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Evaluating Medical Students' Competence in Orthopedic Special Tests for Diagnosing Anterior Cruciate Ligament (ACL) Injuries

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Abstract

Background: Competence in physical examination is essential for medical students, particularly in musculoskeletal assessment. Anterior Cruciate Ligament (ACL) injuries are common and typically evaluated through a combination of clinical history, imaging, and physical tests. This study aimed to assess the ability of medical students from two medical schools to perform three commonly used ACL tests: Lachman's test, anterior drawer test, and Lever sign (Lelli's test).

Methods: In this cross-sectional study, 200 fifth-year medical students from two medical schools in Jordan participated during their orthopedic surgery rotations. Each student performed the Lachman's, anterior drawer, and Lever sign tests on two patients with MRI-confirmed ACL tears and two healthy control subjects. Student performance was evaluated based on correct execution of each test. Comparisons were made between institutions and against a senior resident benchmark. A simulated learning curve model was also generated to illustrate progression across training levels.

Results: A total of 200 fifth-year medical students were evaluated. Correct test performance was highest for the Lever sign (92.0%), followed by the anterior drawer (85.5%) and Lachman's test (81.5%). No significant differences were observed between students from the two institutions ($p = 0.192–0.731$). Performance was higher on control subjects compared to ACL-injured patients. Senior residents demonstrated superior performance across all tests: Lachman's ($p = 0.004$), ($p = 0.001$), and Lever sign ($p = 0.027$). Simulated learning curves indicated higher AULC values for the Lever sign (281.5) compared to the anterior drawer (270.8) and Lachman's test (263.8), suggesting differences in the relative ease of skill acquisition.

Conclusion: Medical students performed ACL special tests with varying success, reflecting the differing technical demands of each maneuver. The Lever sign was most consistently performed correctly, while the Lachman's and anterior drawer tests showed lower performance compared to senior residents. Simulated learning curves emphasized skill acquisition differences, supporting the need for structured, progressive training to improve orthopedic examination competency.

Keywords: Medical education, ACL injury, Orthopedic examination, Clinical skills, Learning curve

INTRODUCTION

Medical education is fundamental in shaping competent healthcare professionals, emphasizing the importance of comprehensive training in history-taking and physical examination skills [1]. These skills serve as the cornerstone of clinical practice, facilitating accurate diagnoses and informed treatment decisions [2]. As such, medical schools prioritize the development of students' abilities to perform thorough physical examinations as part of their training regimen [3]. Mastery of physical examination techniques not only enhances students' clinical acumen but also cultivates their capacity for critical thinking and differential diagnosis formulation [4,5].

Anterior Cruciate Ligament (ACL) injuries represent a prevalent musculoskeletal condition, particularly among athletes engaged in high-impact sports activities [6,7]. These injuries occur frequently during sudden changes in direction, landing maneuvers, or direct trauma to the knee joint [8]. Diagnosis of ACL tears typically involves a combination of patient history, clinical examination, and imaging modalities such as magnetic resonance imaging (MRI) [9]. Treatment options range from conservative management, including physical therapy and bracing, to surgical intervention, such as ACL reconstruction, depending on the severity of the injury and the patient's activity level [10].

Previous studies have assessed the performance of medical students in conducting physical examinations specific to ACL injuries, recognizing the significance of these tests in clinical practice [11,12]. These evaluations aim to elucidate the proficiency of medical students in accurately diagnosing ACL tears through specialized orthopedic tests, such as the Lachman's test, anterior drawer test, and Lever sign (Lelli's) test. By examining medical students' competency in ACL special tests, these studies underscore the intersection between orthopedic clinical skills and medical education, emphasizing the importance of robust training in musculoskeletal examination techniques [13].

The aim of this study was to assess the competence of fifth-year medical students from two medical schools in Jordan in performing three key ACL special tests: Lachman’s test, anterior drawer test, and Lever sign (Lelli’s test). By evaluating their accuracy on patients with confirmed ACL injuries, comparing performance across institutions, and including healthy control subjects, the study explored both technical skill and diagnostic discrimination. Performance is also compared to that of senior orthopedic residents, serving as a benchmark for clinical proficiency.

