

Sensitivity and Specificity of Magnetic Resonance Imaging for Knee injury and Clinical Application for the Naresuan University Hospital

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Background: The accuracy of MRI evaluation for the traumatic knee injury may help the physician selecting the treatment options and informing patient about the prognosis. The purpose of the present study was to analyze the result of the MRI reported from a center in Phitsanulok which would be valuable for orthopaedic surgeons who practicing in the lower northern region of Thailand.

Material and Method: The 1.5 Tesla MRI of 51 injured knees that underwent subsequent arthroscopic knee surgery was independently reviewed by one from the group of radiologists. The sensitivity, specificity, accuracy and negative predictive value of the MRI evaluation for menisci and cruciate ligament pathology compared to the arthroscopic finding is determined.

Results: There were 50 patients with the mean age of 36.7 year old (ranging from 18-75 years) and 30 were males and 20 were females. The sensitivity, specificity, accuracy and negative predictive value (NPV) in detecting the complete tear of the ACL injury were 90.9%, 84.6%, 88.6% and 84.6%, respectively. There were 100%, 97.1%, 97.5% and 100%, respectively, for diagnosis of complete PCL tear. The MRI evaluation for definite medial meniscus tear revealed 100% in sensitivity, 52.6% in specificity, 64% in accuracy and 100% in NPV. For the lateral meniscus, it yielded 55.6%, 83.3%, 75.8% and 83.3%, respectively. Among the 22 patients who underwent the ACL reconstruction without the PCL or collateral ligament injury, there was 50% of associated meniscal injury with similar ratio between medial and lateral side.

Conclusion: The MRI report from the center in Phitsanulok could be useful in detecting the cruciate ligament tear particularly with uncertain clinical examination. With a high negative predictive value, the MRI could be used as a negative diagnostic tool for the meniscal injury.

Keywords: MRI, Knee injury, Lower Northern region of Thailand, Naresuan University hospital

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A knee injury is one of the common conditions seen in orthopedic practice that the injury may be sustained from a sport competition⁽¹⁾, vehicle accident or other trauma. The injury can decrease the physical function of patient and some cause disability which may require a prompt surgery. It has been well accepted for decades that a magnetic resonance imaging (MRI) is accurate to detect the cruciate ligament and meniscal injury. Thus, using a noninvasive evaluation with the MRI is increasing in orthopaedic practice to make a diagnosis, plan for surgery and help informing the patients and prevent unnecessary surgery⁽²⁾ which may be the most important. However, the accuracy of the MRI will depends on many factors such as field strength

of the machine^(3,4), imaging protocol⁽⁵⁾ and variability between interpreters⁽⁶⁾.

A MRI center in Phitsanulok serves several hospitals located in lower northern region of Thailand including the provinces of Phitsanulok, Uttaradit, Kamphaengphet, Sukhothai, Phetchabun and Phichit. This MRI center which its headquarters located in Bangkok was operated in 2007 and was the first and only center that served the hospitals in the region before another center in Phichit was settled in 2011 and the latest one would be operated at Naresuan University hospital in the end of 2012. The MRI was reviewed and reported individually by one of the group of radiologists that was randomized by the MRI center depend on their availability. The author shall expect the value of findings of the sensitivity, specificity and accuracy of the MRI study for an injured knee reported by this MRI center that may help making decision for the physicians practicing in the lower northern region of

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Material and Method

The authors reviewed the data of 50 patients with the age more than 18 years who sustained a traumatic knee injury and had pain, locking, swelling or instability of the knee. All the patients underwent the MRI and subsequent arthroscopic knee surgery at Naresuan University Hospital. The MRI was interpreted by the radiologists who were blinded to a subsequent treatment, thus a verification bias might be assumed as absent. The patient was excluded from the present study if they had previous surgery or hardware implantation on the ipsilateral knee and clinical presentation or imaging shown an infection, tumor, inflammatory joint disease or severe osteoarthritis. All the MRI was performed at the MRI center located in Phitsanulok, Thailand. The MRI machine was Siemens: Magnetom Symphony, 1.5 Tesla (1.5T) and the imaging protocol was axial T1 weighted (T1W)/T2 weighted fat suppression (T2WFS), coronal T1W/proton density fat suppression (PDFS) and sagittal T1W/T2W/PDFS. Slice thickness was 3-3.5 mm in all cases. The MRI of the center was distributed randomly to one from the group of radiologists who worked individually and was mostly remote from Phitsanulok. Although the MRI was done by the same machine and imaging protocol, the result of each MRI was reported by various individual radiologists.

