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Association between a Concomitant Anterolateral Ligament Tear and Pivot Shift Before and After Single-Bundle Anterior Cruciate Ligament Reconstruction: A Retrospective Cohort Study

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Abstract

BACKGROUND: Regardless of the type of intra-articular anterior cruciate ligament (ACL) reconstruction performed, a certain degree of rotatory instability is often seen after surgery. Recent studies suggest that the anterolateral ligament (ALL) plays a significant role in maintaining stability during internal rotation of the tibia at high knee flexion angles. Unrecognized damage to the ALL may potentially be associated with a positive pivot shift despite a surgically reconstructed ACL being done.

AIM: The primary objective of this study was to determine whether a concomitant ALL tear is associated with a high-grade pivot shift before and after ACL reconstruction.

METHODS: This study was a retrospective cohort study of patients that underwent single-bundle ACL reconstruction surgery in our institution from October 2014 to March 2017. One hundred and forty-four patients were included in this study. All data were extracted from the department of ACL registry. All knee MRIs were reviewed by the author and coauthor to determine the integrity of the ALL. Subjects were divided into two groups based on the grade of pivot shift before surgery. The prevalence of ALL tear based on MRI was further compared between high-grade and low-grade pivot-shift groups.

RESULTS: Overall, the prevalence of a concomitant ALL tear was 70.83%. Comparing the prevalence of concomitant ALL tear between the high-grade pivot-shift group (73.11%) and low-grade pivot-shift group (60%), we had insufficient evidence to demonstrate an association between pre-surgery high-grade pivot shift and concomitant ALL tear. After surgery, none of the patients had a high-grade pivot shift or was positive for Lachman's test.

CONCLUSION: There is a high prevalence of concomitant ALL tear in patients with torn ACL. We have insufficient evidence to demonstrate an association between the presence of a torn ALL and high-grade pivot shift before and after single-bundle ACL reconstruction.

Introduction

The anterior cruciate ligament is one of the most important intra-articular structures in the knee that provides anterior translation and rotational stability of the knee [1]. Injuries of the anterior cruciate ligament may lead to unsatisfactory knee function, decreased activity, early intra-articular derangements, and poor knee-related quality of life [2]. Lachman's and pivot-shift tests are the most commonly used and widely known tests to assess the integrity and function of the anterior cruciate ligament (ACL). Clinically, positive Lachman's and pivot-shift tests are highly suggestive of ACL tear [3]. MRI of the knee is usually requested to confirm the diagnosis of ACL tear and evaluate other structures that may be injured concomitantly.

The most common treatment option for ACL injury is either single-bundle or double-bundle ACL reconstruction. Both techniques are effective in restoring native anatomy and kinematics of the joint [4]. Regardless of the type of intra-articular ACL reconstruction performed, a certain degree of rotatory instability, measured through the pivot shift, was often seen after the surgery. Thus, a more comprehensive surgical approach to ACL tear has been suggested, including treatment of injuries to secondary restraints [5].

Recent studies suggest that the anterolateral ligament (ALL) plays a significant role in maintaining stability during internal rotation of the tibia at high knee flexion angles. Unrecognized damage to the ALL could explain the observation of positive pivot shift despite an intact ACL or a surgically reconstructed ACL. Damage to the ALL could possibly result in an additional loss of stability. In addition to the intra-articular reconstruction for the ACL, it may be beneficial that extra-articular reconstruction of the ALL is done [6], [7], [8].

The anterolateral ligament can be analyzed using magnetic resonance imaging (MRI). This structure is visualized as a thin linear structure between lateral meniscus and lateral collateral ligament that presented signal characteristics similar to the other ligament

structures of the knee described as a hyposignal intensity on coronal T2 image. This ligament could be clearly viewed more than 80% on MRI examination [9], [10].

With the current interest in the relationship of ALL integrity in patients with ACL tear, this study was conducted to determine whether a concomitant ALL tear is associated with a high-grade pivot shift before and after single-bundle ACL reconstruction. Furthermore, the prevalence of a concomitant ALL tear between patients with a high-grade versus low-grade pivot shift before ACL reconstruction was also investigated.

Materials and Methods

Research design

We conducted a retrospective cohort study design to determine the role of anterior lateral ligament (ALL) in anterolateral stability of the knee in patients with ACL tear that underwent ACL reconstruction using single-bundle hamstring graft. This study was approved by a PHREB-accredited Institutional Review Board (IRB) before the conduct of the study with protocol IRB number 2017-046.

Study population

All patients that underwent ACL reconstruction surgery in this institution from October 2014 to March 2017 were included in the study. Our institution has an average annual census of 100 patients for ACL reconstruction.