By incorporating multiple institutions, control subjects, and experienced examiners, this study provides a broader evaluation of musculoskeletal clinical skills in undergraduate education. It sought to identify specific gaps in test execution and interpretation, informing efforts to improve orthopedic training in medical curricula.

PATIENTS AND METHODS

Study Design and Research Objectives:

This study employed a descriptive, cross-sectional, comparative design conducted in Jordan. The primary objective was to assess the competence of fifth-year medical students from two medical schools in performing three commonly used physical examination tests for diagnosing ACL tears: Lachman’s test, anterior drawer test, and Lever sign (Lelli’s test). Examinations were performed

on patients with MRI-confirmed complete ACL tears to evaluate technical accuracy. In addition, healthy control subjects were included to assess diagnostic discrimination. A senior orthopedic resident group served as a performance benchmark to contextualize the students' skill level.

Participants and Setting of the Study:

This study included 200 fifth-year medical students from two different medical schools in Jordan, all of whom were completing their orthopedic surgery rotations. To ensure adequate exposure to ACL special tests, assessments were conducted at the end of each rotation.

Data were collected over two separate periods between 2022 and 2025 to accommodate institutional schedules and ensure full participation from both medical schools. Each student performed the Lachman's, anterior drawer, and Lever sign tests on patients with MRI-confirmed ACL injuries as well as on healthy control subjects. In addition, a group of senior orthopedic residents performed the same tests to serve as a benchmark for comparison.

All examinations were conducted at the sports medicine clinic within the hospital premises. Patient comfort and safety were prioritized throughout the study, with students instructed to perform all examinations carefully and respectfully. Informed consent was obtained from all participants.

Study Population:

A total of 200 fifth-year medical students (100 from each of two medical schools in Jordan) were included in this study during their orthopedic surgery rotations. To establish a reference standard for clinical proficiency, 20 senior orthopedic residents (10 from each medical school's affiliated training hospital) were also included. Although the use of multiple institutions may introduce some variation in teaching exposure, it strengthens the generalizability of the findings and offers a broader perspective on student competence across diverse training settings.

Study Protocol:

The study protocol consisted of two main phases: a teaching and exposure phase, followed by an evaluation and assessment phase. This protocol was implemented at two medical schools in Jordan, each contributing 100 fifth-year medical students, for a total sample of 200 participants.

In the first phase, medical students completed a one-month orthopedic surgery rotation as part of their standard curriculum. During this rotation, they received structured instruction and clinical exposure to musculoskeletal examination techniques, including the performance of three special tests for ACL injury: Lachman's test, anterior drawer test, and Lever sign (Lelli's test). Students had multiple opportunities to observe and practice these tests in routine clinical settings under faculty supervision.

The second phase took place at the end of the orthopedic rotation and served as the formal assessment period. Prior to evaluation, students received a standardized refresher session on the three ACL tests, which included demonstration and explanation by an orthopedic surgery consultant to ensure consistent understanding. Each student was then asked to perform the three tests on two patients with confirmed complete ACL tears and two healthy control subjects. Performances were independently evaluated by two orthopedic consultants using a binary scoring system (correct/incorrect) to reduce observer bias and ensure objective assessment.

To establish a comparative standard, a

control group of 20 senior orthopedic residents (final year/board eligible) with approximately 10 years of postgraduate surgical training also performed the same set of tests on the same patients and control subjects.

All patient participants had previously diagnosed complete ACL tears, confirmed by both clinical examination and MRI reviewed by a consultant radiologist. None had acute symptoms, joint effusion, or comorbid musculoskeletal conditions at the time of testing. The control subjects were healthy males with no history of knee injury or ligamentous laxity. Patient and control characteristics are summarized in **Table 1**.

