

# Imaging of Knee Joint Pathologies: A Comparative Study of Ultrasound and Magnetic Resonance Imaging

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## ABSTRACT

**Background:** Magnetic resonance imaging (MRI) has been accepted as the best non-invasive imaging modality for the evaluation of knee joint pathology but the advantages of ultrasound (US) over magnetic resonance imaging (MRI) are that the ultrasound is readily available, cheap and offers real-time imaging. **Aim:** To assess the accuracy of ultrasound in diagnosing knee joint pathologies using MRI as a reference. **Materials And Methods:** 50 patients were evaluated prospectively over a period of 1.5 years by USG followed by MRI of the affected knee. Accuracy of USG was calculated with MRI as reference. **Results:** In our study, the majority of patients were in age group 21-30 years. Perfect agreement was noted between ultrasound and MRI for detecting Baker's cyst. Near perfect agreement was noted between ultrasound and MRI for detecting joint effusion, soft tissue edema and osteophytes. Substantial agreement was noted between ultrasound and MRI for Collateral ligaments tear and Meniscal injuries. Moderate agreement was noted between ultrasound and MRI for PCL tear. Fair agreement was noted between ultrasound and MRI for ACL tear. **Conclusion:** Knee USG has high accuracy in diagnosing pathologies like knee joint effusion, synovitis, popliteal/baker's cysts, soft tissue edema/cellulitis, arthritic changes, collateral ligament and meniscal tears.

**KEY WORDS:** Knee joint pathologies, Ultrasound, MRI, Ligaments.

## Introduction

Large numbers of people suffer from problems of knee joint. Due to limited bony support, stability of the joint is highly dependent upon the ligaments, cartilages, tendons and menisci therefore they are more prone to injuries<sup>[1,2]</sup>. For early treatment, accurate diagnosis regarding the type and extent of injuries is essential. The most widely used diagnostic modalities to assess the joint injury are USG, MRI and arthroscopy. Arthroscopy, though accurate,

is invasive and can cause complications<sup>[3,4]</sup>. For non-invasive evaluation of knee injuries, Magnetic resonance imaging (MRI) has now been accepted as the best imaging modality. The advantages of ultrasound (US) over magnetic resonance imaging (MRI) are that the ultrasound is non-invasive, readily available, well-accepted by patients, cheap and that it has the advantage of both dynamic evaluation and real-time imaging<sup>[5]</sup>. In this study, there is a comparison between ultrasound and MRI in characterization of knee joint pathologies. Various knee pathologies can be identified on ultrasound including meniscal tears, ACL/PCL tears, collateral ligament injuries, joint effusions & bursitis, soft tissue edema & cellulitis, baker's cyst and arthritic changes<sup>[6]</sup>.

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### Material and methods

The present study is a prospective comparative study conducted on 50 patients of all ages and both sexes for 1.5 years presenting with knee joint pain. After clinical evaluation, once the patient satisfied the inclusion and exclusion criteria for this study, he or she was taken for sonographic evaluation of the knee joint followed by MRI of the affected knee.

The inclusion criteria were patients with history of pain in the knee with or without swelling, patients with clinically suspected tears and patients with restriction of movement at the knee joint following trivial trauma. The exclusion criteria were patients not giving consent, claustrophobic patients, patient with metallic implant and post-operative cases.

### Statistical Analysis

MRI was regarded as gold standard. Comparison was made between ultrasound and MRI. Data collected from the USG & MRI results was analyzed for the significant correlation between USG and MRI findings of knee joint using IBM SPSS software by kappa statistics.

### Results

50 patients with the complaint of knee joint pain were evaluated using ultrasound, which were further followed by MRI. Maximum patients (18) were in the age group of 21-30 years (36%) followed by below 20 years (22%) and minimum in the age group of above 50 years (12%). Of the 50 cases, 40 (80%) were males and 10 (20%) were females. While evaluating the different knee pathologies on USG and MRI, most common pathology detected on USG was joint effusion in 28 cases (56%) and most common pathology on MRI was ACL tear in 38 cases (76%). Of all the knee ligaments, most commonly involved was ACL.

