Comparative Study between High Resolution Ultrasound (HRUS) and MRI in Diagnosis of Meniscal and Cruciate Ligaments Injury of the Knee

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Abstract

Objective: The purpose of this study is to evaluate the role of high resolution ultrasound (HRUS) in comparison to MRI in diagnosis of meniscal and cruciate ligaments injury of the knee.

Patients and Methods: In the period from November 2010 to November 2011 a total of 35 persons were examined including 5 cases in control group and 30 cases in patient group. All cases were subjected to high resolution ultrasound and MRI of the knee. We evaluated the menisci, ACL & PCL.

Results: The study included 30 symptomatic patients with history of acute or chronic knee trauma, 24 males and 6 females. Their ages ranged from 18-35 years. All patients were known or suspected to have knee derangement as a sequela of trauma. All of them were presented with knee pain and/or limitation of movement.

Conclusion: High resolution ultrasound gives high accuracy & specificity which nearly approaches that of MRI. As regarding its sensitivity, it is of lower comparable value than that of MRI. So it is preferable to use high resolution ultrasound as a preliminary investigation for diagnosis as the patient can avoid performing the high cost MRI unless the patient was proved to be injured and needing MRI.

Key Words: (HRUS) high resolution ultrasound – (MRI) magnetic resonance imaging – Meniscus – Cruciate ligaments.

Introduction

KNEE injuries are common, especially when taking part in sport. Injuries to soft tissues, such as ligaments, cartilage (meniscus) and tendons, are the most common, though damage to the bones is also possible [1].

High Resolution Ultrasound (HRUS) is emerging as a viable imaging modality in the diagnosis and assessment of the musculoskeletal system. Advantages of High Resolution Ultrasound include its easy availability and multiplanar capability, as well as economic advantages. Unlike magnetic resonance imaging, ultrasound demonstrates the fibrillar microanatomy of tendons, ligaments and muscles, enhancing its diagnostic capability. The ability to compress, dynamically assess structures and compare easily with the contra lateral side is advantageous [2].

The most common causes of knee pain and disability are tears in medial or lateral menisci. Meniscal injuries are common in both athletes and the general population. Ultrasound can demonstrate different types of injury in the meniscus [2].

Indirect or dynamic techniques are generally applied in conjunction with sonography to diagnose anterior cruciate ligament tears (ACL). In contrast, sonography can clearly depict the posterior cruciate ligament (PCL) [4].

MRI stills the gold-standard imaging technique for evaluation of the intra-articular structures of the knee, and the use of sonography remains controversial. Sonography nevertheless is a useful alternative in several conditions as in suspected meniscus or ligament lesion, where it may provide a positive diagnosis but is not sufficient to exclude intra-articular lesions [4].

Patients and Methods

In a period from November 2010 to November 2011 a total of 35 persons were examined. They were 27 males & 8 females, with an age range between 18-35 years, they were classified to control group and patient group.
Control group:
To demonstrate the ultrasound appearance of the normal menisci, ACL & PCL, we performed ultrasound examination on 10 knees in 5 asymptomatic persons 3 men & 2 women as a control group after having the patient consent with no history of knee trauma or disorders.

Patients group:
Included 30 symptomatic patients attending the radiology department and the outpatient clinics of orthopedics of Zagazig University Hospital.

The patients suffer from unilateral or bilateral joint disorders such as pain, swelling, locking & limitation of movements as sequelae of old or recent knee trauma. We evaluated the menisci, ACL & PCL.

All patients are subjected to the following:
• History taking.
• Real time high resolution ultrasonography (HRUS) examination.
• Magnetic resonance imaging (MRI) examination.

