JMedSci

Journal of the Medical Sciences
(Berkala Ilmu Kedokteran)

Volume 53, Number 2, 2021; 159-168
http://dx.doi.org/10.19106/JMedSci005302202107

Comparison of diagnostic accuracy between clinical examination and magnetic resonance imaging (MRI) in diagnosing anterior cruciate ligament (ACL) rupture on Indonesian population

Luthfi Hidayat[1,2*], Aditya Fuad Robby Triangga[1], Muhamad Afrizal Farkhan[1], Bernadeta Fuad Paramita Rahayu[1], Rahadyan Magetsari[1]

[1]Department of Orthopaedics and Traumatology, Dr. Sardjito General Hospital/Faculty of Medicine, Public Health and Nursing, [2]Department of Orthopaedics and Traumatology, Universitas Gadjah Mada Academic Hospital, Universitas Gadjah, Yogyakarta.

Submited: 2021-02-18
Accepted : 2021-04-21

ABSTRACT

Anterior cruciate ligament (ACL) injury is the most common knee ligament injured. Anterior drawer and Lachman tests are the most common physical examinations for helping diagnose ACL injuries, while magnetic resonance imaging (MRI) is the first choice of supporting examination for evaluating any internal abnormality of the knee. However, studies concerning the accuracy of those examinations in the Indonesian population are limited. This study aimed to compare the accuracy between the anterior drawer test, Lachman test, and MRI in diagnosing ACL injury in Javanese patients. This retrospective study used medical records data of patients who underwent knee arthroscopy in the Department of Orthopaedics and Traumatology, Dr. Sardjito General Hospital, Yogyakarta in 2018. The MRI and the clinical examination results were compared to the arthroscopy results as the gold standard. The study showed the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy for the anterior drawer test were 86.67% (95%CI: 69.28-96.24%), 80% (CI: 44.39-97.48%), 92.86% (CI: 78.88-97.84), 66.67% (CI: 43.28-83.98%), and 85% (CI: 70.16-94.29%), respectively. Lachman test had 96.67% (CI: 82.78-99.92%) sensitivity, 90% (CI: 55.50-99.75%) specificity, 96.67% (CI: 81.86-99.47%) PPV, 90% (CI: 56.44-98.43%) NPV, and 95% (CI: 83.08-99.39%) accuracy. The diagnostic parameters of MRI were 83.33% (CI: 65.28-94.36%) for sensitivity, 60% (CI: 26.24-87.84%) for specificity, 86.21% (CI: 74.21-93.14%) for PPV, 54.55% (CI: 31.77-75.57%) for NPV, and 77.50% (CI: 61.55-89.16%) for accuracy. In conclusion, the Lachman test has better accuracy than the anterior drawer test. Both the anterior drawer and Lachman tests had higher accuracy compared to the MRI.

ABSTRAK

Cedera *anterior cruciate ligament* (ACL) merupakan cedera ligament lutut yang paling sering dijumpai. Tes *anterior drawer* dan tes Lachman merupakan pemeriksaan fisik yang paling sering digunakan untuk membantu diagnosis cedera ACL. *Magnetic resonance imaging* (MRI) merupakan pemeriksaan penunjang pilihan pertama untuk kelainan internal lutut. Namun demikian penelitian tentang akurasi pemeriksaan tersebut pada populasi Indonesia masih terbatas. Penelitian ini betujuan mengkaji akurasi tes *anterior drawer*, tes Lachman dan MRI dalam diagnosis cedera ACL pada etnis Jawa. Penelitian ini bertujuan membandingkan akurasi tes *anterior drawer*, tes Lachman dengan MRI untuk mendiagnosis cedera ACL pada etnis Jawa. Penelitian retrospektif ini menggunakan data rekam medis pasien yang menjalani artroskopi lutut di Departemen Ortopedi dan Traumatologi, Rumah Sakit Umum Pusat Dr. Sardjito, Yogyakarta tahun 2018. Hasil pemeriksaan klinik dan MRI dibandingkan dengan hasil ortoskopi sebagai standar emas. Hasil penelitian menunjukkan sensitivitas, spesifisitas, nilai duga positif (*positive predictive value*/PPV), nilai duga negatif (*negative predictive value*/NPV) dan akurasi dari tes *anterior drawer* berturut-turut adalah 86,67% (95% CI:

