International Journal of Surgery 65 (2019) 25–31

Contents lists available at ScienceDirect

International Journal of Surgery

journal homepage: www.elsevier.com/locate/ijsu

Original Research

# Does anterolateral ligament rupture affect functional outcomes in patients who underwent an anterior cruciate ligament reconstruction?

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ARTICLE INFO

*Keywords:*
Anterior cruciate ligament
Anterolateral ligament
Arthroscopic reconstruction
MRI
Functional scoring of the knee

ABSTRACT

*Background:* Studies have shown that the anterolateral ligament contributes to knee stability. This study aims to compare the results of postoperative physical examinations, knee joint stability tests, and functional assessment tests of patients with intact anterolateral (AL) ligaments and patients with ruptured anterolateral (AL) ligaments.
*Material and method:* This study consisted of 101 patients, with at least a 12-month follow-up period, who underwent an anterior cruciate ligament reconstruction between 2010 and 2016, and whose AL ligaments were evaluated by the radiologist with the preoperative and postoperative magnetic resonance images (MRI). Of these patients, 41 had intact AL ligament (Group 1) in MRI and other 60 had ruptured AL ligament (Group 2). Groups were compared according to postoperative physical examinations, knee joint stability tests, and functional assessment tests.
*Results:* The average Lysholm score of Group 1 was 94.9 (range: 81–100), and the score of Group 2 was 87.2 (range: 74–100). The modified Cincinnati score of Group 1 was 28.7 (24–30), while the score of Group 2 was 25.6 (21–30). The average IKDC subjective knee evaluation score of Group 1 was 91.9 (range: 83–100), and the score of Group 2 was 86.6 (range: 75–100). The average thigh atrophy value was 1.5 centimeters (cm) in Group 1 and 2.4 cm in Group 2. Thirty-three patients in Group 1 were able to jump over 85% of the distance in single-legged hop test compared to the intact side, while 16 patients in Group 2 were able to jump over this distance successfully.

As a result of the analysis, it was determined that the Lysholm activity scoring results, the Modified Cincinnati scoring results, IKDC subjective knee evaluation results, two-cycle IKDC activity scale results, comparison of thigh diameters and the single-legged hop tests of two groups showed a statistically significant difference, and the results of the patients with intact AL ligaments who underwent an ACL reconstruction were found to be better ($p < 0.05$). No significant difference was found in other examinations and tests.
*Conclusion:* Since the rupture of the AL ligament has negative effects on functional outcomes, we think that the reconstruction of the AL ligament in the same session with the ACL reconstruction or later will have a positive effect on functional outcomes.

## 1. Introduction

The anterior cruciate ligament rupture is one of the common problems observed by orthopaedic surgeons. The most frequently injured ligament in the knee is the anterior cruciate ligament [1].

The continuation of the rotational instability in some patients after the anterior cruciate ligament reconstruction suggested that there might be other support structures that are effective in this stability. The anterolateral (AL) ligament was shown to play an important role in the stability of the knee together with the anterior cruciate ligament [2–5].

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https://doi.org/10.1016/j.ijsu.2019.03.010
Received 14 October 2018; Received in revised form 23 February 2019; Accepted 11 March 2019
Available online 16 March 2019
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The aim of this study was to compare the effect of ruptured AL ligament or intact AL ligament on the results of postoperative physical examinations, knee joint stability tests and functional assessment tests with the retrospective evaluation of preoperative or postoperative magnetic resonance imaging (MRI) of patients who underwent a ligament reconstruction with the anatomic single bundle method after an anterior cruciate ligament rupture.

## 2. Material and method

This study was approved by the Local Ethical Committee dated 28/12/2017 and numbered 2017/113/12/01.