After gathering the report of MRI of 50 patients, the authors categorized the report of cruciate ligament as partial and complete tear group whether it was described as possibly, probably or definitely tear (Fig. 1). The report of medial and lateral meniscus was divided separately into indefinite tear and definite tear. If the grading of tear was not specified or it was described

as grade 2 tear or degenerative tear, it would be included into the indefinite meniscal tear group (Fig. 2). If it was described as a flap, complex, bucket handle (abnormal morphology of the meniscus) or grade 3 tear (high signal inside the meniscus and abutting an articular surface)⁽⁷⁾, it would be included into the group of definite meniscal tear (Fig. 3). All the arthroscopic surgeries were done by an experienced orthopedic surgeon (AL) who regularly performed the arthroscopic knee procedure. The MRI result was compared with intraoperative finding that was used as a standard reference and was classified into true-positive, true-negative, false-positive and false-negative categories. A statistical analysis was carried out by Statistical Package for the Social Sciences (SPSS) software. The present study was approved by the ethics committee for human research of Naresuan University.



Fig. 2 A, The MRI of left knee of 42 years old female was reported as focally increased signal intensity which was suspicious for grade 2 tear. B, The MRI of 21 years old male was reported as longitudinal complex tear of body of medial meniscus of left knee without grading specified. Subsequently, the meniscus appeared intact during the arthroscopic ACL reconstruction

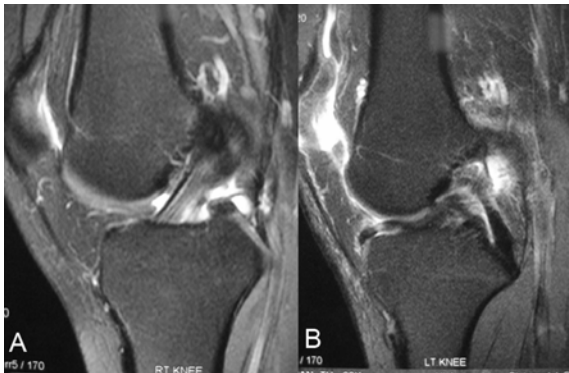


Fig. 1 A) The MRI showed an intact ACL, B) Comparing to a complete tear of ACL

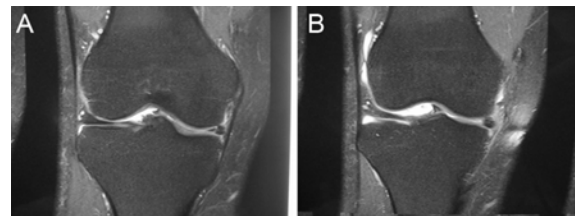


Fig. 3 The MRI of right knee of 39 years old male was reported as: A, vertical hyperintensity lesion in the body of medial meniscus. B, Medially displaced meniscal fragment located in the medial intercondylar fossa suspected bucket handle tear of the medial meniscus.

Results

There were 51 knees of 50 patients included with the mean age of 36.7 years (ranging from 18-75 years). The present study group was composed of 30 males and 20 females which 21 patients sustained right knee injury, 28 with left knee and 1 with bilateral knee. The arthroscopic procedure performed in the 51 knees consisted of 22 anterior cruciate ligament (ACL) reconstruction, 2 arthroscopic posterior cruciate ligament (PCL) reconstruction, 2 arthroscopic combined PCL and ACL reconstructions, 1 combined PCL, ACL and posterolateral corner reconstruction, 2 combined PCL and posterolateral corner reconstructions, 1 combined PCL and medial collateral ligament (MCL) reconstruction, 1 MCL reconstruction, 7 arthroscopic meniscal repairs, 15 arthroscopic partial meniscectomy, 4 arthroscopic chondroplasty, 4 arthroscopic plica resections, 8 arthroscopic debridement or synovectomy and 3 knees were normal on the arthroscopic examination.

Anterior cruciate ligament

For the partial tear group, there were 8 true-positives, 11 true-negatives, 10 false-positives and 2 false-negatives. The MRI revealed 20 true-positives,

11 true-negatives, 2 false-positives and 2 false-negatives for the ACL reported as a complete tear.