Keywords:
ACL rupture;
Lachman test;
anterior drawer test;
MRI;
accuracy;

*corresponding author: luthfi.hidayat@ugm.ac.id

69,28–96,24%), 80% (CI: 44,39-97,48%), 92,86% (CI: 78,88- 97,84%), 66,67% (CI: 43,28 - 83,98%), and 85% (CI: 70,16–94,29%). Tes Lachman memiliki sensitivitas 96,67% (CI: 82,78 – 99,92%), spesifisitas 90% (CI: 55,50 – 99,75%), PPV 96,67% (CI: 81,86 – 99,47%), NPV 90% (CI: 56,44 – 98,43%), dan akurasi 95% (CI: 83,08 - 99.39%). Nilai parameter diagnosis MRI adalah 83,33% (CI: 65,28 – 94,36%) untuk sensitivitas, 60% (CI: 26,24 – 87,84%) untuk spesifisitas, 86,21% (CI: 74,21 – 93,14%) untuk PPV, 54,55% (CI: 31,77 – 75,57%) untuk NPV, dan 77,5% (CI: 61,55 – 89,16%) untuk akurasi. Dapat disimpulkan, tes Lachman memiliki akurasi yang lebih baik dari tes *anterior drawer*. Baik tes *anterior drawer* maupun tes Lachman memiliki akurasi yang lebih baik dari MRI.

INTRODUCTION

Anterior cruciate ligament (ACL) injury is the most common knee ligament injury which occurred during athletic activities.[1] The incidence of ACL injury significantly increases in the population due to the increase in sports participation.[2] Diagnosing ACL injuries requires a thorough history taking and physical examination, including some specific tests of ACL injury. Anterior drawer and Lachman tests are the most common physical examinations for helping diagnose ACL injuries. However, awide range in sensitivity and specificity of the both tests are reported. The sensitivity and specificity of the anterior drawer test were 18-92% and 78-98%, respectively. While, the sensitivity (63-93%) and specificity (55-99%) of Lachman test were relatively higher than drawer test.[3]

A non-invasive examination using magnetic resonance imaging (MRI) has been applied on patients with ACL injury to increase accuracy of the diagnosis.[4] Currently, MRI is the first choice of supporting examination for evaluating any internal abnormality of the knee. However, the MRI examination is not always available in health facilities in Indonesia. Even it is available, the MRI examination can not be performed due to economic reason of patients. Therefore, specific physical examinations are recommended for the ACL injury screening due to they have a similar accuracy with MRI if performed by a skilled orthopedic surgeon.[5] Furthermore, the orthopedic surgeon may do an arthroscopy procedure to diagnose and directly treat the abnormalities of patients with ACL injury.

Although the accuracy of the Lachman and anterior drawer tests is reported to be comparable to MRI examination, no study has been conducted in the Indonesian population. It is believed that the knee morphology varies between population which affect the accuracy of the ACL injury test.[6,7] This study aimed to compare the accuracy between the anterior drawer test and Lachman test as well as MRI examination in diagnosing ACL injury in Javanese patients.

MATERIALS AND METHODS

Patients

This study has been approved by the Medical and Health Research Ethics Committee, Faculty of Medicine, Public Health and Nursing, Universitas Gadjah Mada/Dr. Sardjito General Hospital, Yogyakarta. This retrospective study used medical records data of patients who underwent knee arthroscopy in the Department of Orthopaedics and Traumatology, Dr. Sardjito General Hospital, Yogyakarta in 2018. The MRI and the clinical examination results were compared to the arthroscopy results as the gold standard. Patients who did not have MRI results, patients with a history of fracture around the knee, knee dislocation, general laxity, tumor

or infection around the knee, history of musculoskeletal or nervous system disorder which limited the knee motion, previous history of surgical procedure around the knee before the arthroscopy procedure, and patients with body mass index (BMI) <18.5 or >25 were excluded from this study.

