



Elimination of the Pivot-Shift Sign After Repair of an Occult Anterolateral Ligament Injury in an ACL-Deficient Knee

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Several biomechanical studies have demonstrated the importance of the anterolateral ligament (ALL) in rotational instability of the knee.^{1,10,12,14} Despite this, the precise role of the ALL in eliminating the pivot shift remains controversial.^{9,11,13} This disparity exists secondary to the nature of cadaveric research and the subsequent creation of artificial injury patterns that are not a true representation of in vivo characteristics. This case report provides clinical evidence of the important role that the anterolateral structure plays in anterolateral rotational instability, as demonstrated by the pivot-shift sign.

CASE PRESENTATION

A 17-year-old female volleyball player presented to the emergency department after a noncontact injury of the left knee sustained during the impact of landing from a jump. She reported that she heard a “crack” and experienced immediate pain and swelling in the knee. Physical examination revealed

a moderate effusion, a 0° to 80° range of motion, and a grade 2 Lachman test. The pivot-shift test could not be reliably performed due to pain and subsequent muscular contraction.

Plain radiographs showed no evidence of a bony injury. The patient underwent 1.5-T magnetic resonance imaging (MRI), which confirmed the clinical diagnosis of anterior cruciate ligament (ACL) rupture and revealed characteristic bone bruising of the lateral femoral condyle. Even though no ALL or anterolateral capsule lesion was reported by the radiologist, it was possible to identify abnormalities of the ALL according to previously reported imaging parameters of this structure⁵ (Figure 1A).

The patient was admitted to the hospital for an ACL reconstruction, which was performed 5 days after the injury. Examination under general anesthesia revealed a full range of motion, positive Lachman test, and grade 2 pivot shift (see the online Video Supplement). Varus and valgus stress tests were both negative at 0° and 30° of flexion. The semitendinosus and gracilis tendons were harvested for the ACL graft. Due to the presence of a grade 2 pivot shift and suspicion of injury to the anterolateral structures, the lateral compartment was approached by a hockey stick incision. After skin flaps were lifted, the fascia lata was confirmed to be completely normal, with no visible tear, bruise, or hematoma (Figure 1B). It was then incised, in line with its fibers, to reveal heavily blood-stained synovial fluid exiting the joint via a 1-cm-wide lesion of the anterolateral capsule (Figure 1C). The lesion was repaired by 3 parallel stitches with square knots (No. 2 Vicryl; Ethicon) in tension with the knee at 90° of flexion and neutral rotation (Figure 1D). Physical examination was repeated prior to ACL reconstruction and revealed the continued presence of a positive Lachman test but a complete resolution of the pivot shift, in contrast to the grade 2 pivot shift present prior to repair of the anterolateral capsule and ligament.

Arthroscopic evaluation showed normal medial and lateral menisci and a grade 3, midlevel ACL rupture. ACL reconstruction was then performed with a doubled

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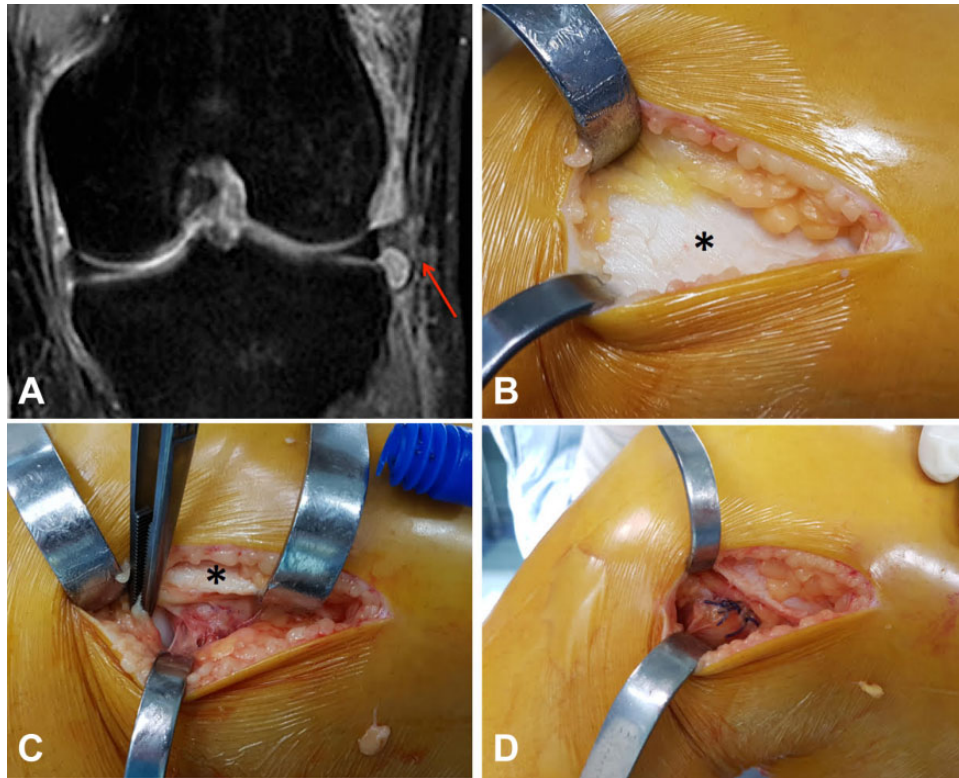


