

Research Article / Araştırma Makalesi

# Incidence rates of injuries associated with anterior cruciate ligament tear diagnosed by magnetic resonance imaging: A retrospective cohort study

## Manyetik rezonans görüntüleme ile tanı konulmuş ön çapraz bağ yırtığı ile ilişkili yaralanmaların görülme sıklığı: Retrospektif kohort çalışması

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### ABSTRACT

**Objective:** Preceding studies to date have assessed the relationship between anterior cruciate ligament (ACL) tears and other related injuries without evaluating the ACL tear as partial or complete. In this study, we aimed to investigate the relationship between the type of an ACL tear assessed with magnetic resonance imaging and demographic factors, injury characteristics, and concomitant injuries.

**Material and Methods:** A retrospective cohort study was performed on patients admitted to the Sports Medicine Outpatient Clinic. The diagnosis of ACL tear was based on magnetic resonance imaging. Of the 310 patients with an acute ACL injury, 90 patients diagnosed with ACL tear by magnetic resonance imaging were divided into two groups according to the tear type; partial (n=26) and complete tear (n=64). Demographic factors, injury characteristics and meniscal, articular cartilage, collateral ligament, and posterior cruciate ligament lesions confirmed by magnetic resonance imaging were recorded.

**Results:** The mean age of the participants was 27.2 ± 7.9 years. Most of the patients (74.4%) were recreational athletes and football was the most common sports discipline (65.6%) among the patients. The most common accompanying injury was meniscal tear (61.1%), followed by articular cartilage damage (45.6%). There were no significant differences between partial tear and complete tear groups regarding incidence rates of injuries accompanying the ACL tear (p > 0.05 for all).

**Conclusion:** We found similar incidence rates of menisci, articular cartilage, collateral ligaments, and posterior cruciate ligament injuries associated with ACL tear among the partial ACL tear and the complete ACL tear groups.

**Keywords:** Knee, anterior cruciate ligament injury, meniscus, cartilage

### ÖZ

**Amaç:** Bugüne kadar yapılan çalışmalarda, ön çapraz bağ (ÖÇB) yırtığı ile buna eşlik eden diğer yaralanmalar arasındaki ilişki, ÖÇB yırtığı kısmi veya tam kat olarak ayrılmaksızın incelenmiştir. Bu çalışmada, manyetik rezonans görüntüleme aracılığıyla değerlendirilen ÖÇB yırtığının tipi ile demografik faktörler, yaralanma özellikleri ve eşlik eden yaralanmalar arasındaki ilişkinin incelenmesi amaçlanmıştır.

**Gereç ve Yöntem:** Spor Hekimliği Polikliniğine başvuran hastalar retrospektif kohort yöntemiyle değerlendirildi. ÖÇB yırtığı tanısı manyetik rezonans görüntüleme ile konuldu. Akut ÖÇB yaralanması geçiren 310 hastadan manyetik rezonans görüntülemesi ile ÖÇB yırtığı tanısı alan 90 hasta yırtık tipine göre kısmi (n=26) ve tam kat yırtık (n=64) olarak iki gruba ayrıldı. Demografik faktörler, yaralanma özellikleri ve manyetik rezonans görüntüleme ile teyit edilmiş menisküs, eklem kıkırdağı, kollateral ligamentler ve arka çapraz bağ lezyonları kaydedildi.

**Bulgular:** Katılımcıların yaş ortalaması 27.2±7.9 yıl idi. Hastaların çoğu (%74.4) rekreasyonel sporcular olup, en yaygın spor disiplini futboldu (%65.6). En sık eşlik eden yaralanmalar menisküs yırtığı (%61.1) ve eklem kıkırdağı hasarı (%45.6) olarak bulundu. ÖÇB yırtığına eşlik eden yaralanmaların görülme sıklığı açısından kısmi yırtık ve tam kat yırtık grupları arasında istatistiksel anlamlı fark gözlemlenmedi (tümü için p>0.05).

