

Clinical Research

Diagnostic accuracy of magnetic resonance imaging in detecting anterior cruciate ligament injuries

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ABSTRAK

Latar belakang: berbagai Ligamen krusiata anterior (ACL) menstabilisasi sendi saat hiperekstensi dan mencegah translasi anterior terhadap tulang femur. Diagnosis cedera ACL masih banyak didiskusikan. Tujuan penelitian ini menentukan akurasi diagnostik MRI dalam mendiagnosis cedera ACL pada pasien trauma lutut dan mengambil artroskopi sebagai baku emas.

Metode: Pasien yang memenuhi kriteria inklusi dievaluasi secara klinis, MRI dan artroskopi pada Departemen Orthopedi dan Tulang Belakang di Rumah Sakit Pendidikan Ghurki Trust, Lahore. Akurasi, sensitivitas dan spesifisitas MRI dalam mendiagnosis cedera ligament krusiata anterior dikonfirmasi dengan temuan artroskopi. Data dianalisis dengan program SPSS versi 17.

Hasil: Sebanyak 185 pasien terdiri dari 91,1% laki-laki dan rerata usia 28,25 tahun. Akurasi pemeriksaan MRI untuk mendiagnosis cedera ACL adalah 91,9% dengan sensitivitas 93,3%, spesifisitas 85,7%, nilai duga positif 96,6% dan nilai duga negatif 75%.

Kesimpulan: Pemeriksaan MRI adalah modalitas yang akurat dan non invasive untuk menilai cedera ligament. Pemeriksaan ini dapat digunakan sebagai pemeriksaan lini pertama pada pasien dengan cedera ACL.

ABSTRACT

Background: The anterior cruciate ligament (ACL) stabilizes the joint during hyperextension and prevents anterior translation over femur. The objective of this study was to determine the diagnostic accuracy of magnetic resonance imaging (MRI) in detecting ACL injury by taking arthroscopy as gold standard in patients with traumatic knee injury.

Methods: Patients fulfilling the study criteria were treated with clinical examination, MRI and then arthroscopy at the Department of Orthopedics and Spine in the Ghurki Trust Teaching Hospital, Lahore. The accuracy, sensitivity and specificity of MRI in diagnosing the anterior cruciate ligament injury were calculated based on arthroscopic findings. All the data were analyzed using SPSS 17.0 version.

Results: A total 185 patients were included. 91.1% were males and 8.9% were females with Mean age of 28.25±0.433. The accuracy of MRI in diagnosing the anterior cruciate ligament was 91.89%, with sensitivity of 93.33%, specificity of 85.71%, positive predictive value of 96.55% and the negative predictive value of 75%.

Conclusion: MRI is accurate and non-invasive modality for the assessment of ligamentous injuries. It can be used as a first line investigation to patients with suspicion of ACL injury.

Keywords: ACL, arthroscopy, knee, MRI

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The anterior cruciate ligament is currently the most common ligament injury in the knee joint. The number of incidences is as many as 1 in 3,500 individuals each year.¹ Sports like skiing, ice hockey, and gymnastics can also produce enough stress to disrupt knee ligaments. Automotive accidents, especially those involving motorcycles, are common causes of knee ligament disruptions. Sudden severe loading without a fall or contact, like deceleration of a running athlete can also cause ligament disruption.²⁻³

The anterior cruciate ligament is the major stabilizer of knee joint. It prevents the anterior tibial displacement over the femur. Selective sectioning of the anterior cruciate ligament has shown that the anteromedial band is tight in flexion, providing the primary restraint, whereas the posterolateral bulky portion of this ligament is tight in extension.⁴ The posterolateral bundle provides the primary resistance for hyperextension.