212 patients who underwent an anterior cruciate ligament reconstruction were evaluated between 2010 and 2016 at a single clinic. Of these patients, 190 patients who underwent an anatomic single bundle arthroscopic ACL reconstruction with autogenous hamstring tendons were determined. The surgeries of these patients were performed by two experienced orthopaedists specialized in sports medicine. The same rehabilitation program was applied to all patients. Patients who could not be evaluated by MRI regarding the AL ligament and who had a follow-up of fewer than 12 months were excluded from the study. A hundred-one patients who could be evaluated by MRI regarding the AL ligament and who had a sufficient follow-up time were determined.

After the evaluation of MRIs by an experienced musculoskeletal system radiologist, 41 (Group 1) patients with intact AL ligament and 60 patients (Group 2) with ruptured AL ligament were determined.

The results of the active and passive range of motion, stability evaluation, and thigh atrophy evaluation were compared in the postoperative knee examination of the patients. In the evaluation of the postoperative stability, the Lachman test and anterior-posterior drawer test were evaluated as negative, 1(+), 2(+) and 3(+) [6,7]. In the evaluation of thigh atrophy, as applied by Risberg et al., the circumference of both thighs was compared by measuring from 15 cm proximal to the patella superior border [8].

The International Knee Documentation Committee (IKDC) knee examination, the IKDC subjective knee evaluation, the two-cycle IKDC activity scale, the Lysholm activity scoring and the modified Cincinnati scoring forms were used to compare the results of both groups. Postoperative examinations of the patients were performed by a single orthopaedic surgeon for standardization purpose.

According to these evaluations, it was assessed whether there was a statistically significant difference between the patients with intact AL ligaments who underwent an ACL reconstruction and the patients with ruptured AL ligaments who underwent an ACL reconstruction in terms of their physical examinations, knee joint stability tests and functional assessment tests.

The exclusion criteria of this study were that patients with multiple ligament injuries (PCL, MCL, LCL, PLC), meniscus injury, cartilaginous injury, skeletally immature, heavy manual workers, severe osteoarthritis, additional lower extremity fractures and patients who did not perform the single-legged hop test. Our study has been reported in line with the STROCSS criteria [9].

### 2.1. Statistical analysis

In this study, statistical analyses were performed using the SPSS 18.0 packaged software. In addition to descriptive statistical methods, the *t*-test, Mann-Whitney *U* test, and ANOVA test were used to compare data. The results were evaluated at a significance level of $p < 0.05$.

## 3. Results

The average age of 41 patients with intact AL ligament (Group 1) was 24.7 years (range:17–35) and their average follow-up period was 31.8 months (range:13–65). The average age of 32 patients with ruptured AL ligament (Group 2) was 25.1 years (range:17–35) and their average follow-up period was 33.5 months (range:12–60) (Table 1). The average age of two groups (p:0.70) and the follow-up period of two groups were not evaluated to be statistically significant (p:0.60).

**Table 1**
Assessment of age and follow-up duration intact ALL and ruptured ALL.

| | Intact ALL (n = 41) | Ruptured ALL (n = 60) |
|---|---|---|
| Age (year) | 24.7 ± 4.72 | 25.11 ± 5.53 |
| Follow up duration (month) | 31.8 ± 16.6 | 33.57 ± 16.6 |

Of the patients in Group 1, 38 (92.7%) were male. Twenty-two of these patients (53.6%) underwent reconstruction in the left knee and 19 (46.3%) in the right knee. Of the patients in Group 2, 54 (90%) were male. Thirty of these patients (50%) underwent reconstruction in the right knee and 30 (50%) in the left knee. The gender and side distribution of two groups were not evaluated to be statistically significant (p:0.64, p:0.71 respectively).

The average Lysholm activity score of the Group 1 patients was 94.9 ± 5.2 (range: 81–100) and the average of the Group 2 patients was 87.2 ± 8.48 (range: 74–100). The Lysholm activity score of the 61%(n = 25) patients with Group 1 was excellent, 34% (n = 14) was good, 5% (n = 2) was poor level. On the other hand, the Lysholm activity score of the 31.7% (n = 19) patients with Group 2 was excellent, 38.3% (n = 23) was good; 30% (n = 18) was poor level. It was observed that Lysholm activity scores were apparently better in group 1 (Fig. 1). This was also found to be statistically significant ($p < 0.01$).