**Sonuç:** Kısmi ÖÇB yırtığı ve tam kat ÖÇB yırtığı grupları arasında ÖÇB yırtılması ile ilişkili menisküs, eklem kıkırdağı, kollateral ligamentler ve arka çapraz bağ yaralanmaları açısından benzer görülme sıklığı bulundu.

**Anahtar Sözcükler:** Diz, ön çapraz bağ yaralanması, meniskü, kıkırdak

### INTRODUCTION

The anterior cruciate ligament (ACL) is accountable for resisting translational and rotational load at the knee, especially during the pivoting movement, as it gives high rotational stress on the knee (1). An isolated ACL tear is rare and

occurs in less than ten percent of cases (2). Consequently, further evaluation is necessary for the presence of ACL-associated injuries (2).

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The most common injuries related to ACL tear are meniscal, articular cartilage, medial collateral ligament (MCL) and lateral collateral ligament (LCL) injuries owing to the anatomical and functional relations of these structures with ACL (2). The incidence of accompanying meniscal injury is about 60% (3,4), articular cartilage injury is between 16 - 46% (5), and MCL and LCL injury is between 5 - 24% (6,7).

The disruption of ACL eventually causes changes in knee kinematics due to instability in the joint (8,9). Patients with partial ACL tears often suffer similar to a complete tear, however, mechanical instability of the knee is rather small in a partial tear than a complete tear (9). Demographic and other confounding variables such as sports discipline, skill level, and mechanism of injury, which constitute a risk factor for accompanying injuries in patients with ACL rupture, have been previously studied (4,10,11). Previous studies have evaluated the relationship between ACL tears and other related injuries without considering the ACL tear as partial or complete (4,10,11). As mentioned above, in partial tear, mechanical instability of the knee is rather small when compared to complete tear. Therefore, the incidence of injuries accompanying partial and complete ACL tears might vary. To our best of knowledge, no studies have been reported on the relationship between the type of an ACL tear, as partial or complete, and demographic factors, injury characteristics, and concomitant injuries.

The aims of our study were; to evaluate the epidemiology of injuries accompanying ACL tear, and to assess whether there was a difference in the incidence of concomitant injuries between partial ACL tear and complete ACL tear.

## MATERIAL and METHODS

### Study Design

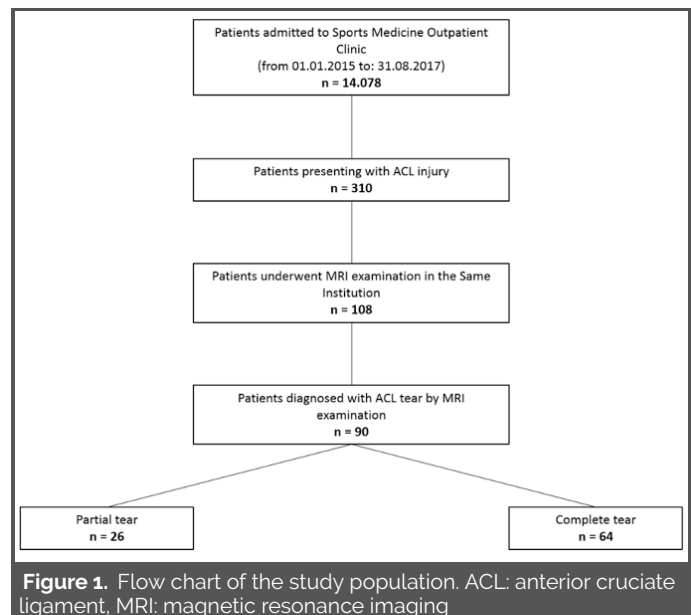
A retrospective cohort study was performed on patients admitted to the Sports Medicine Outpatient Clinic to investigate the association between the type of an ACL tear and demographic factors, injury characteristics, knee magnetic resonance (MR) imaging findings. The Local Research Ethics Committee approved the study with GO/17/681-38 Decision Number.