Posterior cruciate ligament

There were 6 knees interpreted as a complete PCL tear and the MRI yielded 5 true-positives, 34 true-negatives, 1 false-positive and none of false-negative. The partial tear of PCL was not included because it was reported in only 2 patients in the present study.

Medial Meniscus

The MRI report of indefinite medial meniscal tear revealed 3 true-positives, 10 true-negatives, 23 false-positives and none of false-negative. For the definite tear, it consisted of 6 true-positives, 10 true-negatives, 9 false-positives and none of false-negative.

Lateral meniscus

The MRI evaluation of the indefinite tear of lateral meniscus showed 3 true-positives, 20 true-negatives, 11 false-positives and 4 false-negatives. In the definite tear category, it yielded 5 true-positives, 20 true-negatives, 4 false-positives and 4 false-negatives.

The sensitivity, specificity, accuracy and negative predictive value of each divided group was

Table 1. The sensitivity, specificity, accuracy and negative predictive value of MRI study on the cruciate ligament

Report of cruciate ligament	Sensitivity(%)	Specificity(%)	Accuracy(%)	Negative predictive value (%)
Anterior cruciate ligament (ACL)				
Partial tear	80.0	52.4	61.3	84.6
Complete tear	90.9	84.6	88.6	84.6
Posterior cruciate ligament (PCL)				
Complete tear	100	97.1	97.5	100

Table 2. The sensitivity, specificity, accuracy and negative predictive value of MRI study on the menisci.

Report of meniscus	Sensitivity(%)	Specificity(%)	Accuracy(%)	Negative predictive value (%)
Medial Meniscus				
Indefinite tear	100	30.3	36.1	100
Definite tear	100	52.6	64	100
Lateral Meniscus				
Indefinite tear	42.9	60.6	60.5	83.3
Definite tear	55.6	83.3	75.8	83.3

shown in Table 1 and 2.

Among the 22 patients who undergone the ACL reconstruction without the PCL or collateral ligament injury, there were 4 associated medial meniscal tear, 4 lateral meniscal tear and 3 both menisci tear. This could be implied that 50% of ACL tear would have the meniscal injury with similar ratio between medial and lateral side.

Discussion

The present study demonstrated that the sensitivity, specificity and accuracy of the MRI which performed at the center in Phitsanulok in detecting the complete tear of the ACL injury was 90.9%, 84.6% and 88.6%, respectively. This result was comparable to other reports that showed sensitivity, specificity and accuracy for diagnosis of the ACL tear varied from 64-100%, 89-100% and 86-91%, respectively when using the 1.5T MRI⁽⁸⁻¹⁰⁾. The MRI of the PCL tear was also highly sensitive and specific correlated with results from the other authors that showed 80-100% sensitivity, 97-100% specificity, and 96-100% accuracy⁽¹⁰⁻¹²⁾. For the meniscus, it has been well documented that the sensitivity and specificity of the MRI was more inferior⁽³⁾ than the cruciate ligament. Many reports revealed the result of 1.5T MRI of the knee with 74-96% sensitivity, 63-89% specificity, and 68-81% accuracy for diagnosis of the medial meniscal tear, and 62-93% sensitivity, 88-95%, and 77-86% accuracy for diagnosis of the lateral meniscal tear^(8-10,13,14). In the present study, the MRI report of the definite tear of medial meniscus yielded 53% specificity and 64% accuracy while the lateral meniscus consisted of 56% sensitivity, 83% specificity and 76% accuracy which it seemed to be more inferior compared to the previous literature. However, the result of the present study was comparable to the prospective study by Rayan et al⁽¹⁵⁾ who reported 76% sensitivity, 52% specificity and 63% accuracy for the medial meniscal tear and 61%, 92% and 85% respectively for the lateral meniscal tear. The physicians should realize that the accuracy of the MRI in detecting the meniscal pathology is more inferior if it was categorized into the indefinite meniscal tear group. The inferiority of the MRI in detecting the meniscal pathology in the present study might be due to the field strength of the MRI (1.5 Tesla) and various radiologists got randomly involved.

A systemic review demonstrated that the higher field strength MRI provided a trend of better diagnostic performance than the lower field strength MRI with statistically significant for ACL tear⁽³⁾.

