Evaluation of the anterolateral ligament of the knee by magnetic resonance imaging in patients with chronic anterior cruciate ligament rupture

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ABSTRACT

Objective: The purpose of this study was to evaluate the visibility of the anterolateral ligament (ALL) by magnetic resonance imaging (MRI) in patients with chronic anterior cruciate ligament (ACL) rupture.

Materials and methods: This retrospective case – control study compared 1.5 - T MRI scans for 50 patients with a chronic ACL rupture with those of a control group of 50 patients with an intact ACL. The ALL was evaluated in three portions: femoral, meniscal, and tibial. The status of each portion was classified as visualized or non-visualized. Two radiologists separately reviewed all the MRI scans to evaluate inter-observer reliability.

Results: At least one portion of the ALL was visualized in 100% of the control group and 72% of the chronic ACL rupture group. All three portions of the ALL were identified in 72% of the control group but only 10% of the chronic ACL rupture group. In both groups, the most commonly visualized portion was the meniscal portion and the least visualized was the tibial portion. In 18% of the chronic ACL rupture group, no portion of the ALL was visualized.

Conclusions: The visibility of the ALL of the knee was significantly lower in patients with a chronic ACL rupture than in those with an intact one.

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1. Introduction

The anterolateral ligament (ALL) was first noted in 1879 by Segond, who described a “pearly resistant fibrous band” on the anterolateral aspect of the knee.¹ However, it took until 2012 for the structure to be identified and named, in an anatomical study of the anterolateral capsule by Vincent et al.² In a similar study in 2013 of embalmed knee specimens, Claes et al. described the origin and insertion of the ALL.³

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The anterior cruciate ligament (ACL) is the ligament of the knee most frequently injured. Common mechanisms of injury include valgus stress and internal rotation of the tibia or external rotation of the femur applied to a flexed knee. Combined ACL–ALL lesions generally involve similar trauma mechanisms to those of isolated ACL injuries.⁴ Assessment of the ALL clinically or arthroscopically is difficult,⁵ but studies of uninjured knees have shown that the ALL can be clearly defined on magnetic resonance imaging (MRI).^{5–8} It is therefore important to conduct MRI studies that identify the ALL in ACL-deficient knees. Most previous studies of the ALL have focused on patients with acute ACL injuries; however, to the best of our knowledge, no studies have used MRI to simultaneously evaluate the visibility of the ALL and investigate the relationship between the ALL and chronic ACL rupture.

The purpose of this study was to evaluate the visibility of ALL by MRI in patients with chronic ACL rupture.

2. Materials and Methods

2.1. Patients

This retrospective case - control study included consecutive subjects undergoing ACL reconstructive surgery between January and December 2017 at our hospital. The study was approved by the hospital's Institutional Review Board. The following exclusion criteria were applied: an MRI showing acute injury of the ACL, considered to be when the patient reported knee trauma that had occurred less than 6 months before the examination, with MRI showing a bone bruise in the femoral condyles and tibial plateau; any previous surgery on the examined knee; and the presence of metallic hardware that might cause artifacts. In total, 50 patients were included in the study. A control group was established with 50 patients presenting with knee joint pain but with MRI evidence of an intact ACL.

2.2. MRI evaluation

The MRI was acquired with a 1.5-T unit (Optima, GE Medical System, Milwaukee, WI, USA) using an extremity coil. The patient was placed in the supine position with the knee in full extension. A standardized MRI examination protocol was used, and the following six sequences were performed for each patient:

Sagittal fast spin-echo T1-weighted [repetition time (TR)/echo time (TE): 300–500/5–10 ms, matrix: 288 × 224, field of view (FOV): 18 × 18 cm, slice thickness: 3 mm]; sagittal fat-suppressed proton density-weighted (PDW) (TR/TE: 2300–2800/20–40 ms, matrix: 256 × 192, FOV: 18 × 18 cm, slice thickness: 3 mm); coronal fast spin-echo T1-weighted (TR/TE: 300–500/5–10 ms, matrix: 288 × 224, FOV: 20 × 20 cm, slice thickness: 3 mm); coronal fat-suppressed PDW (TR/TE: 2300–2800/20–40 ms, matrix: 288 × 224, FOV: 20 × 20 cm, slice thickness: 3 mm); coronal fast spin -echo PDW (TR/TE: 2300–2800/20–40 ms, matrix: 288 × 224, FOV: 18 × 18 cm, slice thickness: 2 mm); and axial fat-suppressed PDW (TR/TE: 2300–2800/20–40 ms, matrix: 288 × 224, FOV: 18 × 18 cm, slice thickness: 4 mm).