Imaging methods & study design:
- High Resolution Ultrasonography:
- Instrumentation:
  High resolution ultrasound scanner (General Electric with small linear probe of 7.5 to 12 Mhz frequency and Laser page printer) was used for real time B mode scanning.
- Technique of High Resolution Ultrasonography (HRUS) examination:
  • The anterior horns of the medial & lateral menisci were examined while the patient was in supine position with 30°-90° flexion of the knee, the transducer was placed in sagittal & coronal planes of the medial & lateral aspects of the knee joint.
  • The posterior horns of the medial and lateral menisci were examined while patient was in prone position with some degree of knee flexion obtained by a paper roll placed at lower leg to achieve knee flexion about 20°. A 7.5 MHz linear array probe was placed in sagittal and coronal oblique planes.
  • For assessment of ACL in the control group, persons were in supine position with the knee hyperflexed and internally rotated, and then the 7.5-12 Mhz linear array probe was positioned longitudinally over the patellar tendon to evaluate distal ACL fibers, then patients were turned to prone position with knee extended and the probe placed transversely in intercondylar fossa to examine the hyperechoic anterior cruciate ligament and the adjacent hyperechoic fat taking the popliteal artery as landmark. In patient group we were depending on the indirect signs. Patients were in prone position with knee extended and the 7.5-12 MHz linear array probe was placed transversely in the popliteal fossa to evaluate hypoechoic hematoma formed in acute injuries. Another indirect sign was assessed. The knee was flexed about 20° supported by a paper roll placed at lower leg, the 7.5-12 MHz linear array probe was placed in sagittal plane in medial aspect of the popliteal fossa to measure the distance between medial femoral condyle and the posterior aspect of the tibia at rest and after manual pressure for estimation of the anterior tibial translation seen in chronic injuries.
  • The transducer was moved over the midline of the posterior knee to visualize the posterior cruciate ligament. One helpful landmark is the characteristic bone contours of the tibial plateau at the posterior cruciate ligament attachment. The transducer is then rotated slightly to elongate the posterior cruciate ligament.
  • The focus of the transducer was adjusted at the level of examined meniscus or ligament.
  • Examination of the contra lateral uninjured knee in the same patient attempted routinely for comparison.
  • We evaluated the meniscal echogenicity & width while the PCL was evaluated for thickness and echogenicity & ACL was evaluated indirectly for hematoma and anterior tibial translation.

- Magnetic Resonance Imaging (MRI):
  MRI (philips achiva II Medical systems, netherlands) was performed within 24 hours after ultrasound examination. Examinations were done on (0.2 &1.5 T) MRI machines by using the imaging standard protocols.

  Patients were placed supine with the knee extended and slightly externally rotated (10-15°) in an extremity coil to optimize the signal to noise ratio. Images were obtained in both the sagittal and coronal planes. Sagittal images were obtained with the knee externally rotated to permit imaging in the plane of the ACL. Axial images were also obtained to study the supporting ligaments around the knee. Routine MRI sequences were used including turbo spin echo sagittal proton density, T2 & T1 weighted images and also coronal STIR. These were obtained using a field of view of 14-16cm, a section thickness of 4-5mm, and a matrix
of at 192 X 256 steps in the phase-and frequency-encoding directions. A skip of 0.5 to 1mm was used between imaging sections.

Statistical analysis was done to evaluate the diagnostic accuracy of ultrasonography in the evaluation of meniscal and cruciate injuries.

Results

The study included 30 symptomatic patients with history of acute or chronic knee trauma, 24 males and 6 females. Their ages ranged from 18-35 years. All patients were known or suspected to have knee derangement as a sequelae of trauma. All of them were presented with knee pain and/or limitation of movement.

Age & sex:

Patient age ranged from 18-35 years with mean of 27.

The relation between patient sex and meniscal affection had been shown in Table (1).

Table (1)

<table>
<thead>
<tr>
<th></th>
<th>Number of U/S positive cases</th>
<th>Number of U/S negative cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>24</td>
<td>2</td>
</tr>
<tr>
<td>Females</td>
<td>6</td>
<td>5</td>
</tr>
</tbody>
</table>

The relation between patient sex and cruciate ligaments affection had been shown in Table (2).