The average modified Cincinnati score of the Group 1 patients was 28.7 ± 1.4 (24–30), while the average of the Group 2 was 25.6 ± 3.27 (21–30). Ninety-five percent (n = 39) of the Group 1 patients were at the excellent level and 5% (n = 2) were at good level; while 53.3% (n = 32) of the Group 2 patients were at the excellent level; 46.7% (n = 28) were at good level (Fig. 2). The average modified Cincinnati scores were evaluated to be statistically significant ($p < 0.01$).

The average IKDC subjective knee evaluation score of the Group 1 patients was 91.9 ± 5.01 (range: 83–100) and the average of the Group 2 patients was 86.6 ± 8.1 (range: 75–100). The IKDC subjective knee evaluation score of the 41.5% (n = 17) patients with Group 1 was excellent, 56% (n = 23) was good; 2.5% (n = 1) was poor level. On the other hand, IKDC subjective knee evaluation score of the 21.7% (n = 13) patients with Group 2 was excellent, 38.3% (n = 23) was good; 40% (n = 24) was poor level. It was observed that IKDC subjective knee evaluation scores were apparently better in group 1 (Fig. 3). This was also found to be statistically significant ($p < 0.01$).

According to the IKDC knee examination score, 73.1% (n = 30) of the Group 1 patients had normal results, 26.9% (n = 11) had near-normal results, while 60% (n = 36) of the Group 2 patients had normal results and 40% (n = 24) had near-normal results. All of the patients in both groups to whom IKDC knee examination scoring was applied during their final follow-up were in the group with A and B scores (Table 2). The results of IKDC knee examination scoring were not evaluated to be statistically significant (p:0.17).

Thirty patients (73.1%) were at intensive activity and 11 patients (26.9%) at moderate activity before trauma in Group 1. 27 patients (66%) were at intensive activity, 12 patients (29%) at moderate activity and two patient (5%) at low activity during the final follow-up in Group 1. Forty-one patients (68.3%) were at an intensive activity and 19 patients (31.7%) at moderate activity before trauma in Group 2. 22 patients (36.7%) were at an intensive activity, 29 patients (48.3%) at a moderate activity and nine patient (15%) at low activity during the final follow-up in Group 2. There was no statistically significant difference between two-cycle IKDC activity scale ratios in the pre-traumatic period (p = 0.60), while the activities of Group 1 patients were better compared to Group 2 patients in the post-treatment period

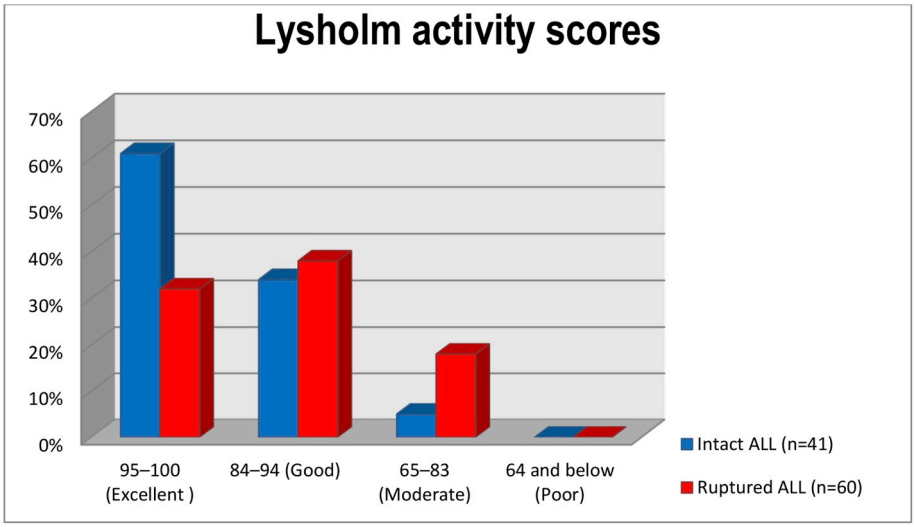


**Fig. 1.** The results of the patients with intact and ruptured AL ligaments according to the comparative Lysholm activity scores.

