Evaluating the compatibility between magnetic resonance imaging (MRI) and arthroscopy in diagnosis of anterior cruciate ligament injury

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Abstract

Introduction: This research aims to evaluate the compatibility between magnetic resonance imaging (MRI) and arthroscopy in diagnosis of types and locations of anterior cruciate ligament tear (ACL).

Patients and methods: We report 75 case series undergoing arthroscopy with imaging of ACL tear on MRI, then investigated the compatibility between MRI and arthroscopy. Kappa index for MRI-arthroscopy compatibility is then calculated.

Results: MRI findings indicated 68% of cases are complete tears and 32% of cases are partial tears whereas the proportions of these types in arthroscopy are 73,3% and 26,7% respectively. By calculating the match between MRI and arthroscopy using Kappa index, this fit was good (Kappa = 0,62). According to the location of ACL tears on MRI, cases with proximal tear account for 54,7%, medial tear and distal tear account for 29,3% and 16%. Meanwhile, the percentage of these locations in arthroscopy are 60%, 25,3% and 14,7% respectively. The probability of identifying injury using MRI was high, with Kappa index for MRI-arthroscopy compatibility at 0,84.

Conclusion: MRI evaluations demonstrated high accuracy in the diagnosis of ACL injuries in the comparison with arthroscopy.

Keywords: Knee joint, ACL tear, arthroscopy, MRI.

Introduction

In Vietnam, in recent years, the massive increase of means of transport has led to an increasing rate of traffic accidents. Besides, the number of people playing sports is increasing, the types of sports are increasingly diverse. Therefore, the rate of injury to the motor system in general and the knee joint in particular is also increasing [1], [2].

The knee joint has a complex and stable structure, being one of the major weight-bearing joints. The maximum force measured applied to the knee joint when walking is about 2 to 4 times complete body weight [3]. Among the components that ensure the stability of the knee joint, the anterior cruciate ligament (ACL) plays an important role in resisting the motions of anterior tibial subluxation and internal

tibial rotation relative to the femoral condyle [4]. ACL tear is a common type of injury, each year in the United States, about 100,000-250,000 cases of ACL injuries are recorded [5].

Injury to the ACL, if not diagnosed and treated promptly, will cause instability and degenerative knee joint that resulting the patient disabled. Therefore, early and accurate diagnosis of ACL injury makes an important contribution to helping doctors in providing appropriate treatment for patients. In terms of imaging, the introduction of MRI helps to classify the injury and diagnose the location of ACL injury more accurately.

Most studies comparing MRI with arthroscopy show that this method is a highly reliable method in diagnosing ACL injury. The study of Pieter Van Dyck found that the sensitivity, specificity and accuracy of MRI in assessing damage to ligaments and meniscus of the knee joint were 69%, 96% and 90%, respectively [6]. According to research by Ruth Crawford, the sensitivity, specificity and accuracy of MRI in evaluating ACL injury are 86.5%, respectively; 95.2% and 93.4% [7]. In a domestic study by Nguyen Viet Nam and Truong Tri Huu, the sensitivity, specificity and accuracy of MRI in diagnosing ACL injury were 99%, 100% and 99%, respectively [8].

However, in clinical practice, there are cases of incompatible ACL injury image on MRI and arthroscopy result. According to the studies reported in Vietnam, there are very few articles on applying MRI for diagnosing ACL injury in a systematic and complete manner.

Materials and methods

Research subjects: 75 patients who received MRI of their knee joints, diagnosed with ACL injury, and underwent arthroscopy at the Department of Trauma and Orthopedics Surgery, Thong Nhat Hospital from 01/01/2021 until 22/04/2022.

Research method: prospective cohort, descriptive study.

Criteria: all patients received MRI of the knee with ACL injury recorded, underwent arthroscopy and agreed to participate in the study.

Exclusion criteria: patients with a history of cruciate ligament reconstruction or knee bone and soft tissue surgery.

Criteria for diagnosis of ACL injury

Images of ACL on MRI as following types

a. Complete tear: is characterized by complete discontinuity of ligament fibers, hyperintense signal, and often associated with aNBormal orientation. If a mass at the end of the ligament is seen and a less steep ACL line, complete tear is more likely to occur [11].

b. Partial tear: manifested by aNBormal ACL signal accompanied by aNBormal shape or partial discontinuity of ligament fibers. If the ACL remains oblique and directional, the lesion is only partially tear [11].

Diagnosis of ACL injury location on MRI

The location of ACL tear is classified into 3 types: injury of the femoral condylar attachment point (femoral attachment point sprain or proximal femoral attachment point tear), medial tear and distal tear (tibial attachment point sprain or proximal tibial attachment point tear). [17].

Data processing method: the data was processed by SPSS 20 software. We used Kappa index to evaluate the compatibility of MRI with arthroscopy in classifying and locating the ACL injury.

