EVALUATING DIFFERENT CLINICAL DIAGNOSIS OF ANTERIOR CRUCIATE LIGAMENT RUPTURES IN PROVIDERS WITH DIFFERENT TRAINING BACKGROUNDS

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ABSTRACT

Introduction: Previous studies have shown that provider training and the tests performed play a role in the accuracy of diagnosis of anterior cruciate ligament (ACL) injuries. The specific aim of the current study is to determine the examiner proficiency and accuracy in performing the different proactive tests of ACL rupture before and after the induction of anesthesia prior to a definitive surgical procedure.

Materials and Methods: A case series was performed from January of 2015 through July of 2015. Two examiners were included (an experienced orthopaedic sports surgeon with more than 16 years in practice and an experienced orthopaedic physician assistant with 6 years of clinical experience in orthopaedic sports medicine). Three different physical examination tests were used before and after the induction of anesthesia to the patient: 1) Lachman test, 2) pivot shift test, and 3) Lelli test. Relevant patient demographic information such as BMI, thigh girth, and calf girth were recorded. Diagnosis of ACL rupture had been established pre-operatively.

Results: Thirty three patients met the inclusion criteria (males: 21 (64%), female: 12 (36%)). High percent of false negative was found with pivot shift test for both before and after anesthesia when compared to the other two tests. The Lelli test seemed to be most favorable to both the surgeon and the physician assistant with at least 67% favorable, while the pivot shift was least often felt to be the most useful test. No relationship was found for either patients' thigh or patients' calf girths with the physical examination test results for both examiners for any of the three tests (p = 0.110).

Conclusion: The diagnostic accuracy and limitations of the various tests for ACL injury need to be understood. Clinically, it is recommended performing at least two different examinations, as each test has its own specific limitations.

Level of Evidence: III- Prospective Cohort Study without blinding

Keywords: Lelli Test; Lachman Test; Pivot Shift Test; Arthroscopic Surgery; Anterior Cruciate Ligament

INTRODUCTION

Anterior cruciate ligament (ACL) injuries are common athletic injuries of the knee with an annual incidence of 68.6 per 100,000 person-years in the United States[1]. They largely occur in sports which require a sudden change of direction on a weight-bearing knee. Accurate diagnosis of ACL rupture relies on a combination of the patient's history, a clinical examination, and by Magnetic Resonance Imaging (MRI) scanning and diagnostic arthroscopy if needed[2,3]. The initial presentation of ACL injuries often includes a history of non-contact injury and a hemorrhagic effusion[4,5]. The early diagnosis of an ACL injury is of importance as there is good evidence that a delay between ACL injury and reconstruction is associated with a higher risk of subsequent damage to the menisci, particularly the medial meniscus, and the articular cartilage[6-18].

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After ACL rupture, most patients have detectable signs and symptoms of excess knee laxity and instability[19]. There are several commonly used physical examination applied tests to determine an ACL injury such as the anterior drawer test, the Lachman test, the pivot shift test, and the Lelli test ("lever sign" test)[20-23]. It is, however, difficult to ascertain the benchmark for diagnostic accuracy following an ACL injury, and a significant percentage of subjects are misdiagnosed due to the limitations of each of these physical examination tests. Most of the literature has reported on the sensitivity, reliability, and specificity of these different physical examination tests to detect an ACL injury[21-37], but most are reporting experienced surgeons performing the examination. There is limited data available in the literature on less-experienced physicians or surgeons or even physician assistants using these physical examination tests for the ACL lesion by their simplicity, reliability, and specificity. Geraets et al[28] performed a study to assess the diagnostic value of ACL-specific medical history assessment and physical examination between primary and secondary care medical specialists, and found that a primary care physician was able to correctly identify 62% of chronic ACL injuries compared to 94% by an orthopaedic surgeon. This suggests that different providers with different training can have different interpretations with the same patients. The specific aim of the current study is to determine the examiner proficiency and accuracy in performing the different clinical diagnosis of ACL ruptures before and after the induction of anesthesia.

