



Original Research Article

Imaging evaluation by sonography of the soft tissue injuries around the knee joint with correlation of arthroscopic findings

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Abstract

Background: Ultrasonography is a noninvasive imaging modality used for the assessment of the musculoskeletal system. It can provide clinically useful information on a wide range of pathologic conditions affecting components of the knee joint, including the tendons, ligaments, muscles, synovial space, articular cartilage, and surrounding soft tissues. Now our concern of this study is to find out the modality of investigation of choice with accuracy, promptness and cost effectiveness.

Materials & Methods: In this prospective interventional comparative study patients of all age group of either sex attending the orthopaedic OPD of IPGMER & SSKM Hospital with clinical features suggestive of soft tissue around knee were included in the study during the period of Feb 2008 to Aug 2009. Sonography technique for evaluation of soft tissue injuries of knee as per AIUM 2007 (American Institute of Ultrasound in Medicine) standard protocols for knee joint sonography- The examination is divided into 4 quadrants (anterior, medial, lateral and posterior).

Results: Maximum number of patients belonged to 20-30 age group, which was comprised 36% of the whole study group. The average age of the study group was 32. Male subjects were showing definite male preponderance. In 64% of cases right knee joint was involved. Out of 100 patients, 48 cases showed ACL tears, 22 patients showed PCL tear arthroscopically. Out of 48 ACL tears confirmed by arthroscopy the diagnosis by USG was just 21 out of 48.

Conclusion: Ultrasound is a reliable, non invasive method for diagnosing injuries to the tendons, ligaments, and muscles of the knee. It is important to recognize the limitations of this method for examining the menisci and bony lesions. In experienced hands, ultrasonography can play an important role in the assessment of pathologic conditions involving the knee joint.

Keywords: Soft tissue injuries, Menisci, Ligaments, Knee joint, USG, Arthroscopy, Diagnosis.

Introduction

The knee joint is one of the most frequently injured joint because of its anatomical structure, it's exposure to external forces, and the functional demand placed on it. Apart from injuries involving osseous structure, the understanding of injuries related to extra articular structures (tendons & ligaments) and intra articular structures (menisci and cruciates) are of great importance. These internal derangements of knee, resulting due to trauma, are severely disabling unless diagnosed promptly and treated efficiently.¹

Ultrasonography is a noninvasive imaging modality used for the assessment of the musculoskeletal system. It can provide clinically useful information on a wide range of pathologic conditions affecting components of the knee joint, including the tendons, ligaments, muscles, synovial space, articular cartilage, and surrounding soft tissues. Color and power Doppler techniques can be used to measure neovascularization within the synovial lining of the joints, tendons, and soft-tissue masses. The advantages of ultrasound include low cost, portability, real-time assessment, and facilitated side-by-side comparisons. Its major disadvantage is its operator-dependence: it requires trained experienced hands with appropriate high-resolution equipment.³

The advantages of high frequency ultrasonography are:

It is the only real-time and dynamic cross-sectional imaging technique. It is a rapid non-invasive examination and acutely ill patients can be examined painlessly without any special preparation. Scanning can be done in virtually any plane or body section with the patient in any position. It provides to do image guided intervention (aspiration or biopsies). This is the only modality which can demonstrate the detailed microanatomy of tendons, ligaments and muscles. Power Doppler is useful for assessment of soft tissue hyperaemia. No hazards of ionizing radiation or contrast materials. It has got an excellent spatial resolution. Percentage of lesion

can be determined is some partial tendon tears. It has high specificity and sensitivity rates. It is very useful in the evaluation of changes of the pathology with time. It is a widely available and low cost procedure.