(p:0.01) (Fig. 4).

The average degree of flexion was 137.9° ± 8.8° (range: 125°–150°) in Group 1 patients, while it was 136.1° ± 10.7° (range: 120°–150°) in Group 2 patients (p:0.38).

The passive Lachman and anterior drawer tests were applied to the patients during their final controls. The results were evaluated as recommended by the American Medical Association [10] as 0–2 mm:(–), 3–5 mm:(+), 6–10 mm: (++), 11–15 mm (+++) (Tables 3 and 4). The anterior drawer test in a patient with an intact AL ligament, the anterior drawer test in a patient with a ruptured AL ligament and the Lachman test in two patients were determined as (+++). The results of the ACL stability tests were not statistically significant ($p > 0.05$).

In the evaluation of thigh atrophy, the circumference of both thighs was compared by measuring from 15 cm proximal to the patella superior border, and they were divided into three groups according to the determined circumference differences. The difference between the average thigh diameters was 1.5 ± 0.88 cm in Group 1 and 2.4 ± 1.06 cm in Group 2 (Fig. 5). The results of the thigh atrophy evaluation were found to be statistically significant ($p < 0.01$).

The patients were asked to jump as far as they could on a single leg, and the test results on the operated and non-operated sides were compared after three repeated tests for both knees. In Group 1, 33 patients were determined over 85% and in Group 2, 44 patients were determined under 85% (Fig. 6). The single-legged hop test results were evaluated to be statistically significant ($p < 0.01$).

As a result of the analysis, it was determined that the Lysholm activity scoring results, the modified Cincinnati scoring results, the IKDC subjective knee evaluation scoring results, two-cycle IKDC activity scale results, comparison of thigh diameters and single-legged hop tests of two groups showed a statistically significant difference, and the results of the patients with intact AL ligaments who underwent an ACL reconstruction were found to be better ($p < 0.05$). No significant difference was found in other examinations and tests.

Furthermore, physical examination and functional scoring results were found to be worse in patients with longer follow-up periods and ruptured AL ligament.

## 4. Discussion

The incidence of knee ligament injuries increases due to the increase in sports activities in the world, and the most frequent knee injury is the ACL injury. Although the frequency of the ACL injury varies by populations, it is 30–40/100000 per year [1,11]. Treatment of the anterior cruciate ligament is performed conservatively or surgically. The aim of

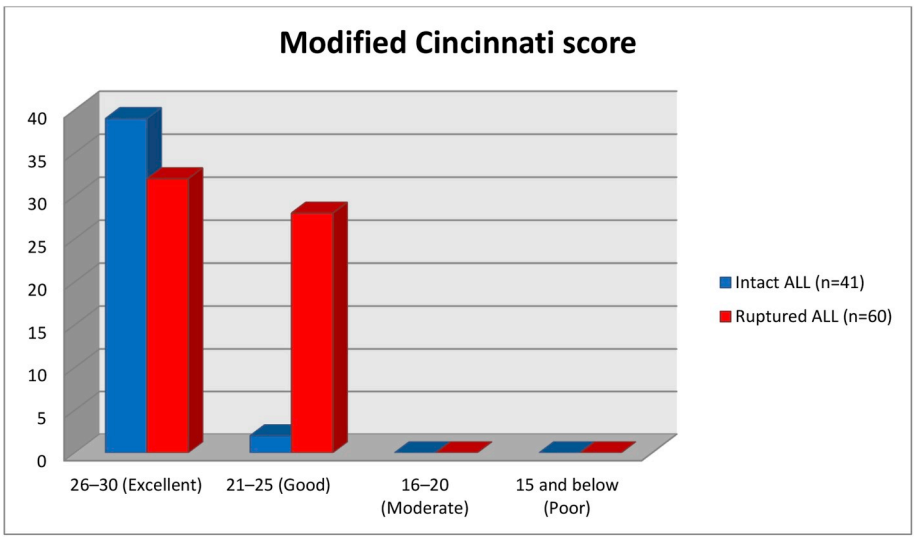


**Fig. 2.** The results of the patients with intact and ruptured AL ligaments according to the comparative Modified Cincinnati scoring.