Result

Compatibility rate of MRI with arthroscopy result in the diagnosis of ACL injury

Age characteristics

The average age of the subjects participating in the study was 38 ± 12 years, in which the youngest is 18 years old, the highest is 67 years old. The ≤ 20 age group has 3 cases (4%), the 21-30 age group has 18 cases (24%), the 31-40 age group has 24 cases (32%), the > 40 age group have 30 cases (40%).

Cause of trauma characteristics

The results of the study on 75 patients showed that the most common cause of injury was traffic

accidents with 27 cases (36%), the second was domestic accidents with 26 cases (34.7%), the third is sports accidents with 17 cases (22.7%), the least common is occupational accidents with 5 cases (6.6%).

Characteristics of ACL injury on MRI

In 75 cases of ACL injury on MRI, we found that complete tear was more common with the rate of 68%, partial tear was less common with the rate of 32.00%.

Table 3.1. The rate of ACL injury on MRI in studies

ACL tear type	Our result (Vietnam)	Vo Thanh Toan (Vietnam)	Dang Thi Ngoc Anh (Vietnam)	Mengou Zhao (China)
Partial tear	32%	34,4%	22,6%	57%
Complete tear	68%	64%	77,4%	43%

Characteristics of ACL injury on arthroscopy

In 75 cases of ACL injury found on arthroscopy, more cases of complete tear were found with the rate of 73.33%, less cases of partial tear were found with the rate of 26.67%.

Table 3.2. The rate of ACL injury on arthroscopy in studies.

ACL tear type	Our study (Vietnam)	Truong Tri Huu (Vietnam)	Huynh Le Anh Vu (Vietnam)	Mengou Zhao (China)
Complete tear	73,33%	89,03%	20,00%	42,42%
Partial tear	26,67%	6,45%	53,30%	57,58%
No sign of ACL tear	0,00%	4,52%	26,70%	0,00%

The importance of MRI in diagnosing ACL tear type

Comparing the results between MRI and arthroscopy in the diagnosis of ACL tear type, Table 3.3. Number of ACL tear type on MRI and arthroscopy (n = 75) showed that the results in 63/75 cases were compatible between MRI and arthroscopy, accounting for 84.00%. Specifically:

MRI showed 51 cases of complete tear, but in fact there were only 47 cases on arthroscopy, the remaining 4 cases were partial tear. The reason for this incompatibility can possibly because of the difficulty in the differential diagnosis of partial or complete tear if complete discontinuity of the ligamentous fibers is unclear and confusing.

There were 24 cases of MRI that showed ACL partial tear, but only 16 cases of arthroscopy gave a suitable result, the remaining 8 cases showed a complete tear of the ACL.

Table 3.3. Number of ACL tear type on MRI and arthroscopy (n = 75)

Diagnosis method		Arthroscopy		Total
		Partial tear	Complete tear	
Knee joint MRI	Partial tear	16 21,33%	8 10,67%	24 32,00%
	Complete tear	4 5,33%	47 62,67%	51 68,00%
Total		20 26,67%	55 73,33%	75 100%

Table 3.4. Compatibility between MRI and arthroscopy in diagnosing type of ACL tear in studies

Studies	Mengou Zhao (China)	Huynh Le Anh Vu (Vietnam)	Our study (Vietnam)
Kappa index	0,91	0,67	0,62

Compatibility rate between MRI and arthroscopy in diagnosing ACL tear location

Characteristics of ACL tear location on MRI

In 75 cases of ACL tear on MRI, proximal tear was the most common with 41 cases (54.67%), medial tear was less common with 22 cases (29.33%), the least common are 12 cases of distal tear (16.00%).

Table 3.5. Rate of ACL tear location on MRI in studies

ACL tear location on MRI	Vo Thanh Tuan (Vietnam)	Jelled P. (USA)	Our study (Vietnam)
Proximal tear	22,20%	43,05%	54,67%
Medial tear	66,70%	52,12%	29,33%
Distal tear	11,10%	4,83%	16,00%

Characteristics of ACL tear location on arthroscopy

In 75 cases of ACL tear on arthroscopy, we encountered ACL proximal tear with the highest rate (60.00%), ACL mid substance tear (25.33%), distal tear is the least common injury. (14.67%).