The disadvantages of USG are very negligible and can be overcome easily:

It is operator dependent. It has a long learning curve. Considerable experience is necessary for accurate result. There may be some technique related artifacts e.g. hypoechogenicity in case of obliquity of the transducer beam i.e. anisotropy. It is often difficult to detect the exact anatomical extension of the relatively very large lesion. There is lack of optimal window for intraarticular injuries evaluation. MRI of the knee is most commonly indicated in patients with suspected injuries of the menisci and cruciate ligaments (intra-articular injuries).^{4,5}

Ligament injuries may appear as a complete interruption or replacement of the ligament by hypoechoic granulation tissue (complete tears); with partial tears, where there is focal hypoechogenicity.⁶ In acute ligament injuries, the ligament is swollen with inhomogeneous echogenicity, whereas chronic injuries are associated with ligament swelling and hypoechogenicity. A complete tear of the ligament appears as a discontinuity; partial tears cause hypoechoic thickening. The collateral ligaments of the knee are easier to visualize with ultrasound than the cruciate ligaments due to their superficial location. Comparison with findings for the normal contralateral ligament is advisable to confirm the diagnosis.^{6,7,8}

Arthroscopy of the knee has been used since 1970 as a diagnostic and therapeutic tool in the management of these acute, subacute and chronic knee complaints; however arthroscopy of the knee is an invasive procedure with associated risks and leading to discomfort for patient. Therefore it should primarily be used for treatment and the fraction of non-therapeutic arthroscopies should be limited.^{9,10}

Apart from clinical examination, there are other important diagnosing modality to soft tissue injury around the knee i.e. USG, MRI and arthroscopy. Now our concern of this study is to find out the USG with accuracy, promptness and cost effectiveness. In this study, all the selected patients on the basis of suggestive clinical features of soft tissue injury around knee (except for those coming under the criteria for exclusion) was subjected to sonography followed by arthroscopy after proper counselling and consent.

Aims & Objectives

- Whether the sonography should be performed after clinical suspicion of soft tissue of in general?
- Correlate the findings of sonography with arthroscopic findings

Materials & Methods

In this prospective interventional comparative study patients of all age group of either sex attending the orthopaedic OPD of IPGMER & SSKM Hospital with clinical features suggestive of soft tissue around knee were included in the study during the period of Feb 2008 to Aug 2009.

Inclusion Criteria

Any patients having history of knee injury with suggestive soft tissue involvement as per clinical evaluation

Exclusion Criteria

1. Patients having any suggestive infection and sepsis
2. Partial or complete ankylosis of knee
3. Patients with neoplasm and infectious disorder
4. Major capsular disruptions of knee joint

Demographic information, clinical examination, imaging evaluation by USG and arthroscopic findings were noted.

Study tools:

USG: Toshiba made model XARIO using probe of frequency 7 to 14 MHz.

Arthroscopy: Specification of instrument not required

Sonography technique for evaluation of soft tissue injuries of knee as per AIUM 2007 (American Institute of Ultrasound in Medicine) standard protocols for knee joint sonography- The examination is divided into 4 quadrants (anterior, medial, lateral and posterior). Either a comprehensive structured examination of the whole knee or, alternatively a limited study tailored to the clinical presentation is performed.

Results

In the present study 100 cases of knee evaluated based on the clinical history and examination a provisional diagnosis was made. Then these patients were subjected to USG. If there is indication for arthroscopy (intra-articular injuries) arthroscopy done.

Table 1: Demographic and clinical characteristics of study participants

Characteristics	No. of patients [%]
Age group [Yrs]	
0-10	0
11-20	32 [32]
21-30	38 [38]
31-40	22 [22]
41-50	16 [16]
51-60	0
Male	72 [72]
Female	28 [28]
Side effected	
Right	64 [64]
Left	36 [36]

Their age was ranged from 15 to 49. Maximum number of patients belonged to 20-30 age group, which was comprised 36% of the whole study group. The average age of the study group was 32. Male subjects were showing definite male preponderance. In 64% of cases right knee joint was involved. This may be due to overuse or overdependence of the right knee joint in sports and daily activities [Table 1].

