tears, allows for accurate preoperative prediction of HG\_PS. Given the routine use of MRI prior to ACL surgery, D\_ATS measured with the bone axis method may offer a reliable means of preoperative risk stratification and surgical decision-making.

