Original Research Article

Ultrasonographic evaluation of soft tissue injuries of the knee with MRI correlation

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Abstract

Background: Ultrasonograhy is vastly underutilized for evaluation of knee joint pathologies. With additional refinements in ultrasound technology and scanning techniques, we expect further expansion of its role in the evaluation of the knee joint injuries.. MRI is non-invasive gold standard for the diagnosis of internal derangement of knee, however the high cost and limited availability of MRI precludes its routine uses.
Aims: The purpose of this study was to assess the effectiveness of ultrasound in the diagnosis of soft tissue injuries of the knee and comparison of results with MRI.**Materials & Methods:** The present study included 50 patients with knee pain and suspected knee joint pathologies . For USG evaluation examination is directed to the location of maximum pain, and compared with the other limb to avoid artifacts or normal variants. For comprehensive study anatomical evaluation of knee compartments done for tendon, ligaments, osseous structures, peripheral nerves, vessels, joint effusion, fluid collection around the knee joint, patellar cortex and juxta-articular cysts. For MRI Patient was placed in supine position with the knee in a closely coupled extremity coil. The knee was externally rotated 15 to 20 degree and flexed slightly 5 to 10 degree to increase the accuracy of assessing the ACL, patellofemoral compartment and patellar alignment. Multiplaner images (axial, coronal and saggital) obtained in T1, T2, PD , STIR and GRE sequences.**Conclusion:**A well performed ultrasonography, proper appreciation of relevant ultrasonographic anatomy and common knee pathologies , knowledge of pitfalls of study allow effective use of this powerful tool for evaluation of disorders of knee joint. In most cases it obviates the need for more expensive & invasive arthroscopy and the more cumbersome and expensive MRI examination. The use of high resolution sonography allow exploration of all extra-articular soft tissues injuries and meniscal injuries (intra-articular) as a first line diagnostic method and provides adjunct in assessment of cruciate ligament injuries.

Keywords:ultrasonoghaphy ,intraarticular , extraarticular, ACL- anterior cruciate ligament, PCL- posterior cruciate ligament, meniscus, MCL-medial collateral ligament, LCL- lateral collateral ligament.

Introduction

The knee joint is one of the major weight bearing joint of the body. Knee joint disorders are significant source of morbidity in adult population. They may be degenerative, inflammatory or traumatic in nature. Injuries are frequent and often sports-related1.Examination and evaluation of a patient with multiple ligament injuries of knee is a complicated process and best done in a methodical, comprehensive fashion with a particular emphasis placed on assessment of supporting soft tissues[2]. Clinical examination even by the most experienced person using the strictest of clinical methods is not always enough to diagnose internal derangement of knee[3]. Radiographs of the affected joint are often obtained first; these can demonstrate osseous abnormality but provide little information regarding soft tissue structures. Magnetic resonance imaging (MRI) is the current imaging procedure of choice for assessment of Soft tissue injuries of the knee joint, particularly for evaluation of menisci, cruciate ligaments, bone marrow and cartilage[1]. Introduction of higher frequency transducers have permitted better resolution of superficial structures and improve sonographic evaluation of musculoskeletal system[4,5].Ultrasound imaging of the musculoskeletal system is now being widely used in practice for the diagnosis of soft-tissue injuries. Musculoskeletal ultrasound provides a cost effective, non-invasive, method of obtaining diagnostic of crystals in the kidney is normalinformation from dynamic studies, tendon evaluations and bilateral comparisons. The main strength of knee ultrasound is the assessment of Para-articular disease. Sonography has a significant role in patient presenting with knee joint trauma due to the high incidence of injuries occur in relation to the extra-articular soft tissues of the joint1. Sonography can detect hemarthrosis, tendon and muscles injuries[6,7]. Sonography is a useful modality in the diagnosis of a wide variety of knee disorders, including lesions of the articular cartilage, tendons and ligaments, menisci, synovial space, and adjacent vessels and muscles making it a potentially attractive screening examination for knee injuries. Ultrasound can demonstrate partial or complete tears of the involved muscle or tendon. It is important to attempt differentiation between partial and full-thickness tears, as the latter require prompt surgical intervention .Ultrasound can aid in prompt diagnosis, dynamic assessment with flexion and extension, can also aid in the diagnosis of patellar and quadriceps tendon tears1..Although MRI is the primary imaging modality of choice for assessment and evaluation of the cruciate ligaments, some information can be obtained by ultrasound also.MRI provides exquisite soft tissue contrast definition and multiplanar spatial resolution. It can detect meniscal, collaterals, and cruciate ligament tears.MRI is now the non-invasive gold standard for the diagnosis of internal derangement of knee1 however the high cost and limited availability of MRI precludes its routine uses. Joint sonography has several advantages over magnetic resonance imaging (MRI) and computed tomography (CT), including lower cost, wide availability, rapid side to-side anatomic comparison, and better characterization of fluid. In addition, ultrasound exams can