Table (2)

<table>
<thead>
<tr>
<th></th>
<th>Number of U/S positive cases</th>
<th>Number of U/S negative cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>24</td>
<td>13</td>
</tr>
<tr>
<td>Females</td>
<td>6</td>
<td>2</td>
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</tbody>
</table>

The relation between the site of injury & the frequency of affection had been shown in Table (3).

Table (3)

<table>
<thead>
<tr>
<th>The site of Injury</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
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<td>Anterior horn. Medial meniscus</td>
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<td>26.6%</td>
</tr>
<tr>
<td>Posterior horn. Medial meniscus</td>
<td>12</td>
<td>40%</td>
</tr>
<tr>
<td>Anterior horn. Lateral meniscus</td>
<td>2</td>
<td>6.66%</td>
</tr>
<tr>
<td>Posterior horn. Lateral meniscus</td>
<td>5</td>
<td>16.66%</td>
</tr>
<tr>
<td>ACL</td>
<td>12</td>
<td>40%</td>
</tr>
<tr>
<td>PCL</td>
<td>3</td>
<td>10%</td>
</tr>
</tbody>
</table>

Evaluation of medial meniscus by ultrasound:

- **Anterior horn (Figs. 1A,B):**
  - Out of 30 cases, 8 cases were positive by HRUS. Only 2 cases of them proved to be positive by MRI, the other 6 cases were negative by MRI.
  - Out of 30 cases, 22 cases were negative by HRUS. Twenty cases were proved to be negative by MRI and the other 2 cases were positive by MRI.
  - The accuracy = 73.3%.
  - The sensitivity = 50%.
  - The specificity = 79.9%.

- **Posterior horn (Figs. 2A,B):**
  - Out of 30 cases, 12 cases were positive by HRUS. Only 9 cases of them proved to be positive by MRI, the other 3 cases were negative by MRI.
  - Out of 30 cases, 18 cases were negative by HRUS. Only 12 of them proved to be negative by MRI the other 6 cases were positive by MRI.
  - The accuracy = 70%.
  - The sensitivity = 60%.
  - The specificity = 80%.
Evaluation of lateral meniscus by ultrasound:

- **Anterior horn (Figs. 3A,B):**
  - Out of 30 cases, 2 cases were positive by HRUS. Only 1 case of them proved to be positive by MRI, the other one was negative by MRI.
  - Out of 30 cases, 28 cases were negative by HRUS. Twenty six cases proved to be negative by MRI the other 2 cases were positive by MRI.
  - The accuracy = 90%.
  - The sensitivity = 33.3%.
  - The specificity = 96.3%.

- **Posterior horn (Figs. 4A,B):**
  - Out of 30 cases, 5 cases were positive by HRUS. Only 2 cases of them proved to be positive by MRI, the other 3 cases were negative by MRI.
  - Out of 30 cases, 25 cases were negative by HRUS. Twenty four cases proved to be negative by MRI. The other case was positive by MRI.
  - The accuracy = 86.7%.
  - The sensitivity = 66.7%.
  - The specificity = 88.9%.
Evaluation of ACL by ultrasound (Figs. 5A,B):
- Out of 30 cases, 12 cases were positive by HRUS. Only 9 cases of them proved to be positive by MRI, the other 3 cases were negative by MRI.
- Out of 30 cases, 18 cases were negative by HRUS. Sixteen of them proved to be negative by MRI, the other 2 cases were positive by MRI.
- The accuracy = 83.3%.
- The sensitivity = 81.81%.
- The specificity = 84.2%.