Protocol of study

The MRI and the clinical examination results were compared to the arthroscopy results as the gold standard. The results of the anterior drawer and Lachman tests from the medical records when the patient was examined after > 6 weeks from time of injury (chronic condition), without anesthesia were obtained. The physical examination was performed by skilled chief residents and the arthroscopy procedure was performed by a senior orthopedic surgeon. Torn ACL was diagnosed when discontinuity of ACL (partial or complete) was seen during the arthroscopy.

The MRI was also performed > 6 weeks after injury and the result was interpreted by radiology specialist staff in our hospital, who were on duty on the examination day. The MRI used in this study was Philips Multiva 1.5 Tesla. The examination was done in axial, sagittal, and coronal planes; with following sequences: T1W, T2 SPAIR (spectral attenuation inversion recovery), PD SPAIR (proton density with spectral attenuation inversion recovery), STIR (short tau inversion recovery), T2 FFE (fast field echo technique); and without intravenous gadolinium contrast. The MRI and the physical examinations were performed on the same day.

The anterior drawer test was performed with the patient in the supine position, the hip was flexed to 45 degrees and the knee was flexed to 90 degrees. The examiner sat on the patient's feet to stabilize the leg. After making sure that the hamstring muscles relaxed, the forward force was applied to the tibia. The forward movement of more than 6-8 mm than the normal knee was considered positive.[8]

The Lachman test was performed with the knee flexed to 20 degrees. The examiner grabbing the distal thigh with one hand, while the other hand grabbing the proximal leg. The anterior force was then applied to the leg. The abnormal forward movement suggests the positive Lachman test and indicates an ACL injury.[9]

Statistical analysis

The data analysis was conducted by using SPSS (11.5 version). Descriptive analysis was performed for the sociodemographic characteristics of the patient. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy for the two clinical examinations and MRI were calculated using the Thorner-Remain test.

RESULTS

There were 42 patients who underwent knee arthroscopy in 2018. ACL tears were seen in 30 patients: 26 lesions were complete (FIGURE 1); 4 lesions were partial.

The final diagnoses for the patients are shown in FIGURE 2 and the sociodemographic characteristics of the patients are shown in TABLE 1. Two patients with knee osteoarthritis and fracture of ACL insertion were excluded.

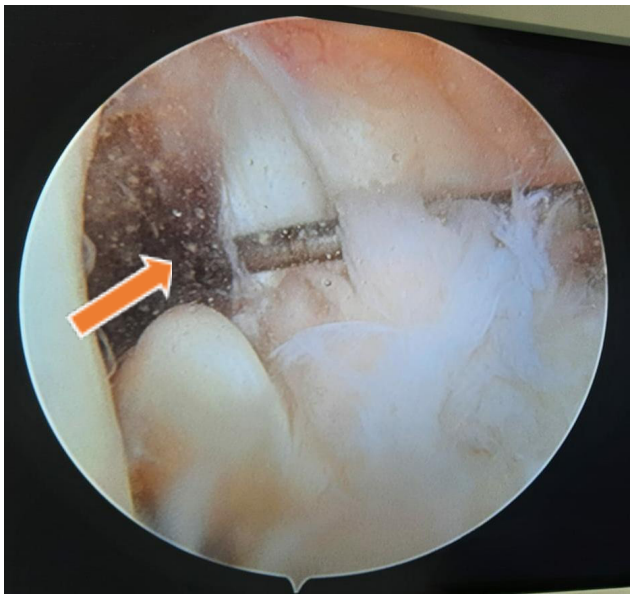

FIGURE 1. Arthroscopic view showing total rupture of anteromedial and posterolateral bundle of ACL, producing the *empty wall* appearance (arrow).