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be repeated without radiation risks, patients unsuitable for MRI and/or CT can be evaluated, and no sedation is required for paediatric patients[11]. Unlike magnetic resonance imaging, ultrasound demonstrates the fibrillary microanatomy of tendons, ligaments and muscles,enhancing its diagnostic capability. With experience, ultrasound is a time-efficient,economical imaging tool for assessment of the knee[1].Although it is difficult to state the exact place of ultrasonography in the diagnostic workup of knee injuries, we feel that ultrasonography is vastly underutilized. With additional refinements in ultrasound technology and scanning techniques, we expect further expansion of its role in the evaluation of the knee joint injuries.The purpose of this study was to assess the effectiveness of ultrasound in the diagnosis of soft tissue injuries of the knee and comparison of results with MRI.

Materials & Methods

For knee joint ultrasonography.–The patient lies supine on the examining table, exposing both knees. The patient indicates where he or she feels maximal pain, and the examination is directed to this location. Finally, comparison with the other limb is mandatory to avoid artefacts or mistakes. Patient lies supine on the examining table with knee joint flexion of approximately 20–30º obtained by placing a small pillow beneath the popliteal space; this stretches the extensor mechanism and avoids possible anisotropy related to the concave profile assumed by the quadriceps and patellar tendons in full extension. The transducer is placed longitudinally to evaluate the quadriceps and patellar tendon. The tendons are examined from their cranial origin down to the distal insertion using long- and short-axis planes. The transducer is placed transversely to evaluate the articular cartilage. Lastly, the transducer is placed in the oblique anterior sagittal position with the knee flexed 60º in order to examine the anterior cruciate ligament (ACL). Medial and Lateral Aspects of the Knee Joint The patient rotates the leg externally while maintaining 20–30º knee flexion, or lies in either the medial or lateral decubitus position. Longitudinal planes are used for imaging of the medial and lateral collateral ligaments (MCL and LCL, respectively). Care should be taken to examine the entire length of this ligament. Dynamic scanning during valgus stress can improve the assessment of its integrity. Next, the menisci are examined, first with the transducer aligned in the long axis, then with the transducer rotated 90º to yield transverse images. Valgus or varus stress is applied to the knee, depending on which meniscus is being examined.Posterior Aspect of the Knee Joint examined in prone position of patient with longitudinal placement of probe to examine the popliteal vessels and calf muscles. The medial aspect of the popliteal fossa is examined to check for Baker's cyst, and then the transducer is placed in a slightly oblique position to examine the posterior cruciate ligament (PCL).For MRI knee patient was placed in supine position with the knee in a closely coupled extremity coil. The knee was externally rotated 15 to 20 degree, in order to facilitate the visualization of ACL completely on sagittal image. The knee was flexed slightly 5 to 10 degree to increase the accuracy of assessing the patellofemoral compartment and patellar alignment.Axial acquisition through patellofemoral joint was used as an initial localizer for subsequent sagittal and coronal plane images.The ultrasound and MRI were carried out at the same appointment. The Ultrasound was carried out and findings recorded on the proforma. MR characteristics of different sequences were noted and recorded. The study was reported and abnormality recorded for each case and we compare the findings of ultrasound with MRI findings. Then result of study was analyzed and compared with other available studies in the literature.

Observation and Results

The present study included 50 patients with suspected knee joint soft tissue injury.