Table 1. Baseline Characteristics of Examined Subjects

Group	Subject ID	Age (yrs)	BMI (kg/m²)	Mechanism of Injury	ACL Tear Confirmed	Comorbidities
Patients	Patient 1	26	22.1	Sports injury	Yes	None
	Patient 2	25	29.2	Sports injury	Yes	Asthma
	Patient 3	27	23.4	Direct trauma	Yes	None
	Patient 4	22	25.1	Twisting injury	Yes	None
Controls	Control 1	28	23	-	-	None
	Control 2	27	24.8	-	-	None
	Control 3	29	22.7	-	-	None
	Control 4	26	23.5	-	-	None

Outcome Variable Definition:

The assessed outcome focused on the students' proficiency in accurately performing the physical examination maneuvers. A test was considered correctly performed if the student executed the technique properly and elicited the appropriate clinical finding—positive in ACL-injured patients and negative in healthy controls.

Positive Lachman's Test:

A positive Lachman's test indicates laxity or instability in the ACL. During the test, increased anterior translation of the tibia relative to the femur is observed, suggesting a lack of restraint in the ACL.

Technique: The patient lies supine with the knee flexed to 20-30 degrees. The examiner stabilizes the femur with one hand while grasping the proximal tibia with the other hand. Then, the examiner attempts to translate the tibia anteriorly. Excessive anterior translation or a soft endpoint is considered a positive result [14]. **Figure 1** is an illustration of Lachman's test.

Positive Anterior Drawer Test:

A positive anterior drawer test indicates laxity or instability in the ACL. It is suggestive of an ACL tear or injury. During the test, excessive anterior translation of the tibia relative to the femur is observed, indicating a lack of restraint in the ACL.

Technique: The patient is positioned supine with the hip flexed to 45 degrees and the knee flexed to 90 degrees. The examiner sits at the edge of the examination table and uses their thigh or buttock to stabilize the patient's foot. Next, the examiner grasps the proximal tibia with both hands and applies anterior traction while the patient's knee remains flexed and relaxed. A positive test is indicated by anterior translation of the tibia in

relation to the femur or the absence of an endpoint compared to the contralateral side [15]. Figure 2 is an illustration of anterior drawer test.

Figure 1. Demonstration of the Lachman's Test Technique.

Figure 2. Demonstration of the anterior drawer test Technique.

Positive Lilli's Test:

Also known as Lever sign test. A positive anterior drawer test indicates laxity or instability in the ACL. It is suggestive of an ACL tear or injury.

Technique: The patient lies supine with both legs fully extended. The clinician positions one fist under the proximal third of the calf of one leg. Using the other hand, a downward force is applied over the distal

third of the patient's quadriceps of the same leg. A positive test suggests ACL incompetence, as applying downward force causes anterior translation of the tibia relative to the femoral condyle. Consequently, the heel does not rise in this scenario [11]. Figure 3 is an illustration of level sign test (Lilli's test).

Figure 3. Illustration of Lever sign test (Lilli's test) technique.

Inclusion and Exclusion Criteria:

The study included all fifth-year medical students from two medical schools in Jordan who were completing their orthopedic surgery rotations during the designated study periods. Students were excluded if they declined to participate, had physical limitations affecting their ability to perform the tests, or were absent for a significant portion of their orthopedic rotation. Additional exclusion criteria included failure to complete the standardized ACL examination instruction provided during the rotation.

Ethical Considerations:

The study was approved by the Institutional Review Board of Mutah University (Approval No. 77/2022). Informed consent was obtained from all participating patients and control subjects.

Data Collection and Statistical Analysis:

Student performance in the three ACL special tests was documented as a binary outcome (correct or incorrect) based on standardized criteria. Each test was performed on both ACL-injured patients and healthy control subjects. Data were organized by test type, student group, and subject category.

Descriptive statistics were used to summarize performance outcomes, and chi-square tests were applied to compare accuracy across institutions, test types, and between students and senior residents. Statistical significance was defined as $p < 0.05$.

To visually illustrate key findings, bar graphs were used to compare correct performance rates by group and test type. Statistical analysis was done using the Statistical Package for Social Sciences (SPSS®) version 22.