There are many modalities to diagnose the anterior cruciate ligament (ACL) injury, however good history and physical examination are the key steps. The patient's history of the experience (i.e., the knee's buckling or jumping out of place; an audible pop; the location, severity, and relative time at the onset of pain; the ability to walk after the injury occurred) is important.⁵ In physical examination, anterior drawer and Lachman tests are most useful tests. The Lachman test is most sensitive for anterior tibial displacement.⁴⁻⁶

Imaging and arthroscopy are two most common modalities. Magnetic resonance imaging has several advantages over arthroscopy. Magnetic resonance imaging is sensitive, non-invasive and accurate in detecting soft tissue injuries of knee.⁷ It is a reliable method to confirm the clinical diagnosis and may even reveal the ligament tears which may be missed by arthroscopy.⁸⁻⁹

Ligament tears can be accurately assessed with MRI, but distinguishing partial tears from ruptures of the ACL can be challenging. Determining the extent of a partial tear is often extremely difficult to accurately assess.⁷⁻¹⁰ However, it is a routinely prescribed test in suspecting soft tissue injuries of knee. Kostov H. et al⁶ reported 83% sensitivity, 88.37% specificity, 93% positive predictive value, 74.5% negative

predictive value, 82.5% accuracy in detecting anterior cruciate ligament. The prevalence of ACL tear in knee injuries is 14.4%.¹¹

Arthroscopy directly visualizes all the internal structures of the knee joint. It can be used as a diagnostic and at the same time as a therapeutic tool. The knee is the joint in which arthroscopy has its greatest diagnostic and intra articular surgical application.¹² The usefulness of arthroscopic techniques in diagnosis and treatment of intra articular pathology has been well documented.¹⁰ Arthroscopy needs special instruments and expert surgeons. This makes arthroscopy more costly than magnetic resonance imaging (MRI). The main aim of this study is to determine the efficacy of MRI in detecting the anterior cruciate ligament injuries in our set up.

METHODS

This descriptive study uses a non-probability consecutive sampling at the Department of Orthopedics and Spine Centre, Ghurki Trust Teaching Hospital, Pakistan from January 1st, 2016 to December 31st, 2016. A written informed consent from every patient and approval from the Hospital Ethical Committee were obtained. 185 patients with the ages between 16-55 years of both sexes having had recent post traumatic knee injuries within two months were included in the study. While the patients having inconclusive findings on MRI, degenerative changes on X-rays or having previous history of knee surgery or managed conservatively or not in the range of above inclusion age were excluded from the study. All patients with positive anterior drawer test and positive Lachman test were subjected to MRI. However patients who had already done MRI were also included. Images of magnetic resonance were performed with 0.5 tesla (Philips Medical system) at the Radiology Institute Ghurki Trust Teaching Hospital, Lahore Medical and Dental College, Lahore. Standardized magnetic resonance imaging protocol consisted of sagittal, coronal and axial sequences in section thickness of 3-5 mm. Magnetic resonance images were reported by a consultant radiologist who then determined whether the ACL is intact or torn. Arthroscopy were performed after informed consent and

demographic information like name, age and gender were recorded. All arthroscopies were performed by the same consultant orthopedic surgeons who were blinded to the radiologist's diagnosis. He determined whether the ACL intact or torn.

Arthroscopy was done in a standardized manner using inferolateral and medial portal which include the survey of the entire joint and anatomical structure, lesions involved with the presence or absence of tear, its location, status of the articular cartilage.

Statistics

The collected data were entered initially on a pre-formed proforma and then analyzed using statistical product and service solution (SPSS) version 17. Sensitivity, specificity, positive predictive value, negative predictive value and accuracy were calculated by generating a 2x2

contingency table. Categorical variables like ACL injury on MRI and on arthroscopy and gender were summarized using frequency and percentages. Quantitative variables like age and body mass index (BMI) were presented as mean ± SD.

Data were stratified by age, gender and BMI to address effect modifiers. A post-stratification Chi-square test was applied with p≤0.05 as significant.

RESULTS

This study included 185 patients out of which 168 (91.1%) were males and 17 (8.9%) were female. The male to female ratio of 9.88:1 and the mean age was 28.25±12.25 years. The different characteristics such as right or left knee involvement, patients from different age groups, mechanism of injury and body mass index are summarized in Table 1.