Table 2: Clinical presentation of various patients

Clinical features	No. of patients
Pain	72
Swelling	64
Locking	28
Muscle wasting	24
Feeling of giving away	28
Others	12

Pain was the most common presenting symptom followed by swelling and locking respectively [Table 2].

Table 3: Duration between onset of symptoms and USG

Time gap between onset of symptoms & USG (weeks)	No. of Patients [%]
1-5	52 [52]
6-10	26 [26]
11-15	12 [12]
16-20	8 [8]
21-25	2 [2]
Total	100

About 52% of the patients were subjected to USG within 5 weeks after the onset of their sufferings. The earliest one to get USG done was after 1 week of onset of symptoms and on the other extreme was by 37 weeks after onset of symptoms. This observation gave a clear idea of duration of sufferings of the study group [Table 3].

Table 4: Frequency of potential diagnosis

Injury	No. of Cases [%]
Medial meniscal tear	64 [64]
Lateral meniscal tear	32 [32]
ACL tear	36 [36]
PCL tear	16 [16]
MCL tear	24 [24]
LCL tear	4 [4]

Most common structure being injured was medial meniscus in about 64% cases. Cases following kinematic principal medial meniscal injury were seen associated with medial collateral ligament in all 24 cases of MCL injury. From 36 cases of ACL injury 32 had associated medial meniscal injury whereas only 4 showed associated lateral collateral ligament as well (triad of O'donaghue's) [Table 4, Fig 1-8].

Table 5: Categorization of diagnosis into major groups

Injury	No. of Cases [%]
Ligamentous	52 [52]
Menisci	84 [84]
Bone	60 [60]
Injury	
ACL	36 [36]
PCL	8 [8]
Medial Menisci	36 [36]
Lateral Menisci	24 [24]
Bone	8 [8]

Among major group of injuries meniscal injuries were predominant followed by bony injuries and ligamentous injuries [Table 5].

Correlation of USG findings with arthroscopic findings

In our study, arthroscopy had been taken as gold standard but arthroscopy is useful for intraarticular structures and its injuries only. So the correlation of intraarticular structures i.e. meniscus & cruciates can be done only. Out of 100 patients, 48 cases showed ACL tears, 22 patients showed PCL tear arthroscopically. Out of 48 ACL tears confirmed by arthroscopy the diagnosis by USG was just 21 out of 48 [Table 6].

Table 6: Injuries diagnosed by USG and confirmed by arthroscopy

USG Findings	Injury to ACL confirmed by arthroscopy		
	Present	Absent	Total
Positive	21	0	21
Negative	27	52	79
Total	48	52	100

Therefore different parameters of correlation of USG with arthroscopic findings were sensitivity 43.75%, specificity 100%, PPV 100%, NPV 65.8%, percentage of false negative 56.25% and percentage of false positive 0% [Table 6]. Out of 14 PCL tears confirmed by arthroscopy, the diagnosis by USG was just 2 out of 14.

Table 7: Injuries to PCL diagnosed by USG and confirmed by arthroscopy

USG Findings	Injury to PCL confirmed by arthroscopy		
	Present	Absent	Total
Positive	2	0	2
Negative	12	86	98
Total	14	86	100

Therefore different parameters of correlation of USG with arthroscopic findings were sensitivity 14.3%, specificity 100%, PPV 100%, NPV 87.7%, percentage of false negative 85.7% and percentage of false positive 0% [Table 7].

Out of 100 patients, 62 cases showed medial meniscus tear, 22 patients showed lateral meniscus tear arthroscopically. Out of 62 medial meniscus tear confirmed by arthroscopy, the diagnosis by USG was just 61 out of 62 [Fig 1-4].