Table 3.6. Rate of ACL injury on arthroscopy in studies

ACL tear location on arthroscopy	Sherman (USA)	Our study (Vietnam)
Proximal tear	56,00%	60,00%
Medial tear	44,00%	25,33%
Distal tear	0,00%	14,67%

The importance of MRI in diagnosing ACL tear location

Table 3.7. ACL tear location on MRI and arthroscopy (n = 75)

Diagnosis methods		Arthroscopy			Total
		Proximal tear	Distal tear	Medial tear	
Knee joint MRI	Proximal tear	41 54,67%	0 0,00%	0 0,00%	41 54,67%
	Distal tear	0 0,00%	10 13,33%	2 2,67%	12 16,00%
	Medial tear	4 5,33%	1 1,33%	17 22,67%	22 29,33%
Total		45 60,00%	11 14,67%	19 25,33%	75 100%

Comparing the results between MRI and arthroscopy in diagnosing the ACL tear location, Table 3.7. ACL tear location on MRI and arthroscopy showed that the results in 68/75 cases were compatible between MRI and arthroscopy, accounting for 90.67%. In detail:

MRI showed 41 cases of proximal tear and practically all of the above cases have the similar results on arthroscopy. The results can be explained because this tear location is noticeable on the MRI image with a high accuracy.

There are 12 cases of MRI in which distal tear was found, in fact, the number was 10 on arthroscopy, the remaining 2 cases are the medial tear type. This shows the high accuracy of MRI in diagnosing cases of ACL attachment point injury.

There are 22 cases of medial tear found on MRI, but in fact, there are only 17 cases on arthroscopy, the remaining 5 cases include 4 cases of proximal tear and 1 case of tibial attachment point injury. Thus, the compatibility of MRI in the cases of medial tear is lower than in the cases of attachment point injury. This can be explained by the fact that the image of the medial tear is more difficult to detect on MRI than the ACL tear in other locations, especially on a scanner with a magnetic field not as high as 0.35 Tesla, the details are less noticeable.

In our study, the Kappa index = 0.84 showed a high compatibility between MRI and arthroscopy results in diagnosing ACL tear.

Discussion

The results of this study show that the frequency of ACL tear was most common in the group patient aged more than 40 years old. This can be explained by the ACL degeneration in the elderly, leading to higher ACL vulnerability when injury occurs. In addition, the age group over 40 years old are mostly workers with heavy workload, so the frequency of injuries is higher.

The reason for the majority of traffic accidents can be explained by the complicated traffic situation in Vietnam, numerous cases of accident occur every

year making traffic accidents the highest proportion of the ACL tear cause. The second most common cause is domestic accident, followed by sports accident, which may be due to the characteristics of the sample population. With the patient age ranging from 26 to 50 years old, especially in the context of the Covid-19 epidemic when social distancing is implemented, domestic accidents at home are more likely to occur comparing to sports accidents. Finally, the least common cause is work-related accidents.

Regarding the ACL tear type on MRI, there are compatibilities between our study and other domestic studies. According to the author Vo Thanh Toan [12], in the cases of ACL injury diagnosed on MRI at Thong Nhat Hospital, complete tear is more common with the rate of 64.00% and partial tear is less common with the rate of 34.40%. According to Dang Thi Ngoc Anh et al at Duc Giang General Hospital [13], the rate of complete and partial tear diagnosed on MRI is 77.40% and 22.60% respectively. This similarity may come from the cause of ACL tear of Vietnamese people mainly due to traffic accidents. In Vietnam, the rapid development of personal vehicles leads to an increasingly complex traffic situation in Vietnam, making ACL injuries caused by traffic accidents a type of high-energy trauma. Therefore, the common type of ACL injury is complete tear.

However, our study results have no compatibilities with the study by Mengou Zhao at Shijiazhuang Hospital, China in 2020 [14]. Mengou Zhao's study noted that partial tear is more common with the rate of 57.00%, complete tear are less common with the rate of 43.00%. This difference may be due to the epidemiological characteristics of the sampled population between the two studies. In our study, the average age was 38 ± 12 years, the most common cause of ACL injury was traffic accident. Meanwhile, the patients participating in Mengou Zhao's study had an average age of 43 ± 7, the cause of ACL injuries mainly came from sports accidents, the least common cause are traffic accidents. Sports activities in this age group are usually of light intensity. Since then, ACL injury due to sports accident can be mild, leading to the tear type on MRI is mainly partial tear.

Regarding the ACL tear type on arthroscopy, our study has similarities with the study of Truong Tri Huu [8]. Among 155 patients with indications for arthroscopic knee surgery studied at the Hospital of Trauma and Orthopedics, the majority are patients with complete tear (89.03%), a small number of partial tear type was found (6.45%). This similarity can be explained by the fact that the two studies have similar sample population characteristics in terms of race and study age. In addition, complete tear usually causes significant knee instability compared to partial tear, so ACL reconstruction surgery is often indicated in complete tear case while partial tear case can be indicated with conservative treatment, therefore, complete tear occupies the majority of arthroscopy.

