ORIGINAL ARTICLE

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Anterolateral Ligament Injuries in Partial Anterior Cruciate Ligament Injuries

Kısmi Ön Çapraz Bağ Yaralanmalarında Anterolateral Bağ Yaralanması

Mehmet Ümit ÇETİN[1], Abdulkadir SARI[1], Fatih ERDOĞAN[2], Bedriye KOYUNCU SÖKMEN[3]

[1]Tekirdağ Namık Kemal University Faculty of Medicine, Department of Orthopedics and Traumatology, Tekirdağ, Türkiye
[2]Çorlu State Hospital, Clinic of Orthopaedics and Traumatology, Çorlu, Türkiye
[3]Acıbadem University, Atakent Hospital, Clinic of Radiology, İstanbul, Türkiye

ABSTRACT

Aim: This study aimed to evaluate the relationship between the type of acute partial anterior cruciate ligament (ACL) injury and anterolateral ligament (ALL) injury.

Materials and Methods: One hundred and forty-eight patients aged 18-40 years with a clinical pre-diagnosis of ACL injury who underwent 3T knee magnetic resonance image between January 2016 and December 2020 were retrospectively analyzed. Acute ACL injury was defined as cases with a history of knee trauma within the last month. Demographic data, ALL visibility, classification of ALL components, presence and type of ACL and ALL injury, injury location, and accompanying lesions were recorded. Correlations between ACL/ALL injury characteristics and accompanying lesions were evaluated.

Results: There was a significant correlation between ACL injury type and both the presence and type of ALL injury (p=0.002 and p=0.013, respectively). There was also a significant correlation between ALL injury and lateral meniscus tear (p=0.024). The diameter of the ALL was significantly increased in injured patients compared to non-injured patients (p=0.001).

Conclusion: A high rate of ALL injury was observed in this series, which predominantly included partial ACL injury cases. Our results suggest that ALL injury should be considered in the management of partial ACL injuries to avoid potential complications.

Keywords: Anterolateral ligament, anterior cruciate ligament, partial lesions, sports injury

ÖZ

Amaç: Bu çalışmada amacımız, akut parsiyel ön çapraz bağ (ACL) yaralanması tipi ile anterolateral bağ (ALL) yaralanması arasındaki ilişkiyi ortaya koymaktır.

Gereç ve Yöntem: Ocak 2016 ile Aralık 2020 tarihleri arasında klinik olarak ACL yaralanması ön tanısı konulan ve diz manyetik rezonans görüntüleri 3T çekilen 18-40 yaşları arasındaki 148 hasta retrospektif olarak incelendi. Son bir ay içinde eş zamanlı diz travması öyküsü olan olgular arasında akut ACL yaralanması tespit edildi. Olguların demografik verileri, ALL'nin görünürlüğü, bileşenlerin sınıflandırılması, ACL ve ALL yaralanmasının varlığı, yaralanmanın yeri ve yaralanma tipi kaydedildi. ACL ve ALL yaralanma özellikleri ile eşlik eden lezyonlar arasındaki korelasyonlar değerlendirildi.

Bulgular: ACL yaralanma tipi ile ALL yaralanmasının varlığı ve tipi arasında anlamlı bir korelasyon vardı (sırasıyla p=0,002 ve p=0,013). ALL yaralanması varlığı ile lateral menisküs yırtığı arasında anlamlı bir korelasyon vardı (p=0,024). ALL çapı, yaralanması olan hastalarda yaralanması olmayanlara kıyasla artmıştı (p=0,001).

Sonuç: Çoğunlukla kısmi ACL yaralanması olan hastalardan oluşan vaka serimizde yüksek oranda ALL yaralanması tespit edildi. Bulgularımız, olası komplikasyonları önlemek için kısmi ACL yaralanması olan olguların tedavisinde ALL yaralanmasının varlığının dikkate alınması gerektiğini göstermektedir.