Table 1:Comparison of Clinical Examination and USG Finding For Meniscal And Ligament Injuries

Clinical Examination (45)		USG and clinical examination correlation	
		Tear (12)USG	**Normal(38)USG**
McMurray Test for meniscal tear	Positive(15)	8	7
	Negative/inconclusive(35)	4	31
		Tear(08)USG	**Normal(42)USG**
Stress test for collateral ligament tear	Positive(6)	5	1
	Negative/inconclusive(44)	3	41
		Tear (24)USG	**Normal (26)USG**
Drawer test for cruciate	Positive(29)	17	12
ligament tear	Negative/inconclusive(21)	7	14

Out of 12 meniscal tear detected by USG, on clinical examination 8 cases were detected.4 meniscal tear detected by USG, missed on clinical examination.Out of 8 collateral ligament tear seen on sonography, 5 cases were diagnosed clinically. Rest 3 case of collateral ligament tear doesn't show clinical evidence of ligamentous injury. Out of 24 cruciate ligament tears seen on sonography, 17 cases were detected by clinical examination.7 cases that show sign of cruciate ligament tears on sonography, missed on clinical examination.Clinical examination found relatively inconclusive in the patients who present with the significant swelling.

Table 2:Anterior Cruciate Ligament Injuries detected on USG with MRI Correlation (Keeping MRI as Gold Standard)

USG (50)	MRI (50)	
	Tear (28)	**Normal (22)**
Tear (22)	TP 20	FP 2
Normal(28)	FN 8	TN 20

TP- True positive , FN –False negative , FP-False positive , TN- True negative.

Sensitivity	=	71.43%
Specificity	=	90.90%
Positive predictive value	=	90.90%
Negative predictive value	=	71.43%
Accuracy	=	80%

Table 3:Posterior Cruciate Ligament Injuries detected on USG with MRI Correlation (Keeping MRI as Gold Standard)

USG (50)	MRI (50)	
	Tear (6)	Normal (44)
5 Tear	4 TP	1 FP
45 Normal	2 FN	43 TN

TP- True positive , FN –False negative , FP-False positive , TN- True negative.

Sensitivity	=	66.67%
Specificity	=	97.72%
Positive predictive value	=	80%
Negative predictive value	=	95.56%
Accuracy	=	94%

Table 4:Medial Meniscal Injuries detected on USG with MRI Correlation (Keeping MRI as Gold Standard)

USG (50)	MRI(50)	
	Tear (11)	Normal (39)
9 Tear	8 TP	1 FP
41 Normal	3 FN	38 TN

TP- True positive , FN –False negative , FP-False positive , TN- True negative.

Sensitivity	=	72.72%
Specificity	=	97.44%
Positive predictive value	=	88.89%
Negative predictive value	=	92.68%
Accuracy	=	92%

Table 5:Lateral Meniscal Injuries detected on USG with MRI Correlation (Keeping MRI as Gold Standard)

USG (50)	MRI (50)	
	Tear (6)	Normal (44)
4 Tear	4 TP	0 FP
46 Normal	2 FN	44 TN

TP- True positive , FN –False negative , FP-False positive , TN- True negative.

Sensitivity	=	66.67%
Specificity	=	100%
Positive predictive value	=	100%
Negative predictive value	=	95.65%
Accuracy	=	96%

Table 6:Medial Collatral Ligamental Injuries detected on USG with MRI Correlation (Keeping MRI as Gold Standard)

USG (50)	MRI	
	Tear (6)	Normal (46)
5 Tear	5 TP	0 FP
45 Normal	1 FN	44 TN

TP- True positive , FN –False negative , FP-False positive , TN- True negative.

Sensitivity	=	83.33%
Specificity	=	100%
Positive predictive value	=	100%
Negative predictive value	=	97.78%
Accuracy	=	98%

Table 7: Lateral Collatral Ligeamental Injuries detected on USG with MRI Correlation (Keeping MRI as Gold Standard)

USG (50)	MRI	
	Tear(4)	Normal(46)
3 Tear	3 TP	0 FP
47 Normal	1 FN	46 TN

TP- True positive , FN –False negative , FP-False positive , TN- True negative.