RESULTS

A total of 200 fifth-year medical students participated (100 per medical school), along with 20 senior orthopedic residents (10 per institution) as a performance benchmark. All performed Lachman's, anterior drawer, and Lever sign tests on 2 ACL-injured patients and 2 healthy controls. University A vs. University B students were 56% vs. 59% male (p = 0.682), with mean ages of 23.4 vs. 23.7 years (p = 0.341), prior orthopedic exposure in 40% vs. 46% (p = 0.312), and prior ACL test training in 32% vs. 35% (p = 0.524). All baseline characteristics were relatively similar between the two student groups, with no statistically significant differences observed, indicating that they were comparable for analysis. Baseline characteristics are summarized in **Table 2**.

Table 2. Student baseline characteristics across both universities.

Variable		University A (n=100)	University B (n=100)	p-value
Gender	(Male %)	56	59	0.682
	(Female %)	44	41	
Mean age (years)		23.4	23.7	0.341
Prior orthopedic exposure (%)		40	46	0.312
Previous ACL test training (%)		32	35	0.524

Across both institutions, the Lever sign test had the highest overall correct performance among students, ranging from 89% to 94% across all patients and control subjects. The anterior drawer test followed, with correct performance rates between 84% and 92%, while the Lachman's test showed the lowest performance, ranging from 79% to 89%. In contrast, senior orthopedic residents demonstrated consistently high accuracy across all tests (99–100%). The largest performance gaps between students and residents were observed in the Lachman's test for patient cases, with absolute differences of 17–20% (e.g., 79% vs. 99%, p = 0.022; 83% vs. 100%, p = 0.031). Anterior drawer tests also showed notable student-resident differences, ranging from 12% to 15% (p = 0.011–0.043). These differences were statistically significant in all patient comparisons for both Lachman's and anterior drawer tests.

For the Lever sign, performance differences between students and residents were smaller (6–11%) and not statistically significant across any of the comparisons (p = 0.091–0.724), suggesting greater ease of use or intuitive execution. On control subjects, student performance was generally higher and more consistent, ranging from 89% to 94% across all tests, with no significant differences from residents (p-values: 0.137–0.724). Detailed comparisons by institution, subject type, test, and group are provided in **Table 3**.

Table 3. Summary of Correct Performance of ACL Special Tests by Medical Students and Senior Residents Across Two Universities. Comparison of correct performance rates for ACL-injured patients and control subjects across two universities. Differences (%) and p-values indicate statistical significance in performance between groups. Bolded values marked with an asterisk (*) indicate statistically significant differences ($p < 0.05$).

University/ Medical School	Subjects	Test performed	Students' performance (n=100)	Senior resident's performance (n=10)	Differences (%)	p-value
			Correct (%)	Correct (%)		
University A	Patient (1)	Lachman's Test	81	100	18	**0.019***
		Anterior drawer Test	87	99	12	**0.021***
		Lever Sign Test	92	100	8	0.193
	Patient (2)	Lachman's Test	83	100	17	**0.031***
		Anterior drawer Test	85	100	15	**0.043***
		Lever Sign Test	89	100	10	0.091
	Control (1)	Lachman's Test	89	99	10	0.371
		Anterior drawer Test	91	99	8	0.232
		Lever Sign Test	93	100	7	0.415
	Control (2)	Lachman's Test	89	99	10	0.424
		Anterior drawer Test	90	99	9	0.393
		Lever Sign Test	92	100	8	0.593
University B	Patient (3)	Lachman's Test	79	99	20	**0.022***
		Anterior drawer Test	84	99	15	**0.034***
		Lever Sign Test	89	100	11	0.095
	Patient (4)	Lachman's Test	82	99	17	**0.018***
		Anterior drawer Test	86	100	14	**0.011***
		Lever Sign Test	91	100	9	0.365
	Control (3)	Lachman's Test	89	100	11	0.231
		Anterior drawer Test	92	99	7	0.412

University/ Medical School	Subjects	Test performed	Students' performance (n=100)	Senior resident's performance (n=10)	Differences (%)	p-value
			Correct (%)	Correct (%)		
		Lever Sign Test	94	100	6	0.724
	Control (4)	Lachman's Test	89	99	10	0.137
		Anterior drawer Test	91	99	8	0.213
		Lever Sign Test	93	100	6	0.719

Student performance was comparable between University A and University B across all test types, with no statistically significant differences observed: Lachman's test (82.5% vs. 80.5%, p = 0.521), anterior drawer test (86% vs. 85%, p = 0.731), and Lever sign (90.5% vs. 93.5%, p = 0.192). Senior residents outperformed students in all tests with statistically significant differences: Lachman's test (98.5% vs. 81.5%, p = 0.004), anterior drawer (99.5% vs. 85.5%, p = 0.001), and Lever sign (100% vs. 92.0%, p = 0.027). Full performance comparisons are presented in **Table 4**.