Anahtar Kelimeler: Anterolateral bağ, ön çapraz bağ, kısmi lezyonlar, spor yaralanması

Address for Correspondence: Abdulkadir SARI MD, Tekirdağ Namık Kemal University Faculty of Medicine, Department of Orthopedics and Traumatology, Tekirdağ, Türkiye
E-mail: drortopedist@yahoo.com **ORCID ID:** orcid.org/0000-0003-3416-5666
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INTRODUCTION

Partial lesions comprise approximately 10% to 27% of isolated anterior cruciate ligament (ACL) lesions[1,2]. Conservative treatment is often recommended for stable partial lesions; however, success rates vary widely in young and active individuals. These lesions may progress to complete tears in 14% to 56% of cases and cause significant morbidity if not managed appropriately[3].

ACL injuries commonly occur via non-contact mechanisms involving valgus stress and internal rotation[4]. Similar mechanisms have been reported to cause injuries to the anterolateral ligament (ALL), first described by Segond in 1879[5]. Claes et al.[6] defined the ALL as a distinct ligament anterolateral to the knee and described its role as an important stabilizer against internal rotation, particularly between 30° and 90° of knee flexion. ALL injury has also been associated with a high-grade pivot-shift phenomenon in ACL-deficient knees[7].

Residual rotational instability may persist after ACL reconstruction[8,9]. It has been suggested that ALL reconstruction may help address persistent pivot-shift[10]. Despite extensive research on the ALL as a secondary restraint to the ACL, consensus on its anatomy and functional role remains lacking[11]. Moreover, most studies have focused on complete ACL tears, with limited data on ALL injury in partial ACL injuries.

This study aimed to investigate the relationship between acute partial ACL injury type and ALL injury in young, active individuals and to provide insights for future clinical and biomechanical studies.

MATERIALS AND METHODS

Our study was approved by the Tekirdağ Namık Kemal University Non-Interventional Clinical Research Ethics Committee (protocol number: 2021.46.02.09, date: 23.02.2021). Two hundred patients who were clinically pre-diagnosed with ACL injury and underwent knee magnetic resonance image (MRI) at our institution between January 2016 and December 2020 were retrospectively analyzed. Written informed consents of all cases were obtained. All images were created using an 8-channel knee coil on a 3T MRI system (Signa HDx; GE Healthcare, Chicago, IL, USA). Our standard knee imaging protocol included axial fat-suppressed proton density-weighted turbo spin-echo sequences [repetition time (TR): 2300 ms, echo time (TE): 35 ms], axial T2-weighted turbo spin-echo sequences (TR: 6700 ms, TE: 70 ms), sagittal fat-suppressed proton density-weighted turbo spin-echo sequences (TR: 3890 ms, TE: 35 ms), sagittal proton density-weighted sequences (TR: 3400 ms, TE: 35 ms), coronal fat-suppressed proton density-weighted turbo spin-echo sequences (TR: 4010 ms, TE: 37 ms), and coronal T1-weighted turbo spin-echo sequences (TR: 690 ms, TE: 9 ms). The section thicknesses were 3 mm for each sequence and the intersection gap was 0.3 mm. For all sequences the matrix size was 352×256 and the field of view was 16 cm.

The images were evaluated by a musculoskeletal radiologist and an orthopedic surgeon. One hundred and forty-eight patients between the ages of 18 and 40 years, who had acute ACL lesions (with a trauma history within the last month) were included in the study, whereas patients with no previous knee surgery, no arthrosis findings, no metal artifacts, or no inflammatory arthritis were excluded.

In the images on the picture archiving communication system, loss of integrity in any sequence or hyperintensity in T2 sequences was considered as ACL injury, and the injury was described as "partial" or "complete" according to the continuity of the fibers and clinical laxity[12]. The presence of the ALL was investigated in all sequences, the femoral origin was evaluated on the axial and coronal sequences while the meniscal attachment and tibial insertion were evaluated only on the coronal sequences[13]. The distance between the inferior aspect of the lateral meniscus and tibial insertion, and the thickness of the ALL at the subchondral bone level were measured. ALL injury was examined on the coronal T2 sequences. An increased intensity without disruption in ALL fiber continuity was examined. In the cases with disruption, the lesion was examined to check whether it was a partial or complete one (Figures 1,2)[6,13].