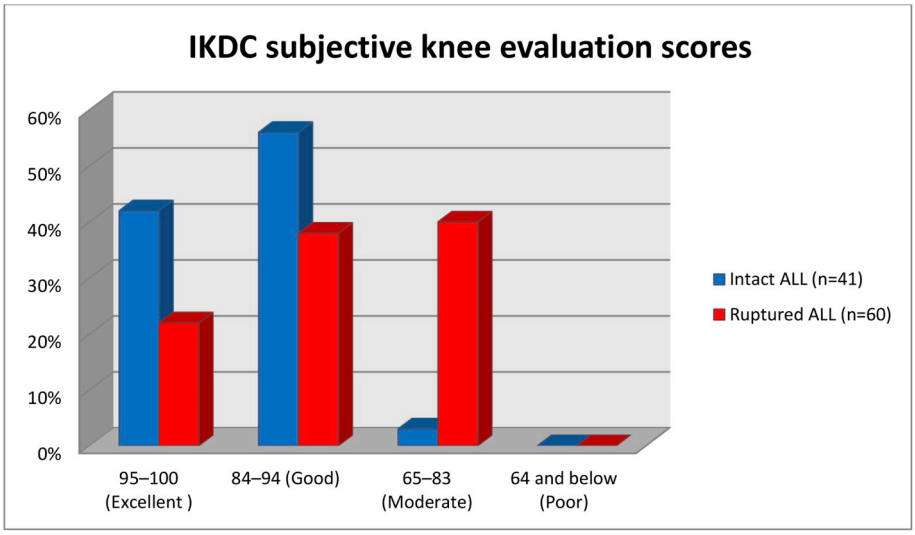


**Fig. 3.** The results of the patients with intact and ruptured AL ligaments according to the comparative IKDC subjective knee evaluation scoring.

**Table 2**
The results of the patients with intact and ruptured AL ligaments according to the comparative IKDC knee examination scoring.

| IKDC Score | Intact ALL n (%) (n = 41) | Ruptured ALL n (%) (n = 60) |
|---|---|---|
| A (Normal) | 73.1% (n = 30) | 60% (n = 36) |
| B (Near-Normal) | 26.9% (n = 11) | 40% (n = 24) |
| C (Abnormal) | 0% | 0% |
| D (Poor) | 0% | 0% |

the treatment is to return the patient to his/her daily and sports activities as soon as possible, as well as to protect him/her from recurrent traumas. Each new trauma causes a basis for a new meniscal, chondral and ligament damage, thus resulting with a more unstable knee [12]. The importance of AL ligament in the knee stability is confirmed with the study.

Despite many studies, the anatomy and function of the ACL are still being discussed [13]. Anatomical studies have shown that the ACL is divided into anteromedial (AM) and posterolateral (PL) bundles according to the location of tibial adhesion [14]. The anteromedial bundle primarily provides anterior tibial stability, especially during knee flexion, while the posterolateral bundle contributes to rotational knee stability, especially during knee extension [15–17].

After the ACL injuries, the activity of the individual is restricted and his/her quality of life decreases. To protect the knee and to provide the person with a higher quality of life, treatment of the ACL injury in the appropriate individuals is crucial. Regardless of which treatment method is selected for the ACL injuries, the main objective should be to protect the knee from recurrent traumas and to return the patient to his/her pre-injury activity and routine work as soon as possible [18]. Significant progress has been made in the ACL surgery, especially with the advance of arthroscopic techniques in the last 30 years [19]. However, as a result of all these studies, although the biology, biomechanics, and pathology of the ACL were better understood, a standard could not be established in the treatment of the ACL.