Table 4. Average Correct Performance by ACL Test Type Across Groups. Mean correct performance percentages calculated by averaging results across all patient and control subjects. Comparisons shown for students from two medical schools and senior residents. Bolded values with an asterisk indicate statistically significant differences (p < 0.05).

Test Type	University A Students (%)	University B Students (%)	p-value (Uni. A vs B)	Senior Residents (%)	p-value (Students vs Residents)
Lachman's Test	82.5	80.5	0.521	98.5	**0.004***
Anterior Drawer	86	85	0.731	99.5	**0.001***
Lever Sign	90.5	93.5	0.192	100	**0.027***

Inter-rater reliability between the two orthopedic consultant evaluators was high across all ACL tests. Cohen's kappa values indicated strong agreement for the Lachman's test ($\kappa = 0.81$) and anterior drawer test ($\kappa = 0.84$), and very strong agreement for the Lever sign ($\kappa = 0.90$). These results support the consistency and objectivity of the performance assessments used in this study, as detailed in **Table 5**.

A line graph provides a visual representation of performance differences between students and senior residents across the three ACL tests. The steepest slope is seen in the Lachman's test (p = 0.004), indicating the largest gap, followed by anterior drawer (p = 0.001). The Lever sign shows the smallest difference, with a flatter line and higher student performance (p = 0.027). Detailed comparisons are presented in **Figure 4**.

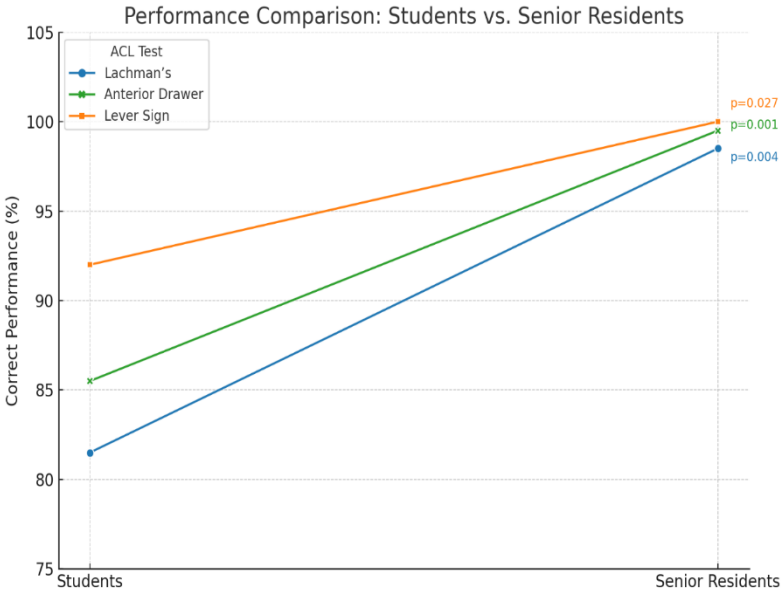

Figure 4. Line Graph Comparing Student and Senior Resident Performance Across ACL Tests. Visual representation of average correct performance rates for Lachman's, anterior drawer, and Lever sign tests. Steeper slopes indicate greater performance differences between groups, p-values less than 0.05 indicate statistical significance.

A line graph illustrates the comparative performance of students from University A and University B across all three ACL tests. Correct performance rates were similar between the two groups, with only slight variations observed. Lever sign had the highest scores in both universities (90.5% vs. 93.5%, p = 0.192), followed by anterior drawer (86% vs. 85%, p = 0.731) and Lachman's test (82.5% vs. 80.5%, p = 0.521). No statistically significant differences were found between the two groups. A visual summary is provided in **Figure 5**.

