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Original Article

Radiology Section

Correlation between Anterolateral Ligament and Anterior Cruciate Ligament Tears-MRI Study

ANITA SOUNDARAPANDIAN, ANUSHA PALANISWAMY, MANOJ KUMAR BALASUNDARAM, NATARAJAN SHANMUGAM

ABSTRACT

Introduction: Various, very well established ligaments and menisci form the framework of stability to the knee and all these structures are already being clearly evaluated on an MRI examination. The Anterolateral Ligament (ALL) however is a relatively newly described structure in the knee which is causing a lot of anticipation for its role in rotational stability.

Aim: The present study was done with the aim of identifying tears of the anterolateral ligament, classifying them according to the involved segment and to assess the segment wise association of tears of Anterior cruciate ligament (ACL) with Anterolateral Ligament (ALL).

Materials and Methods: A study population of 125 patients presenting with post traumatic knee instability were studied for a period of one year and one month. A 1.5T MRI was used for the study with dedicated high resolution sequences. The results were analysed by calculating the number of patients with ALL tears and by analysing how many of these had a segment wise associated tear of the ACL.

Results: The results were analysed by calculating the number of patients with ALL tears and by analysing how many of these had a segment wise associated tear of the ACL. Among the study population, 68 (54.40%) participants had a tear of the ACL at its femoral attachment, 24 (19.20%) participants had a mid segment ACL tear and 14 (11.20%) participants had tear of the tibial insertion of the ACL. Among the study population, 47 (37.60%) participants had a tear of the femoral attachment of ALL, 7 (5.60%) had a tear of the meniscal segment of ALL and 8 (6.40%) participants had a tear of the tibial attachment of ALL. Majority of the patients with femoral and tibial attachment tears of the ALL had a corresponding segment tear of the ACL.

Conclusion: A strong, segment wise association of tears of ACL and ALL was established by this study when it came to tears involving their femoral attachments and the tibial attachments, thereby ascertaining a causal factor of both ligaments in rotational stability of knee. It is essential that the integrity of ALL is established before an ACL reconstruction.

Keywords: Femoral attachment, Meniscal attachment, Rotational instability, Segond's fracture, Tibial attachment

INTRODUCTION

Stability of the knee joint is provided by a spectrum of ligamentous and meniscal structures, most of which have been thoroughly studied and moreover form a part of day to day MRI examinations and reporting.

A comparatively understudied, contributory ligament in rotational instability is the anterolateral ligament of knee. It was in 1879, that Dr. Paul Segond described a 'pearly, resistant, fibrous band which invariably showed extreme amounts of tension during forced internal rotation of the knee' [1].

It was a century later in 1976, Hughston JC et al., attempted to classify the lateral compartment ligaments of the knee into three divisions based on their anatomy [2]. In this division, the iliotibial band and deeper capsular structures were in the middle compartment. The deep lateral capsular ligament was said to attach to the lateral femoral epicondyle proximally and lateral tibia distally. This was further divided into meniscofemoral and meniscotibial components. The detailed anatomy of the anterolateral ligament which came in many later studies was on the basis of this initially described anatomy in this study [2].

From previous cadaveric and MRI studies, ALL is a ligament which has been demonstrated to be in the antero-lateral aspect of knee anterior to the fibular collateral ligament [3-5]. The possibility that it plays a crucial adjunct role to ACL in maintaining rotational stability of the knee has been studied and established to an extent [6,7].

However, unresolved questions do exist. Like, it is not certain if an anterolateral ligament injury can exist in the absence of

an ACL injury. Furthermore, it is yet to be established if such an isolated ALL injury with an intact anterior cruciate ligament injury can occur, does that result in a rotational instability. The importance of assessing the ALL before attempting a surgical reconstruction of the ACL is yet to be determined. A small but still significant number of patients, ranging from 5 to 15%, who undergo ACL repair or reconstruction after an ACL injury, have persistent, post surgical instability [8]. This necessitated the need for further studies to assess if this residual instability could be attributed to associated injuries of anterolateral ligament tears.

The aim of the study was to identify and classify segment wise tears of the ALL and to assess the segment wise association of tears of ACL with ALL.