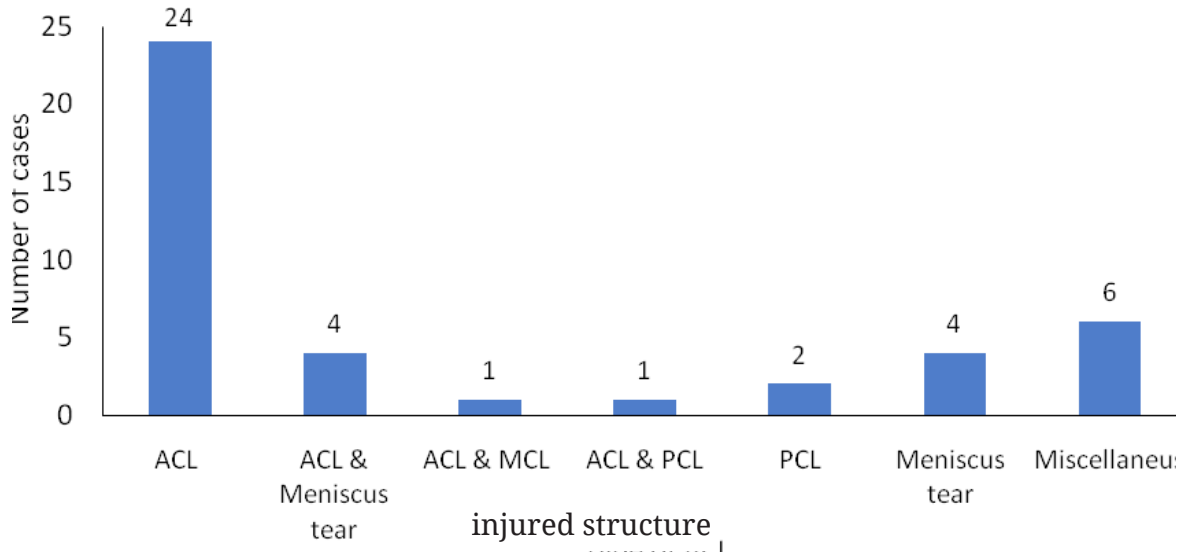

FIGURE 2. The final diagnosis of patients who underwent knee arthroscopy in 2018.

TABLE 1. Final diagnosis and demographic characteristics of the patients involved in this study

Variable	n	Percentage (%)
Age		
• 17-35 years old	34	80.95
• 36-58 years old	8	19.04
Sex		
• Male	29	69.04
• Female	13	30.95
Side of involvement		
• Right	20	47.61
• Left	22	52.38
Mechanism of injury		
• Sports	20	47.61
• Traffic Accident	14	33.33
• Miscellaneous	8	19.04

Anterior drawer test

The results of anterior drawer test in diagnosing ACL injuries compared to the arthroscopy results are shown in TABLE 2. The sensitivity, specificity, PPV, NPV, and the accuracy for this test were 86.67% (95% confidence interval [95% CI]: 69.28 - 96.24%), 80% (CI: 44.39 - 97.48%), 92.86% (CI: 78.88 - 97.84%), 66.67% (CI: 43.28 - 83.98%), and 85% (CI: 70.16 to 94.29%), respectively.

Lachman test

The diagnostic performance of the Lachman test for ACL injuries is shown in TABLE 3. Lachman test had 96.67% (CI: 82.78 - 99.92%) sensitivity, 90% (CI: 55.50 - 99.75%) specificity, 96.67% (CI: 81.86 - 99.47%) PPV, 90% (CI: 56.44 - 98.43%) NPV, and 95% (CI: 83.08 - 99.39%) accuracy.