Sampson et al⁽¹⁶⁾ reported an improvement of diagnostic capability of 3.0T MR imaging with 100% sensitivity and specificity for the ACL tear and Van dyck⁽¹⁷⁾ also showed a better sensitivity, specificity and accuracy (77, 97 and 95%, respectively) in detecting a partial ACL tear by using the 3.0T MRI. For the meniscus, Jaovisidha et al⁽⁴⁾ evaluated the 3.0 Tesla MRI of the knee and reported the sensitivity, specificity and accuracy as 100%, 76.9% and 90.6% respectively for the medial meniscal tear while it was 90%, 72.7% and 78.1% for the lateral meniscal tear. It seemed to be better than the previous result of the 1.5T MR imaging but it was not a direct comparison. While, Grossman et al⁽¹⁸⁾ compared the result of 1.5T and 3.0T MRI in detecting the meniscal tear and found no difference.

Some study that the MRI was interpreted by experienced radiologists working in the similar institution reported a high sensitivity and specificity in diagnosis of the medial meniscal injury which range from 92-96% and 87-89% respectively and range from 84-93% and 90-95% for detecting the lateral meniscal tear^(8,14). Each of the MRI from the center in Phitsanulok was distributed randomly to one from the group of radiologists who was a consultant of the center for interpretation. These consisted of various level of experience of the radiologists and therefore, diagnostic criteria and grading system might be also different between individual radiologists. Interestingly, Servant et al⁽⁶⁾ revealed the accuracy among 7 experienced musculoskeletal radiologists in diagnosing 10 cases of chronic PCL injury and they showed the accuracy ranging from 40-80%. This data might illustrate the difficulty of interpretation of chronic PCL tear and reliability between radiologists. There was some limitation of the present study that was not able to investigate intra- and inter-observer reliability since it consisted of small group of patients.

The MRI for the lateral meniscal injury was reported to be lower sensitive than the medial meniscus while the specificity was higher^(10,12,18). Grossman et al⁽¹⁸⁾ showed the result of the 1.5 T MRI with 68.4% sensitivity and 95.2% specificity for the lateral meniscal tear compared to 92.7% and 82.2% for the medial meniscal tear. With 3.0 T MRI, the sensitivity and specificity was 69.2% and 91.8% for the lateral meniscus compared with 92.6% and 76.1% respectively for the medial meniscus. The systemic review by Oei⁽³⁾ also demonstrated that the lateral meniscus had a lower pooled weighted sensitivity but higher pooled weighted specificity compared to the medial meniscus and the result of the recent study was correlated to the previous

study. The retrospective study by De Smet et al⁽²⁰⁾ showed a significant missed lateral meniscal tear was associated with a posterior horn tear or the tear involving only one-third of the meniscus. The sensitivity was more inferior when the lateral meniscal tear presented with ACL tear, but it was not statistical significant.

Even if, the advantage of MRI is demonstrated, an unnecessary MRI evaluation should be avoided otherwise it may increase a financial burden. The physician should emphasize that symptoms and physical examination are still very important. Although, there were many reports showed that the clinical examination was not as reliable as the MRI^(10,21-23). Kocabey et al⁽²⁴⁾ demonstrated that the accuracy of clinical examination for medial or lateral meniscal or ACL tears was equal to the MRI if it was done by a well-trained knee surgeon. Rayan et al⁽¹⁵⁾ found that the clinical examination had a better sensitivity and specificity than the MRI in diagnosis of medial meniscus and had a marginal difference for lateral meniscus and ACL, thus the MRI might not be necessary. The MRI might be more beneficial if it was considered when the diagnosis was questionable after a careful knee examination.

With a high negative predictive value in detecting the cruciate ligament and meniscal tear, the report from the MRI center in Phitsanulok has a strong value in guiding the physician to treat the injured knee conservatively if the report shows negative for any pathology. The cruciate ligament reconstruction instruments should be prompt if the complete ligament tear is emphasized by the MRI and the surgical intervention is agreed. A conservative management with an intensive rehabilitation may be recommended for the patients who have the partial torn ACL, unless the gross laxity is proved clinically. The choice of treatment may be more controversial for the indefinite meniscal tear particularly the medial meniscus since it was shown with low specificity combined with uncertain reliability of clinical examination. The more conservative way of treatment may be justified for these cases since 3 cases of the recent study that the MRI reported indefinite tear of medial meniscus underwent the arthroscopic surgery without any abnormal finding intraoperatively. On the other hand, the arthroscopic surgery and preparation of meniscal repaired instruments should be considered for the case showed the definite tear of the meniscus particularly lateral meniscus. It is also recommended to perform the attentive examination during the surgery for the lateral meniscus especially with the presence of ACL tear, even

if the tear is not reported by the MRI.