MATERIALS AND METHODS

This was a cross sectional observational study done over a period from January 2017 to February 2018 at the Department of Radiology at Saveetha Medical College and Hospital.The study was performed after obtaining permission from the Institutional review board (SMC/IEC/2017/182). An informed consent was obtained from all patients prior to the study after explaining the procedure of the examination to the patient. We studied 125 patients who presented with rotational instability and clinically suspected internal derangement of knee specifically involving the ACL during the period of the study.

Inclusion criteria: Both male and female patients, with no age restriction, presenting for knee MRI with clinically suspected internal derangements were included in the study.

Exclusion criteria: Patients suffering from claustrophobia or with incompatible hardware were excluded from the study. Patients presenting with arthritic complaints were excluded from the study.

An informed consent was obtained prior to the study after explaining the procedure of the examination to the patient.

The examinations were carried out in a Philips 1.5 TESLA MRI machine. MRI sequences include high resolution, thin 2.5 mm slices, proton density weighted axial, sagittal, coronal planes.

Femoral, meniscal and tibial attachments of the ALL were studied. Findings were described as increased signal, discontinuity or complete non-visualisation of its fibers. The injury were classified as sprain if there was increased signal without tear, partial tear, complete tear and non visualisation.

The association of the ALL injury with ACL injuries were identified and the results documented.

RESULTS

A total of 125 subjects were included in the study. The age range was between 7 years to 68 years (35.51±12.95) (95% CI 33.22 to 37.80) in the study population. Among the study population, 87 (69.60%) were male patients and the remaining 38 (30.40%) were female patients.

Side Affected: Among the study population 68 (54.40%) participants were affected on right side and 57 (45.60%) participants were affected on left side.

Among the study population, all 125 (100%) participants had history of a blunt trauma to the knee, either due to a road traffic accident, accidental fall or a sports injury.

Summary of ACL tear in study population (N=125): Among the study population, 68 (54.40%) participants had a tear of the ACL at its femoral attachment, 24 (19.20%) participants had a mid segment ACL tear and 14 (11.20%) participants had tear of the tibial insertion of the ACL.

Descriptive analysis of Lateral Collateral Ligament (LCL) tear in study population (N=125): Among the study population, 20 (16%) participants had lateral collateral ligament tear.

Summary of bucket handle lateral meniscal tear in study population (N=125): Among the study population, 30 (24%) participants had a lateral meniscal tear.

Summary of fractures in study population (N=125): Among the study population, 2 (1.60%) participants had Segonds fractures and 2 (1.60%) participants had other fractures.

Visualization of anterolateral ligament in study population (N=125): Among the study population, the anterolateral ligament was well evaluable in 124 (99.20%) participants.

Summary of ALL tear in study population (N=125): Among the study population, 77 (61.60%) participants had no tear of the femoral attachment of ALL, 47 (37.60%) participants had a tear of the femoral attachment of ALL.

Among the study population, 115 (92%) participants had a normal meniscal attachment of ALL, 2 (1.60%) participants had thickened and fibrotic appearing meniscal attachment of ALL and 7 (5.60%) participants had a tear of the meniscal attachment ALL.

Among the study population, 114 (91.20%) participants had no tear of the tibial attachment of ALL, 2 (1.60%) participants had a thickened tibial attachment of ALL and 8 (6.40%) participants had a tear of the tibial attachment of ALL. Among the study population, 5 (4%) participants had a sprain of the ALL [Table/Fig-1].

Comparison of tear of the femoral attachment of ALL with tear of the femoral attachment of ACL (N=125): Among the study population, 68.1% (32) of patients with tear of the femoral attachment of ACL had a tear of the femoral attachment of ALL [Table/Fig-2].

Comparison of tear of the meniscal attachment of ALL with ACL mid segment tear (N=125): Only 14.3% (1 patient) of the present study population with mid segment ACL tear had a tear of the meniscal segment of ALL [Table/Fig-3].

ALL tear	Frequency	Percentages
Femoral attachment		
Normal	77	61.60%
Torn	47	37.60%
Not seen	1	0.80%
Meniscal attachment		
Normal	115	92.00%
Thickened	2	1.60%
Torn	7	5.60%
Not seen	1	0.80%
Tibial attachment		
Normal	114	91.20%
Thickened	2	1.60%
Torn	8	6.40%
Not seen	1	0.80%
Sprains		
Present	5	4.00%
Absent	120	96.00%

[Table/Fig-1]: Summary of ALL tear in study population (N=125).