PATIENTS AND METHODS

Institutional review board approval was obtained for the study and consent was obtained from the patients prior to enrollment in the study. A case series was performed looking at consecutive examiner's proficiency and accuracy in performing the different clinical diagnosis of ACL ruptures before and after the induction of anesthesia from January 2015 through July 2016. The inclusion criteria for this study were patients who presented to the lead orthopedic surgeon with a unilateral knee injury that resulted in symptomatic instability at two selected facilities. There was no prior history of knee problems or injuries on the involved side, no prior ACL reconstruction or repair, the knee injury was not sustained within 72 hours prior to data collection, and there had been no surgical procedures on the involved knee in the six weeks prior to data collection.

The exclusion criteria for this study included all patients who presented with an ACL injury outside of the collection period, patients who had a previous knee surgery or infection on the affected side, patients presenting within 72 hours after injury, patients with chronic knee pain, patients with associated ligament injuries, and patients complaining of hip, ankle and foot symptoms.

Two examiners were included in this study: a sports medicine fellowship-trained orthopaedic surgeon with more than 16 years in practice and the other examiner was an orthopaedic physician assistant with 6 years of clinical experience in orthopaedic sports medicine. Three different physical examination tests (Figure 1) were used to evaluate for an ACL injury on both the affected and the non-affected extremities: 1) Lachman test, 2) pivot shift test, and 3) Lelli test. These tests were performed in the operating suite before and after the induction of anesthesia to the patient, and examinations were performed independently, without the other provider in the room and without discussing the results prior to recording the examination. All ACL injuries were confirmed arthroscopically.

Lachman Test (Figure 1a)

The Lachman test was performed with the patient lying supine with the examiner on the side of the extremity to be examined. The knee was flexed between 15º and 30º while the heel remained on the table. The examiner placed one hand behind the tibia and with the other hand grasped the patient's thigh. The examiner's thumb was placed on the tibial tuberosity. With the femur thus stabilized, firm pressure was then applied to the posterior tibia in an attempt to translate it anteriorly. A positive test indicating disruption of the ACL is one in which there is proprioceptive and/or visual anterior translation of the tibia in relation to the femur with a characteristic "mushy" or "soft" end point. This is in contrast to the "hard" end point of an intact ACL36. The grades of laxity were defined by the amount of anterior tibial translation relative to contralateral knee: Grade I: 1-5mm; Grade II: 6-10mm; and Grade III: >10mm.

Pivot Shift Test (Figure 1b)

The pivot shift test was performed with the patient lying in the supine position. The leg was then picked up at the ankle with one of the examiner's hands while the other hand was placed behind the fibula, over the lateral head of the gastrocnemius. The knee is initially flexed to 30º then slowly brought to full extension, with a slight valgus strain combined with 20º of internal rotation of the leg. The hand placed at the lateral portion of the leg at the level of the superior tibiofibular joint gives a strong valgus strain to prevent easy reduction of the tibia on the femur. If the tibia's position on the femur reduces as the knee is flexed in the range of 30º to 40º or if there is an anterior subluxation felt during knee extension, the test is positive for instability.