Table 8: Injuries to medial meniscus diagnosed by USG and confirmed by arthroscopy

USG Findings	Injury to medial meniscus confirmed by arthroscopy		
	Present	Absent	Total
Positive	61	3	64
Negative	1	35	36
Total	62	38	100

Therefore different parameters of correlation of USG with arthroscopic findings were sensitivity 98.4%, specificity 92.1%, PPV 95.3%, NPV 97.2%, percentage of false negative 1.6% and percentage of false positive 7.9% [Table 8]. Out of 22 lateral meniscus tear confirmed by arthroscopy, the diagnosis by USG was just 20 out of 22.

Table 9: Injuries to lateral meniscus diagnosed by USG and confirmed by arthroscopy

USG Findings	Injury to lateral meniscus confirmed by arthroscopy		
	Present	Absent	Total
Positive	20	1	21
Negative	2	77	79
Total	22	78	100

Therefore different parameters of correlation of USG with arthroscopic findings were sensitivity 90.9%, specificity 98.7%, PPV 95.2%, NPV 98.7%, percentage of false negative 9.1% and percentage of false positive 1.3% [Table 9].

Discussion

Age

The age group of our study is compared with that of other studies in the following chart:

Study	Age group (Years)	Average age (Years)
Scott Lintner et al (1996) ¹¹	17-74	39
Neal et al (2015) ¹²	16-59	38
Lossifidis (1996) ¹³	17-64	36
Shinichi Yoshiya et al (1998) ¹⁴	14-64	-
Our study	15-49	32

The age group and the average age of study group are comparable to that of other studies. The observations show that patients having soft tissue injuries around the knee joints fall in the reproductive age group.

Sex Distribution

The following chart compares the sex distribution of the study group with that of others

Study	Male-female ratio
Neal et al (2015) ¹²	80:20
Takahashi T et al (2004) ¹⁵	54:46
Lossifidis (1996) ¹³	73:27
Our study	78:28

The male-female ratio shows a wide variation with that of some studies, but at the same time it is similar to other studies. The high male-female ratio in our study may be because of the fact that males are more involved in outdoor activities, sports, travelling, industrial works etc, which make them vulnerable to knee injuries and other knee joint problems. Social obligations are more towards the female in this part of the country, which may also contribute to this high male-female ratio.

Side Distribution

The right/left knee involvement in our study group is compared with that of the other available study in the following table.

Study	Right/Left ratio
Neal et al (1994) ¹²	49:51
Our study	64:36

The right/left ratio is not mentioned in other studies, may be due to its less importance in diagnostic point of view. The high incidence of right side may be due to the fact that our study group is small or may be due to overuse or overdependence of right knee joint in sports and daily activities.

Meniscal Injury

Palmer et al described most trauma related medial meniscal tears peripheral in location and longitudinally oriented, whereas lateral meniscal tears involve the free margin and are transverse in orientation.¹⁶ Traumatic mechanism determines location and configuration of meniscal tear. When a distractive force separates the femorotibial joint, tensile stress is transmitted across the joint capsule to the meniscocapsular junction, creating traction and causing peripheral tear. Comprehensive force

entrap, splay and split the free margin of meniscus due to axial load across the joint compartment. Because the most common traumatic mechanisms in the knee involve valgus rather than varus load, the medial femorotibial compartment is distracted whereas the lateral compartment is compromised. Medial distraction means that the medial meniscus is at the risk for peripheral avulsion injury at the capsular attachment side. Lateral compression means that the lateral meniscus is at risk for entrapment and tear along the free margin.^{17, 18}

The statistical parameters of meniscal injuries diagnosis in our study group compared with other studies available is in the following table [Fig. 1-8].

Comparison of USG findings of our study with others

Study	Results			
	Medial meniscus		Lateral meniscus	
	Sensitivity	Specificity	Sensitivity	Specificity
Azzoni et al 2002 ¹⁹	61%	21%	61%	21%
Najafi et al 2006 ²⁰	100%	95%	100%	95%
Our study	98.4%	92.1%	97.6%	97.4%

The sensitivity and specificity of our study group shows wide variation with some studies and similarity with most recent study. These variations may be because of the fact that the advent of high resolution microconvex probe, the speckle artefacts got diminished and better visualization of meniscal pathology.