Tear of femoral attachment of ACL	Femoral attachment of ALL		
	Normal	Torn	Not seen
Yes	36 (46.8%)	32 (68.1%)	0 (0%)
No	41 (53.2%)	15 (31.9%)	1 (100%)

[Table/Fig-2]: Comparison of tear of the femoral attachment of ALL with tear of the femoral attachment of ACL (N=125).
*No statistical test was applied- due to 0 subjects in the cells

Mid segment ACL tear	Meniscal attachment of ALL			
	Normal	Thickened	Torn	Not seen
Yes	22 (19.1%)	0 (0%)	1 (14.3%)	1 (100%)
No	93 (80.9%)	2 (100%)	6 (85.7%)	0 (0%)

[Table/Fig-3]: Comparison of tear of the meniscal attachment of ALL with ACL mid segment tear (N=125).
*No statistical test was applied- due to 0 subjects in the cells

Comparison of tear of tibial attachment of ALL with tear of tibial attachment of ACL (N=125): In patients with tear of the tibial attachment of ACL, 2 (25%) participants had tear of the tibial attachments of the ALL [Table/Fig-4]. Both these patients had avulsion type of tear of the tibial attachment ALL tear with a Segond's fracture.

Tear of the Tibial attachment of ACL	Tibial attachment of ALL			
	Normal	Thickened	Torn	Not seen
Yes	12 (10.5%)	0 (0%)	2 (25%)	0 (0%)
No	102 (89.5%)	2 (100%)	6 (75%)	1 (100%)

[Table/Fig-4]: Comparison of tear of tibial attachment of ALL with tear of tibial attachment of ACL (N=125).
*No statistical test was applied- due to 0 subjects in the cells

DISCUSSION

There have been quite a few MRI studies previously which have established both the existence of ALL as a definite structure as well as the imaging anatomy of the ALL [9-11]. Some cadaveric studies have also confirmed the existence of ALL and its anatomy [11].

There was one contradicting cadaveric study in 2017 by Herbst E et al., that concluded that a separate anterolateral ligament is not present and that the anterolateral ligament described in other studies possibly is the capsulo-osseous layer or the mid-third capsular ligament [12].

Very few studies have been done to assess the association of ALL tears in the background of ACL injuries. Claes S et al., studied 206 patients with ACL tears and showed that 75% had a parallel ALL tear and that most of these tears occurred at the tibial attachment of ALL [6]. Contrary to this, in the present study, most of the anterolateral ligament tears we came across were at the femoral attachment.

In 2017, Patel KA et al., said that though the ALL was identified in all the patients with ACL injuries, it was not possible to establish whether ALL was intact or injured in a 1.5T MRI when the slice thickness of 4 mm. A 3.0 T MRI is better at identifying this elusive ALL [13]. However, when the present study was performed with a slice thickness of 2.5 mm, we were able to adequately visualize the ALL in 124 out of the 125 patients.

In 2014, Wodicka R et al., concluded that there was no direct association between the ALL injury and the severity of rotational instability. It further concluded that ALL is possibly an extension of the iliotibial band [14]. In the 125 patients of the present study population, none of the patients with ALL tear had an associated tear of the iliotibial band.

Claes S et al., was conclusive in establishing the hypothesis that the tibial insertion of ALL is the exact location from where Segond fractures always avulse, therefore confirming that Segond fracture is a bony avulsion of the tibial insertion of ALL [15]. This was further established in the present study where the two patients with Segond's fracture had an avulsion of the tibial insertion of the ALL.

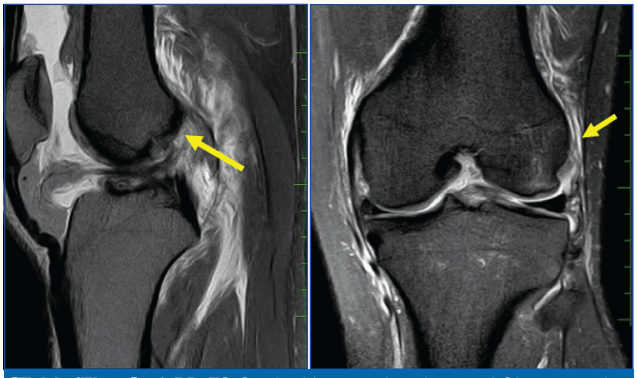
Another study in 2017, which tried to establish both the MR anatomy in normal knees as well as tears of ALL, along with its association with other internal derangements of knee did show an association of ACL tears and ALL tears [16]. But this study was limited by the small study population in the second group of internal derangement patients.