The demographic data of the cases, visibility of the ALL, classification of the components, presence of ACL and ALL injury, location of the injury, and injury type were recorded. Correlations between the ACL and ALL injury characteristics and accompanying lesions were evaluated. Interobserver reliability was also evaluated.

Statistical Analysis

Statistical analyses were performed using Number Cruncher Statistical system 2007 (Kaysville, UT, USA). Descriptive statistics (mean, standard deviation, median, frequency, ratio, minimum, maximum) were used. Normality was tested with the Shapiro-Wilk test. The Mann-Whitney U test was used for quantitative data without normal distribution. Chi-square test was used for qualitative variables. Significance was set at $p<0.01$.

RESULTS

Results are summarized in Table 1. The majority (54.4%) of ACL lesions were partial and located proximally. The ALL could not be visualized in 10.8% of cases. Among cases where the ALL was visible, injury was detected in 81%, and the majority (81.3%) showed loss of continuity. Most ALL injuries (68.2%) occurred at the femoral origin. No bone avulsion was observed.

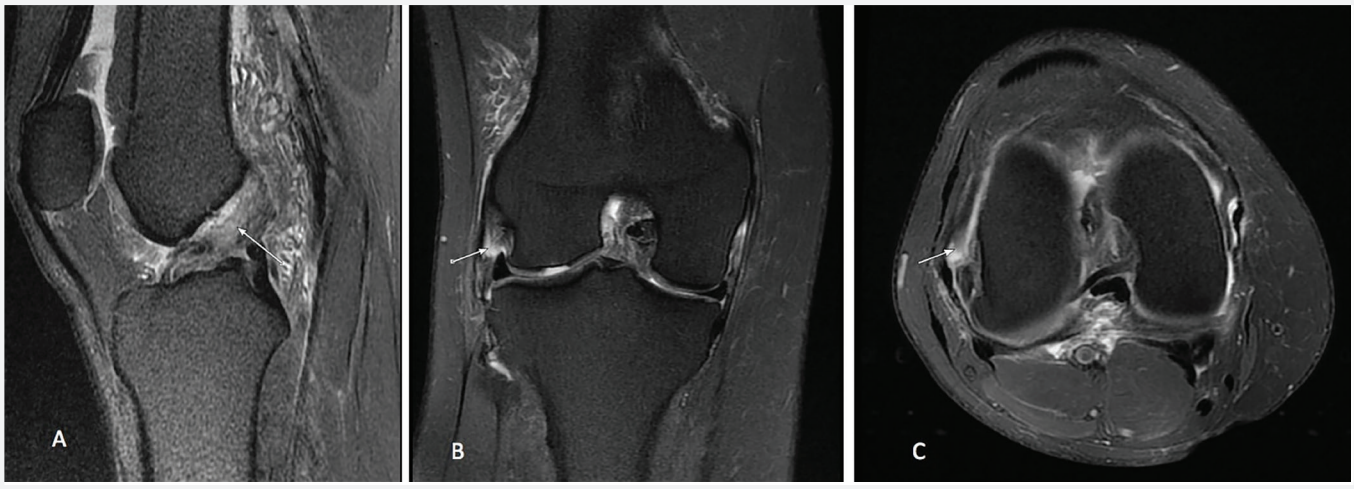

Figure 1. (A) Complete ACL injury on a sagittal T2 image. (B) Complete ALL injury in the femoral location on a coronal T2 image. (C) Complete ALL injury on the axial sequence