Evaluation of PCL by ultrasound (Figs. 6A,B):
- Out of 30 cases, 3 cases were positive by HRUS. Only 2 cases of them proved to be positive by MRI, the other one was negative by MRI.
- Out of 30 cases, 27 cases were negative by HRUS. Twenty five cases proved to be negative by MRI, the other 2 cases were positive by MRI.
- The accuracy = 90%.
- The sensitivity = 50%.
- The specificity = 96.1%.
Fig. (7): Right knee of a male patient (A) Sagittal sonogram shows hypoechoic cleft within the posterior horn of the lateral meniscus (PHLM). In the image (B) There is a hypoechoic meniscal cyst is seen connected to the hypoechoic area. C) Sagittal (proton density weighted image) PD WI and D) Sagittal T2 WI of the same case show abnormal signal intensity in the posterior horn of the lateral meniscus reaching the articular surface (horizontal tear) connected with meniscal cyst.

Fig. (8): Left knee of a female patient (A) Sagittal oblique sonogram showing heterogeneous thickened (10mm) PCL. (B) Sagittal sonogram shows hypoechoic area within the posterior horn of the medial meniscus (PHMM). (C) MRI sagittal (proton density weighted image) PD WI shows complete tear of the PCL. (D) Sagittal PD WI shows abnormal signal intensity in the posterior horn of the medial meniscus reaching the articular surface; horizontal posterior horn medial meniscus tear.
Fig. (9): Right knee of a female patient (A) Sagittal sonogram of medial aspect of the popliteal fossa at rest shows distance between femur and tibia 5.4mm (B) Sagittal sonogram of medial aspect of the popliteal fossa with pressure shows tibial translation 10.6mm; translation difference 5.2mm (C) Sagittal PD WI & (D) Coronal T1 WI show thickened ACL with abnormal signal intensity within its substance; tear.

Fig. (10): Left knee of a male patient (A) Transverse sonogram at intercondylar fossa shows hypoechoic area at medial aspect of the lateral femoral condyle; hematoma at femoral attachment of the ACL. (B) Sagittal sonogram image shows hypoechoic areas within the posterior horn of the medial meniscus (PHMM). (C) Sagittal PD WI shows ACL tear. (D) Sagittal PD WI shows posterior horn medial meniscus vertical tear.
Discussion

In the last decade, musculoskeletal imaging has rapidly expanded due to the imaging capabilities of magnetic resonance imaging and ultrasound [5].

Musculoskeletal ultrasound has shown considerable expansion in the last few years. The main reasons to explain this development are: Better quality of images due to technical improvement (development of high-frequency transducers, refined focusing and sensitive color and power Doppler technology) and growth of interest in low-cost imaging modalities due to economic motivation [6].

High resolution ultrasound (HRUS) has also been widely used as a screening imaging tool for decades. The advantages of HRUS include low cost, no radiation exposure, direct visualization of soft tissues, and a readily available dynamic study [7].

The number of males was 24 and the females was 6 in our study, this could be explained by the fact that males are more vulnerable to such traumatic knee injury during daily activity and sports injury, while females are more vulnerable to meniscal degeneration resulting from weight bearing due to obesity.

The average age in our study was 26.5 years, which was similar to a study done in 2004 [8] whose average age was 28.4 years.

Regarding the ACL, in our study, we evaluated the ACL by the linear array probe depending on the indirect signs. First sign is hematoma formed at femoral attachment of acutely disrupted ACL. As the hematoma reduces in size gradually the accuracy of this technique will decrease with time. The same technique was used by other studies [7,9,10]. The second indirect sign to detect ACL tears is to measure the ventral translation of the tibial head used by 2 studies [7,11].

There was a study reported that a sensitivity of 87% and a specificity of 98% [12] while in another study the sensitivity was 95.24% [13]. This results are higher than ours which was 81.8% and 84.2% respectively. This may be due to our limited number of cases compared to other studies. On the other hand, there was a study believed that ultrasound is still of limited value in evaluation of cruciate ligaments [14]. This was agreed by another study who declared that US did not allow cruciate ligament lesions to be demonstrated [15].