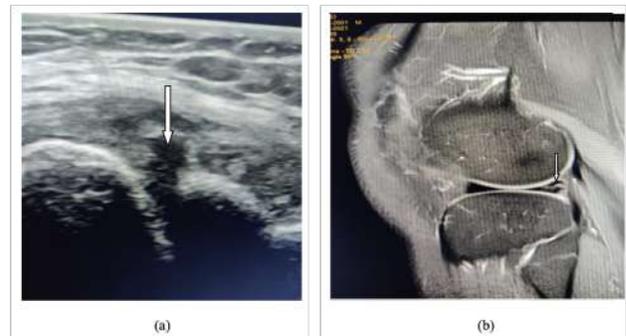
**Table 1: Age distribution of patients studied**

Age in years	Number	%
Up to 20	11	22%
21-30	18	36%
31-40	7	14%
41-50	8	16%
>50	6	12%
Total	50	100%

Mean +/-SD 33.2 +/-10.6



**Figure 1:** (a) USG of patient showing extruded medial meniscus with reduced medial joint space, (b) PDFS coronal image of left knee joint in same patient showing hyperintensity in body and posterior horn of medial meniscus with extrusion of fibers beyond the joint space



**Figure 2:** (a) USG image of left knee joint showing focal hypoechoic areas within lateral meniscus likely suggestive of lateral meniscus injury, (b) PDFS sagittal image of left knee joint in same patient shows focal PDFS hyperintensity in posterior horn of lateral meniscus reaching upto the peripheral margin and the articular margin in body region likely tear



**Figure 3:** (a) USG image of the patient shows diffuse thickening and heteroechogenicity in MCL at femoral end, (b)PDFS coronal image of left knee joint of same patient showing hyperintensity within MCL near femoral attachment with its thickening. Also seen is high grade ACL tear

**Table 4: Accuracy of USG over MRI**

Structures	Sensitivity %	Specificity %	PPV %	NPV %	Accuracy %
ACL	57.9%	83.3%	91.6%	38.4%	64%
PCL	50%	97.6%	80%	91.1%	90%
MCL	83%	95.4%	71.4%	97.7%	94%
LCL	75%	97.6%	85.7%	95.3%	94%
MM	83.3%	93.7%	88.2%	90.9%	90%
LM	75%	94.1%	85.7%	88.8%	88%
Joint effusion	93.3%	100%	100%	90.9%	96%
Soft tissue edema	86.3%	100%	100%	90.3%	94%
Popliteal / baker's cyst	100%	100%	100%	100%	100%
Osteophytes / arthritis	75%	100%	100%	95.4%	96%

**Table 2: Sex distribution of patients studied**

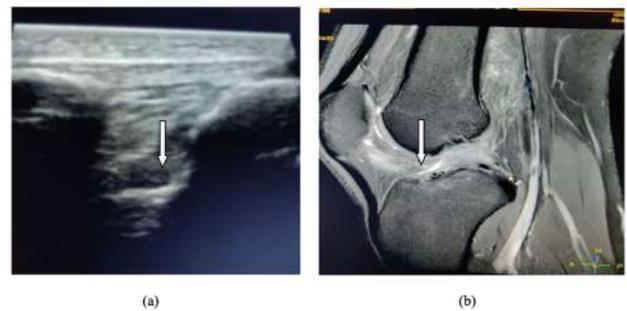
Sex	Number	%
Male	40	80%
Female	10	20%

**Table 3: Spectrum of USG and MRI findings**

Findings	Frequency On USG (Percentage)	Frequency On MRI (Percentage)
ACL Tear	24 (48%)	38 (76%)
PCL Tear	5 (10%)	8 (16%)
MCL Injury	7 (14%)	6 (12%)
LCL Injury	7 (14%)	8 (16%)
MM Tear	17 (34%)	18 (36%)
LM Tear	14 (28%)	16 (32%)
Joint effusion	28 (56%)	30 (60%)
Soft tissue edema	19 (38%)	22 (44%)
Popliteal cyst	7 (14%)	7 (14%)
Osteoarthritis	6 (12%)	8(16%)

**Discussion**

MRI is accepted as the gold standard technique for evaluation of various knee pathologies<sup>[7,8]</sup>. However, in India MRI is not always available on demand especially in small hospitals. It also does not allow dynamic testing and is a rather lengthy and expensive imaging modality. The benefits of ultrasound include portability, low cost, high spatial resolution, dynamic imaging, and ability to guide percutaneous interventions when indicated. USG also allows direct patient contact, facilitating immediate clinical correlation



**Figure 4:** (a) USG image of patient showing mildly thickened and hypoechoic visualized part of ACL. (b) PDFS sagittal image in same patient showing mild hyperintensity in ACL throughout its length & mild periligamentous edema with focal disruption of fibers at distal insertion into tibia suggestive of partial ACL tear

and the ability to compare with the contralateral knee<sup>[9]</sup>.