ACL: Anterior cruciate ligament, ALL: Anterolateral ligament

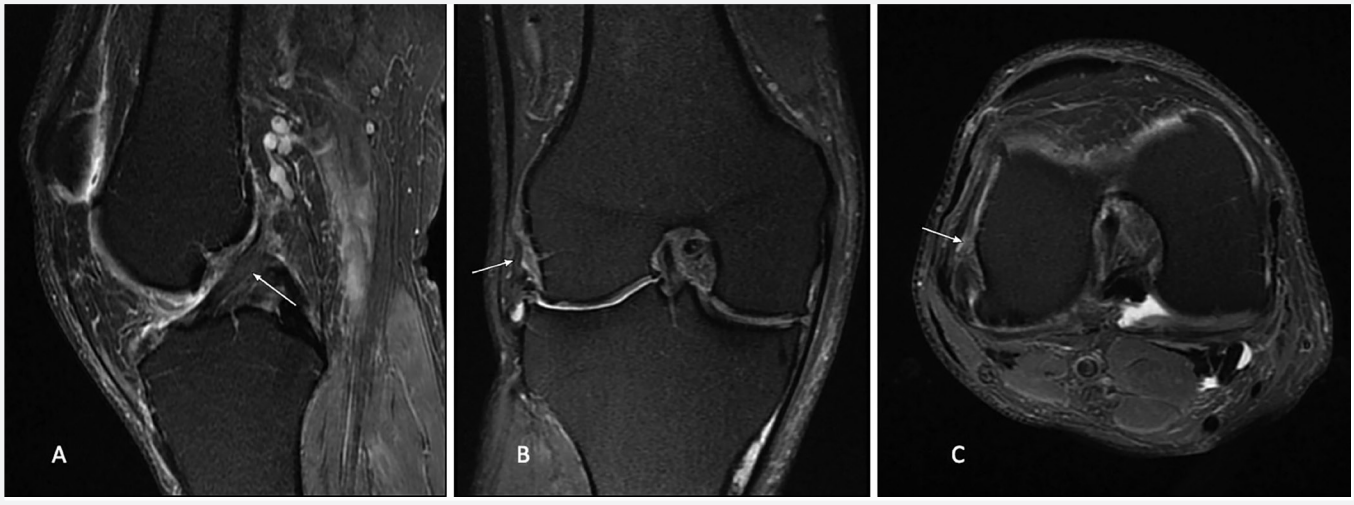

Figure 2. (A) Partial ACL injury on a sagittal T2 image. (B) Partial ALL injury in the femoral origin region on a coronal T2 image. (C) Partial ALL injury on an axial T2 image

ACL: Anterior cruciate ligament, ALL: Anterolateral ligament

As shown in Table 2, there was a significant correlation between ACL injury type and presence of ALL injury (p=0.002). No significant correlation was found between ACL injury type and location (Table 3). A significant correlation existed between ACL injury type and both presence and type of ALL injury (p=0.002 and p=0.013, respectively) (Table 4). No correlation was observed between meniscal attachment morphology and ALL injury or lateral meniscus tear (Table 5). Medial meniscus tear was seen in only seven cases. Lateral meniscus tear occurred in 32 cases and was significantly associated with ALL injury (p=0.024). Medial kollateral ligament injury was detected in six cases and lateral collateral ligament (LCL) injury in 17 cases; no significant correlation was found with ALL injury or bone contusion (Table 6). ALL diameter was significantly increased in injured patients compared to non-injured patients (p=0.001) (Table 7). Interobserver reliability was excellent [confidence interval (CI): 0.98; 95% CI: 0.98-0.99].

Table 1. Demographics and clinical examination and measurement results of the patients

Age (years)	31.8 (range: 20 to 40)
Gender (male: female)	100:48
Side (right: left)	72:76
Time between trauma and MRI (days)	11.43 (range: 1 to 25)
Distance to tibial attachment (mm)	4.26 (range: 4 to 10.4)
Diameter of the ALL (mm)	3.54 (range: 1.1 to 9)
Femoral origin	
Not visualized	16 (10.8%)
LE	116 (78.4%)
AD-LE	8 (5.4%)
PP-LE	8 (5.4%)
Tibial visualization	
Not visualized	16 (10.8%)
Visualized	132 (89.2%)
Meniscal attachment	
Not visualized	16 (10.8%)
Inferior	2 (1.4%)
Bipolar	52 (35.1%)
Complete	65 (43.9%)
Central	13 (8.8%)
ACL injury type	
Partial	80 (54.1%)
Complete	68 (45.9%)
ACL injury location	
Proximal	137 (92.6%)
Middle	2 (1.4%)
Distal	9 (6.1%)
ALL injury	
Not visualized	16 (10.8%)
Injured	107 (72.3%)
Non-injured	25 (16.9%)
ALL injury type (n=107)	
Increased intensity	20 (18.7%)
Partial	57 (53.3%)
Complete	30 (28.0%)
ALL injury location	
Femur	73 (68.2%)
Meniscus	5 (4.7%)
Tibia	13 (12.1%)
Complete	16 (15.0%)

