



Role of Sagittal-Oblique and Flexion MR Technique for Evaluation of Anterior Cruciate Ligament Injury in the Knee

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Abstract

Background: *In complete tear of ACL the normal technique can easily diagnose it. When it comes to partial tear the standard technique has less sensitive for it because the normal knee technique will not give us the complete course of ACL in a single image. In this case sagittal-oblique and flexion sequences are added. These sequences will give us the complete course of ACL in single image which improves the diagnostic quality.*

Aims and Objective: *To Evaluate the Diagnostic value of sagittal-oblique and flexion MR sequences to detect Partial Tear in Anterior Cruciate Ligament of Knee in Comparison with other Routine Sagittal Knee Sequences.*

Result: *In routine sagittal imaging of knee 9 patients (30%) were found to have normal ACL, 8 (26.6%) had partial tear and 13 (43.3%) had complete tear of ACL. On sagittal-oblique and flexion technique 13 (43.3%) patients were diagnosed with partial tear of ACL. Therefore in 4 cases partial tear was missed on routine sagittal imaging. The percentage of complete tear using standard sagittal imaging was 43.3% (13 patients). Both flexion and sagittal-oblique imaging had the same efficacy as routine sagittal technique in diagnosing complete tear.*

Conclusion: *Lower accuracy of standard MR protocol for partial tear of ACL can be improved by using additional sagittal-oblique and flexion technique MR.*

Keywords: *Knee MRI, anterior cruciate ligament, partial tear, complete tear, sagittal-oblique technique, flexion technique.*

Introduction

Anterior Cruciate Ligament (ACL) is known to be the vital stabilizers of the knee joint. ACL is the most commonly injured large ligament in the knee joint, with an occurrence of 8.1 in 100,000 every year. ⁽¹⁾ Ligament weakness may lead to patient demobilization, with frequent incidence of degenerative knee joint disease.

Hyperextension is the most common cause responsible for ACL tears or due to a large force being applied on the back of the knee when is partially flexed. Anterior drawer test, Lachman test and pivot shift test are the most commonly used to tests to diagnose ACL tear clinically. ⁽²⁾ Rupture of ACL is a serious and common knee injury and may occur in variety of ways. The

patient complains of a tearing sensation accompanied by immediate severe pain. Significant swelling may be present and occurs usually within two hours.

ACL consists of two bundle of fibres namely anteromedial and posterolateral bundles.⁽³⁾ ACL tears could be partial or complete. Partial tears can present as a minor tear involving only few fibres or as a high grade near-complete tear involving almost all the fibres. Partial tears may involve only one or both bundles to a varying degree. The anteromedial band tends to be more commonly affected. Sometimes plastic deformity of ACL without any fibre discontinuity may occur resulting in ACL insufficiency. Internal rotation of tibia relative to femur results of ACL injury which commonly occurs in falls while skiing and contact sports such as football. About 80% are complete tears, involving the middle one-third of ACL (90%) or less commonly at the femoral (7%) or tibial (3%) attachment sites.

Magnetic Resonance Imaging (MRI) is the most recommended non-invasive way to assess anterior cruciate ligament injuries. MRI is more sensitive than other modes of imaging to access the ligament injuries. But when it comes to ACL tear MRI also have its own drawback. In complete tear of ACL the normal technique can easily diagnose it when it comes to partial tear the standard technique has less sensitive for it because the normal knee technique will not give us the complete course of ACL in a single image.

So in Partial rapture of ACL we add an extra Sagittal-oblique sequence in order to improve the diagnostic quality. This sequence will give us the complete course of ACL in single image. This was achieved by planning the sequence parallel to the ACL. When it comes to ACL tear this Sagittal-oblique sequence has high sensitive than other sequences because this additional sequence is only concentrated on ACL. This technique does not require repositioning the patient as in flexion technique. Therefore the reproducibility of this method is easier in patients with expected re-examinations. Treatment of ACL injuries depend

on the type of injury, skeletal maturity of patient and concomitant internal derangements of the knee.⁽⁴⁾

Imaging of Anterior Cruciate Ligament Tear

MRI is a non-invasive imaging method for evaluating knee lesions such as it has good soft tissue contrast, multiparameter and multi-range and high spatial resolution.⁽⁵⁾

2D fast spin echo sequences either with or without fat suppression are accurate for visualization of ACL pathologies. MRI evaluation of ACL is satisfactory in majority of cases using sagittal plane with the knee in 10-15 degree of external rotation.⁽⁶⁾ Along with the usual sequences additional sequences like flexion views, oblique views, T1-weighted sequences and small FOV or small coil are used when necessary.

Suspicious fracture or loose bodies within the knee in the form of osseous fragments can be detected in T1-weighted sequences. The presence, location and severity of ACL tears can be determined in oblique views.