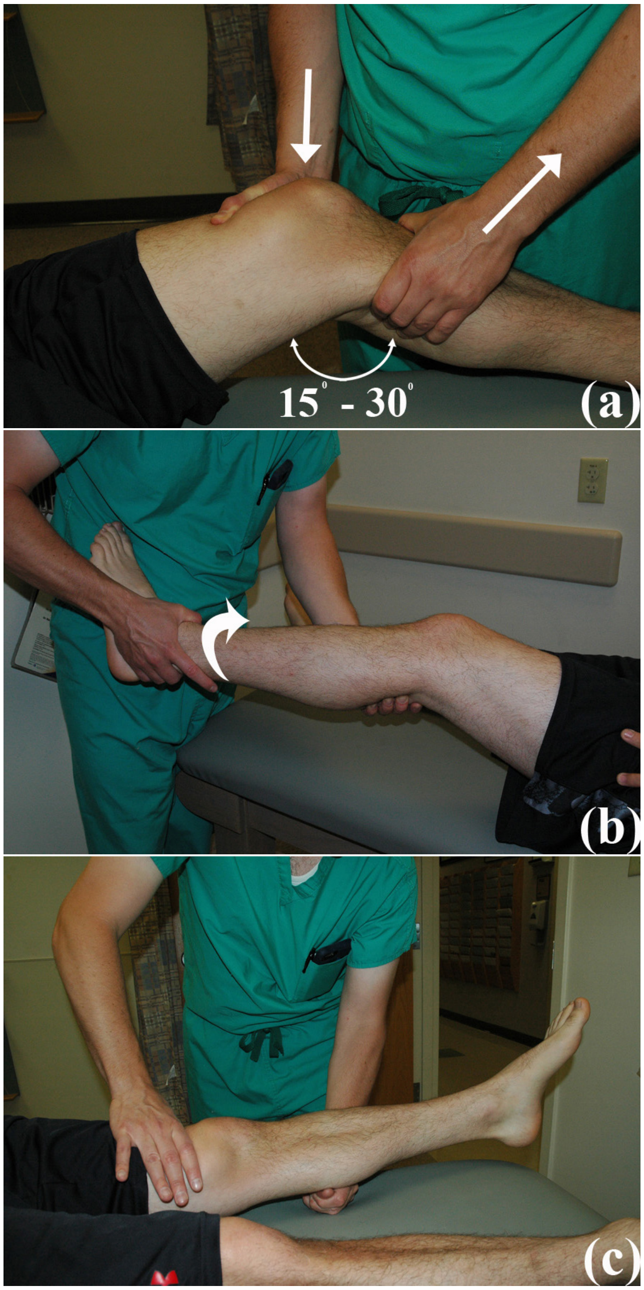

Figure 1. Physical Examination Test Performed. (a) Lachman Test, (b) Pivot Shift Test, and (c) Lelli Test

Lelli Test (Figure 1c)

The Lelli test, or the lever sign test, was described by Lelli et al[23]. The patient was placed supine with the knee fully extended on a hard surface. The examiner placed a closed fist under the proximal third of the patient's calf. The other hand of the examiner then applied a moderate downward force to the distal third of the quadriceps. An intact ACL allows the heel to lift off the examination table. Whereas an ACL deficient knee, the heel remain on the examination table.

Table 1. Patient Demographics

	Male (N = 21)	Female (N = 12)	P value
Age (Years)	30.9 ± 14.3 (11 – 62)	30.6 ± 17.0 (15 – 60)	0.299
Weight (kg)	95.2 ± 19.5 (43.1 – 127.0)	75.3 ± 19.8 (59.4 – 116.1)	0.690
Height (cm)	178 ± 10 (145 – 193)	163 ± 7 (150 – 175)	0.247
BMI (kg/m2)	29.8 ± 4.5 (20.6 – 36.9)	28.3 ± 8.1 (19.9 – 45.3)	0.024
Thigh girth (cm)	45.0 ± 6.0 (35 – 58)	43.7 ± 6.7 (35.1 – 60)	0.918
Calf girth (cm)	35.8 ± 4.3 (30 – 51)	37.8 ± 4.5 (31 – 46)	0.888

Data Collection

The size of the examinees' hand span from the tip of the thumb to the tip of the fifth digit (small finger) with the hand in maximal abduction was physically measured. The patient demographics including the patient's age, gender, height, weight, body mass index (BMI), and side of injury were collected. The girth of the patient's thigh and calf on the affected side (8cm above and below the midpoint of the patella) were also measured.

Statistical analysis

The independent sample t-test was performed using SPSS software (Version 19.0; SPSS Inc, Chicago, IL) and was used to determine if there were any observed differences between male and female with respect to patient demographics, thigh circumference and calf circumference. The level of significant difference was defined as $p<0.05$. The Kappa statistic using SPSS software (Version 19.0; SPSS Inc, Chicago, IL) was used to compare the inter- and intra-observer agreement for each of the three tests and for each provider. According to guidelines described by Landis and Koch[38], a value of ≤0.2 indicates "poor" agreement, 0.21-0.40 is "fair" agreement, 0.41-0.60 is "moderate" agreement, 0.61-0.80 is "substantial" agreement, and >0.80 is "excellent" agreement. Sensitivity was calculated by dividing the number of true positives by the number of subjects with ACL injuries.