TABLE 2. 2x2 contingency table depicting results of anterior drawer test

Variable	ACL rupture (+)	ACL rupture (-)
Anterior drawer(+)	26	2
Anteriordrawer (-)	4	8

TABLE 3. 2x2 contingency table depicting results of Lachman test

Variable	ACL rupture (+)	ACL rupture (-)
Lachman(+)	29	1
Lachman (-)	1	9

MRI

The results of MRI compared to arthroscopy as the gold standard are shown in TABLE 4. Imaging signs suggesting ACL rupture were present in 29 patients (FIGURE 3 and 4).

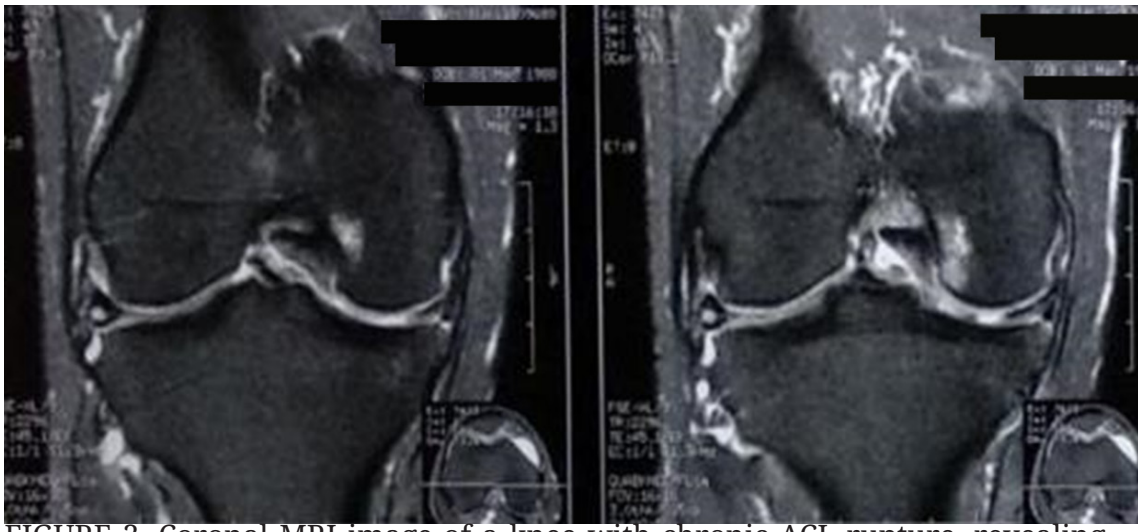

FIGURE 3. Coronal MRI image of a knee with chronic ACL rupture, revealing non-visualization of the ACL fiber and positive empty wall sign.

FIGURE 4. Sagittal MRI image of a knee with chronic ACL rupture, revealing PCL buckling and disrupted ACL fiber.

When compared to the arthroscopy, the diagnostic parameters of MRI were 83.33% (CI: 65.28 - 94.36%) for sensitivity, 60% (CI: 26.24 - 87.84%) for specificity, 86.21% (CI: 74.21 - 93.14%) for PPV, 54.55% (CI: 31.77 - 75.57%) for NPV, and 77.5% (CI: 61.55 - 89.16%) for accuracy.

Compared to the anterior drawer test and Lachman test, MRI had the lowest score in all of the diagnostic parameters (FIGURE 5).