### Study Population

Inclusion criteria for this study were; to have an acute ACL injury according to the history and physical examination, to have an MR image at the same institution, and to have a partial or total ACL rupture according to MR imaging at the initial presentation. Since multiplanar MR imaging of ACL provides improved accuracy and confidence regarding the diagnosis of ACL tears, all MR examinations were performed in the axial, coronal, and sagittal plane (12). Recurrent ACL injury, a history of previous surgery involving knee, li-

gamentous lesions or osteoarthritis, and the absence of an MR image in the same institution were exclusion criteria.

For this purpose, a total of 14.078 patients applied to our institution for any complaints between 01.01.2015 - 31.08.2017 were reviewed retrospectively from medical records (Figure 1). The diagnosis for ACL injury was based on history and/or physical examination, whereas the diagnosis of ACL tear was based on MR imaging. Accordingly, there were 310 patients with an acute ACL injury, and 108 of them had an MR image at our institution. Finally, 90 patients diagnosed with ACL tear by MR imaging were divided into two groups according to the type of the tear: partial tear (n = 26) and complete tear (n = 64).



### Data Collection

The clinical notes were reviewed to gather data regarding patients' age, gender, level of sports activity, sports discipline, injury side, and injury type.

In all patients, meniscal, articular cartilage, MCL, LCL, and posterior cruciate ligament (PCL) lesions were confirmed by MR imaging. Meniscal tears were classified according to the International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine (ISAKOS) classification (13). Meniscal tears were further classified according to their presence in the medial and/or lateral meniscus, and in the anterior horn, the body, and/or the posterior horn.

### Statistical Analysis

Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 21 software (IBM SPSS Statistics for Windows, Version 21.0., Armonk, New York, USA). The variables were investigated using visual (histograms and probability plots) and analytical met-

hods (Kolmogorov-Smirnov test and Shapiro-Wilk test) to determine normal or non-normal distributions. Descriptive analyses were presented using means and standard deviations, medians and range, or frequencies and percentages, where appropriate. The Mann-Whitney U test was used to compare age between groups. The Chi-square test or Fisher's exact test was used to compare the gender, level of sports activity, sports discipline, ACL injury side, ACL injury type, and the knee MR imaging findings between groups. The correlation between the type of an ACL tear and other variables was investigated using the Spearman test because the ordinal variables were present. A 5% type-I error level was used to infer statistical significance.

**RESULTS**

Demographic characteristics, level of sports activity, and sports discipline of the patients are given in Table 1. The mean age of the participants was 27.2 ± 7.9 years. Most of the patients (74.4%) were recreational athletes. Football was the most common sports discipline (65.6%) among the patients, followed by basketball (10 %) and volleyball (5.6%).

**Table 1.** Demographic characteristics of the patients

	Total (n = 90)	Male (n = 80)	Female (n = 10)
<b>Age, years</b>			
Mean ± SD	27.2 ± 7.9	27.9 ± 7.6	20.9 ± 7.9
<b>Level of sports activity</b>			
Recreational, n (%)	67 (74.4)	64 (80)	3 (30)
Professional, n (%)	23 (25.6)	16 (16)	7 (70)
<b>Sports discipline</b>			
Football, n (%)	59 (65.6)	59 (73.8)	-
Basketball, n (%)	9 (10)	6 (7.5)	3 (30)
Volleyball, n (%)	5 (5.6)	2 (2.5)	3 (30)
Kickboxing, n (%)	3 (3.3)	2 (2.5)	1 (10)
Ski, n (%)	2 (2.2)	1 (1.3)	1 (10)
Athletics, n (%)	2 (2.2)	1 (1.3)	1 (10)
American football, n (%)	2 (2.2)	2 (2.5)	-
Others*, n (%)	8 (8.9)	7 (8.6)	1 (10)

\*Other sports disciplines: badminton, bicycle, gymnastics, handball, rugby, ultimate frisbee, wrestling.

Comparisons between the partial tear and complete tear groups according to age, sex, level of sports activity, sports discipline, and side of injury are given in Table 2. There were no significant differences between the groups in terms of the aforementioned parameters (p > 0.05 for all).