The study included 50 patients. The average age in this study was 33.2 years, with standard deviation of 10.6. The results were similar to study by EL-Monem SA and Enaba MM, whose average age was 28.4 years<sup>[10]</sup>. Maximum cases were seen in the age range of 21-30 years, which suggest that young adults were more commonly involved in knee pathologies due to sports and athletic activities<sup>[11]</sup>.

The age distribution pattern observed in the present study was also comparable to the study of D S Shetty et al in which commonest age group was 21 to 30 years for both males and females<sup>[12]</sup>. Singh et al also found that majority of the patients with knee injury were in third decade<sup>[13]</sup>.

In the present study, 80% of the patients were male and 20% were female with male to female ratio 4:1. This corresponded with the sex distribution pattern reported in the study by Anil Madurwar *et al* where authors noted, out of 50 patients of knee trauma examined, 42 patients (76%) were males and 8 of them were females. Similar results were shown by Singh *et al*<sup>[13]</sup> and D S Shetty *et al*<sup>[12]</sup>. This could be explained by the fact that the males are the one who are physically active, engaged in increased various outdoor activities and sports events while females are more vulnerable to meniscal degeneration resulting from weight bearing due to obesity and less involvement in outdoor activities<sup>[14]</sup>.

In the present study, 25 patients (50%) had injury in the left knee and 25 patients (50%) had injury in the right knee. Thus, both knees were involved equally. This is in contradiction to a study conducted by Amandeep *et al* where left knee was involved more frequently than right knee.

Most common pathology detected on USG was knee joint effusion in 28 cases (56%) and on MRI was ACL tear in 38 cases (76%).

Effusion was also seen as most common ultrasound finding in other studies by Singh B *et al*<sup>[13]</sup> and Yousuf *et al*. Knee effusion is commonly seen in various knee pathologies and can be detected by ultrasound. In our study near perfect agreement was noted between ultrasound and MRI in detection of effusion. Ultrasound also demonstrated sensitivity of 93.3%, specificity of 100%, and accuracy of 96%. Similar sensitivity and specificity of ultrasound was also seen in study by Draghi F *et al*<sup>[15]</sup>. In recent study by Singh B *et al*<sup>[13]</sup> ultrasound showed sensitivity, specificity and accuracy of 100% for detecting knee effusion.

Meniscal lesions are a major cause of knee pain and have adverse effects on the proper functioning of the knee joint. Tears and degenerations constitute the majority of meniscal lesions. In our study, almost substantial agreement was noted between USG and MRI in detection of medial meniscus tears. Ultrasound in comparison to MRI in our study showed a sensitivity of 83.3%, specificity of 93.7% and accuracy of 90%. Unlu EN *et al* in their study showed moderate agreement between US and MRI in detection of tears<sup>[16]</sup>. Similarly, in study by Singh A *et al* sensitivity of ultrasound in detecting medial meniscal tears was 77.7%, specificity was 90.4% and

accuracy was 86.6% with MRI as gold standard<sup>[17]</sup>. However, in study by Ghosh N *et al* ultrasound showed sensitivity of 100% but lower specificity of 40% as compared to our study<sup>[18]</sup>.

For detecting lateral meniscus tears substantial agreement was noted between ultrasound and MRI in our study and in study by Unlu EN *et al*<sup>[16]</sup>. In our study the sensitivity, specificity and accuracy of ultrasound in detection of lateral meniscal tears were 75%, 94.1% and 88% respectively. Similar results were seen in studies by Singh B *et al*, Unlu EN *et al* and Singh A *et al* who evaluated various knee pathologies on ultrasound and used MRI as gold standard<sup>[13,16,17]</sup>.

Collateral ligaments are also commonly injured during sports or traffic injuries. In our study substantial agreement was noted between ultrasound and MRI in detection of medial collateral ligament tear. Ultrasound demonstrated sensitivity of 83%, specificity of 95.4% and accuracy of 94%. Compared to our study Singh B *et al* and Singh A *et al* showed sensitivity (83.3% and 84.6%) and similar specificity (97.7% and 98%) and accuracy (96% and 96.6%) of ultrasound for detecting medial collateral ligaments tears<sup>[13,17]</sup>. Ghosh N *et al* showed lower sensitivity of 67.0% and specificity of 83.0% for ultrasound in their study<sup>[18]</sup>. For detecting lateral collateral ligament tear substantial agreement was noted between ultrasound and MRI in our study. Ultrasound also demonstrated sensitivity of 75%, specificity of 97.6% and accuracy of 94% in our study. In study done by Singh B *et al* sensitivity, specificity and accuracy of USG in diagnosing lateral collateral ligament tears were 84.6%, 97.8% and 95.0% respectively<sup>[13]</sup>. Thus ultrasound can be an effective imaging modality for evaluating patients with collateral ligament injuries.