The data in parentheses indicate the incidence, while the data outside the parentheses indicate the number of cases (n)

ACL: Anterior cruciate ligament, ALL: Anterolateral ligament, LE: Lateral epicondyle, AD: Anterodistal, PP: Posteroproximal, MRI: Magnetic resonance image

Table 2. Relationship between the ACL injury type and the presence of ALL injury

		Presence of ALL injury		p*
		Non-injured	Injured	
ACL injury type	**Partial**	20 (80%)	50 (46.7%)	0.002†
	Complete	5 (20%)	57 (53.3%)	

The data in parentheses indicate the incidence, while the data outside the parentheses indicate the number of cases (n)

ACL: Anterior cruciate ligament, ALL: Anterolateral ligament, *: Chi-square test, †: p<0.01

Table 3. Relationship between the ACL injury type and ALL injury location

		ACL injury type		p*
		Partial	Complete	
ALL injury location	**Proximal**	37 (52.9%)	36 (58.1%)	0.254
	Meniscal	3 (4.3%)	2 (3.2%)	
	Tibial	6 (8.6%)	7 (11.3%)	
	Complete	8 (11.4%)	8 (12.9%)	
	None	16 (22.9%)	9 (14.5%)	

The data in parentheses indicate the incidence, while the data outside the parentheses indicate the number of cases (n)

ACL: Anterior cruciate ligament, ALL: Anterolateral ligament, *: Chi-square test

Table 4. Relationship between the ACL injury type and ALL injury type

		ACL injury type		p*
		Partial	Complete	
ALL injury type	**Partial**	33 (47.1%)	24 (38.7%)	0.013†
	Complete	9 (12.9%)	21 (33.9%)	
	Increased intensity	12 (17.1%)	8 (12.9%)	
	None	16 (22.9%)	9 (14.5%)	

The data in parentheses indicate the incidence, while the data outside the parentheses indicate the number of cases (n)

ACL: Anterior cruciate ligament, ALL: Anterolateral ligament, *: Chi-square test, †: p<0.01

DISCUSSION

The most important finding of this study was the high rate of ALL injury accompanying partial ACL injuries.

There is still no consensus regarding the posttraumatic morphology of the ALL[6,14,15]. Following ACL injury, the ALL could not be visualized in 24% of cases in Claes et al.[6], 12.8% in Helito et al.[16] and 10.8% in our series. ALL injury rates were 32.6% in Helito et al.[16] and 78.8% in Claes et al.[6]. Our rate of 81% was notably high, possibly due to inclusion of increased signal intensity as injury and the predominance of partial ACL cases (Figure 3).

Lesion classification is as critical as radiographic anatomy when considering surgical reconstruction. Ferretti et al.[17] reported

Table 5. Relationship between meniscal attachment and the presence of ALL injury and lateral meniscus tear				
		Presence of ALL injury		p*
		Non-injured	Injured	
Meniscal attachment	Inferior	0 (0%)	2 (1.9%)	0.594
	Bipolar	8 (32%)	44 (41.1%)	
	Complete	13 (52%)	52 (48.6%)	
	Central	4 (16%)	9 (8.4%)	
		Lateral meniscus tear		p*
		Absent	Present	
Meniscal attachment	Inferior	2 (2%)	0 (0%)	0.390
	Bipolar	39 (39.8%)	13 (38.2%)	
	Complete	46 (47%)	19 (55.9%)	
	Central	11 (11.2%)	2 (5.9%)	

The data in parentheses indicate the incidence, while the data outside the parentheses indicate the number of cases (n)
ALL: Anterolateral ligament, *: Chi-square test