Regarding the PCL, in our study we evaluate the PCL using the same technique used by other studies [16,17]. They could detect the torn PCL by evaluating the increase in thickness, ill definition of borders and heterogeneous echogenicity.

In a study stated that the thickness of the PCL at a cut off value of 4-8mm had a sensitivity & specificity of 100% [18]. This matching with specificity in our results but our sensitivity was 50%. This may be due to limited number of cases.

In our study, it was difficult to differentiate between meniscal degeneration and meniscal tear. The same was reported by other study [7] and on the contrary to another one who described vertical meniscal tear as sharp bright line echo and the degeneration as hypoechoic areas but they confirmed that different types of meniscal tears could not be differentiated by ultrasound [19].

In our work, the accuracy rate for menisci varied between 70% and 90%, the specificity varied between 76.9 and 88.9%, this was agreed with other study who reported accuracy rate between 74% and 93%, specificity between 50% and 97% [3]. Although this matching, our sensitivity varied between 33.3% and 66.7%, this was not the same as their sensitivity ranged between 76% and 100%, which was higher than ours. Also our results regarding the sensitivity and specificity was in agreement with a study whose results showed a sensitivity of 30% and specificity of 85% [20] and with the sensitivity of another study which was 60% [21].

In a study stated that US is capable to detect normal meniscus by 100% accuracy but has no role in diagnosis of pathological meniscus [22], while in our work, we can detect the normal as well as the injured meniscus.

There was a study concluded that sonography is not accurate enough to be used as the only imaging modality for diagnosing tears of the knee menisci [21]. We can say from our results that the higher specificity and lower sensitivity reflect the power of high resolution ultrasound to confirm that the meniscus is normal rather than to diagnose the pathology, thus it is a good negative test.

In our work, we can detect joint effusion; this was in agreement with another study who stated that joint effusions are easily identified as anechoic or hypoechoic fluid collection, typically with well defined margins [23].
Conclusion:

Knee pain and related symptoms is common complain that may derive from damage to one or more of the soft tissue structures that stabilize and cushion the knee joint including the ligaments, muscles, tendons, and menisci.

The use of high resolution ultrasound has helped in the last few years in the evaluation of musculoskeletal disorders with high efficiency as regard to its availability, low cost in comparison to different imaging modalities, availability of dynamic study and comparison with the other side.

This study included 30 symptomatic patients from Zagazig University hospital; all of them were exposed to knee joint trauma either acute or chronic with suspected injury of medial, lateral meniscus or cruciate ligaments.

The study was carried out at Radiology department of Zagazig University hospital, during the period from Nov 2010 to June 2011. MRI in addition to high resolution ultrasound was performed to compare the accuracy of each of them in the detection of the extent of injury.

The study revealed that the mean accuracy of high resolution ultrasound in the diagnosis of both medial & lateral meniscal injury was 80%, mean sensitivity was 52.5% and the mean specificity was 84.15%. And also ultrasound recorded an accuracy of 83.3%, sensitivity of 81.2% and specificity of 84.2% in diagnosis of ACL injury. For PCL, its results were as follows: Accuracy 90%, sensitivity 50% and specificity 96%.

From this we can conclude that high resolution ultrasound gives high accuracy & specificity which nearly approaches that of MRI. As regarding its sensitivity, it is of lower comparable value than that of MRI. So it is preferable to use high resolution ultrasound as a preliminary investigation for diagnosis as the patient can avoid performing the high cost MRI unless the patient was proved to be injured and needing MRI.

Recommendations:

If there is a patient with history of knee trauma and clinical suspicion of cruciate ligaments and/or meniscal injuries, we recommend to start with high resolution ultrasound examination as screening tool. For negative examinations follow-up, if no improvement the second step is MRI examination to rule out cruciate and meniscal injuries.

For positive results MRI examination is recommended to prove cruciate ligaments and meniscal injuries and for more details.

References