RESULTS

Of the 33 patients that met the inclusion criteria, 21 patients (64%) were males and 12 patients (36%) were female. The mean age for the male and female groups were 30.9±14.3 years (range: 11-62 years) and 30.6±17.0 years (range: 15-60 years), respectively. The mean BMI for the male group (mean: 29.8±4.5 kg/m^2; range: 20.6-36.9 kg/m^2) was statistically significantly higher than the female group (mean: 28.3±8.1 kg/m^2; range: 19.9-45.3 kg/m^2;

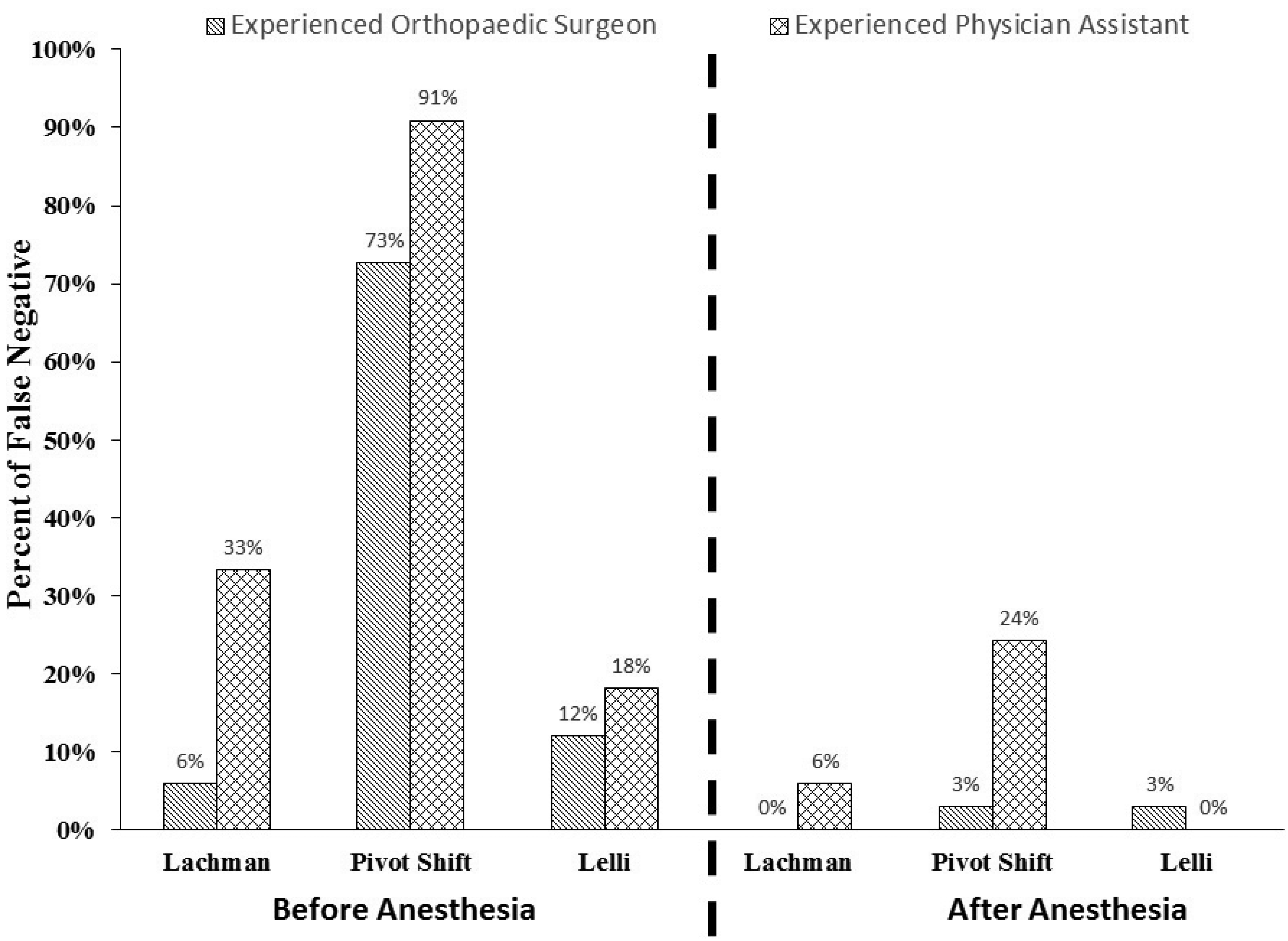

Figure 2. Validity For All Three Physical Examination ACL Tests Judgment of Negative Test

p=0.024). Statistically, there was no significant difference detected between males and females in terms of thigh girth and calf girth (Table 1). Of the 33 patients with ACL injuries, 32 patients were found to have complete tears during diagnostic arthroscopy, and only one patient was found to have a partial tear with the anteromedial bundle intact and a torn posterolateral bundle.