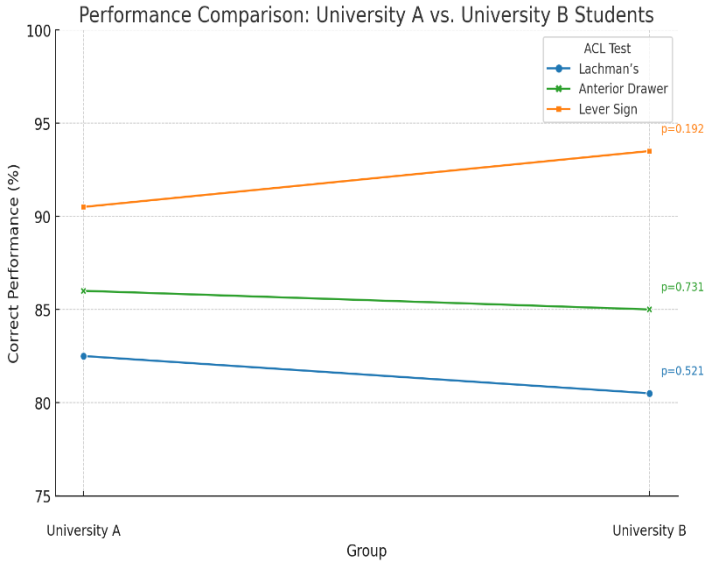

Figure 5. Line Graph Comparing ACL Test Performance Between University A and University B Students. Visual representation of average correct performance rates for Lachman's, anterior drawer, and Lever sign tests across the two medical schools. Differences between groups were minimal and not statistically significant (p > 0.05 for all comparisons).

A simulated line graph illustrates the projected learning curves for Lachman's, anterior drawer, and Lever sign tests across four training stages: student, intern, junior resident, and senior resident. These values were estimated based on observed student and senior resident performance, with intermediate points added to reflect expected improvement as clinical experience increases. This model offers a hypothetical view of skill development and serves as a visual proxy for the relative learning demands of each test.

The area under the learning curve (AULC) was calculated using a step-by-step method that adds up the space beneath each line segment between training levels. It provides a simple numerical summary of overall learning progression, where a higher AULC means the skill is learned more easily or earlier. In this simulation, the Lever sign had the highest AULC (281.5), followed by the anterior drawer (270.8) and Lachman's test (263.8). These results suggest that the Lever sign may be more intuitive and easier to master than the other two tests. Full visualization is shown in **Figure 6.**

Figure 6. Simulated Learning Curve for ACL Special Tests Across Training Stages. Hypothetical line graph illustrating projected performance improvement across four clinical stages—student, intern, junior resident, and senior resident—for Lachman's, anterior drawer, and Lever sign tests. Values between student and resident levels were interpolated from observed data. Area under the learning curve (AULC) reflects relative ease of test mastery.

DISCUSSION

This study evaluated the competence of fifth-year medical students from two Jordanian medical schools in performing three physical examination tests for diagnosing ACL injuries: Lachman's, anterior drawer, and Lever sign tests. Among all tests, the Lever sign demonstrated the highest correct performance across both institutions, while the Lachman's test had the

lowest accuracy and greatest variability. Comparison with senior orthopedic residents revealed statistically significant performance gaps in the Lachman's and anterior drawer tests, but not in the Lever sign. No significant differences were observed between the two student groups, and performance on healthy control subjects was generally higher and more consistent. Together, these findings highlight both the relative ease of learning the Lever sign and the technical challenges students face with more complex maneuvers.

Assessing the learning outcomes and academic progression of medical students during their training is a crucial aspect of establishing high-quality learning and teaching [29-31]. The educational objectives of any medical school are to ensure the capability of their graduate medical students to comfortably perform physical examinations and tests to aid them in the process of proper patient diagnosis and management [17]. Learning orthopedic special examination tests can be challenging and perhaps stressful to medical students due to the detailed technique and position required for the examined limb or joint, the complexity of some tests, and the unfamiliarity of the complex relevant musculoskeletal anatomy required to comprehend these tests [16,17].