Distribution of meniscal, articular cartilage, MCL, LCL, and PCL lesions accompanying ACL tear is presented in Table 3. The most common accompanying injury was meniscal tear (total: n = 55, 61.1%; partial tear: n = 13, 50%; and complete tear: n = 42, 65.6%), followed by articular cartilage damage (total: n = 41, 45.6%, partial tear: n = 10, 38.5%, and complete tear: n = 31, 48.4%).

Of 90 patients; 39 had an isolated medial meniscus tear (43.4%), 6 had an isolated lateral meniscus tear (6.7%), 10

had tears of both menisci (11.1%), and 35 patients had no meniscal tear (38.9%). The meniscus tear was most commonly seen in the medial meniscus (n = 49, 54.4%), and the most common tear location of the medial meniscus was the posterior horn, followed by the body. Also, there were no differences between partial tear and complete tear groups regarding meniscal, articular cartilage, MCL, LCL, and PCL lesions in MR imaging (p > 0.05 for all). There were no significant correlations between the type of an ACL tear and other lesions accompanying ACL tear (p > 0.05 for all).

**Table 2.** Comparison of the groups according to the type of anterior cruciate ligament (ACL) tear by magnetic resonance (MR) imaging

	Total (n = 90)	Partial tear (n = 26)	Complete tear (n = 64)	P
<b>Age</b>				
Mean ± SD	27.2 ± 7.9	28.9 ± 8.2	26.5 ± 7.8	0.25
Median (min-max)	27.5 (15 - 54)	29 (15 - 54)	25 (16 - 54)	
<b>Sex</b>				
Male, n (%)	80 (88.9)	22 (84.6)	58 (90.6)	0.47
Female, n (%)	10 (11.1)	4 (15.4)	6 (9.4)	
<b>Level of sports activity</b>				
Recreational, n (%)	67 (74.4)	23 (88.5)	44 (68.8)	0.05
Professional, n (%)	23 (25.6)	3 (11.5)	20 (31.3)	
<b>Sports discipline</b>				
Football, n (%)	59 (65.6)	16 (61.5)	43 (67.2)	0.61
Others, n (%)	31 (34.4)	10 (38.5)	21 (32.8)	
<b>Injury side</b>				
Right, n (%)	50 (55.6)	15 (57.7)	35 (54.7)	0.79
Left, n (%)	40 (44.4)	11 (42.3)	29 (45.3)	

**DISCUSSION**

Studies have shown that isolated ACL tears are scarce and ACL tears mostly seen with accompanying menisci, articular cartilage, and collateral ligament injuries (4,10,11). In this study, we aimed to assess the relationship between the type of an ACL tear and demographic factors, injury characteristics, and concomitant injuries. Preceding studies to date have assessed the relationship between ACL tears and other related injuries without evaluating the ACL tear as partial or complete. Therefore, according to our current knowledge, the lack of studies assessing the relationship between the type of an ACL tear, as partial or complete, and demographic factors, injury characteristics, and concomitant injuries make our findings significant. Additionally, the fact that the relevant results were obtained from patients who applied to the outpatient clinic for 2.5 years was another important point of our study. Our findings regarding the overall incidence of injuries accompanying ACL rupture were in line with the rates in the literature (3-7).

Football was the most common sports discipline not only in total (65.6%) but also in partial tear (61.5%) and complete tear (67.2%) groups. Similarly, in a study evaluating the patient demographics and injury patterns at the time of ACL reconstruction by activities that lead to ACL injuries, Granan et al. found football as the leading sport which was associated with ACL injuries (14). The position of the player in football as on offense or defense, the action of the player as heading, passing, receiving the ball or tackling have an impact on the risk of ACL injury (15). The fact that there are many defensive and tackling maneuvers in football might explain

why football was the most common sport discipline in patients with ACL tears (15).