Figure 1. Magnetic resonance imaging (MRI) and clinical images of the left knee. (A) Coronal (proton-density, fat-suppressed) MRI demonstrating a tear of the anterolateral ligament/capsule (arrow). (B-D) Clinical photographs of the lateral aspect of the same knee (all images are oriented with the most distal part of the limb to the left). (B) Intact iliotibial band (ITB) (*). (C) Tear of the anterolateral capsule identified after ITB split in line with its fibers (*). (D) Repaired anterolateral capsule.

hamstring tendon graft (size 8 mm). An 8-mm tibial tunnel was drilled at the center of the native footprint with a guide set at 60°. An 8 × 25-mm femoral socket was drilled with an outside-in technique (flip cutter; Arthrex). The center was located at the anatomic insertion of the ACL, midway between the “resident’s ridge” and the posterior wall of the femoral condyle. The graft was passed through the joint via a suture loop, retrieved through the tibial tunnel, and fixed on the femoral side with a TightRope RT adjustable-loop cortical button (Arthrex) and on the tibial side with an absorbable biocomposite 9 × 28-mm interference screw (Arthrex) fixed in 30° of flexion with a posterior drawer applied.

After ACL reconstruction, the physical examination was repeated. Both Lachman and pivot-shift tests were negative. The fascia lata was sutured, and the skin was closed. No drain was used. A long leg brace was applied with the limb placed in extension, and the brace remained in situ for 2 weeks. On postoperative day 2, isometric exercises for quadriceps contraction and muscular strengthening were commenced. Progression to weightbearing as tolerated was encouraged. After 2 weeks, the brace was removed and full active range of motion was encouraged. Activities were increased in physical therapy and progressed to resistance isotonic and isokinetic exercises. In the third month after surgery, the patient advanced to

progressive functional activities and was allowed to run. Return to sport-specific training was authorized at 4 to 6 months after surgery.

At 1-year follow-up, the patient had a negative Lachman test and a negative pivot-shift test, and her status was assessed as grade A on an objective International Knee Documentation Committee (IKDC) evaluation. The Tegner-Lysholm knee score was 100, and the Knee injury and Osteoarthritis Outcome Score (KOOS) score was 98.8. The maximum side-to-side difference as assessed manually with KT-1000 arthrometer was 2 mm. The patient returned to her preinjury level of sport (volleyball).

DISCUSSION

This case report demonstrates 2 important findings. The first is that direct repair of an anterolateral capsule and ligament lesion in an ACL-deficient knee has a significant effect on rotation during the pivot-shift test, even allowing the elimination of the phenomenon prior to ACL reconstruction. The second important finding is that despite good visualization of the anterolateral structures on MRI, no injury was identified preoperatively by the radiologist. Even though we could see an ALL abnormality, it is not routine in most centers to explore these kinds of lesions;

however, an occult injury to the anterolateral capsule and ligament was revealed intraoperatively.