The images were accessed and evaluated using the picture archiving and communication system at our institution. The ACL was evaluated on three-plane MR images and was classified as intact or ruptured. It was classified as completely ruptured if completely absent from all three planes.

The main plane for identifying the ALL was the coronal plane (using fast spin-echo PDW), although the axial and sagittal sequences were useful for locating the anatomical structures used to identify the ligament. The ALL can be followed as a continuous band of low signal intensity from the lateral femoral epicondyle to the anterolateral tibia. The ligament was considered in three portion^{7–9}: femoral (origin to the bifurcation point), meniscal (bifurcation to the meniscal insertion), and tibial (bifurcation to the tibial insertion) (Fig. 1). Each of these portions (and the ALL as a whole) was classified as either visualized or non-visualized. These evaluations were conducted independently by two radiologist (SD and EG) who were blinded to the identities of the subjects.

3. Results

The characteristics of the study patients are presented in Table 1.

In the control group (with the ACL intact), at least one portion of the ALL was visualized in every patient, with all three portions visualized in 36 (72%) patients. The meniscal portion was seen in 46 (92%) patients, the femoral portion in 44 (88%) patients, and the tibial portion in 40 (80%) patients. In the chronic ACL rupture group, at least one portion of the ALL was visualized in 36 (72%) patients,

Fig. 1. A 21-year-old female with a knee pain. Coronal proton density -weighted image shows normal appearance of the anterolateral ligament (ALL) (LFC: lateral femoral condyle LTP: lateral tibial plateau). The dashed white arrow indicates the femoral portion of the ALL. The white arrow shows the meniscal portion of the ALL. The black arrow indicates the tibial portion of the ALL.

Table 1
Characteristic of the study population (n = 100).

	ACL -intact	ACL -rupture
Patients	50	50
Years	31.4 ± 12.1	29.2 ± 10.3
Female/Male	25/25	20/30
Right/Left knee	28/22	36/14

with all three portions visualized in 5 (10%) patients. The meniscal portion was visualized in 24 (48%) patients, the femoral portion in 22 (44%) patients, and the tibial portion in 19 (38%) patients. All three portions of the ALL were not visualized in 9 (18%) patients (Figs. 2 and 3).

The results of all evaluations are summarized in Table 2.

The intra-class correlation coefficient (ICC) for interobserver reliability in visualizing the ligament was 0.90 for the control group

Fig. 2. Proton density-weighted coronal image of a 30-year-old male with anterior cruciate ligament (ACL) rupture. The femoral (white arrow) and tibial (black arrow) portions are visualized in image. The meniscal portion is not visualized in coronal image.

and 0.88 for the chronic ACL rupture group. To evaluate intra-observer reliability, the ALLs were all re-evaluated by the same observer (SD) 2 weeks after the first evaluation. The ICC for intra-observer reliability was 0.92 for the control group and 0.90 for the chronic ACL rupture group.

Fig. 3. A 18 year-old male with a knee injury. Coronal proton density - weighted image shows complete tear of the ACL. The ALL is not visualized on the same plane.

Table 2

Absolute numbers and the percentage of visualizations of each portion of the ALL across the ACL intact and ACL rupture group.

Portion	ACL- intact		ACL-rupture	
	N	%	N	%
Femoral	44	88	22	44
Meniscal	46	92	24	48
Tibial	40	80	19	38
All portion	36	72	5	10
Any portion	50	100	36	72
Not visualize	—	—	9	18

4. Discussion

This study demonstrated that the visibility of the ALL was significantly lower in patients with a chronic ACL rupture than in those with an intact one.