**Table 3.** Knee MR imaging findings of the patients diagnosed with anterior cruciate ligament (ACL) tear

		Total (n = 90)	Partial tear (n = 26)	Complete tear (n = 64)	P
<b>Meniscal tear</b>		55 (61.1)	13 (50)	42 (65.6)	0.17
<b>Medial Meniscus (n = 49)</b>	<b>Posterior horn tear</b>	38 (42.2)	8 (30.8)	30 (46.9)	0.16
	<b>Anterior horn tear</b>	6 (6.7)	-	6 (9.4)	0.18
	<b>Body tear</b>	10 (11.1)	2 (7.7)	8 (12.5)	0.72
<b>Lateral Meniscus (n = 16)</b>	<b>Posterior horn tear</b>	13 (14.4)	2 (7.7)	11 (17.2)	0.33
	<b>Anterior horn tear</b>	5 (5.6)	-	5 (7.8)	0.32
	<b>Body tear</b>	2 (2.2)	2 (7.7)	-	0.08
<b>Articular cartilage damage</b>		41 (45.6)	10 (38.5)	31 (48.4)	0.39
<b>MCL sprain</b>		11 (12.2)	2 (7.7)	9 (14.1)	0.5
<b>LCL sprain</b>		1 (1.1)	-	1 (1.6)	> 0.99
<b>PCL sprain</b>		1 (1.1)	1 (3.8)	-	0.29

Data were presented as number (%). LCL: lateral collateral ligament, MCL: medial collateral ligament, MR: magnetic resonance, PCL: posterior cruciate ligament

When we examined the incidence of meniscus injury, we found that more than half of the patients (54.5%) had a medial meniscal tear, and the most common tear location of both the medial and lateral menisci was the posterior horn. These findings were consistent with the literature (4). The medial meniscus thought to be a secondary stabilizer of the knee after ACL against the anterior displacement of the tibia, therefore, it is subjected to anterior-posterior shear forces (4). High incidence of medial meniscus injury is most likely associated with ACL injury due to this feature.

We did not find a significant difference in terms of the incidence of menisci, articular cartilage, MCL, LCL, and PCL injuries associated with ACL tear between the partial tear and the complete tear groups. Disruption of ACL might eventually cause associated injuries, leading to changes in knee kinematics due to instability in the joint (8,9). Mechanical instability in the knee of patients with a partial tear is thought to be rather small than a complete tear (9). In a study, Fayard et al. assessed the risk factors for a partial ACL tear progressing to a complete tear (16). The authors included 41 patients, who were active in sport and diagnosed with a partial ACL tear, with no concomitant meniscal or chondral lesions on MR imaging. They found that a partial ACL injury progressed to a complete ACL tear in 39% of patients, with half of the complete tears presenting with a concomitant meniscal lesion at the time of reconstruction. In light of the findings of our study and Fayard et al. (16), the impairment of knee biomechanics in ACL tear seems to lead the accompanying injuries in the chronic period rather than acute. Therefore, the similar incidence rates of ACL-related injuries among study groups might be explained by the inclusion of only patients with an acute ACL injury in our study.

Our study has some limitations. First, we did not have data on the lower extremity biomechanics of the participants, so we were not able to include these variables in the analysis. It is known that various mechanisms, such as lower limb alignment and load distribution might affect the frequency of meniscal tears in particular (4,17). Hence, conducting epidemiological studies involving biomechanical analysis will deepen our understanding of this subject. Secondly, although all patients were active in sports, their activity levels were not recorded. Further prospective studies including the aforementioned variables might provide a better understanding of the relationship between grade of ACL tear and the related injuries.

## CONCLUSION

We found football as the leading sport discipline associated with ACL injuries. The most common accompanying injury was the meniscal tear, followed by articular cartilage damage. The meniscal tear was most commonly seen in the medial meniscus, and the most common tear location was the posterior horn. We found similar incidence rates of menisci, articular cartilage, MCL, LCL, and PCL injuries associated with ACL tear among the partial ACL tear and the complete ACL tear groups.

### Conflict of Interest / Çıkar Çatışması

The authors declared no conflicts of interest with respect to authorship and/or publication of the article.

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