For the experienced sports medicine orthopaedic surgeon, prior to the induction of anesthesia, there was 2 (6%) false negatives with notable during Lachman test, 24 (73%) false negative during pivot shift testing (22 (67%) were guarding reaction from the patient due to pain, and 2 (6%) were tested negative) and 4 (12%) false negatives during Lelli test (2 (6%) with a guarding reaction, and 2 (6%) were tested negative). On the other hand, there were no false positives with any of the three tests. The sensitivity of the Lachman test, pivot shift test, and Lelli test were 94%, 27%, and 88 %, respectively. With the patient under general anesthesia, there were no (0%) false negatives with Lachman test, 1 (3%) false negative with the pivot shift maneuver, and 1 (3%) false negative with the Lelli test (Figure 2). There were no false positives on the contralateral limb. The sensitivity of the Lachman test was then determined to be 100%, and 97% for both the pivot shift test and Lelli test.

For the experienced orthopaedic physician assistant, prior to the induction of anesthesia, there were 11 (33%) false negatives with the Lachman test with guarding reaction noted in 10 (30%) patients, 30 (91%) false negatives with pivot shift testing with guarding reaction in 27 (82%) patients, and 6 (18%) false negatives with the Lelli test with guarding reaction in 2 (6%) patient. There were no false positives. The sensitivity for the Lachman test was 67%, for the pivot shift was 9%, and for the Lelli test was 82%. With the patient under general anesthesia, there were 2 (6%) false negatives with the Lachman test,

Table 2. Inter-observer reliability for judgments based on all three different physical examination tests to determine an ACL injury

	Before Anesthesia		After Anesthesia	
	Kappa coefficient	Percent of agreement	Kappa coefficient	Percent of agreement
Lachman test	0.23	73	N/A	94
Pivot shift test	0.23	76	0.18	79
Lelli test	0.30	82	N/A	97

Table 3. Intra-examination test reliability for judgments based on before or after anesthesia

	Experienced Orthopaedic Surgeon		Experienced Physician Assistant	
	Kappa coefficient	Percent of agreement	Kappa coefficient	Percent of agreement
Lachman test	N/A	94	0.23	73
Pivot shift test	0.02	30	0.06	33
Lelli test	0.05	85	N/A	67