Our research results have no similarities with the study of Huynh Le Anh Vu [15] and Mengou Zhao [14]. Huynh Le Anh Vu studied on 45 patients with knee injury who underwent MRI and arthroscopic knee surgery at Viet Duc Hospital in 2008. In the study which 33/45 cases of ACL injury were found on arthroscopy, the rate of complete tear was 20.00%, the partial tear rate was 53.30%. According to Mengou's research conducted in Shijiazhuang, China in 2018, among 66 cases of ACL injury diagnosed on arthroscopy, 42.42% was complete tear and 57.58% was partial tear. This difference can be explained because in recent times, ACL arthroscopic reconstruction indication is more limited, conservative treatment is preferred in cases of partial tear, leading to the result of a higher rate of complete tear than partial tear in our study.

The difference result between MRI and arthroscopy can be explained by the fact that MRI images of synovial sacs and fibrous bands have the similar signal to ACL, which leads to the injury was misread as partial tear instead of a complete tear. [8], or because the patient has other injuries that cause partial tear during the waiting time from MRI to arthroscopy.

When comparing with the study in Shijiazhuang, China conducted by Mengou Zhao et al in 2018. [14], the compatibility between MRI and arthroscopy in complete tear is quite high. The results showed that 26/28 cases of complete tear on MRI had similar results on arthroscopy. This compatibility may be due to the fact that the cases of complete tear are noticeable on MRI images, as well as the qualifications of the trained radiologists, leading to high accuracy results. Meanwhile, the cases of partial tear according to Mengou Zhao's study have a high compatibility with 36/37 cases on MRI with similar results comparing with arthroscopy. The difference may be due to the above study using a Philips Achieva 1.50 Tesla machine resulting in better quality MRI images than the 0.35 Tesla machine at Thong Nhat Hospital.

In our study, the compatibility between MRI and arthroscopy results in diagnosing ACL injury was average with Kappa index = 0.62. In the study of author Huynh Le Anh Vu, the Kappa index = 0.67, which is similar to our study. This similarity probably comes from sample size and sampling method. Compared with the Kappa index = 0.91 in the study by Mengou Zhao in 2018 [14], the rate of compatibility in this study is quite high. This difference may be due to machine, radiologist skills, radiographer skills are not the same between the two studies.

Regarding the location of the ACL injury on MRI, compared with the study by Vo Thanh Toan in 2020 [12], the results in our study are similar when the rate of medial tear and proximal tear are higher than tibial attachment point injury. In a study by Vo Thanh Toan on 63 patients diagnosed with ACL injury at Thong Nhat Hospital, on MRI, the majority of cases are medial tear and proximal tear (88, 90%) compared with the lower rate of distal tear (11.10%). This can be explained by the fact that the medial and proximal part of the ACL attaching to the femur is located in the femoral intercondylar area and the posterior cruciate ligament (PCL). The ACL is subjected to friction between these components and being torn, particularly in indirect contact injury mechanisms due to torsion and rotation. While in the proximal portion of the tibial attachment point, the ACL lies freely and the ligament-bone transition is wider and thicker, providing better weight bearing ability [16]. However, the study of author Vo Thanh Toan showed that ACL medial tear on MRI accounts for the highest percentage (66.70%), followed by proximal tear (22.20%). while our study showed that the image of the ACL medial tear on MRI is less common (29.33%). This difference may be due to the author's study excluding cases of ACL tear in patients with complicated knee osteoarthritis, so the results between the two studies are not the same.

A study by Jelle P. et al conducted in 2017 in a New York hospital on 353 patients with ACL injury also showed image of distal tear was least common on MRI (4.83%). However, the rate of medial tear (52.12%) was higher than that of proximal tear (43.05%) [17]. This difference can be explained by the different sampling criteria between the two studies. Reported by Jelle P. excluded patients with partial tear of the ACL, chronic ACL injury and multiple ligament knee injuries, so the rate of medial tear was the highest while our study showed that proximal tear accounted for the highest percentage.

Regarding the injury location on arthroscopy, compared with the study of Sherman [18] conducted in 1991 at some hospitals in New York, the results in our study have high similarities. Out of the total 50 patients with ACL injury who underwent surgery, proximal tear has the highest percentage with 28 cases (56.00%), the remaining 22 cases are medial tear (44.00%), no cases of distal tear are recorded. This can be explained by the fact that the medial and proximal part of the ACL attaching to the femur is located in the femoral intercondylar area and the posterior cruciate ligament (PCL). The ACL is subjected to friction between these components and being torn, particularly in indirect contact injury mechanisms due to torsion and rotation. While in the proximal portion of the tibial attachment point, the ACL lies freely and the ligament-bone transition is wider and thicker, providing better weight bearing ability [16].

Conclusion

Knee joint MRI should be widely used as a non-invasive diagnostic method in cases of suspected traumatic ACL injury.

On MRI, the results of diagnosing the injury location should be more reliable than diagnosing the type of injury.

More studies with larger sample sizes should be performed to increase reliability.

Conflict of interest: The authors declare that they have no conflict of interest.

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