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Original Article

Is Ultrasound Reliable for the Diagnosis of Knee Medial Collateral Ligament Injury?

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Objective: To compare the diagnostic accuracy of ultrasound with that of magnetic resonance imaging (MRI) for injuries of the medial collateral ligament (MCL) of the knee.

Materials and Methods: Fifty-one consecutive patients from September 1, 2014 to January 31, 2016 were included. Ultrasound of the knee MCL was performed by physiatrists, and the images were re-read by an experienced sonographer (also a physiatrist). MRI (magnetic resonance imaging) scans of the knee MCL were examined by radiologists and the reports were compared with the findings of the ultrasound. The knee MCL was determined to be injured or intact, and the correlation between MRI and ultrasound findings were calculated using the kappa ratio.

Results: The kappa ratios between the MRI and re-read physiatrist reports, and that between the MRI and original ultrasound reports, were 0.41 and 0.24, respectively. Correlation between the original ultrasound reports and re-read reports was 0.4.

Conclusion: In daily practice, the correlation between the findings of MRI and ultrasound for the diagnosis of knee MCL injury was poor-to-fair. Further studies are required to improve the diagnostic accuracy of ultrasound. (Tw J Phys Med Rehabil 2017; 45(1): 27 - 34)

Key Words: knee medial collateral ligament, ultrasound, MRI

INTRODUCTION

Injuries of the medial collateral ligament (MCL) of the knee are a common type of knee injuries.[1] Treatment for knee MCL injury is mostly conservative, except in cases of grade III injury with persistent laxity.[1]Proper management of knee MCL injury, such as the application of knee brace,[2] the duration for knee bracing, and rehabilitation programs, depends on precise diagnosis.[3,4] The diagnosis of knee MCL injuries is generally based on clinical symptoms and physical examinations. According to the American Medical Association (AMA) classification, the amount of medial joint line opening observed in the valgus stress test is used as the grading criterion, and injuries are classified into the following

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grades: opening < 5 mm, grade 1; opening 5–10 mm, grade 2; and opening > 10 mm, grade 3.[5] However, the stress test is not easy to perform in the acute stage of injury because severe pain may be induced by the physical examination, and may cause further damage to the ligament. Furthermore, it provides little information about the extent of soft tissue damage.

Ultrasound has gradually gained popularity for the assessment of knee injuries, and is useful for diagnosing extra-articular soft tissue pathologies.[6,7] With its low cost, easy accessibility, portability, and side-to-side comparisons of the knees, it could be used for early detection of knee MCL injuries; hence, ultrasound could help improve the initial management and prognosis of such injuries.[6]

Magnetic resonance imaging (MRI) is considered the most valuable imaging technique for the knee.[8, 9]Previous studies have compared MRI with clinical examinations or surgical findings for the diagnosis of knee MCL injuries and reported 87% accuracy compared with clinical examination,[10] 79 to 86.4% accuracy compared with arthroscopic findings,[8,11]100% sensitivity and 88% specificity compared with surgical findings,[9] 100% accuracy compared with the findings of arthrotomy,[12] and kappa ratio=0.83 compared with the valgus-varus laxity test.[13]

Although the diagnosis of knee MCL injuries using ultrasound has gained a place in daily practice, the evaluation of its diagnostic accuracy is scarce. To our knowledge, only two studies have discussed the correlation between ultrasound findings and clinical or arthroscopic findings for the knee MCL. However, the sample size was rather small, or the ultrasound technique included dynamic maneuvers.[14, 15] As MCL injuries are treated conservatively in most cases, the use of surgical findings as the golden diagnostic test is not practical. To the best of our knowledge, no study has compared MRI and ultrasound findings for MCL injuries yet; therefore, we attempted to evaluate the correlation between ultrasound and MRI for the diagnosis of MCL injuries.

MATERIALS AND METHODS

This retrospective study was conducted in a tertiary teaching Hospital.

Subject: Patients who underwent MRI and musculoskeletal ultrasound examination in the same knee from September 1, 2014 to January 31, 2016 were identified from the existing clinical database. Considering the natural healing potential of the ligament, we excluded patients if the time interval between the two examinations was more than 30 days; furthermore, those who underwent surgical correction between the MRI and ultrasound examinations were also excluded. A total of 103 patients were recruited, and a total of 51 patients were included in the final analyses.