Recent studies have demonstrated the ALL to be a distinct ligamentous structure of the anterolateral side of the knee, extending from its femoral origin in a region posterior and proximal to the lateral femoral epicondyle to its tibial insertion halfway between the Gerdy's tubercle and the tip of the fibular head.^{3,4,9} Several studies have evaluated the ability of MRI to identify the ALL in uninjured knees. Kosy et al.⁸ reviewed 1.5-T MRI plane images of patients without a known history of ACL rupture or lateral compartment injury and were able to identify the ALL partially in 94% of cases and fully in 57%. Helito et al.⁷ assessed 39 knees by MRI, with the results suggesting that PDW images and T2-weighted MRI images with fat suppression in the coronal plane were the best for visualizing the ALL. Using this method, they visualized the entire ALL on 71.7% of MR images and at least one portion of the ligament was characterized on 97.4% of MR images. The meniscal portion was the most often visualized, with the tibial portion the least often visualized.

In our study, we were able to visualize all three portions of the ligament in 72% of the control group patients with intact ACLs. At least one portion was visualized in all the control group patients. Consistent with previous studies, the most commonly visualized portion was the meniscal portion and the least visualized was the tibial portion.

The ACL is one of the most frequently injured structures in the knee joint and so has been highly studied. Helito et al.¹⁰ suggested that the ALL is only injured when the ACL is completely torn during higher energy injuries. Several recent studies have evaluated the visibility and anatomical features of the ALL and revealed the relationship between the ALL and acute ACL injury on MRI. Claes et al.¹¹ described injuries of the ALL on preoperative MRI in a large consecutive series of ACL reconstructed knees. Their study did not differentiate between acute, subacute, and chronic injuries. Abnormalities of the ALL were classified as proximal (above the meniscus) or inferior (below the meniscus). Of the 206 patients included in the study, 21.3% were considered to have an intact, uninjured ALL, with 78.8% demonstrating radiologic ALL abnormalities. Most of the ALL injuries (77.8%) were to the distal part of the ligament. Helito et al.¹⁰ studied abnormalities of the ALL by MRI in patients with acute ACL injury, evaluating abnormalities in the femoral, meniscal, and tibial portions. They found ALL abnormalities in 32.6% of patients, with most located in the femoral portion. The ALL was not visualized at all in 12.8% of patients. In another study, Kosy et al.¹² reviewed 280 MRI studies of patients who experienced ACL rupture and found that ALL injury was identified in only 10.7% of the patients with ACL rupture. Of these injuries, 2.50% were full-thickness ruptures, all at the tibial insertion of the ALL.

To the best of our knowledge, no previous studies have

evaluated the ALL and investigated the relationship between the ALL and chronic ACL rupture. In this study, we found that in patients with chronic ACL rupture, MRI showed all portions of the ALL to be intact in just 10% of the patients. Consistent with the findings of Helito et al.¹⁰ the ALL was not visualized at all in 18% of the patients, and consistent with the findings of Kosy et al.,¹² we found that the least visualized portion of the ALL was the tibial portion (38%).

Chronic ACL injuries differ from acute injuries in that rupture of the ACL leads to excess anteroposterior laxity of the knee and may produce instability.^{13–15} ACL reconstruction does not restore normal knee biomechanical in patients with chronic instability.¹⁶ Biomechanical studies have reported that the ALL plays an important role in restraining internal rotation in ACL-deficient knees, especially at high flexion angles (35–90°).^{17–19} Combined ACL and ALL reconstruction has been shown to result in a significant reduction in tibial translation and internal rotation compared with isolated ACL reconstruction in ALL-deficient knees.^{4,13,19–21} Studies have reported that ALL injuries should be identified, and repair considered, to improve the control of rotational stability provided by ACL reconstruction.^{4,22} MRI assessment of chronic ACL-deficient knees should include evaluation of the ALL.

Our study had several limitations, mainly related to its retrospective design. Our patient groups were small, and no clinical examination findings that assessed anterolateral instability were available for any of the patients.

In conclusion, the visibility of the ALL of the knee was significantly lower in patients with a chronic ACL rupture than in those with an intact one. MRI can accurately characterize the ALL in the anterolateral region of the knee. MRI assessment of chronic ACL-deficient knees should include evaluation of the ALL.

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Conflict of interest: The authors declare that there is no conflict of interest.

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