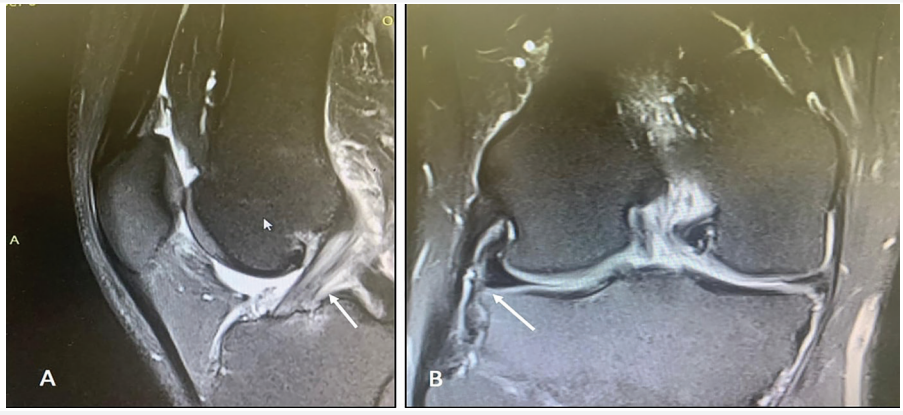

Figure 3. (A) Partial ACL injury on a sagittal image. (B) Increased intensity in the ALL on the coronal sequence
ACL: Anterior cruciate ligament, ALL: Anterolateral ligament

multi-level ALL ruptures in half of their surgical cases. In our MRI evaluation, 16% of cases showed ALL involvement at all three levels. Normal ALL thickness has been reported as 2.09 mm in men and 1.09 mm in women by Daggett et al.[18] and 1.75 mm by Kosy et al.[13] In our ACL injury cohort, ALL thickness was 3.54 mm overall and significantly higher in injured cases (4.03±1.11 mm vs. 3.3±0.59 mm). This increase, likely trauma-related, aligns with Ferretti et al.[15] observations of increased signal (79.4%) and thickness change (64.7%).

The most common site of ALL injury remains controversial. Some studies report tibial predominance,[6,11] while others note femoral predominance (72% in Helito et al.[16] 55.5% in Lee et al.[19]). In our series, 68.2% of injuries were at the femoral origin (Figure 4).

The trauma mechanism injuring the ACL can also affect adjacent structures. Lateral meniscus injury was seen in 22.9% of our cases, similar to 21.7% in Helito et al.[16] A significant correlation was found between ALL injury and lateral meniscus tear, suggesting a shared injury mechanism. Although not statistically significant, bone contusion of the lateral femoral condyle and LCL injury frequently co-occurred with ALL injury, consistent with the literature[20].

It is known that 14% to 56% of conservatively treated partial ACL injuries progress to complete tears within five years[1,21]. In patients under 30 years, Fayard et al.[3] reported progression in 39% of cases, while Fritschy et al.[22] reported 41.8%. Many studies on partial ACL progression have not assessed ALL injury[23]. ALL lesions have limited spontaneous healing potential, with 70% showing poor healing at one-year follow-up[19]. In our study, ALL