In 1879, Dr. Paul Segond described a ligament that causes the anterolateral bone fracture from the proximal tibia in many ACL injuries [20]. In their study in 1976, Dr.Hughston et al. gave information about the anatomy of the AL ligament [21]. In a study in 2013, Claes et al. explained the anatomical location of the AL ligament and its function [22].

Recent studies have shown that current ACL reconstruction techniques do not fully provide normal rotational stability of the knee

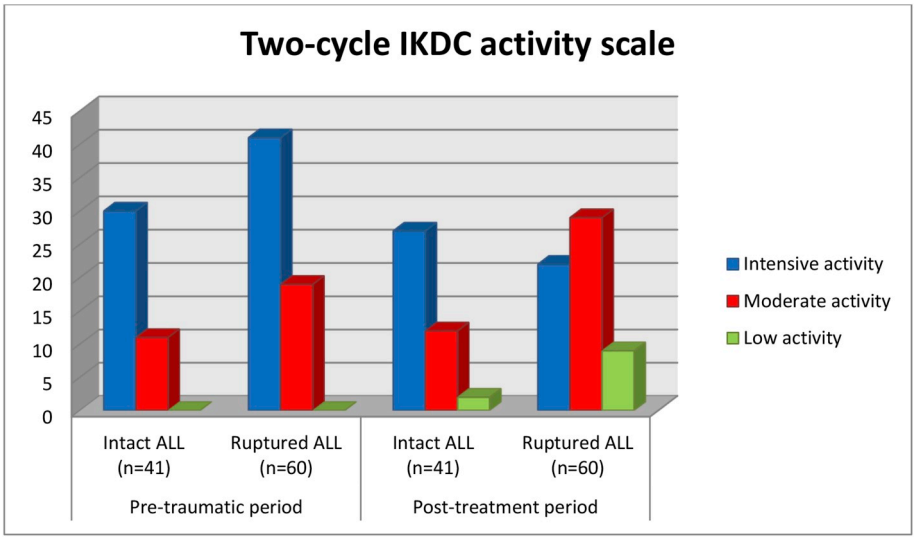


**Fig. 4.** The results of the patients with intact and ruptured AL ligaments according to the comparative two-cycle IKDC activity scale ratios.

**Table 3**
The ACL stability test results of the patients with intact AL ligaments.

| Stability test | (−) Negative n (%) | (+) Positive n (%) | (++) Positive n (%) | (+++) Positive n (%) |
|---|---|---|---|---|
| Anterior Drawer | 0% | 58.5% (n = 24) | 34.1% (n = 14) | 7.5% (n = 3) |
| Passive Lachman | 0% | 66% (n = 27) | 34% (n = 14) | 0% |

[23,24]. We stated that the available techniques were insufficient to provide rotational stability in the study. In many recent publications, the AL ligament has been shown to be particularly effective in knee stability and rotational stability [25,26].

In a study conducted by Hua Zhang et al., they evaluated the patients by dividing them into 3 groups. They included single-bundle reconstruction in the first group, double-bundle reconstruction in the second group, and AL ligament reconstruction as well as single-bundle reconstruction in the third group. In conclusion, it was stated that the application of the ACL reconstruction together with the anatomical AL ligament reconstruction increased the postoperative clinical outcomes [27]. Many techniques of the AL ligament reconstruction are described which have good early results has been reported [28–30]. However, it is emphasized that the ideal technique cannot be described in the publications so far.

Cottet et al. had performed a study about ACL & ALL reconstruction in the same session. They stated that the mean Lysholm score was 51.4 before the surgery and 92 at the last follow-up. At the last follow-up, 76 (91.6%) patients were graded as A and seven (8.4%) patients were graded as B according to the IDKC objective grading [31]. Shahpari et al. reported a study about anatomical transportal ACL reconstruction technique, the mean Lysholm score was 90, 56 patients (68%) had excellent (95–100) and good (84–94) results according to the IKDC objective grades [32].