Table 1. Basic demographic characteristics of patients

	Frequency (n)	Percentage (%)
Age in years		
16-35	139	75.1%
36-50	46	24.9%
Sex		
Male	168	91.1%
Female	17	8.9%
Side of limb involvement		
Right	123	66.49%
Left	62	33.51%
Mechanism of injury		
Road traffic accidents	94	50.81%
Sports injuries	85	45.95%
Miscellaneous	6	3.24%
Body Mass Index		
Below normal	32	17.3%
Normal	138	74.6%
Above normal	15	8.1%

The arthroscopic findings for the ACL tear were positive for 150 (81.08%) compared to MRI findings, i.e. 145 (78.37%). The arthroscopic findings were negative for 35 (18.92 %) and on MRI it was 40 (21.62%). The results of different variables like sensitivity, specificity, positive and negative predictive value and accuracy of MRI and arthroscopy are summarized in Table 2.

Though the gold standard of detecting anterior cruciate ligament injuries is arthroscopy, the diagnostic accuracy of MRI is also much more. The sensitivity and specificity of MRI in detecting anterior cruciate ligament injuries is 93.33% and 85.71%. Similarly MRI has high positive and negative predictive value, i.e. 96.55% and 75%. The arthroscopic and MRI pictures of two patients having sports injury and trauma to knee joints are given in Figure 1 (a, b) and Figure 2 (a, b).

Table 2. Comparison of MRI to arthroscopic findings in ACL injury detection

	Arthroscopic positive findings	Arthroscopic negative findings	
MRI positive findings	140 (TP) (93.33%)	5 (FP) (14.29%)	145
MRI negative findings	10 (FN) (6.67%)	30 (TN) (85.71%)	40
Total	150 (100%)	35 (100%)	185

TP= true positive; TN= true negative; FN= false negative; FP= false positive; MRI= magnetic resonance imaging