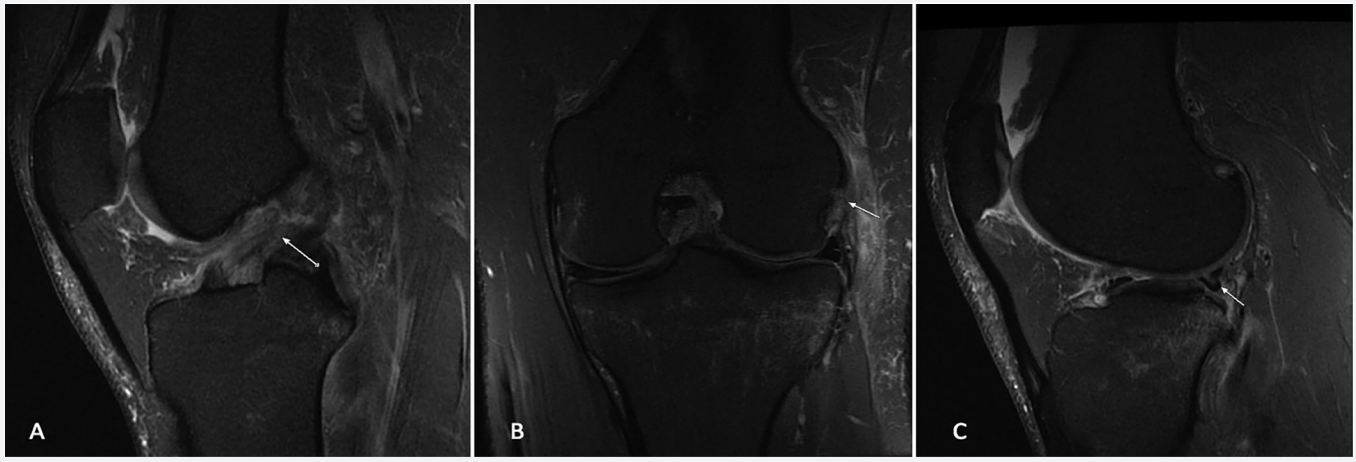

Figure 4. (A) Complete ACL rupture on a sagittal image. (B) Partial ALL injury and tibial bone contusion in the femoral origin region on a coronal T2 sequence. (C) Lateral meniscus injury

ACL: Anterior cruciate ligament, ALL: Anterolateral ligament

Table 6. Relationship between the presence of ALL injury and lateral meniscus tear, lateral collateral ligament injury and bone contusion

		Lateral meniscus tear		p*
		Absent	Present	
Presence of ALL injury	Non-injured	23 (23.5%)	2 (5.9%)	0.024
	Injured	75 (76.5%)	32 (94.1%)	
		LCL injury		
		Absent	Present	
	Non-injured	24 (21.1%)	1 (5.6%)	0.101
	Injured	90 (78.9%)	17 (94.4%)	
		Bone contusion		
		Absent	Present	
	Non-injured	24 (20.7%)	1 (6.3%)	0.167
	Injured	92 (79.3%)	15 (93.7%)	

The data in parentheses indicate the incidence, while the data outside the parentheses indicate the number of cases (n)

ALL: Anterolateral ligament, LCL: Lateral collateral ligament, *: Chi-square test

Table 7. Comparison of the ALL diameter with the presence of ALL injury

		n	Mean ± SD	Minimum-maxim (median)	p*
ALL diameter	Non-injured	25	3.3±0.59	1.6-4.1 (3.3)	**0.001**†
	Injured	107	4.03±1.11	1.2-9 (3.9)	

The data in parentheses indicate the incidence, while the data outside the parentheses indicate the number of cases (n)

ALL: Anterolateral ligament, SD: Standard deviation, *: Kruskal-Wallis test, †: p<0.01

injury was present in the majority of partial ACL cases (77% vs. 85% in complete ACL cases). Therefore, ALL injury should be considered in the progression of partial ACL tears and risk of re-rupture.

Study Limitations

This study has several limitations. It was based solely on radiological findings without clinical correlation. ALL injuries were not surgically verified. The sample size was relatively small, and clinical outcomes were not evaluated. However, the large proportion of partial ACL cases provides a unique perspective on

the relationship between ACL injury type and ALL injury. Further clinical studies on functional outcomes in isolated partial ACL lesions with ALL injury are warranted.

CONCLUSION

In conclusion, a high rate of ALL injury was detected in this series, which predominantly comprised partial ACL injury patients. Our results suggest that the presence of ALL injury should be considered in the management of young and active individuals with partial ACL injuries to avoid potential complications.

Ethics

Ethics Committee Approval: This study was approved by the Tekirdağ Namık Kemal University Non-Interventional Clinical Research Ethics Committee (protocol number: 2021.46.02.09, date: 23.02.2021).

Informed Consent: The study is a retrospective study.

Footnotes

Authorship Contributions

Surgical and Medical Practices: M.Ü.Ç., A.S., F.E., Concept: M.Ü.Ç., A.S., B.K.S., Design: M.Ü.Ç., A.S., F.E., B.K.S., Data Collection or Processing: M.Ü.Ç., A.S., F.E., B.K.S., Analysis or Interpretation: M.Ü.Ç., A.S., F.E., B.K.S., Literature Search: A.S., B.K.S., Writing: M.Ü.Ç., A.S., F.E., B.K.S.

Conflict of Interest: No conflict of interest was declared by the authors.

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