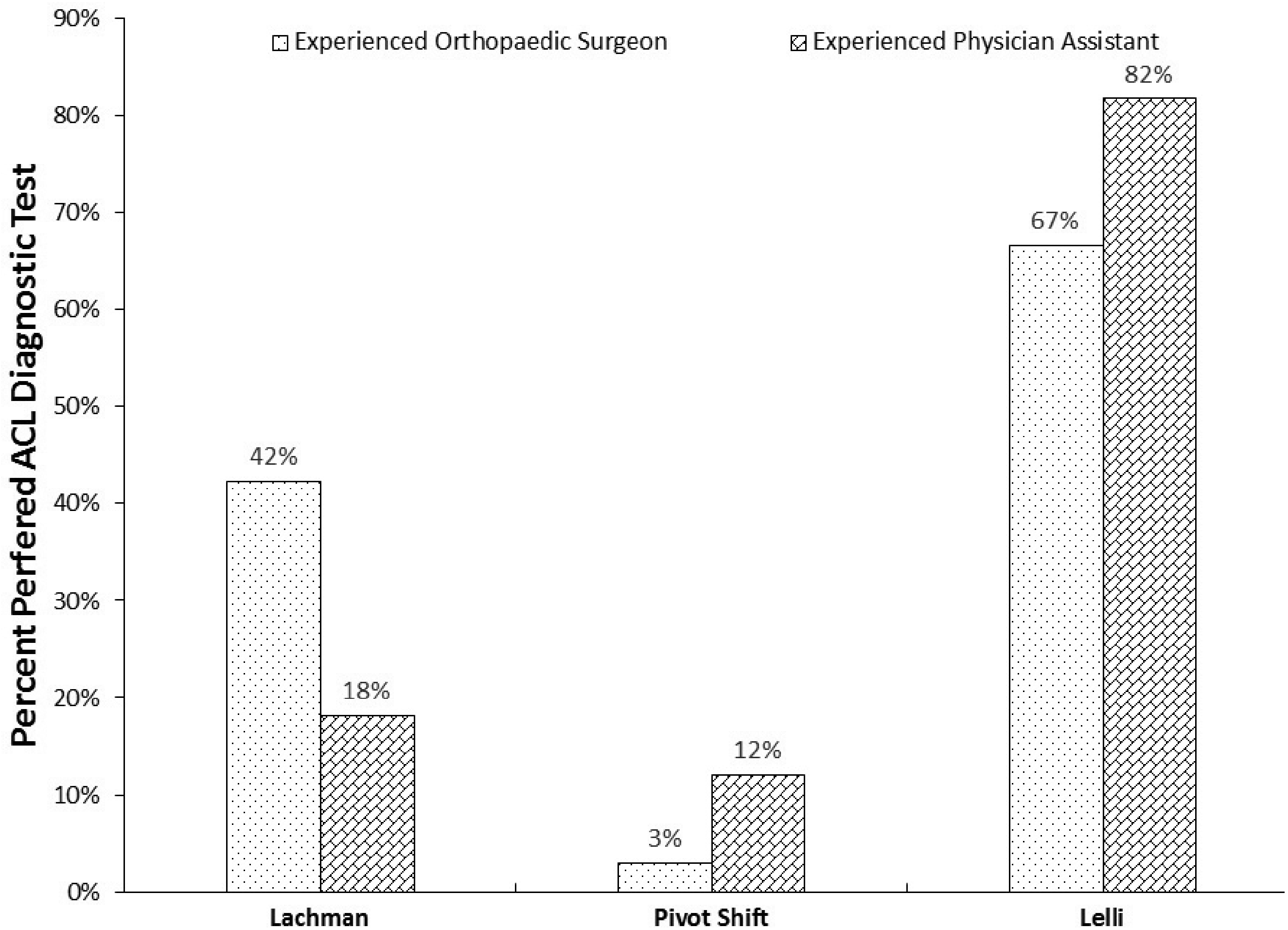

Figure 3. Examiners Preferred ACL Diagnostic Test

8 (24%) false negatives with the pivot shift with guarding in 1 (3%) patient, and no false negatives with the Lelli test (Figure 2). There were no false positives. The sensitivity for the Lachman test, pivot shift test and Lelli test was 94%, 76%, and 100%, respectively.

Inter-observer reliability testing prior to the induction of anesthesia for all the three tests showed "fair" agreement by using the guidelines described by Landis and Koch[38]. The Kappa coefficient for inter-observer agreement of judgments of positive or negative for the two examiners when using Lachman test was 0.23 with 72% agreement, when using pivot shift test was 0.23 with 76% agreement, and when using the Lelli test was 0.30 with 82% agreement. The inter-observer reliability with

Table 4. Examiner Hand Span Size

	Left (cm)	Right (cm)
Orthopaedic Surgeon	21.5	21.5
Experienced Physician Assistant	15.5	15.5

the patient under general anesthesia for the pivot shift test demonstrated "poor" agreement with the Kappa coefficient of 0.18 with 79% agreement. Unfortunately, the intra-observer value could not be computed for the Lachman test because there were no false negatives detected by the experienced surgeon, but there was 94% agreement. Similarly, the intra-observer value could not be calculated for the Lelli test because there were no false negatives for the experienced orthopaedic physician assistant but there was 97% agreement between the two observers (Table 2).

Intra-examiner reliability was calculated by comparing test results before and after the induction of anesthesia for each provider. Each of the three tests showed "poor" agreement except Lachman test for experienced physician assistant using the guidelines described by Landis and Koch[38]. For the experienced orthopaedic surgeon, the intra-observer Kappa value was 0.02 with 30% agreement for the pivot shift test, was 0.05 with 85% agreement for the Lelli test, and was not calculable for the Lachman test due to the lack of false negatives. For the experienced physician assistant, the Kappa coefficient for intra-observer agreement when using the Lachman test was 0.23 with 73% agreement, when using pivot shift test the Kappa value was 0.06 with 33% agreement, and when using Lelli test the Kappa value was not be able to computed as the physician assistant had no false negative results with the patient under anesthesia (Table 3).

The Lelli test seemed to be most favorable to both the surgeon and the physician assistant with at least 67% favorable, while the pivot shift was least often felt to be the most useful test (Figure 3). The experienced surgeon felt the Lachman test was the most beneficial to detect injury in 42% of patients, while the experienced physician assistant only thought it was most beneficial in 18% of patients.