Ultrasound: Knee ultrasound examination was performed by physiatrists in a university hospital. The physiatrists were trained in musculoskeletal ultrasound for at least 2 years, and were certificated in physical medicine and rehabilitation (PM&R) specialties. A total of 12 physiatrists performed the examinations. ACUSON S2000 (Siemens Medical solutions, Erlangen, Germany) with the frequency set at 14 MHz (probe: 14L5) or Toshiba Xario SSA-660A, with the frequency set at 14 MHz (probe 14L7) was used.

For the ultrasound examination, the patient's hip was placed in external rotation with the knee at 0 degrees. The transducer was placed parallel to the orientation of the long-axis of the MCL. Ian Beggs' diagnostic criteria with adjustments were used to diagnose injuries of the MCL using ultrasound.[16]The diagnosis was grade 1 knee MCL injury if hypoechogenicity, increased vascularity, or cortical irregularity was noted (Figure 1); grade 2 knee MCL injury, if partial disruption was noted (Figure 2); and grade 3 injury if complete disruption of the knee MCL was observed. All images were re-read by one of our authors (also a physiatrist), who has ten years of experience with ultrasound examinations and was blinded to the original report of the ultrasound examination.

MRI: MRI was performed by certificated radiologists. Two radiologists were included. Knee MRI was performed with axial, coronal, and sagittal views. MCL injury was graded according to Mink and Deutsh's criteria with some adjustments.[17] An injury was considered grade 1 if there was edematous change or swelling (Figure 3); grade 2, if there was marginal fraying or partial disruption of the MCL (Figure 4); and grade 3, if rupture of the MCL was noted.

Data analyses: The knee MCL was determined to be

injured or intact, and the correlation between MRI and ultrasound findings was calculated using the kappa ratio because MRI is not the gold standard test for diagnosing MCL injuries.

The kappa ratio of the results reported by the two physiatrists was also calculated.

Among the 51 ultrasound reports, there was one report in which the image of the MCL was not obtained; therefore, the original report was regarded as the re-read report. Subsequently, there is 51 patients in MRI versus re-read group, but only 50 patients in ultrasound compared group.