Comparison of USG findings of our study with others

Study	Results			
	Anterior cruciate ligament tear		Posterior cruciate ligament tear	
	Sensitivity	Specificity	Sensitivity	Specificity
Ptasznik et al 1999 ²¹	91%	100%	-	-
Our study	43.75%	100%	14.3%	100%

The sensitivity and specificity of our study group shows wide variation with others. These variations may be because of the fact that the time gap between the injury and USG was more in

comparison to others, so fluid or hematoma get resolve and absorbed, resulting into diminished window.

A classic mechanism for ligament injury is the pivot shift, when valgus stress and axial load are combined with forceful twisting of the knee as the athlete plants his or her foot and quickly turns direction. Excessive traction tears the capsule or meniscus. Conversely, the posterior oblique ligament or medial meniscus may tear results from external rotation, valgus force, or both, the anterior cruciate ligament becomes the last remaining check against anterior tibial translocation, markedly increasing its risk for rupture.^{22, 23, 24}

In our study we found that medial collateral ligament injury were frequently associated with medial meniscus injury seen in 20 out of 24 cases (83%) of MCL injury, which can be explained on the basis of intimate anatomical relation and functional synergism between two. Both are anatomically related through the deep capsular fibres, which attach to meniscus at the meniscocapsular junction. Both simultaneously develop tension during excessive valgus force and, therefore, often are injured together during excessive valgus force besides anatomical functional synergism is seen related through the posterior oblique ligament at the posteromedial corner of the knee. These structures are both stressed by external rotation, with or without valgus force hence often injured together.^{25, 26, 27}

As the medial tibial plateau slides forward, tension builds in the meniscotibial fibres of posterior oblique ligament and is transmitted to the meniscocapsular junction. Excessive traction tears the meniscus.²⁸ Anterior cruciate ligament, medial meniscus and lateral collateral ligament or the unhappy triad was observed in 4 cases who was football player present with fall kinematically had excessive valgus stress in the externally rotated knee which was in full flexion as deduced from the history they gave. In our study we found 28 medial compartment associations as compared to 4 cases of associated lateral collateral and lateral

meniscal injury from which we can conclude medial combined injuries are more frequent than that lateral combined injuries.



Figure 1: USG showing horizontal tear of medial meniscus



Figure 4: Medial meniscal tear



Figure 2: Normal lateral meniscus and posterior horn tear of lateral meniscus



Figure 5: Normal longitudinal posterior cruciate ligament



Figure 3: Meniscal cyst and a horizontal tear in the medial meniscus



Figure 6: Longitudinal posterior cruciate ligament with avulsion fracture



Figure 7: Normal medial collateral ligament longitudinal



Figure 8: Medial collateral ligament rupture longitudinal

Conclusion

Knee injuries are common in early adolescent and adults (11-40) yrs of population. Knee injuries showed a definitive male preponderance with male to female ratio of 72:28. Right side was seen injured more frequently as compared to left side. Pain was the most common presenting symptom in various knee injuries. Sport related injuries presented early with mean age of 29 yrs as compared to non-sporting injuries (mean age 38 years). Medial menisci was the most common structure being injured seen in about 64 percent of cases. The sonography is highly specific and moderately sensitive method for the detection of disruptions of the cruciate ligaments in patients

presenting within 10 weeks of traumatic hemarthrosis. So sonography provides a useful, readily available, and inexpensive adjunct in the assessment of patients with an acute knee injury.

The sonography is very useful in the detection of minor injuries of muscles, tendons and ligaments. Even a minor trauma can be seen as irregularity of fibrillary pattern and hyperaemia on B-mode and Doppler study respectively. Knee trauma often produces predictable groupings of ligamentous and meniscal injuries. Structures that perform related kinematic functions are damaged by the same traumatic mechanisms. When one supporting structure is disrupted, synergistic structures are jeopardized.

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