The hand span for the experienced orthopaedic surgeon and the experienced physician assistant was measured 21.5cm and 15.5cm, respectively (Table 4). The physician assistant stated that hand size was likely a factor in 2 false negative results while performing the Lelli test. No relationship was found for either patients' thigh or patients' calf girths with the physical examination test results for both examiners for any of the three tests (p=0.110).

DISCUSSION

Despite the advent of MRI and its high sensitivity[39], physical examination continues to play a major role in ACL diagnosis. In our study, we observed that all three physical examination tests (Lachman test, Pivot Shift test, and Lelli test) to determine an ACL injury have at least a trend towards increased false negative test results prior to the induction of anesthesia. This is consistent with previous studies that demonstrated that physical examination tests are more accurate with the patient under anesthesia[25,30,40,41]. Despite the increased sensitivity of the Lachman test compared to the pivot shift test and anterior drawer test in the literature, no single test has been consistently shown to detect all ACL injuries[33,35,42]. Scholten et al[35] performed a meta-analysis of the physical diagnostic tests for ACL injuries and reported sensitivities of 62% and 86% for the anterior drawer test and Lachman test respectively, and between 18% and 48% for the pivot shift test. The sensitivity of the Lachman test, however, has been reported from other studies to range from 80% to 99%, with a specificity of 95%[25,29-32,36,43]. In meta-analyses, the sensitivity of the Lachman test is 0.85—0.871 with a specificity of 0.91—0.97, and the pivot shift had a sensitivity of 0.24—0.49 with a specificity of 0.98[33,35,42]. Wagemaker et al[37] assessed the diagnostic accuracy of a clinical history and physical examination in a primary care setting and found that a typical history for ACL injury combined with a positive anterior drawer test had a positive predictive value of between 36% and 80%.

To date, no physical exam maneuver has eliminated false negative test results. Guarding—the protective muscle action of the hamstrings secondary to joint pain—may be responsible for false negatives in some settings[36]. Others believe that some of these tests are not easily performed by examiners who have small hands or on patients with a large thigh girth or large calf girth[26,44]. In our study, even though the experienced physician assistant's hand span was considered small (15.5cm), only reported 2 false negatives (6%) out of the 33 patients that may be due to small hand size.

The findings from our study further demonstrate that the Lelli test may be another useful physical examination maneuver for both physicians and physician assistants. The sensitivity for the Lelli test in our patient population was not significantly different from the Lachman test, and had fewer overall false negatives when combining the data for the providers. However, this test hold little value in distinguishing between partial and complete tears as this test is a binary test (positive or negative result)[23]. Both the Lachman test and pivot shift test are based on a grading system that measures the amount of translation of the tibia relative to the femur, and these tests undoubtedly continue to hold an important role in diagnosis of ACL injuries[45].

Even though in our study both examiners preferred the Lelli test to diagnose ACL injuries in most patients, both examiners observed that soft cushions on the examination table can cause false negative results. Furthermore, if the examiner has a small fist size, or if the patient has a large, soft calf, this may have the potential to cause a false negative.

Several questions and limitations can be raised concerning the validity of our study and the applicability of these results to determine the examiner proficiency and accuracy in performing the different clinical diagnosis of ACL ruptures at clinic. We recognize that our study was performed with a relatively small number of patients, which decreased the chance of finding statistically significant results due to a low power. In addition, in this study we excluded patients who underwent examination within 72 hours of injury, which not only led to decreased enrollment but also prevents us from commenting on the usefulness of the Lelli test when guarding is likely most severe. The lack of blinding of the clinicians to the injury extremity was also another potential area of bias and may be responsible for the lack of any false positive test results in the study. Another weakness is the prevalence of male patients in the study, which may limit generalizability. Further expansion of the study to include more patients and more examiners is planned as future research.

CONCLUSION

A properly performed physical examination of the knee still holds a pivotal role in the diagnosis of ACL injury. The diagnostic accuracy and limitations of the various tests for ACL injury need to be understood. Clinically, in cases of suspicion of ACL injury, it is recommended performing at least two different physical examinations, as each test has its own specific limitations. The implementation of an acute ACL injury clinic may help minimize delays to surgery, which should result in better patient outcomes.

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