BS Structured Summary

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INTRODUCTION / BACKGROUND

The anterior cruciate ligament (ACL) is the primary stabilizer against anterior tibial translation and a secondary stabilizer of internal rotation. The pivot shift (PS) test is the cornerstone of clinical assessment of rotational instability, used for decades to grade the severity of anterolateral instability. Traditionally a qualitative test, the PS has evolved over recent years into a quantitative assessment thanks to validated apps — such as the PIVOT iPad app from the University of Pittsburgh —, providing additional objectivity in characterizing anterolateral instability.

ACL injuries rarely occur in isolation. Peripheral structures such as the anterolateral complex (ALC) — including the anterolateral ligament (ALL) and the Kaplan fibers (KF) — and the lateral meniscus (LM) are frequently involved. Reported prevalence ranges from 19% to 85% for KF, 51% to 76% for ALL, and 30% to 40% for LM tears in acute ACL-injured knees. These secondary injuries may exacerbate instability, modify surgical planning, and impact postoperative outcomes.

The rediscovery of the ALL in 2013 transformed the surgical landscape of ACL injuries, with growing adoption of anterolateral extra-articular procedures — lateral extra-articular tenodesis and ALL reconstruction — for high-grade rotational instability. Studies such as STABILITY have shown reduced re-rupture rates with tenodesis. Despite this, precise indications for adding these procedures remain undefined, and the relative contribution of each peripheral structure to high-grade preoperative pivot shift continues to be debated.

In vitro studies show Kaplan fibers are the primary restraints to internal rotation beyond 30° of flexion; clinical translation of this finding remains controversial. ALL effects are debated — modest

contribution in vitro (10–15% of rotational torque resistance), but more pronounced clinical associations in some studies. As for the LM, significant disruption increases rotational laxity in cadaveric models, but clinical translation has likewise been inconsistent. The present study aimed to prospectively evaluate, in vivo, which of these structures — KF, ALL, or LM — actually drives high-grade preoperative pivot shift.

OBJECTIVE

To investigate the effect of injuries to Kaplan fibers, the anterolateral ligament, and the lateral meniscus on preoperative anterolateral rotational instability in acute ACL-injured knees, quantified through the PIVOT iPad app and clinically graded according to the IKDC.

METHODS

Prospective registry study approved by the ethics committee of the Technical University of Munich. Patients aged 16 to 55 years undergoing primary unilateral ACL reconstruction between January 2021 and September 2024 were included. Final inclusion criteria: preoperative MRI available and performed within 28 days of injury, and no history of contralateral knee injury or surgery.

Exclusion criteria: skin disorders in the knee region, BMI ≥35 kg/m², collateral ligament injuries with grade ≥II instability, bucket-handle tears (medial or lateral) — due to potential blocking effect on knee kinematics —, revision reconstructions, and multiligamentous injuries.

Clinical examination was performed under general anesthesia by three trained independent investigators, eliminating any influence of patient apprehension or muscle tension. Markers were placed at three landmarks: lateral femoral epicondyle, Gerdy's tubercle, and 8 cm posterior to it. The PS was quantified using the PIVOT iPad app — validated, with mean error under 6%. Anterior translation of the lateral tibial plateau (ATLT) was measured and side-to-side difference (SSD) was calculated. The PS was also graded according to IKDC: glide (grade I), clunk (grade II), or gross (grade III), grouped as low-grade (negative + grade I) and high-grade (grades II and III).

Preoperative MRIs were analyzed by a sports medicine orthopaedic consultant (with parallel analysis of 20 cases by a second consultant for ICC calculation). KF were identified proximal to the lateral femoral condyle; ALL as a low-signal structure originating posterior-proximal to the lateral femoral epicondyle. LM tears were classified as radial, longitudinal, complex, posterior root, and horizontal — confirmed intraoperatively. For radial tears, complete (full disruption of circumferential fibers) versus incomplete status was recorded. A priori sample size calculation: 114 patients to detect a 0.4 ± 0.75 mm difference in ATLT with 0.81 power and alpha 0.05.

MAIN RESULTS

A total of 124 patients were included (mean age 29.9 ± 11.2 years; 61% male; 61% right knees; mean BMI 24.7; noncontact mechanism in 83%). Mean interval between trauma and MRI: 6.9 ± 6.6 days; between trauma and surgery: 43.5 ± 32.2 days.

Prevalence of concomitant injuries: ALL in 48% (57 patients), KF in 43% (51), combined ALC + KF in 28% (33), LM in 38% (47) — distributed as 18 longitudinal, 14 radial (5 complete and 9 incomplete), 11

complex, 3 posterior root, and 1 horizontal. Combined ALL + KF + LM in 15% (18). Inter-rater agreement was excellent: ICC 0.894 for ALL and 0.946 for KF.