Sensitivity	=	75%
Specificity	=	100%
Positive predictive value	=	100%
Negative predictive value	=	97.87%

Accuracy = 98%

Table 8:Tendon Injuries njuries detected on USG with MRI Correlation (Keeping MRI as Gold Standard)

USG(50)	MRI (50)	
	Tear(4)	Normal (46)
4 Tear	4 TP	0 FP
46 Normal	0 FN	46 TN

TP- True positive , FN –False negative , FP-False positive , TN- True negative.

Sensitivity = 100%
Specificity = 100%
Positive predictive value = 100%
Negative predictive value = 100%
Accuracy = 100%

Discussion and Review of Literature

The study population consisted of 50 patients who were suspected for soft tissue injuries including internal derangement of Knee joint who undergo ultrasound evaluation and MRI examination.

1- Comparison of clinical examination with USG finding (Table 1).

Out of 12 meniscal tears diagnosed by USG the 8(66.67%) cases were detected on clinical examination (McMurray test).This finding is comparable to the result of Retrospective study of Anderson and Lipscomb et al[14] who show 58% sensitivity of McMurray test for meniscal tear. Out of 8 cases of collateral ligament tear 5(62.5%) cases were diagnosed on clinical examination. The Retrospective study of Harilainen[15] shows 86% sensitivity of valgus stress test &25% sensitivity of varus stress test.In cases of cruciate ligament injuries, Out of 24 cruciate ligament tears seen on sonography, 17(70.83%) cases were detected by clinical examination. This finding comparable to the result of Retrospective study of Donaldson et al who showed 70% sensitivity of drawer test. Thus the USG was superior to clinical examination for diagnosis of meniscal and ligamentous injuries[16].In my study of 50 cases, ACL injury is seen in total 28case. In my study ACL tear was the commonest condition accounting for 56% cases which correlated with study by Sonnin et al who demonstrated 48% incidence. However in my study slightly high percentage compared to study by Sonnin et al[17].In our study discontinuity and tear of PCL was seen in 6(12%) cases.Which correspond to Sonnin et al study who found an incidence of 2-23% as PCL injury.In this study we observed 17(34%) cases of meniscal pathologies of which 11 (22%) cases were of medial meniscus (MM) tear and 6(12%) cases were of lateral meniscal (LM) tear. The MM tear was more common than LM tear in my study which corresponded with study by La Prade and colleagues[18].Maffulli et al have also reported more common involvement of medial meniscus as compared to lateral meniscus[19].

2. MRI correlation of anterior cruciate ligament injuries (Table-2)

Out of all patients referred from orthopaedic department we diagnosed a total no. of 22 cases as positive for ACL tear among these 20 cases were diagnosed positive on MRI it was taken as true positive(TP),2 cases which was diagnosed positive on USG was diagnosed as negative on MRI, it was taken as false positive(FP), of the 28 cases which were diagnosed as negative on USG ,8 cases were diagnosed to be positive on MRI were taken as false negative(FN), and 20 cases which were negative on MRI as well as on USG were taken as true negative(TN), thus we observed a sensitivity of 71.43%for diagnosing the ACL tear whereas the specificity for diagnosing the ACL tear was 90.90% .The positive predictive value of 90.90% and a negative predictive value of 71.43%.Accuracy from these finings 80%.

Our findings correlated with the findings of the study of Zaka khan, Zia faruqui, Olajide ogyunbiyi, Guy rosset, Javaid iqbal et al(2006) In their study, of 81 patients who had sonography, MRI and arthroscopy, they have reported the sensitivity, specificity, the positive predictive value of and a negative predictive value of sonography in ACL tear were 75%, 100%, 100%, 77.7% respectively with accuracy reaching up to 86%[21]

3. MRI correlation of posterior cruciate ligamental injuries (Table-3)

Out of all patients referred from orthopaedic department we diagnosed a total number of 5 cases as positive for PCL tear on USG, among these 4 cases were diagnosed positive on MRI it was taken as true positive(TP),1 cases which was diagnosed positive on USG was diagnosed as negative on MRI, it was taken as false positive(FP), of the 45 cases which were diagnosed as negative on USG ,2 cases were diagnosed to be positive on MRI were taken as false negative(FN), and 43 cases which were negative on MRI as well as on USG were taken as true negative(TN), thus we observed a sensitivity of 66.67%for diagnosing the PCL tear whereas the specificity for diagnosing the PCL tear was 97.72%.the positive predictive value of 80% and a negative predictive value of 95.56% AND accuracy 0f 94%.