TABLE 4. 2x2 contingency table depicting results of MRI

Variable	ACL rupture (+)	ACL rupture (-)
MRI(+)	25	4
MRI (-)	5	6

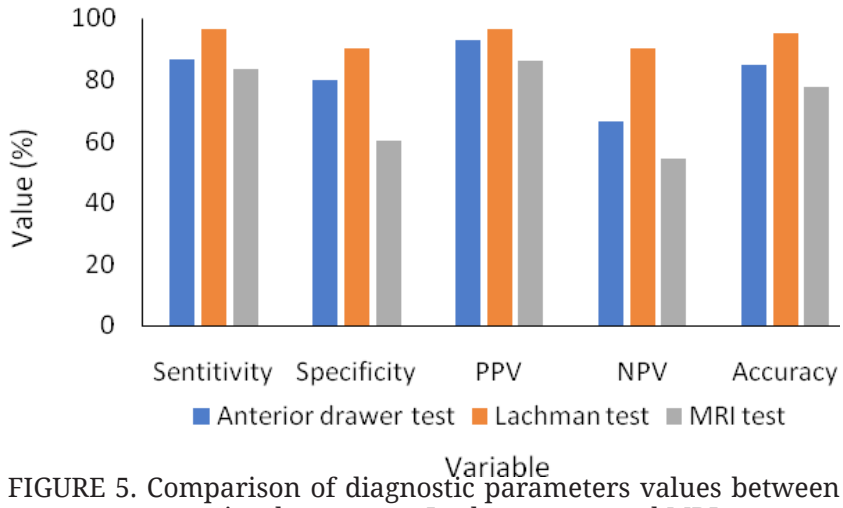

FIGURE 5. Comparison of diagnostic parameters values between anterior drawer test, Lachman test, and MRI.

DISCUSSION

While the diagnostic parameters values for the anterior drawer and Lachman tests ranged widely, our study yields the values when these examinations were performed in the Indonesian mongoloid population, specifically with Javanese ethnicity, in chronic condition.

Anterior drawer test

Our study used the test results when performed in chronic conditions, revealing sensitivity of 86.67% and specificity of 80%. A meta-analysis conducted by Scholten *et al.*[3] reported that the pooled sensitivity was 62% (CI: 42–78%) and the pooled specificity was 88% (CI: 83–92%). Another meta-analysis separating the condition to acute and chronic reported the pooled sensitivity and specificity were 49% (CI: 43-55%) and 58% (CI: 39-76%), respectively in an acute condition, but increased to 92% (CI: 88-95%) and 91% (CI: 87-94%) in the chronic condition.[10]

There are several possible reasons for the low accuracy of the anterior drawer test when performed in acute conditions.[11] The hemarthrosis and reactive synovitis in an acute condition may cause difficulties to flex the knee to 90 degrees. The knee pain may also lead to the protective contraction of hamstring muscles that would prevent the anterior translation of the tibia. When the acute phase subsides, there will be less pain, effusion, and protective muscular contractions will decrease. In this condition, the anterior drawer test will have better accuracy. As expected, our study that was performed in the chronic condition produced much better sensitivity and specificity if compared to the previous study performed in an acute condition, although it was slightly lower than the study that also included chronic patients.

Lachman test

The sensitivity of the Lachman test in our study was 96.67% and the specificity was 90%. The result of our study was similar to the previous study. Benjaminse *et al.*[9] reported that a sensitivity of Lachman test was 94% (CI: 91%-96%) in acute and 95% (CI: 91%-97%) in chronic conditions, whereas the specificity was 97% (93%-99%) in acute and 90% (CI: 87%-94%) in chronic conditions.

The good accuracy of the Lachman

test in both acute and chronic conditions may be due to the position of 20 degrees flexion is less painful and therefore might reduce the pain-induced protective muscle contraction during the test.[11] Another possible reason for the greater accuracy of the Lachman test compared to the anterior drawer test was because this test produced more tension in the ACL bundle, that is the baseline tension in the ACL bundle at 15 degrees of flexion was greater than at 90 degrees.[12]

Despite its good accuracy, this test was relatively difficult to be performed, especially for an examiner with a relatively small hand against the patient's leg. The knee position of 20-30 degrees is crucial, and if the angle is decreased to 10 degrees, the tibia excursion may decrease and may also lead to a false endpoint.[13] In addition, the patient should be able to completely relax their upper leg muscles.