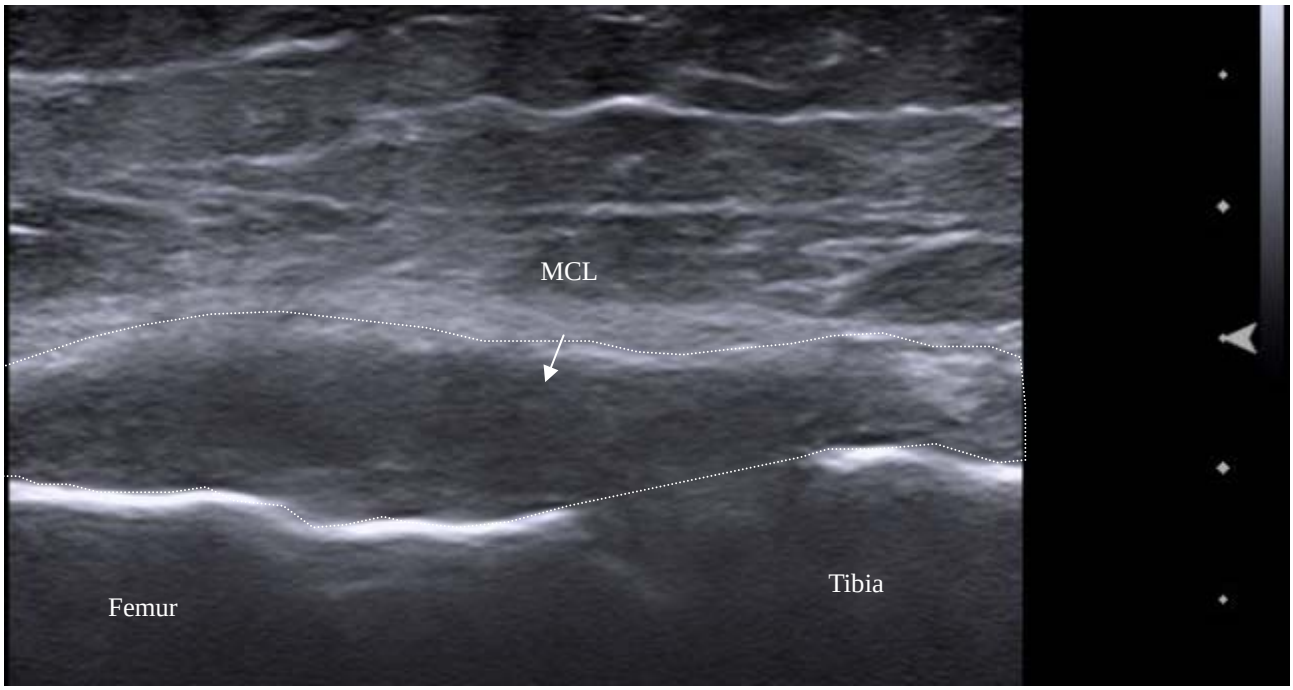

Figure 1. Grade 1 knee medial collateral ligament (MCL) injury observed using ultrasound examination. The knee MCL was hypoechoic and swollen but the fibrillary structures were preserved, indicating a grade 1 injury.

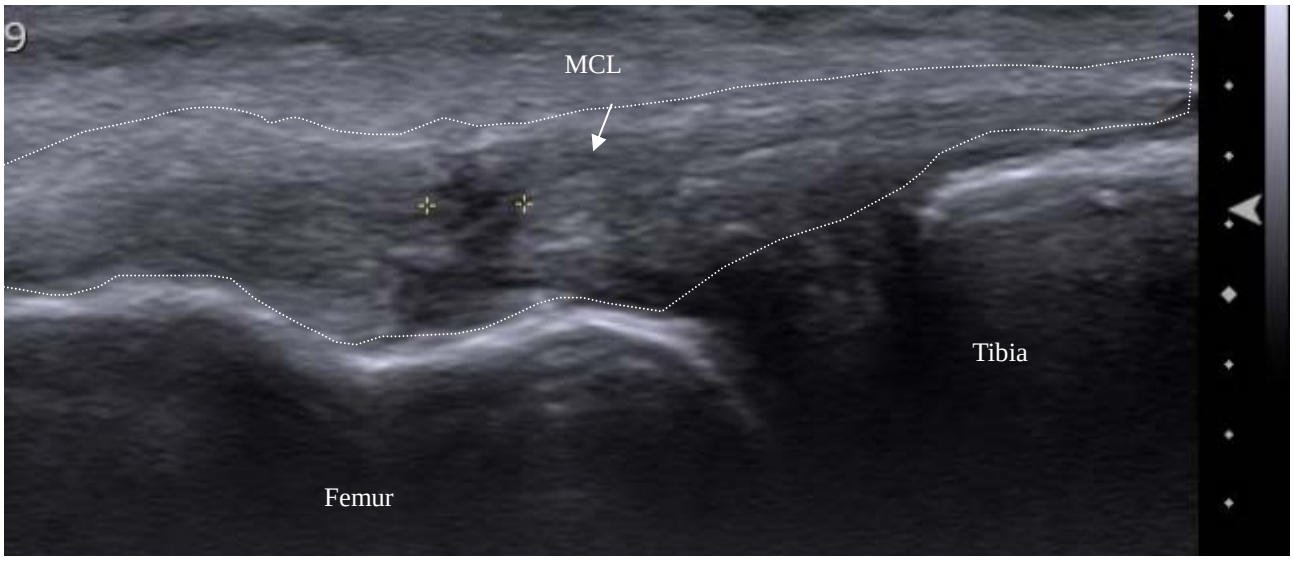

Figure 2. Grade 2 knee medial collateral ligament (MCL) injury observed using ultrasound examination. Partial disruption was noted in the knee MCL, indicating a grade 2 injury.