In conclusion, the sensitivity and specificity of the MRI evaluation from the center located in Phitsanulok is high for the cruciate ligament injury. The MRI for the lateral meniscal injury is lower sensitive compared with the medial meniscus but the specificity is higher. With a high negative predictive value, the MRI can be used as a negative diagnostic tool that helps preventing an unnecessary surgery.

Potential conflicts of interest

None.

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ความไวและความจำเพาะของการประเมินข้อเข่าที่ได้รับบาดเจ็บโดยการตรวจเอกซเรย์ด้วยคลื่นแม่เหล็กไฟฟ้า และการประยุกต์ใช้ในโรงพยาบาลมหาวิทยาลัยนเรศวร

อาทิตย์ เหล่าเรืองธนา, อรรถกร จารุศรีวรรณ

วัตถุประสงค์: เพื่อวิเคราะห์ผลการประเมินข้อเข่าที่ได้รับบาดเจ็บจากอุบัติเหตุโดยการตรวจเอกซเรย์ด้วยคลื่นแม่เหล็กไฟฟ้า ณ ศูนย์เอกซเรย์ด้วยคลื่นแม่เหล็กไฟฟ้า จังหวัดพิษณุโลก และการนำไปประยุกต์ใช้เพื่อพิจารณาแนวทางการรักษาสำหรับศัลยกรรมกระดูกในภูมิภาคภาคเหนือตอนล่างของประเทศไทย

วัสดุและวิธีการ: ทำการศึกษาเปรียบเทียบความสัมพันธ์ระหว่างผลของการประเมินข้อเข่าที่ได้รับบาดเจ็บจากอุบัติเหตุโดยการเอกซเรย์ด้วยคลื่นแม่เหล็กไฟฟ้าขนาด 1.5 เทสลาจากรังสีแพทย์ กับพยาธิสภาพที่พบระหว่างการผ่าตัดส่องกล้องข้อเข่าจำนวน 51 เข่า เพื่อวิเคราะห์หาค่าความไว ความจำเพาะ และค่าพยากรณ์ลบ

ผลการศึกษา: ในจำนวนข้อเข่า 51 เข่า (ผู้ป่วย 50 ราย) อายุเฉลี่ย 36.7 ปี (18-75 ปี) แยกเป็นชาย 30 ราย และหญิง 20 ราย โดยค่าความไว ความจำเพาะ ความแม่นยำ และค่าพยากรณ์ลบของการตรวจพบเส้นเอ็นไขว้หน้าหักขาดเท่ากับ 90.9%, 84.6%, 88.6% และ 84.6% ตามลำดับ การตรวจพบเส้นเอ็นไขว้หลังหักขาดเท่ากับ 100%, 97.1%, 97.5% และ 100% ตามลำดับ สำหรับพยาธิสภาพของหมอนรองกระดูกเข่าด้านในวิเคราะห์ได้ 100%, 52.6%, 64% และ 100% ตามลำดับ และพยาธิสภาพของหมอนรองกระดูกเข่าด้านนอกวิเคราะห์ได้ 55.6%, 83.3%, 75.8% และ 83.3% ตามลำดับ

สรุป: ผลการประเมินข้อเข่าที่ได้รับบาดเจ็บโดยการตรวจเอกซเรย์ด้วยคลื่นแม่เหล็กไฟฟ้า ณ ศูนย์ประจำจังหวัดพิษณุโลก มีความน่าเชื่อถือสำหรับการวินิจฉัยภาวะเส้นเอ็นไขว้ข้อเข่าขาดในกรณีที่ผลการตรวจร่างกายไม่ชัดเจน และเนื่องจากค่าพยากรณ์ลบที่สูงสำหรับการตรวจพบพยาธิสภาพของหมอนรองกระดูกเข่า ดังนั้นจึงสามารถใช้แยกหมอนรองกระดูกที่ปกติออกไปได้เป็นอย่างดี