The superior performance of students in the Lever sign test compared to the Lachman's and anterior drawer tests may be attributed to its relative technical simplicity. Unlike the other two tests, which require coordinated bimanual handling, precise limb positioning, and fine tactile perception of tibial translation, the Lever sign relies on a straightforward unimanual maneuver, making it more intuitive for beginner examiners. This finding aligns with prior reports suggesting that test complexity directly affects learning and retention among medical students [18,19].

Dr. Alessandro Lelli, who first described the Lever sign in 2005 [20], emphasized its simplicity and diagnostic reliability, noting high sensitivity and specificity even in early learners [21]. Jarbo et al. also found no significant difference in Lever sign accuracy between medical students and orthopedic fellows (84% vs. 88%), supporting its potential as an accessible diagnostic tool for trainees [22]. Our findings reinforce this evidence, as students demonstrated high correct performance rates on the Lever sign with only a small performance gap compared to senior residents (92% vs. 100%). Given these observations, the Lever sign appears to offer both diagnostic utility and educational value in early musculoskeletal training.

While the Lever sign demonstrated higher performance among students in our study, the overall differences between the three tests were modest and should be interpreted within context. The Lachman's test, though technically more demanding, remains the most widely validated clinical test for diagnosing ACL tears [23,24], with reported sensitivities ranging from 77.7% to 94.4% [25,26] and superior diagnostic utility compared to the anterior drawer test, particularly in acute injuries [27]. However, its reliability is heavily influenced by examiner experience, positioning, and patient muscle tone [28]—factors that may explain the lower student accuracy in our cohort (81.5%).

Similarly, the anterior drawer test, though generally easier to perform, has demonstrated variable sensitivity in prior studies (18%–94%) and is more susceptible to false negatives in acute injuries, often due to hamstring tension or joint effusion [29,30]. These limitations may influence how

effectively students learn and apply the technique, potentially contributing to the moderate correct performance rate observed in our study (85.5%). Nonetheless, our findings align with existing literature, reinforcing that even well-established clinical tests can present varying levels of difficulty in skill acquisition.

The observed differences in student performance across the three ACL tests highlight the need for medical education programs to consider the varying technical demands of each maneuver. While all tests are clinically important, their complexity can affect how easily they are learned by students. Incorporating these differences into musculoskeletal curricula may help educators structure skill acquisition more effectively. For example, introducing technically simpler tests like the Lever sign early in training may build student confidence and competence, while more complex tests such as Lachman's and anterior drawer can be reinforced through repeated supervised practice and targeted feedback. This tiered approach may enhance learning outcomes and better prepare students for real-world clinical application.

To further explore the skill acquisition process, we developed a hypothetical learning model using a simulated Area Under the Learning Curve (AULC) framework. This visual model, based on interpolated values between student and senior resident performance, offered a simplified representation of how each test might be learned over time. The Lever sign had the highest AULC, indicating it may be mastered earlier and more consistently, followed by the anterior drawer and then the Lachman's test. While simulated, these curves support the idea that some physical examination skills follow a steeper trajectory and require more time and practice to develop. The AULC concept may serve as a useful tool for visualizing educational progression and guiding the structure of procedural skills training in undergraduate medical education.

This study has several limitations that should be acknowledged. The evaluation was limited to three ACL special tests, which, while clinically relevant, may not fully represent the breadth of musculoskeletal examination skills. Additionally, the assessments were conducted on a small number of patients and controls, which may limit the generalizability of certain findings. The simulated AULC model, though useful for illustrating learning progression, is hypothetical and based on interpolated data rather than longitudinal observation. Nonetheless, the study's multi-institutional design, standardized assessment protocol, and inclusion of a senior resident benchmark strengthen the validity of the findings within the scope of undergraduate orthopedic education.

CONCLUSION

This study examined the ability of medical students to perform three physical examination tests for ACL injuries and found notable differences based on test complexity. Students from both medical schools performed similarly, suggesting consistent educational outcomes across institutions. The Lever sign was more commonly performed correctly, while the Lachman's and anterior drawer tests posed greater challenges. Performance was generally better when examining healthy controls compared to patients with ACL injuries, likely reflecting the added difficulty of detecting abnormal findings. These results highlight the importance of emphasizing practical training, particularly for more technically demanding

tests, to strengthen musculoskeletal clinical skills in undergraduate education.