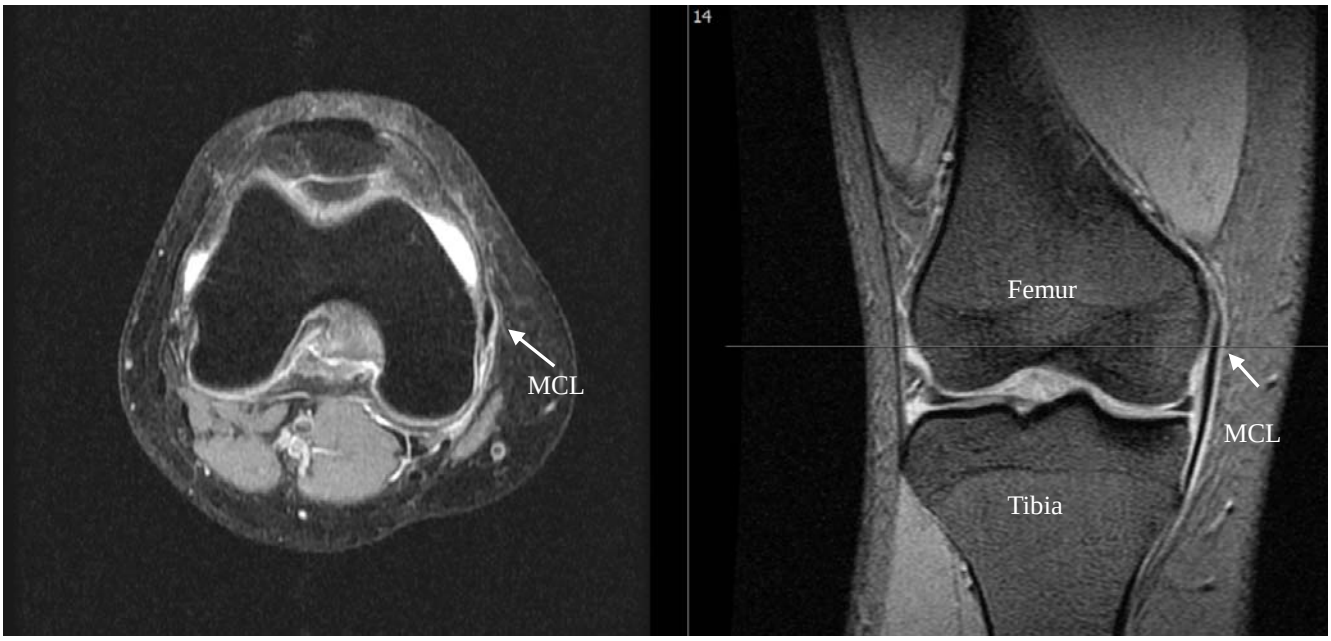

Figure 3. Grade 1 knee medial collateral ligament (MCL) injury observed using magnetic resonance imaging (MRI) (left: axial; right: coronal). Peri-ligamentous edematous change (arrows) was noted surrounding knee MCL, indicating a grade 1 injury.