Currently, MRI and arthroscopy are the reference standards for diagnosing an ACL injury. Due to its deep location and oblique orientation, the anterior cruciate ligament is partially visible with ultrasound, thus it is still not possible to directly visualize the complete ACL using sonography<sup>[19]</sup>. Various direct and indirect methods are described in various studies to look at anterior cruciate ligament. Ultrasound had shown high sensitivity and specificity in diagnosing ACL tear in these studies<sup>[20-22]</sup>. We used anterior approach to look for anterior cruciate ligament tear. In our study, out of 50 cases, 24 cases were positive by USG, out of which 22 cases proved to

be positive by MRI, other 2 were normal. Ultrasound demonstrated sensitivity of 57.9%, specificity of 83.3% and accuracy of 64% in our study. There was fair agreement noted. Compared to our study Sharma VK et al showed only slight agreement between ultrasound and MRI in detecting anterior cruciate ligaments tears<sup>[23]</sup>. But this was lower as compared to other studies. Attya MSA conducted a study in which he recorded an accuracy of 83.3 %, sensitivity of 81.2% and specificity of 84.2% of USG in diagnosis of ACL injury<sup>[24]</sup>. According to study done by Abdel el Monem S and Enaba MM the sensitivity and specificity of USG for ACL tears was 81% and 84% respectively<sup>[25]</sup>.

Posterior cruciate ligament is depicted on ultrasound by posterior approach. The intermediate and distal portion of posterior cruciate ligament is demonstrated by ultrasound. The proximal portion of this ligament and its insertion into femur cannot be demonstrated<sup>[26]</sup>. We used posterior approach to look at PCL injuries. In present study, the sensitivity, specificity and accuracy of USG in diagnosing PCL tears are 50 %, 97.6 % and 90% and moderate agreement noted between USG and MRI. Compared to our study Sharma VK et al showed moderate agreement between ultrasound and MRI in detecting anterior cruciate ligaments tears<sup>[23]</sup>. According to Wang C et al., sonographic examination had a sensitivity of 83.3%, a specificity of 87.0% and an accuracy of 85.7% in detecting PCL tears<sup>[27]</sup>. Specificity and accuracy are comparable; however sensitivity is lesser than latter study. Ultrasound showed low sensitivity in our study which is quiet consistent with study done by Singh A et al who showed sensitivity of 33.3% in their study<sup>[17]</sup>.

For detecting Baker's cyst ultrasound in our study showed sensitivity, specificity and accuracy of 100%. Perfect agreement was noted between USG and MRI in detecting Baker's cyst. In study by Singh B et al, Sharma VK et al and Ward EE et al ultrasound showed similar sensitivity, specificity and accuracy of 100% in detecting baker's cyst<sup>[13,23,28]</sup>.

For detecting osteophytes almost perfect agreement was noted between ultrasound and MRI. Ultrasound showed sensitivity of 75%, specificity of 100% and accuracy of 96% for detecting osteophytes compared to MRI as gold standard. Nearly similar results were seen in study by Podlipská, J. et al<sup>[29]</sup>. For detecting soft tissue edema almost perfect agreement was noted between ultrasound and MRI. Ultrasound

showed sensitivity of 86.3%, specificity of 100% and accuracy of 94% for detecting soft tissue edema compared to MRI as gold standard.

### Limitations

The present study has a limitation of sample size. We recommend that the study should be done on large number of patients as well as at multiple centers.

### Conclusion

Based on our results, it can be concluded that USG is an effective imaging modality that has a positive effect on the management of many patients presenting with knee pain & injuries. Knee USG has high accuracy in diagnosing collateral ligament and meniscal tears. A wide availability, lower cost and better tolerability of USG make it a modality of first choice for evaluation of knee ligamentous and meniscal tears. MRI can be reserved for patients with suspicious USG results. If there is a patient with history of knee trauma and clinical suspicion of cruciate ligaments injuries, we recommend starting with high resolution ultrasound examination as screening tool. For negative examinations, follow up if there is no improvement the second step is MRI examination to rule out cruciate injuries. For positive results MRI examination is recommended to confirm cruciate ligaments injuries and for getting more details. For pathologies like knee joint effusion, synovitis, popliteal cysts, soft tissue edema and arthritic changes, the accuracy of ultrasound is almost comparable to MRI. Hence, USG should be used as first line modality for detecting these modalities.

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