The inclusion criteria for the population in the study were as follows: (1) Males or females aged 18−60 years old with complete ACL tear, confirmed with MRI before surgery and (2) patients who underwent ACL reconstruction using single-bundle hamstring tendon autograft.

The exclusion criteria of this study were patients with concomitant posterior cruciate ligament tear, medial collateral ligament tear and/or lateral collateral ligament tear, iliotibial band ruptured, patients with ACL graft torn after ACL reconstruction, patient diagnosed with generalized laxity, patients with positive Lachman's test after the surgery, and patients who did not undergo magnetic resonance imaging to confirm the diagnosis of an ACL tear.

Data collection

Sources of data

The data regarding pivot-shift test before and after ACL surgery of this study were gathered from the orthopedic department of ACL registry from October 1, 2014, to March 31, 2017. Other data included in the ACL registry were patient's age and sex, surgeon performing the surgery, number of tendon grafts used in the surgery, date of surgery, Lachman's test, and pivot-shift test results done before and immediately after the surgery. Any data that were missing from the registry were retrieved from the patients' charts. The MRI images were collected from our institution's Novarad PACS System and/or from MRI plates or digital images at the attending physician's clinic.

Data collection methods

Based on selection criteria, we were able to include 144 patients in this study. Patients with Grade 2 and Grade 3 pivot shift before surgery were included in the high-grade pivot-shift group and the rest in the low-grade pivot-shift group.

Using the T2-weighted coronal plane MRI, the anterolateral ligament structure was examined. The primary investigator and coinvestigator analyzed the integrity of the ALL and reported it as intact or torn. The intact ALL showed as hyposignal intensity band arise from the lateral epicondyle of the distal femur, running obliquely to the anterolateral border of the tibia, behind to Gerdy's tubercle (Figure 1). Any discontinuity noted by hypersignal intensity in the span of this ligament will be considered as torn ALL [9], [10] (Figure 2).

Figure 1: White arrow shows intact ALL

Statistical analysis

Descriptive statistic was used to summarize the clinical characteristics of the patients. Frequency and proportion were used for nominal variables, median, and range for ordinal variables, and mean and SD for interval/ratio variables.

Figure 2: White arrow shows torn ALL

Crude and adjusted odds ratios and its corresponding 95% confidence intervals were used to determine the association between a concomitant ALL tear and high-grade pivot shift before ACL reconstruction adjusting for age and sex. Adjusted odds ratios were determined through binary logistic regression. Relative risk ratios were computed to compare the incidence of a positive pivot shift after single-bundle ACL reconstruction between those with versus without a concomitant ALL tear. All valid data were included in the analysis. Missing variables were neither replaced nor estimated. Null hypotheses were rejected at 0.05 α-level of significance. STATA 12.0 was used for data analysis.

Results

We analyzed 144 adult patients who underwent single-bundle ACL reconstruction. With an average age of 29.08 ± 7.95 years, the patients were predominantly male (81.25%). Overall, the prevalence of a concomitant ALL tear was 70.83%. Before the surgery, more than half had a high-grade pivot shift. After the surgery, the patients neither had a high-grade pivot shift nor were positive for Lachman's test (Table 1).

Patients in the high-grade pivot-shift group, 87 (73.11%), had a concomitant ALL injury. At the same time, 15 (60%) patients in the low-grade pivot-shift group were found to have a concomitant ALL injury. The prevalence of concomitant ALL injury showed no significant difference between the two groups (p = 0.194) and therefore lack of evidence to demonstrate an association between pre-surgery high-grade pivot shift and concomitant ALL tear (Table 2).

Table 1: Clinical profile of adult patients who underwent ACL reconstruction (n = 144)

	Frequency (%); Mean ± SD; Median (Range)
Age (years)	29.08 ± 7.95
Sex	
Male	117 (81.25)
Female	27 (18.75)
Laterality	
Right	66 (45.8)
Left	78 (54.2)
With ALL tear	102 (70.83)
Pre-ACL pivot shift	
0	0
+1	25 (17.36)
+2	75 (53.08)
+3	44 (30.56)
Post-ACL pivot shift	
0	128 (88.9)
+1	16 (11.1)
+2	0
+3	0
Post-ACL Lachman's test	
Negative	144 (100)
Positive	0

Adjusted on age and sex, patients with concomitant ALL tear were 1.859 times more likely to have a high-grade pivot shift. However, 95% confidence interval ranged from 0.75 to 4.62 and was not statistically significant at P=0.182. Therefore, an association between high-grade pivot shift and concomitant ALL tears cannot be demonstrated (Table 3).