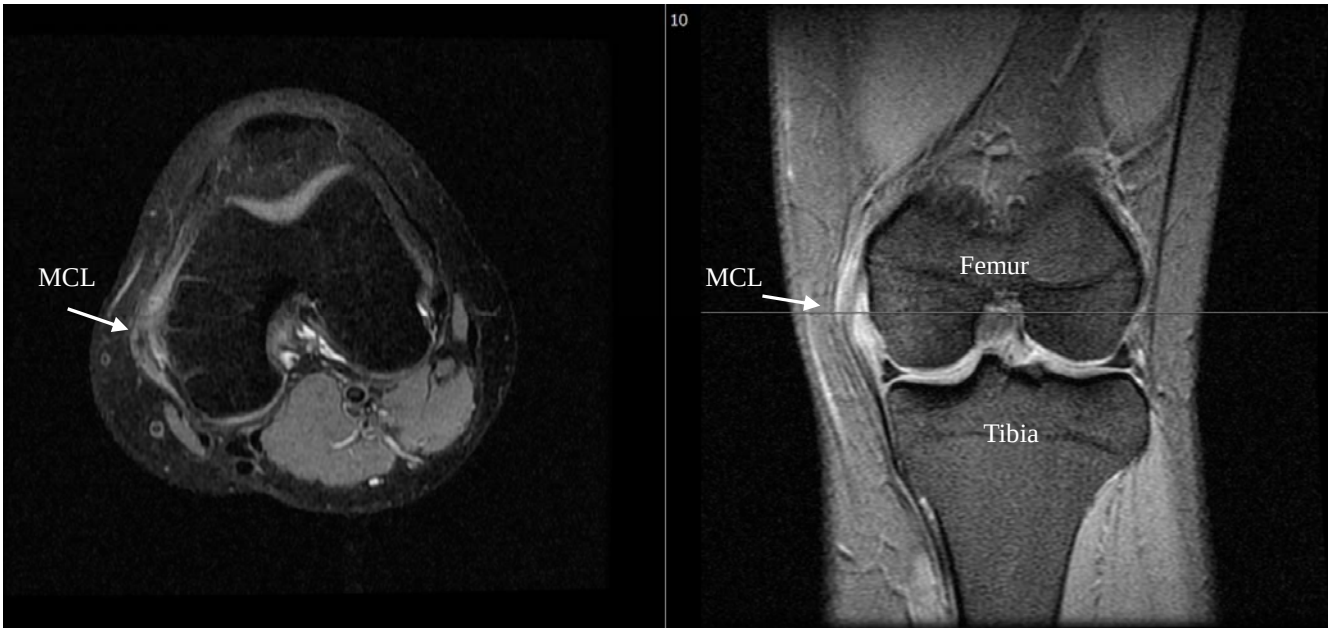

Figure 4. Grade 2 knee medial collateral ligament (MCL) injury observed using magnetic resonance imaging (MRI) (left: axial; right: coronal). Edematous changes and partial disruption (arrows) were noted in the knee MCL, indicating a grade 2 injury.

RESULTS

Demographic data: A total of 51 patients were included in this retrospective study (Table 1). The average age of the cohort was 46.4±16.3years, and 22 of them were men. The mean duration between the two examinations was 14±9.5 days.

Table 1. Demographics of the subjects

Characteristics	Mean or case number**(SD)
Age, yr (SD)	46.4 (16.3)
Gender	
Male, n(%)	22 (43.1)
Female, n(%)	29 (56.9)
Interval*	14 (9.5)

*Interval(in days) between the MRI and ultrasound examinations
**Mean for age and interval; case number for gender
SD: Standard deviation

Correlation between the original ultrasound report and the report re-read by one of our authors: The kappa ratio between the report of the initial examiner and the re-read one was 0.4. There were differences in the diagnoses for 15 MCLs, of which 12 MCLs were initially reported to be intact and 3MCLs were initially reported as injured (Table 2).

Table 2. Comparison of original and re-read ultrasound reports

US/US-R	US-R(+)	US-R(-)
US (+)	13	3
US (-)	12	22

(+): Injured knee MCL
(-): Intact knee MCL
US-R: Re-read ultrasound report

Correlation between MRI and ultrasound: The kappa ratio between the MRI report and the re-read ultrasound report was 0.41(Table 3). Differences in the diagnosis for 15 MCLs were observed, of which 9 MCLs were reported to be intact in the ultrasound report and 6 as intact in the MRI report. The kappa ratio between findings of the MRI and original ultrasound reports was 0.24.

Table 3. Comparison of Magnetic Resonance Imaging (MRI) and re-read ultrasound reports

US-R/MRI	MRI(+)	MRI(-)
US-R (+)	19	6
US-R (-)	9	17

(+): Injured knee MCL
(-): Intact knee MCL
US-R: Re-read ultrasound report

DISCUSSION

To the best of our knowledge, this is the first study to compare the diagnostic correlation between ultrasound and MRI in knee MCL injuries, although the correlation was only fair (kappa ratio=0.41). This could be due to several reasons, including poor skills of the examiner and inaccurate ultrasound examination of MCL injuries.

First, due to the retrospective design, the duration between MRI and ultrasound examinations was rather long (14 ± 9.5 days). A previous study suggested that patients with grade 1 and grade 2 MCL injuries could return to play within 21 days;[18] therefore, a 14-day interval between the two examinations may result in discrepancies due to natural healing, especially in grade 1 injuries. However, in our study, some grade 1 injuries were still noted in both examinations even after intervals longer than 20 days. However, we believe that some of the MCL injuries could have healed in the interval between the two examinations.

Second, because the indication for the MRI study was not limited to MCL injuries, radiologists sometimes focused on more evident and clinically relevant findings. A grade 1 injury of the MCL may have been missed. Of the 6 MCL that were reported to be intact on MRI but abnormal on ultrasound, 3 were determined pathological after being reviewed by the radiologist again (who was blinded to the report of the ultrasound). Of the MCLs for which diagnostic discrepancies between MRI and ultrasound were observed, only few (6/15) were diagnosed as grade 2 injury by either of the examinations. As most discrepancies were observed for grade 1 injuries, which could be affected by the interval or the retrospective design, we believe that ultrasound can be useful for diagnosing grade 2 and 3 MCL injuries.

The same issue was also noted in ultrasound

examinations. Of MCLs for which diagnostic discrepancies between the two physiatrists were observed, only 3 (out of 15) were diagnosed as grade 2 injury by either physiatrist. The other 12 diagnostic discrepancies were in terms of recognition of hypoechoic lesions.