Applicable Remarks

Given the results of our study, the author would like to emphasize the following applicable remarks.

1) Structured, Stepwise Training:

Due to the differing levels of difficulty among ACL tests, medical education should adopt a progressive, skills-based approach. Introducing simpler maneuvers like the Lever sign early, followed by more complex tests such as Lachman's and anterior drawer, may help students build competence more effectively.

2) Early Identification of Technical Challenges:

The study highlights that student struggled more with technically demanding tests such as Lachman's and anterior drawer. Early identification of these challenges through structured formative assessments can help educators intervene with targeted support, reducing the risk of carrying skill gaps into clinical practice or residency training.

Declarations

Ethics approval and Consent

The approval for this study was obtained from the institutional review board of Mutah University Ethics Committee, IRB number (772022). The Code of Ethics of the World Medical Association (Declaration of Helsinki) was followed while conducting the study. Informed written consent were obtained from the patients.

Availability of Data and Materials

The data that support the findings of this study are available upon appropriate request from the corresponding author.

Competing interest

The author declares that they have no competing interests.

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تقييم كفاءة طلبة الطب في الفحوصات الخاصة بتشخيص إصابات الرباط الصليبي الأمامي (ACL) في جراحة العظام

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الملخص

الخلفية والأهداف : تُعدّ الكفاءة في الفحص السريري مهارة أساسية لطلبة الطب، وخصوصًا في تقييم الحالات العضلية الهيكلية. تُعد إصابات الرباط الصليبي الأمامي من الإصابات الشائعة التي تُشخّص من خلال مزيج من التاريخ المرضي، التصوير الطبي، والفحوصات السريرية. هدفت هذه الدراسة إلى تقييم قدرة طلبة الطب من جامعتين في الأردن على إجراء ثلاث فحوصات شائعة للرباط الصليبي الأمامي: اختبار لاخمان، واختبار السحب الأمامي، واختبار الرافعة (اختبار ليلي).

المنهجية: أُجريت دراسة مقطعية شملت 200 طالب طب في السنة الخامسة خلال فترة تدريبهم في جراحة العظام. أجرى كل طالب الفحوصات الثلاثة على حالتين مؤكدتين بإصابة الرباط الصليبي الأمامي من خلال الرنين المغناطيسي، وحالتين سليمتين كضوابط. تم تقييم الأداء بناءً على تنفيذ الفحص بطريقة صحيحة، وتمت المقارنة بين أداء الطلاب في الجامعتين، وأداء طبيب مقيم كبير كمقياس مرجعي. كما تم إنشاء نموذج منحنى تعلم لمحاكاة تطور المهارات مع مستوى التدريب.

النتائج: أظهر الطلاب أعلى نسبة أداء صحيح في اختبار الرافعة (92.0%)، تلاه اختبار السحب الأمامي (85.5%)، ثم اختبار لاخمان (81.5%). لم تُلاحظ فروقات معنوية بين طلاب الجامعتين (القيم الاحتمالية بين 0.192–0.731). كان الأداء أفضل عند فحص الحالات السليمة مقارنة بالحالات المصابة. أظهر الأطباء المقيمون أداءً أعلى في جميع الاختبارات. كما أظهرت منحنيات التعلم المحاكاة أن اختبار الرافعة كان الأسهل من حيث اكتساب المهارة.

الاستنتاج: أظهر طلبة الطب تباينًا في كفاءتهم في أداء الفحوصات الخاصة بالرباط الصليبي الأمامي، ويُعزى ذلك إلى اختلاف الصعوبة التقنية بين الفحوصات. يدعم هذا التباين الحاجة إلى برامج تدريبية ممنهجة وتدريجية لتحسين الكفاءة في الفحص السريري في جراحة العظام.

الكلمات الدالة: تعليم طبي، إصابة الرباط الصليبي الأمامي، فحص سريري، مهارات سريرية، منحنى التعلم.