Table 2: Association between concomitant ALL tear and pre-surgery pivot shift (n = 144)

	With high- grade pivot shift (+2 or+3) (n = 119)	With low-grade pivot shift (0 or+1) (n = 25)	Crude odds ratio (95% CI)	p value
	Mean ± SD; frequency (%)			
Age	29.45 ± 8.15	27.32 ± 6.79	1.039 (0.98–1.11)	0.225
Male	96 (80.67)	21 (84)	0.795	0.699
Female	23 (19.33)	4 (16)	(0.25–2.54) (reference)	-
With concomitant	87 (73.11)	15 (60)	1.813	0.194
ALL tear	32 (26.89)	10 (40)	(0.74–4.44)	-
With intact ALL			(reference)	

The relative risks cannot be calculated because none of the patients had a high-grade pivot-shift post-ACL reconstruction. If the comparison was made with a +1 pivot shift compared to none, there was insufficient evidence to demonstrate a difference in the prevalence of positive pivot shift between the two groups (Table 4).

Table 3: Age and sex adjusted odds ratio of a concomitant ALL tear and pre-surgery pivot shift (n = 144)

	Adjusted odds ratio	95% confidence interval	p value
Age	1.039	0.98–1.11	0.221
Female	(reference)	-	-
Male	0.707	0.22–2.32	0.567
With intact ALL	(reference)	-	-
With concomitant ALL tear	1.859	0.75–4.62	0.182

p value = 0.315; R^2 = 2.67%

Discussion

The key findings of this study showed that the prevalence of a concomitant ALL tear was high (70.83%) among our patients with torn ACL and that we

Table 4: Post-ACL reconstruction outcomes (n = 144)

	With ALL tear (n = 102)	With intact ALL (n = 42)	Relative risk (95% CI)	p value
	Frequency (%)			
Pivot-shift test				
Negative (zero)	92 (90.2)	36 (85.71)	(reference)	-
Positive 1	10 (9.80)	6 (14.29)	0.686 (0.27–1.77)	0.437
Positive 2	0	0	-	-
Positive 3	0	0	-	-
Lachman test				
Negative	102 (100)	42 (100)	(reference)	-
Positive	0	0	-	-

had insufficient evidence to demonstrate an association between high-grade pivot shift and concomitant ALL tears.

Early studies of ALL hypothesized that ALL is a distinct ligamentous structure on the knee that affects the stability of internal tibia rotation; thus, pivot shift might present once this ligament is torn [11], [12], [13]. This theory was confirmed with biomechanical studies that showed significant role of ALL as a stabilizer in tibia internal rotation [5], [6], [7], [14]. However, beside the ACL and ALL, the stability of internal tibia rotation also affected another structures such as iliotibial band, lateral meniscus, posterolateral corner, and LCL that affect the pivot-shift phenomenon [3], [5], [15].

A previous study by Song *et al*. had conflicting results with our study. Their study showed that patients with high-grade pivot-shift phenomenon had higher concomitant ALL injury prevalence than those with low-grade pivot-shift phenomenon after acute ACL injuries [16]. These discrepancies might be due to the difference in sample selection where their study focused on patients with acute ACL injuries, which was not focused in our study.

Only a few clinical studies were done regarding the function of ALL in ACL injured patients. A combined ACL and minimally invasive ALL reconstruction could be an effective procedure to eliminate residual pivot shift in ACL surgery [17]. A study comparing combined intra- and extra-articular ACL reconstruction to intra-articular ACL reconstruction alone found no significant difference in functional outcome. However, patients who underwent combined reconstruction were more likely to show improved stability based on the pivot-shift and Lachman's test [18].

Furthermore, our study showed that none of our patients had positive Lachman's test and no high-grade residual pivot shift after the surgery. Only 11.11% of patients had low-grade residual pivot shift after single-bundle ACL reconstruction regardless of the presence of ALL tear.

The main limitation of this study was the evaluation of MRI to determine the integrity of ALL mainly based on the experience of the investigators. Another limitation was the subjective nature of the pivot-shift test, where the results were highly related to the experience of the examiner even though pivot-shift tests were performed with the patients under regional block anesthesia. This study also only tests the pivot-shift right after the surgery, and no follow-up test was performed. Finally, due to a small sample, our study may have been underpowered to establish an association between ALL tear and pivot shifts.

Evaluation of other structures that contribute to the stability of tibia internal rotation in conjunction with ALL might be beneficial in understanding the high-grade pivot-shift phenomenon in patients with ACL tear. The use of measurable tools to evaluate the knee's stability is strongly recommended to determine the degrees of rotation beside pivot shift objectively. Nevertheless, prospective cohort studies may be necessary to achieve more objective results.

Conclusion

There is a high prevalence of concomitant ALL tear in patients with torn ACL. We have insufficient evidence to demonstrate that a concomitant ALL tear is associated with high grade of pivot shift before and after single-bundle ACL reconstruction.

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