Third, ultrasound is highly operator-dependent.[19] Our study included 12 physiatrists, and the correlation between the ultrasound findings reported by both experienced and inexperienced operators together and the MRI findings was calculated (kappa ratio=0.24). Although a mix of good operators and poorer ones was used in our study, these conditions are more representative of the real-world scenario. The correlation between the ultrasound findings reported by the more experienced physiatrist and the MRI findings was also calculated (kappa ratio=0.41), which again indicated that ultrasound is highly operator-dependent, although even the more experienced physiatrist could achieve only a fair correlation with MRI reports.

In previous studies that used ultrasound for evaluating knee MCL, only two studies assessed its sensitivity and specificity. One study compared dynamic ultrasound (valgus stress test) findings with arthroscopic findings, with 87% sensitivity for complete rupture, 63% sensitivity for partial rupture, and 96% specificity.[15] However, most of the patients had severe knee MCL injuries (54/84 were ruptured). Another study compared ultrasound findings with those of clinical examination and reported 94% accuracy. However, the sample size of cases was small (16 patients) and clinical examination may has low reliability. Our study design was more representative of everyday clinical practice, with most MCL injuries being not completely ruptured, and a larger patient cohort(N=51).

Our study compared ultrasound findings with those of MRI for diagnosing MCL injuries. While comparison with surgical findings would have been preferred, such a study is not practical because most MCL injuries are treated conservatively. Not many studies have investigated the accuracy of MRI for diagnosing MCL injuries. Only four studies compared MRI findings with surgical findings, and most reported high accuracy.[8,9,11,12] Lundberg et al observed an accuracy of 79% using MRI, but the reference criterion used in that study was increased opening of the medial compartment during arthroscopy instead of direct visualization.[8] Twaddle et al evaluated 17 knees with severe ligament derangement and dislocation, and reported 100% sensitivity and 88% specificity.[9] Lonner et al observed 100% accuracy for intact, torn, and sprained MCLs.[12] Halinen et al investigated MCL injuries that were later surgically repaired, and reported 86.4% sensitivity and accuracy.[11] As previous studies have reported good accuracy of MRI for diagnosing MCL injuries, we believe that it is reasonable to compare ultrasound and MRI findings for the diagnosis of MCL injuries. However, because MRI is not the gold standard for diagnosing MCL injuries, we used the kappa ratio, instead of sensitivity or specificity, to report our observations.

LIMITATION

Due to the retrospective design, the physiatrist who performed the re-evaluation could only examine the images obtained by the original physiatrist, and a repeat examination was not performed.

CONCLUSION

The correlation between MRI and ultrasound findings for diagnosing knee MCL pathology was poor-to-fair, which could be due to the experience of the ultrasound operator, or the retrospective design of the study. Discrepancies were most commonly observed for grade 1 MCL injuries. Therefore, we believe that ultrasound is a reliable method for detecting grade 2 or grade 3 injuries of the MCL. Further prospective studies are required to evaluate and improve the diagnostic accuracy of ultrasound.

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利用超音波診斷膝關節內側副韌帶損傷可靠嗎？

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研究目的：探討利用超音波診斷膝蓋內側副韌帶損傷之正確性。

研究方法：本研究中，總共蒐集了 51 位病人，其平均年齡為 46 歲。這 51 位病人的膝關節同時接受了磁振造影檢查及超音波檢查。其中超音波檢查由復健科醫師執行並判讀，而其檢查影像，會再由一位資深復健科醫師判讀。磁振造影檢查則由影像醫學部醫師判圖，將兩種檢查之判讀結果計算 kappa ratio 作為相關係數。

結果：超音波與磁振造影在診斷膝關節內側副韌帶之相關性 kappa ratio 為 0.24。若取較資深復健科醫師之判讀結果，則 Kappa ratio 略微提升至 0.41。在兩位復健科醫師之間，kappa ratio 則為 0.4。

結論：在現行臨床狀況下，超音波在診斷膝關節內側副韌帶損傷，與磁振造影之相關係數仍不盡理想，需更多努力以增加超音波在診斷膝蓋內側副韌帶之正確性。（台灣復健醫誌 2017；45(1)：27 - 34）

關鍵詞：內側副韌帶(MCL)、超音波(Ultrasound)、磁振造影(MRI)

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