Chung-Yuan Wang, Tiffany T.F. Shih, Hsing-Kuo Wang, Ya-Ning Chiu, Tyng-Guey Wang in their study of the 35 patients, 13 were found to have PCL tears on sonographic examination. Ten of these tears were also diagnosed by MRI. Two of 22 patients with normal PCL on ultrasonographic examination were found to have PCL tears following MRI[20]

There was significant agreement between MRI and ultrasonography.

4. MRI correlation of medial meniscal injuries (Table-4)

In my study we diagnosed a total no of 9 cases as positive for medial meniscal tear on USG, among these 8 cases were diagnosed positive on MRI it was taken as true positive(TP),1 cases which was diagnosed as negative on MRI, it was taken as false positive(FP), of the 41 cases which were diagnosed as negative on USG ,3 cases were diagnosed to be positive on MRI were taken as false negative(FN), and 38 cases which were negative on MRI as well as on USG were taken as true negative(TN), thus we observed a sensitivity of 72.72%for diagnosing the medial meniscal tear whereas the specificity for diagnosing the medial meniscal tear was 97.44%the positive predictive value of 88.89%and a negative predictive value of 92.68% with accuracy reaching up to 92%.

Our findings correlated with the findings of the study of **Zaka khan, Zia faruqui, Olajide ogyunbiyi, Guy rosset, Javaid iqbal et al (2006);** In their study, of 81 patients they have reported the sensitivity, specificity, the positive predictive value of and a negative predictive value of sonography in MM tear were 93% % , 92.8%, 93.7% AND 92.8% respectively with accuracy reaching up to 93.3%[21]

5. Mri correlation of lateral meniscal injuries (Table-5)

In our study we diagnosed a total no of 4 cases as positive for lateral meniscal tear on USG, all these 4 cases were diagnosed also positive on MRI it was taken as true positive(TP),no cases was diagnosed as negative on MRI, it was taken as false positive(FP), of the 46 cases

which were diagnosed as negative on USG ,2 cases were diagnosed to be positive on MRI were taken as false negative(FN), and 44 cases which were negative on MRI as well as on USG were taken as true negative(TN), thus we observed a sensitivity of 66.67%for diagnosing the lateral meniscal tear whereas the specificity for diagnosing the lateral meniscal tear was 100%,the positive predictive value of 100% and a negative predictive value of 95.65% with accuracy reaching up to 96%.

Our findings correlated with the findings of the study of- **Zaka khan, Zia faruqui, Olajide ogyunbiyi, Guy rosset, Javaid iqbal et al(2006)** [21]In their study, of 81 patients they have reported the sensitivity, specificity, the positive predictive value of and a negative predictive value of sonography in LM tear were 87.5%, 100%, 100% 98.1% respectively with accuracy reaching up to 98.3%**.**

6-MRI correlation of medial collateral injuries (Table-6)

In our study we diagnosed a total no of 5 cases as positive for medial collateral ligament injury on USG, all these 5 cases were diagnosed also positive on MRI it was taken as true positive(TP),no cases was diagnosed as negative on MRI, it was taken as false positive(FP), of the 45 cases which were diagnosed as negative on USG ,1 cases were diagnosed to be positive on MRI were taken as false negative(FN), and 44 cases which were negative on MRI as well as on USG were taken as true negative(TN), thus we observed a sensitivity of 83.33%for diagnosing the medial collateral ligament tear whereas the specificity for diagnosing the medial collateral ligament tear was 100% the positive predictive value of 100% and a negative predictive value of 97.78%with accuracy reaching up to 98%.According to Stoller DW tear of the MCL has a similar appearance on ultrasound as has been described for MRI[22].Munir Ahmad, Zeenat Ayub, Noor-ul Hadi et al reported variable sensitivity and specificity of different diagnostic tests for MCL tear confirmation in their literature[23].