MRI

The sensitivity and specificity of MRI in our study were 83.33% and 60%. The misdiagnosis of ACL injury in MRI examination is particularly more likely to happen in the chronic patient with an incomplete tear. The possible reason is due to the special sensitivity to the hydrogen atom and may be associated with volume effects and synovial hyperplasia.[14] This study included both patients with partial and complete tears yet excluded the acute injury. Not surprisingly, our result was lower than the previous study that only included the complete tear. A meta-analysis by Smith *et al.*[15] reported a higher value of sensitivity and specificity of MRI for detecting complete ACL tear, which were 94.5% (CI: 92–96%) for sensitivity, 95.3% (CI: 93–97%) for specificity. Similarly, the high sensitivity and specificity of the MRI test were also reported by Oei *et al.*[16] where the value of sensitivity was 94.4 (CI: 92.3-96.6%) and the specificity was 94.3 (CI: 92.7-95.9%).

Our result was similar to a study by Murmu *et al.*[17] where they reported 87.5% of sensitivity and 66.6% of specificity. As in our study, they only included patients with non-acute knee pain (> 6 weeks). Nonetheless, they did not specify whether they also included the partial rupture or only included the complete rupture of ACL.

In addition to the onset and degree of the ACL tear, other factors that may affect the MRI accuracy are magnetic field intensities of the MRI and type of MRI sequence. Increased magnetic field intensities offer a greater signal-to-noise ratio that may enhance resolution and create clearer images. However, a meta-analysis by Li *et al.*[14] reported no significant difference in accuracy between MRI with greater or equal to 1.5T and MRI with less than 1.5T in diagnosing ACL injury. Furthermore, they reported that conventional sequences with proton density weighted imaging are just slightly superior in their accuracy compared to the conventional sequences, and the difference was not statistically significant. Another study by Ng *et al.*[18] found that the addition of oblique axial imaging to the standard orthogonal sequences may increase accuracy for identifying ACL partial tears as well as assessment of individual bundle tears. This imaging plane can be a valuable adjunct to the standard orthogonal sequences when ACL injury is suspected.

This study has several limitations. Due to its retrospective nature, the examiner blinding to the other test result was unknown and we could not control the inter-observer variability. Also, the sample size was small, and the time from injury to the MRI was different between the patients. Further research with prospective design and larger samples is required to complement the limitations of our study. Besides, we recommended further research to be conducted to

compare the accuracy of the tests when performed in several situations: acute vs. chronic, with anesthesia vs. without anesthesia, and performed by orthopedic surgeons vs. performed by general practitioners. Additional comparison with other physical examinations such as pivot shift and lever sign tests is also suggested. Despite these limitations, our study provides new evidence that the anterior drawer and Lachman tests can be used as the gold standard for selecting patients for arthroscopy when MRI is not readily available in our population.

CONCLUSIONS

In conclusion, both the anterior drawer and Lachman tests performed in the Javanese patient provide higher sensitivity and specificity compared to the MRI in diagnosing ACL injury.

ACKNOWLEDGEMENTS

We would like to thank all the members of the Department of Orthopaedics and Traumatology, Dr. Sardjito General Hospital for their great support throughout this study.