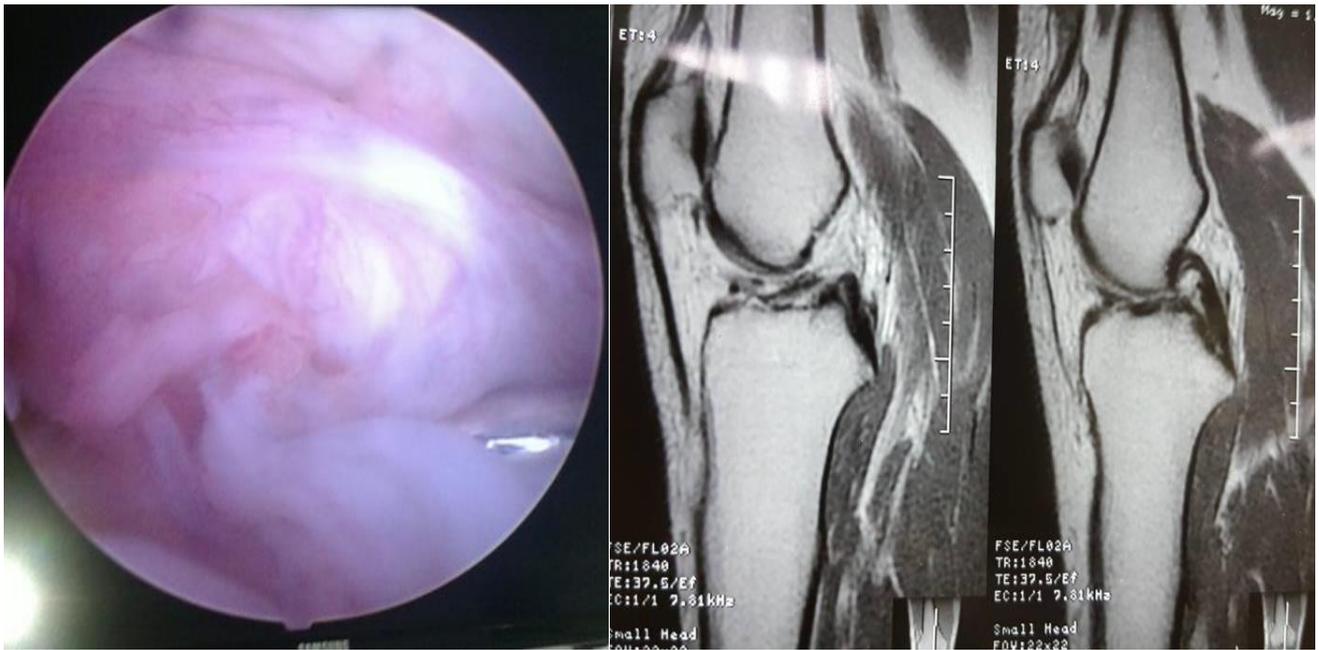


Figure 1. Arthroscopic and MRI image of 35 years-old-male having twist injury to right knee joint. Complete tear of ACL are shown in arthroscopy as well as MRI

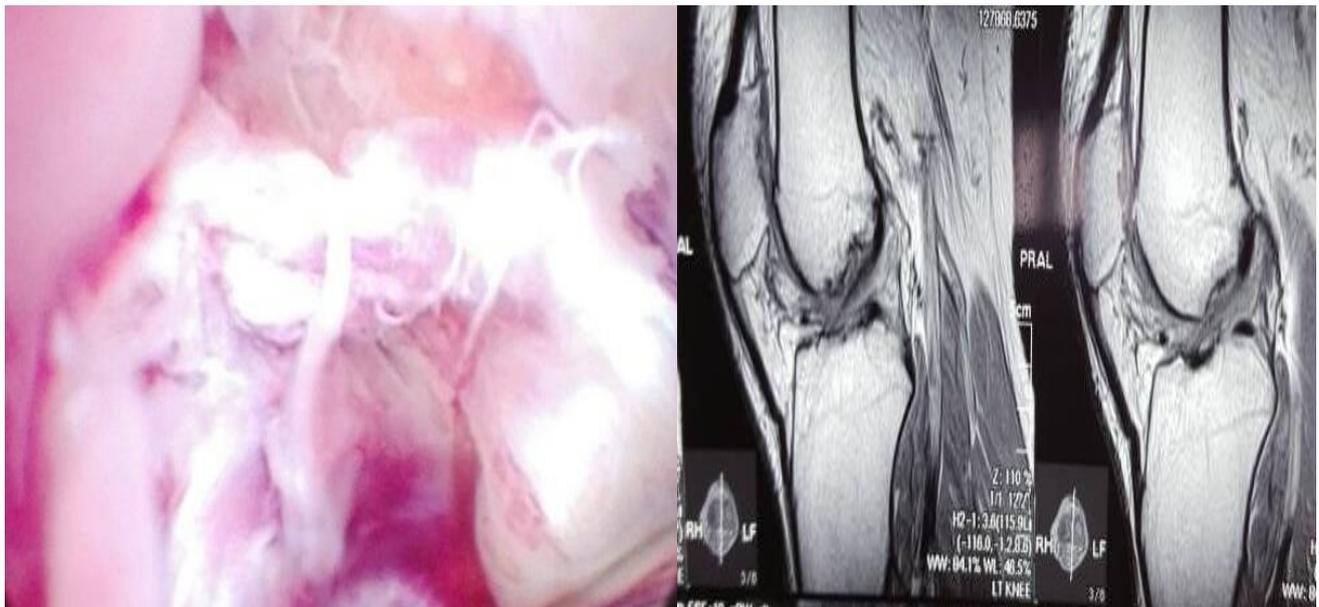


Figure 2. Arthroscopic and MRI image of 29 years-old-male had left knee injury during sports. There is complete ACL tear found on arthroscopy as well as MRI

DISCUSSION

MRI commonly uses modality to diagnose soft tissue injuries when other modalities fail to diagnose. It plays a vital role in diagnosing meniscal and ligamentous knee injuries. The knee often experiences injured joint due to its involvement in motion. It is complicated joint

that includes multiple structures for support and stability. Cruciate ligaments, collateral ligaments and menisci provide stability during motion. The ACL commonly gets injured during sports and accidents. It can occur isolated or associated with menisci and other ligaments. The first diagnosis of ACL tear was made by Galin and Stark¹² and the first intra articular ACL reconstruction was made by the father of ligamentoplasties i.e. Hey Groves.