Lee et al. compared single bundle and double-bundle ACL reconstruction techniques in a meta-analysis. They reported that clinical outcome scores were the same, such as the Lysholm knee function scores, the Tegner activity scores, side-to-side differences and the IKDC objective grades [33]. In the study, we found the average Lysholm knee functional score of the Group 1 patients as 94.9 ± 5.2 (range: 81–100) and the average of the Group 2 patients as 87.2 ± 8.48 (range: 74–100). The average modified Cincinnati score of the Group 1 patients was 28.7 ± 1.4 (24–30), while the average of the Group 2 was 25.6 ± 3.27 (21–30). The average IKDC subjective knee evaluation score of the Group 1 patients was 91.9 ± 5.01 (range: 83–100) and the average of the Group 2 patients was 86.6 ± 8.1 (range: 75–100). According to the IKDC objective grades, 73.1% (n = 30) of the Group 1 patients had normal results, 26.9% (n = 11) had near-normal results, while 60% (n = 36) of the Group 2 patients had normal results and 40% (n = 24) had near-normal results. Our results of the patients who had an intact ALL were similar as ACL and ALL reconstruction patients. The difference between the average thigh diameters was 1.5 ± 0.88 cm in ALL intact and 2.4 ± 1.06 cm in ALL ruptured patients. ALL ruptured patients have got more atrophy in the thigh. The single-legged hop test results of 33 patients were determined over 85% in ALL intact group while 44 patients were determined under 85% in ALL ruptured group.

The functional outcomes of patients were evaluated retrospectively, who had enough follow-up and could be evaluated to have a ruptured or intact AL ligament by the radiologist with the help of the MRIs of the patients. In this study, we found that patients with poor functional scores had ruptured AL ligaments in parallel with the publications. The follow-up period of the patients with ruptured AL ligaments gets longer, the functional scores of the patients also get worse according to our observation. However, since our average follow-up period was short and the number of patients with long-term follow-up was insufficient, we concluded that our patients should be followed for a longer period to reach more significant results. The superiority of our publication over other publications is that physical examination and functional scoring of patients were combined with the MRI interpretation.

The first limitation of the study is that the pivot-shift test performed preoperatively and postoperatively was not included in the study as it was not applied under anesthesia. Secondly, we could not evaluate each patient in the same time within the postoperative follow-up period, examination and functional scoring were performed during the period when the patients came to the outpatient clinic due to the retrospective structure of the study.

## 5. Conclusion

Since the rupture of the AL ligament has negative effects on functional scores and physical activity, we suggest that in the patients diagnosed with a ruptured AL ligament, the surgery of the AL ligament reconstruction in the same session with the ACL reconstruction, or if the patient's rotational complaints continue after the ACL reconstruction, the surgery of the AL ligament reconstruction by planning a reoperation will have positive effects on functional outcomes.

## Ethical approval

For our study, ethics committee approval, dated 28/12/2017 and numbered 2017/113/12/01, was obtained from the Local Ethical Committee.

## Sources of funding

This research received no specific grant from any funding agency in the public commercial, or not-for-profit sectors.

## Author contribution

Burak Gunaydin - study desing, data collections, writing, final corrections.
Ali Turgut - study desing, data analysis, writing, final corrections.
Abdulkadir Sari - data analysis, writing.
Cagatay Tekin - data collections, data analysis.
Bekir Eray Kilinc - data analysis, writing.
Ibrahim Kusak - data collections, data analysis.
Gulcan Gucer Sahin - data collections, data analysis.