REFERENCES

1. Gianotti SM, Marshall SW, Hume PA, Bunt L. Incidence of anterior cruciate ligament injury and other knee ligament injuries: a national population-based study. J Sci Med Sport 2009; 12(6):622-7. https://doi.org/10.1016/j.jsams.2008.07.005
2. Kaeding CC, Léger-St-Jean B, Magnussen RA. Epidemiology and diagnosis of anterior cruciate ligament injuries. Clin Sports Med 2017; 36(1):1-8. https://doi.org/10.1016/j.csm.2016.08.001
3. Scholten RJPM, Opstelten W, van der Plas CG, Bijl D, Deville WLJM, Bouter LM. Accuracy of physical diagnostic tests for assessing ruptures of the anterior cruciate ligament: a meta-analysis. J Fam Pract 2003; 52(9):689-94.
4. Muthuuri JM. A comparison of accuracy of clinical tests and MRI in the diagnosis of meniscal and anterior cruciate ligament injuries. East African Orthop J 2017; 11(1):6-11.
5. Khan AH, Ahad H, Sharma P, Bajaj P, Hassan N, Kamal Y. Correlation between magnetic resonance imaging and arthroscopic findings in the knee joint. Trauma Mon 2015; 20(1):e18635. https://doi.org/10.5812/traumamon.18635
6. van Eck CF, van den Bekerom MPJ, Fu FH, Poolman RW, Kerkhoffs GMMJ. Methods to diagnose acute anterior cruciate ligament rupture: a meta-analysis of physical examinations with and without anaesthesia. Knee Surg Sport Traumatol Arthrosc 2013; 21(8):1895-903. https://doi.org/10.1007/s00167-012-2250-9
7. Kim TK, Phillips M, Bhandari M, Watson J, Malhotra R. What differences in morphologic features of the knee exist among patients of various races? a systematic review. Clin OrthopRelat Res 2017; 475(1):170-82. https://doi.org/10.1007/s11999-016-5097-4
8. Canale ST, Beaty JH. Campbell's Operative Orthopaedics. 12th ed. Philadelphia, PA: Mosby Elsevier; 2012.
9. Blom A, Warwick D, Whitehouse MR. Apley and Solomon's System of Orthopaedics and Trauma. 10th ed. Boca Raton: CRC Press; 2018.
10. Benjaminse A, Gokeler A, van der Schans CP. Clinical diagnosis of an anterior cruciate ligament rupture: a meta-analysis. J Orthop Sport Phys Ther 2006; 36(5):267-88.

https://doi.org/10.2519/jospt.2006.2011
11. Torg JS, Conrad W, Kalen V. Clinical diagnosis of anterior cruciate ligament instability in the athlete. Am J Sports Med 1976;4(2):84-93. https://doi.org/10.1177/0363546576-00400206
12. Rosenberg TD, Rasmussen GL. The function of the anterior cruciate ligament during anterior drawer and Lachman's testing. Am J Sports Med 1984;12(4):318-22. https://doi.org/10.1177/036354658401200413
13. Donaldson WF, Warren RF, Wickiewicz T. A comparison of acute anterior cruciate ligament examinations. Initial versus examination under anesthesia. Am J Sports Med 1985;13(1):5-10. https://doi.org/10.1177/03635465850-1300102
14. Li K, Du J, Huang LX, Ni L, Liu T, Yang HL. The diagnostic accuracy of magnetic resonance imaging for anterior cruciate ligament injury in comparison to arthroscopy: a meta-analysis. Sci Rep 2017;7(1):7583. https://doi.org/10.1038/s41598-017-08133-4
15. Smith TO, Lewis M, Song F, Toms AP, Donell ST, Hing CB. The diagnostic accuracy of anterior cruciate ligament rupture using magnetic resonance imaging: a meta-analysis. Eur J Orthop Surg Traumatol 2012; 22(4):315-26. https://doi.org/10.1007/s00590-011-0829-3
16. Oei EHG, Nikken JJ, Verstijnen ACM, Ginai AZ, Myriam Hunink MG. MR Imaging of the menisci and cruciate ligaments: a systematic review. Radiology 2003;226(3):837-48. https://doi.org/10.1148/radiol.2263011892
17. Murmu C, Tiwari PK, Sircar S, Agrawal VK. Accuracy of magnetic resonance imaging in diagnosis of knee injuries. Int J Orthop Sci 2017;3(1):85-8. https://doi.org/10.22271/ortho.2017.v3.i1b.15
18. Ng AWH, Griffith JF, Hung EHY, Law KY, Yung PSH. MRI diagnosis of ACL bundle tears: value of oblique axial imaging. Skeletal Radiol 2013;42(2):209-17. https://doi.org/10.1007/s00256-012-1372-y