The quantified PS was significantly higher in the injured versus contralateral healthy knee (ATLT: 3.2 ± 1.6 mm vs. 1.5 ± 0.9 mm; p<0.001), confirming the method's sensitivity. Clinical IKDC grading was documented in 81 of 124 patients — 54% low-grade and 46% high-grade. Patients with high-grade PS had significantly higher ATLT (2.2 ± 1.8 mm vs. 1.3 ± 1.1 mm; p<0.01).

Central finding — comparison by structure: isolated KF injuries did NOT increase quantified PS or high-grade clinical PS. Isolated ALL injuries ALSO did NOT increase either outcome. The combination KF + ALL ALSO was not associated with high-grade PS or increased ATLT. Even the combination of all three (KF + ALL + LM) did not reach significance for quantified PS.

In contrast, lateral meniscus injury was associated with a higher proportion of high-grade clinical PS (p=0.043), with an Odds Ratio of 2.5 (95% CI 1.019–6.237; p<0.05). Subgroup analysis by meniscal tear type revealed the most striking finding: COMPLETE radial tears significantly increased ATLT in the quantified PS (3.5 ± 1.8 mm vs. 1.7 ± 1.4 mm in intact menisci; p=0.027) — an effect not observed in incomplete radial tears (1.5 ± 0.5 mm), longitudinal, or complex tears.

Interestingly, LM posterior root tears (n=3) did not significantly increase ATLT — possibly due to maintenance of the ring structure via intact meniscofemoral ligament. The quantified PS did not correlate with age, height, weight, BMI, or sex, and was negatively correlated with time between trauma and MRI (r=-0.295; p<0.01) — signaling that delayed measurements may underestimate instability.

AUTHORS' CONCLUSION

In acute ACL-injured knees, lateral meniscus injuries — especially complete radial tears that disrupt the circumferential fibers — were associated with high-grade pivot shift and a significant increase in anterior translation of the lateral tibial plateau. Isolated or combined injuries to the Kaplan fibers and anterolateral ligament, by contrast, did NOT increase the quantified PS or the frequency of high-grade clinical PS. The study provides relevant clinical evidence that lateral meniscal integrity is a key determinant of anterolateral rotational instability, underscoring the importance of properly addressing the LM during ACL reconstruction.

BS DISCUSSION

This paper is provocative and deserves careful reading. In an era when anterolateral extra-articular reinforcement — lateral tenodesis and ALL reconstruction — has been gaining increasing space in ACL reconstruction protocols, Willinger et al.'s work raises a difficult question: which peripheral structure actually drives high-grade pivot shift? The answer found here pushes back against part of the dominant narrative of recent years.

The study's design elegance lies in three points: (1) prospective assessment under anesthesia, eliminating patient apprehension bias; (2) objective quantification via the PIVOT iPad app, with validated correlation against 3D kinematics; and (3) stratified

analysis by meniscal tear subtype — this last point being particularly key for interpretation. When all LM tear types are pooled, the effect on ATLT is not significant. But when complete radial tears are isolated, a robust effect emerges: ATLT of 3.5 mm versus 1.7 mm in intact menisci. In other words, full disruption of the circumferential fibers is what biomechanically matters — consistent with the meniscus-as-functional-ring concept.

The clinical message for BS is twofold. First, it reinforces what we have been intuitively sensing: not every high-grade pivot shift is the "fault" of the anterolateral structures. Lateral meniscal integrity is a substantial — and likely underestimated — determinant of rotational instability. LM repair, whenever technically feasible, should be prioritized, particularly for complete radial tears in knees with high-grade preoperative pivot. Second, this study invites reflection before indicating anterolateral reinforcement based solely on isolated MRI findings of ALL or KF injury. The data suggest these injuries, isolated or combined, do not justify automatic upgrading of the reconstruction's aggressiveness.

It is important to note what the paper does NOT say. It does NOT claim that lateral tenodesis or ALL reconstruction don't work — postoperative clinical studies continue to show reduced re-rupture rates. What it says is that isolated ALC injury on imaging does not appear to amplify preoperative pivot shift in a measurable way. The indication for anterolateral reinforcement should therefore continue to be based on factors such as actual high-grade pivot, hyperlaxity, tibial slope, age, and athletic level — not merely on the radiological finding of ALL or KF injury.

Limitations are honest and relevant. MRIs from different services with variable quality, three different examiners for the PS, clinical IKDC not documented in the first 43 patients (only 81 with full grading), and statistical power calculated based on a smaller standard deviation than observed — leaving room for type II error in the non-significant ALC findings. Despite this, the consistency of the results with the meniscal "ring" physiology and prior biomechanical studies lends strength to the central message. For BS Papers, this work should open a productive discussion: are we adequately preserving the lateral meniscus in our ACL reconstructions?

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