The role of the anterolateral structures in rotational control of the knee has been demonstrated recently by several robotic cadaveric studies that evaluated the effect of an ALL lesion in addition to an ACL injury. In a cadaveric model using a navigation system, Sonnery-Cottet et al¹² reported that the ALL is involved in rotational control of the knee at varying degrees of knee flexion and during a simulated pivot shift. Similarly, Rasmussen et al¹⁰ concluded that the ALL is an important structure that provides rotational stability of the knee. Using a different navigation system in a cadaveric model, Monaco et al⁸ demonstrated that an ALL lesion in an ACL-deficient knee significantly increases tibial rotation and is correlated with the clinical appearance of an explosive pivot shift in most cases. Bonanzinga et al¹ evaluated the effect of progressive lesions of the ACL and ALL during the pivot-shift test. The investigators specifically evaluated acceleration during the pivot-shift test, a parameter that has been shown to correlate with the clinical grade of pivot shift. They found that while an isolated lesion of the ACL did not significantly affect acceleration during the pivot-shift test, an additional injury of the ALL resulted in a significant increase in acceleration. Bonanzinga et al¹ postulated that when high-grade pivots occur in vivo, this may indicate an unrecognized injury to the anterolateral structures of the knee. Spencer et al,¹⁴ in their sequential cutting study, found that the ALL was effective in controlling internal rotation in the setting of a combined complete ACL and ALL tear during the early phase of simulated pivot shift.

The aforementioned biomechanical studies^{1,10,12,14} support the first important finding of this clinical case report, which is that the ALL plays an important role in the pivot-shift phenomenon. In contrast, Saiegh et al¹¹ did not find that sectioning the ALL in an ACL-deficient knee increased tibiofemoral rotation or contributed further to the pivot-shift grade. Evaluation of their published dissections reveals that they may have failed to correctly identify the anatomic structure; the structure they label as the ALL has a femoral attachment anterior to the lateral epicondyle, whereas the current consensus is that a femoral attachment in most cases is located proximal and posterior to the lateral epicondyle.² Similarly, Guenther et al⁴ stated that the anterolateral capsule carries negligible force in a longitudinal direction in the cadaver and instead behaves like a sheet of fibrous tissue. In contrast, our case report demonstrates that when the anterolateral structures were repaired in a real patient, the pivot shift was abolished. However, this is a single case and we cannot confirm whether the same result would be obtained in all knees with an ACL injury and a grade 2 pivot shift. Although laboratory studies have played an important role in defining anatomic structures, the major limitation of such studies is the difficulty of extrapolating biomechanical data from cadaveric specimens (with artificially created injuries and an absence of dynamic muscle forces) to real-world, dynamic clinical scenarios that entail high functional demand.

The second important finding of this study, as mentioned, pertains to the failure to identify anterolateral capsule and ligament injury on preoperative MRI. This is

perhaps not particularly surprising given the considerable disparity between the rates of concomitant ALL injury identified in ACL-deficient knees, depending on whether the evaluation was surgical or based on MRI. In a recent in vivo study, Ferretti et al³ reported the prevalence and pattern of lateral injuries in 60 consecutive patients who underwent an acute ACL reconstruction (within 7 days after injury). The investigators found that anterolateral capsule injuries occurred in approximately 90% of patients with acute ACL tears. In particular, Ferretti et al³ found that 21% of lesions were type 3 lesions, involving only the ALL. Similar findings have been reported by several authors.^{7,15} In contrast, in an MRI study, Helito et al⁶ identified a 32.6% rate of ALL injury in knees with an acutely ruptured ACL; 54.4% of their patients had a normal ALL on MRI, and in 12.8% of patients the ALL was not adequately visualized. Further, the rate of failure to characterize the ALL was twice as high in patients who underwent 1.5-T MRI compared with 3-T MRI. This indicates that current imaging modalities are not sensitive enough, and probably radiologists and knee surgeons are not yet familiar with these types of lesions, thus explaining the injury assessment disparity in the current case report. This suggests that a “normal” MRI result should not preclude consideration of injury to the anterolateral structures of the knee.

CONCLUSION

In the patient described in this clinical case report, the ALL was an important determinant of the pivot-shift test. This concept has been demonstrated previously in laboratory studies, which have shown that ALL injury contributes to the acceleration, degree of internal rotation, and grade of pivot shift. To our knowledge, this is the first report in which the repair of an ALL lesion was able to abolish the pivot shift in vivo. This case also highlights that a “normal” MRI report should not preclude consideration of injury to the anterolateral structures and ALL of the knee.

A Video Supplement for this article is available at <http://journals.sagepub.com/doi/suppl/10.1177/2325967117728877>.

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