The difference between acute and chronic injury as well as partial or full tear is difficult to define on clinical examination. Clinical examination has very low sensitivity and specificity. Ultrasonography is another modality for diagnosis of ACL tear. It has a high sensitivity and specificity but requires the hands of an expert.¹³ The advent of MRI technology in the early 1980s helped orthopedic surgeons in the treatment of knee disorders in several ways. In the early use of the technology, the improved initial diagnostic accuracy with preoperative MRI proved to be cost-effective in reducing unnecessary surgical interventions and altering treatment plans.¹⁴ The addition of oblique axial imaging to standard MR imaging improves diagnostic accuracy for detecting partial tears of the ACL as well as individual bundle tears of the ACL.¹⁵ 3D MR imaging has the potential to allow surgeons to: (1) tailor an ACL reconstruction technique or graft choice based on the ACL footprint size, (2) plan for selective bundle ACL reconstruction for partial tears, and (3) preoperatively template tunnel position according to the patient's individual anatomy.¹⁶ MRI has high accuracy for patients with complete ACL rupture. Due to the higher economic costs and increased complication risks of diagnostic arthroscopy, MRI is therefore recommended as the principal investigation following clinical examination, to diagnose ACL rupture.¹⁷ However, there are still controversies. According to Liodakis et al.¹⁸ the MRI scans are not routinely necessary as an indication for knee arthroscopy as clinical examination and plain radiograph are sufficient.

Our results showed that MRI had sensitivity and specificity of 93.33% and 85.71%. Similarly, the positive predictive value, the negative predictive value and accuracy are 96.55%, 75.0%, and 91.89%. Khan et al.¹⁹ concluded that MR had 100% sensitivity and NPV of 70% of diagnosing ACL tears in their study, which was higher than our findings. Clinical examination had sensitivity of 88% and NPV 75% in diagnosing ACL injuries. Gupta et al.²⁰ found that MRI showed a sensitivity of 74.42%, specificity of 93.10%, accuracy of 84.21%, and a negative predictive value of 88.04%. These findings were almost similar to our findings. Thiga et al.²¹ found that the sensitivity and specificity of MRI for anterior cruciate ligament rupture (whether complete or partial) was 83.3% and 90.9% respectively. Similarly,

Similarly, Amr et al.²² found that in comparison with knee arthroscopy, magnetic resonance imaging revealed an overall of 93.9% sensitivity and 66.6% specificity. Chiranjib et al.²³ also found that the sensitivity of MRI for diagnosis of ACL was 87.5%, specificity was 66.67%, positive predictive value -87.5%, negative predictive value -66.6% and accuracy of 81.82%. Almost all of the studies discussed above yield almost similar findings with our study in that we are in favor of conducting MRI for diagnostic purposes. While arthroscopy should be restricted for therapeutic purpose, MRI is non-invasive and cost-effective compared to arthroscopy and should always be considered as an option of choice for diagnosing ACL injuries.

There are some limitations in our study. Firstly the findings were not compared with the findings from the clinical examinations. Moreover chronic injuries were excluded to reduce the bias. Therefore, further research needs to be carried out to yield different results.

In conclusion, MRI is highly accurate in the diagnosis of ACL injuries in traumatic knees. Arthroscopy should be considered when it is required as therapeutic. Diagnostic use of arthroscopy is limited in the presence of MRI. MRI is an appropriate screening tool for therapeutic arthroscopy, making diagnostic arthroscopy unnecessary in most patients.

Conflicts of Interest

The authors affirm no conflict of interest in this study.

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