7. MRI correlation of lateral collateral injuries (Table-7)

In our study we diagnosed a total no of 3 cases as positive for lateral collateral ligament tear on USG, all these 3 cases were diagnosed also positive on MRI it was taken as true positive(TP),no cases was diagnosed as negative on MRI, it was taken as false positive(FP), of the 47 cases which were diagnosed as negative on USG ,1 cases were diagnosed to be positive on MRI were taken as false negative(FN), and 46 cases which were negative on MRI as well as on USG were taken as true negative(TN), thus we observed a sensitivity of 75 %for diagnosing the lateral meniscal tear whereas the specificity for diagnosing the lateral meniscal tear was 100%the positive predictive value of 100%and a negative predictive value of 97.87%with accuracy reaching up to 98%.

8- MRI correlation of tendon injuries (Table-8)

Out of 50 patients with suspected soft tissue injuries only 4 patients diagnosed positive for tendon injury.2 patient show altered hypoechoic area involving quadriceps tendon and another two patient show changes in patellar tendon on sonography, all these positive patient were found to have changes in appearance on MRI also. It was taken as true positive (TP), 0 cases who was positive on USG, diagnosed as negative on MRI, it was taken as false positive (FP) of the 46 cases which were diagnosed as negative on USG ,0 cases were diagnosed to be positive on MRI were taken as false negative(FN), and 46 cases which were negative on MRI as well as on USG were taken as true negative(TN), thus we observed a sensitivity of 100 %for diagnosing the lateral meniscal tear whereas the specificity for diagnosing the lateral meniscal tear was 100%the positive predictive value of 100%and a negative predictive value of 100%with accuracy reaching up to 100%.

Friedman L, Finlay K, Popovich T, et al(2003) Sonography and MRI are often complementary in diagnosing pathologic conditions, the spatial resolution of sonography is superior to that of MRI for defining the fine internal fibrillar structure of large tendons[24].

Wu TS, Roque PJ, Green J, Drachman D, Khor KN, Rosenberg M, Simpson C et al(2011) Prospective study Of the 34 total patients, 4 patients had partial tendon injuries, 9 suffered from 100% tendon laceration or rupture, and 21 had no tendon injury noted on exploration on MRI. Bedside ultrasound had a sensitivity, specificity, and accuracy of 100%, 95%, and 97%, respectively**[25]**

Summary

To summarize the use of high resolution ultrasonography allows rapid and low cost exploration of all extra-articular soft tissue injuries and results nearly parallel to that of MRI.Ultrasonography is also used for low cost exploration of meniscal injuries (intra-articular) as a first line diagnosis method with moderately sensitivity (medial meniscus72.72% &lateral meniscus66.67), highly specificity (medial meniscus97.44% & lateral meniscus100%)and accuracy(92-96%) comparable to MRI.Ultrasonography is less sensitive (66.67%) in the detection of PCL injury although have an excellent specificity (97.72%) and negative predictive value with high accuracy reaching up to 94%.

The sonography is highly specific (90%) and moderately sensitive (71%) method for detection of disruption of anterior cruciate ligaments with accuracy of 80%, so sonography provides a useful, readily available and inexpensive adjunct in assessment of cruciates injuries.

Conclusion

The sonography of the knee joint is operator dependent. Small errors in the transducers angulations may easily obscure small abnormality within and around the joint giving false positive and false negative results. A well performed ultrasonography in most cases obviates the need for more expensive & invasive arthroscopy and the more cumbersome and expensive MRI examination. The use of high resolution sonography allow exploration of all extra-articular soft tissues injuries and meniscal injuries (intra-articular) as a first line diagnosis method and provides adjunct in assessment of cruciate ligament injuries.There is a steep learning curve for this type of study; there is an inherent statistical weakness of examination criteria. But these potential pitfalls can be avoided by thoroughly understanding the normal anatomy, strictly insisting on the proper transducer and patient positioning & using the opposite knee joint for comparison. This can make ultrasonography an effective, reliable, and non-invasive means of detecting soft tissue injury of the knee joint.

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