**Table 4**
The ACL stability test results of the patients with ruptured AL ligaments.

| Stability test | (−) Negative n (%) | (+) Positive n (%) | (++) Positive n (%) | (+++) Positive n (%) |
|---|---|---|---|---|
| Anterior Drawer | 0% | 46.7% (n = 28) | 50% (n = 30) | 3.3% (n = 2) |
| Passive Lachman | 0% | 38.3% (n = 23) | 53.3% (n = 32) | 8.3% (n = 5) |

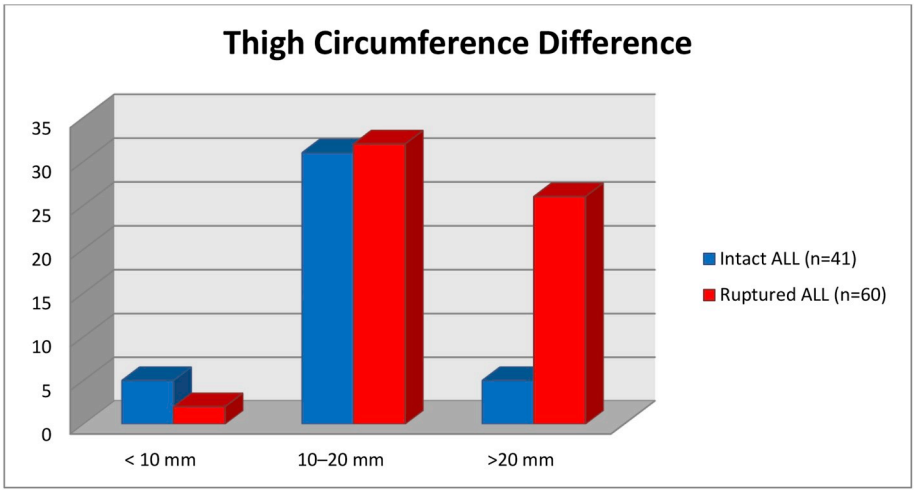


**Fig. 5.** The comparative results of the difference between the diameters of the two thigh circumferences of the patients with intact and ruptured AL ligaments.

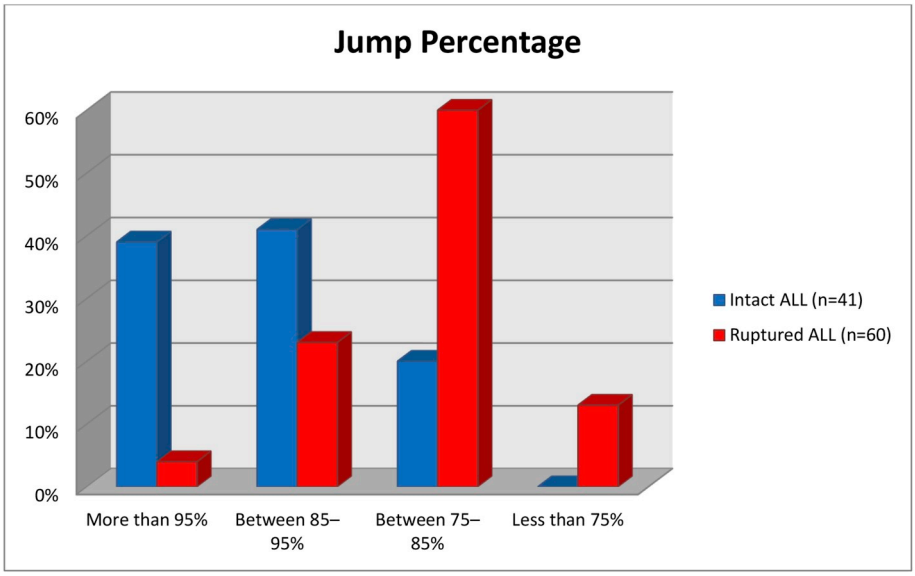


**Fig. 6.** The comparative results of the one leg hop test of the patients with intact and ruptured AL ligaments.

Onder Kalenderer - study desing, data collections.
Yavuz Selim Kabukcuoglu - study desing, final corrections.
All authors approve final version of paper for submission.

## Conflicts of interest

All named authors hereby declare that they have no conflicts of interest to disclose.

## Research registration number (UIN)

researchregistry4462.

## Guarantor

Burak Gunaydin - Ali Turgut.

## Provenance and peer review

Not commissioned, externally peer-reviewed.

## Acknowledgment

Authors declare that there is no conflict of interest or funding for this study.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijsu.2019.03.010.

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