Due to such contradicting study reports, the need for further studies to find a definite association between ALL and ACL injuries arose. In order to make this study more precise, It was decided to classify both ALL and ACL tears according to femoral attachment, tibial attachment and mid segment (meniscal component in the case of ALL) respectively and we strove to establish or negate a segment wise association of tears of these two ligaments. To our knowledge, this segment wise association of tears of ACL and ALL has not been studied or documented previously in literature.

Femoral Attachment of ACL and ALL: On studying the MRI knees of 125 patients who were clinically suspected ACL

injuries, It was found that ACL was injured commonly at the femoral attachment. A majority of these patients with proximal ACL injuries had an associated tear of the femoral attachment of the ALL [Table/Fig-5a,b]. This appeared to show a strong direct association of tears of both ligaments at the femoral attachment.

Case 1: femoral attachment ACL tear with femoral attachment ALL tear –



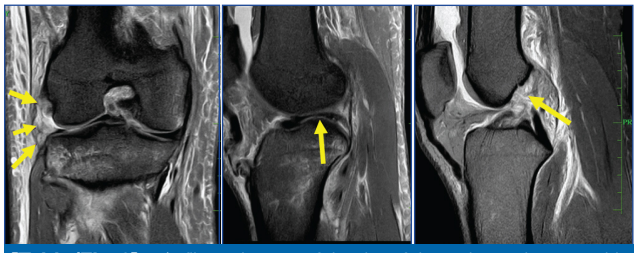
[Table/Fig-5]: a) PD FS Sagittal image showing an ACL tear at the femoral attachment (yellow arrow); b) Coronal PD FS image showing a tear of the ALL at the femoral attachment (yellow arrow). (left to right)

Mid Segment of ACL and Meniscal Attachment of ALL: Mid segment ACL tears were seen in 24 patients in the present study population. However, only one of these 24 patients had an associated tear of the meniscal attachment of the ALL.

The results showed that seven patients had a tear of the meniscal attachment of the ALL. These seven patients had an associated flipped tear of the body of lateral meniscus, which was possibly the cause for a tear of the meniscofemoral and meniscotibial components of the ALL [Table/Fig-6a-c]. However, this study demonstrated that the tears of the meniscal attachment of the ALL had a strong association with body of lateral meniscus tears rather than with ACL tears.

Case 2: mid segment ACL tear, with tear of the meniscal attachment of ALL with tear of body of lateral meniscus –

Tibial Insertion of ACL and ALL: Out of the 125 patients, 14 patients had a tear of the tibial attachment of the ACL.

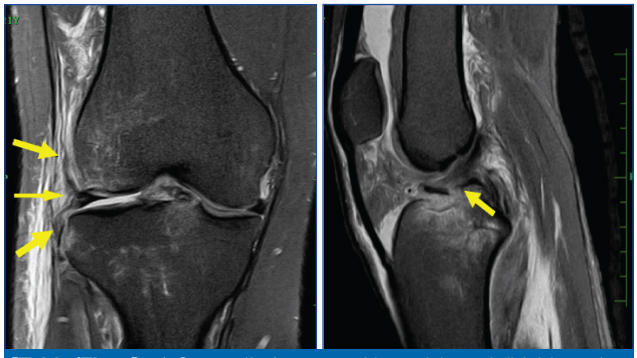


[Table/Fig-6]: a) flipped tear of body of lateral meniscus, with avulsed meniscal attachment of ALL (yellow arrows). Diffuse edema seen in the ALL; b) Flipped fragment of body of lateral meniscus (yellow arrow); c) mid segment tear of the ACL (yellow arrow). (left to right)

Two out of these 14 patients had an associated tear of the tibial insertion of the ALL. The interesting fact was that both patients with tibial attachment tears of the ALL were patients with Segond's fractures [Table/Fig-7a]. This further proves the hypotheses that tibial insertion of ALL corresponds to that part of tibia which is involved in Segond's fracture and that Segond's fracture is actually an avulsion fracture of ALL [7,15,16]. It was inferred that the previously described association of Segond's fracture with anterior cruciate ligament tears was actually an association of Segond's fracture with anterolateral ligament injury, which in turn is often associated with an anterior cruciate ligament injury

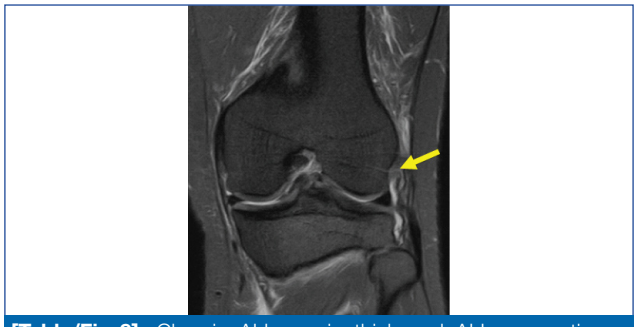
One of these two patients had a tibial avulsion of the ACL as well [Table/Fig-7b]. This further strengthened the present hypothesis that there could be a direct segment wise association of ACL and ALL injuries.

Case 3: Segond's fracture with avulsion of the tibial insertion of the ALL, with tibial avulsion of the ACL



[Table/Fig-7]: a) Segond's fracture with avulsion of tibial insertion of ALL. Diffuse edema seen in the ALL (yellow arrows); b) Tibial avulsion of ACL (yellow arrow). (left to right)

Thickened ALL: Five of the present patients had a distorted and thickened anterolateral ligament [Table/Fig-8]; these patients also had a sprain or tear of the lateral collateral ligament complex. The present inference was possibly the chronic sprain on the anterolateral ligament due to the lateral collateral ligament injury had resulted in thickening and fibrosis of the same. The ACL appeared intact in these five patients.



[Table/Fig-8]: Chronic ALL sprain thickened ALL suggesting a chronic sprain with fibrosis

LIMITATION

The limitation of the present study was that we performed the examinations in a 1.5 T MRI machine. A 3 T MRI study with the same purpose might have better demonstrated the attachments of ALL, and picked up more subtle tears. In the study period, patients presenting with Segond's fracture were only two. The only patients with a tibial attachment tear of the ALL were the patients with Segond's fracture. More patients with this finding would have helped us establish conclusively the association between tibial attachment tears of ALL and ACL.

Patients of post ACL reconstruction with persistent rotation instability need to be studied in future to assess the status of ALL in this group of patients. That would further help in establishing the contributory role of ALL in maintaining rotational instability of knee.

The segment wise association of ACL and ALL tears discussed in this study needs to be validated with more such studies in the future.

CONCLUSION

A segment wise correlation of tears of ACL and ALL was established by this study when it came to tears involving their femoral attachments and the tibial attachments.

There was no significant correlation when it came to tears of the meniscal segment of ALL and the mid segment of ACL. In fact, the meniscal segment ALL tear correlated more with lateral meniscal tears.

We conclude that the presence of ALL tears in a major group of patients with ACL tears in our study population presenting with rotational instability does establish a contributory role of both ligaments in maintaining stability and the integrity of ALL needs to be assessed before proceeding for an ACL reconstruction.

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AUTHOR(S):

1. Dr. Anita Soundarapandian
2. Dr. Anusha Palaniswamy
3. Dr. Manoj Kumar Balasundaram
4. Dr. Natarajan Shanmugam

PARTICULARS OF CONTRIBUTORS:

1. Associate Professor, Department of Radiology, Saveetha Medical College, Chennai, Tamilnadu, India.
2. Resident, Department of Radiology, Saveetha Medical College, Chennai, Tamilnadu, India.
3. Senior Resident, Department of Radiology, Saveetha Medical College, Chennai, Tamilnadu, India.
4. Professor, Department of Orthopedics, Saveetha Medical College, Chennai, Tamilnadu, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:

Dr. Anita Soundarapandian,
Flat 3A, Navanya Apartments, 3/31, 12th Street, B Block,
Anna Nagar East, Chennai-600102, Tamil Nadu, India.
E-mail: anita.soundarapandian@gmail.com

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