MR images of knee taken in flexion provides more space around the ACL within the intercondylar area which helps to decrease the volume-averaging artifact and helps in optimal depiction of femoral end of the ligament.

The normal ACL is low to intermediate signal intensity with continuous fibres in all sequences and planes. The posterolateral bundle has higher signal intensity than anteromedial bundle. MRI has more than 90% sensitivity, specificity and accuracy for diagnosing ACL tears. Diagnosis of ACL tear on MR images is usually based on direct signs. The discontinuity of fibre is the primary sign. The empty notch sign on coronal imaging is a common finding in complete ACL tear. In normal ACL its axial configuration is either smooth ellipse or oval.⁽⁷⁾ Partial ACL tear is more difficult to diagnose than complete tears. High grade tear is more than 50% of ACL fibres torn, medium grade tear is 10-50% of fibres torn and a low grade tear is less than 10% of fibres torn. Lateral most compartment injuries are associated

with injury to medial knee and ACL. ⁽⁸⁾ Patients with partial ACL tear presents with limitation in strenuous activities. ⁽⁹⁾ More than 90% cases of ACL disruption can be diagnosed at the time of injury. ⁽¹⁰⁾

Associated Injuries

Meniscal Injury

Around 65%-70% of ACL tear is associated with meniscal tear. Acute ACL tear is possibly associated with peripheral vertical tear in the posterior horn of lateral meniscus (posterolateral corner tear). Chronic ACL tear increases the probability of peripheral vertical tear at posterior horn of medial meniscus due to chronic femorotibial instability. Together with ACL tear and MCL tear, form the classical O'Donoghue's triad. ⁽¹¹⁾

Posterolateral Corner Injury

Posterolateral corner injury includes the popliteus muscle and tendon, fibular collateral ligament, popliteofibular ligament, the lateral and posterolateral capsule and biceps femoris tendon. The use of a coronal oblique plane of imaging to improve depiction of finer, obliquely oriented structures of posterolateral corner, including the arcuate, popliteofibular, and fabellofibular ligaments.

Mucoid degeneration and ganglion cyst of ACL:

Cystic degeneration of ACL is considered as intrasubstance ACL tear. On MR imaging, cystic degeneration can manifest as well-defined ganglion cysts arising from the ACL. It occurs in about 1% of patients. Increased signal intensity of whole ACL giving rise to an appearance similar to stalk of celery. ⁽¹²⁻¹⁵⁾ This increase in signal intensity is due to deposition of amorphous mucoid matrix among the ACL fibres.

Material and Methods

A retrospective cohort study was conducted in the Department of Radiology, Chettinad hospital and Research Institute, Chennai. All the medical records of the people diagnosed with ACL tear

between February 2018 to February 2019 were reviewed. 30 patients who presented with painful knee joint, popping sensation, swelling, restricted motion, instability, locking of knee joint due to knee soft tissues trauma and suspected ACL injury were included in the study. All patients signed a term of free and informed consent. The study was approved by the Ethics Committee (Research) of the institute. Previous knee surgery, inflammatory joint disease, metabolic bone disease, MR contraindication like cardiac pacemaker, cochlear implant, claustrophobia were excluded from the study.

MRI acquisition

All patients were examined with standard MRI protocol for the knee followed by sagittal-oblique technique and flexion technique. SIGNA GE HDxt 1.5 tesla MRI scanner was used to scan the patients with an 8 channel NV (NAVIGATOR) Radiofrequency coil was used. The bore size of the machine is 60cm.

Standard MRI protocol for the knee consisted of triplanar images. Patient was put in supine position with extended knee in external rotation. After standard MRI protocol, additional sagittal oblique and flexion technique were performed in all patients using same parameters as standard MRI protocol.

Localizer

Three plane localizers are used.

Axial planes which are parallel to the knee joint line these include the entire patella and the fibular head.

The coronal planes are parallel to the posterior aspect of the femoral condyles and they include the entire patella upto 2cm posterior to femoral condyles.

The sagittal oblique planes are parallel to the medial aspect of the lateral condyle and they include both medial and lateral collateral ligaments. Flexion MRI is performed by repositioning the patients knee in 17 degree flexion followed by sagittal topogram with orientation of slices without angling. The collected

data were analysed with IBM.SPSS statistics software 23.0 Version.To describe about the data descriptive statistics frequency analysis, percentage analysis were used. To find the

significance in categorical data Chi-Square test was used. In the above statistical tool the probability value 0.05 is considered as significant level.

Table 1: The various sequences used in MRI Knee.

	Slice thickness	Matrix (min)	FOV (max)	TE
Ax Int FS	2-3 mm	256x256	16cm	40-50
Cor Int FS	2-3 mm	256x256	16cm	40-50
Cor T1	2-3 mm	256x256	16cm	40-50
Sag Obl Int	2-3 mm	256x256	16cm	40-50
Sag Obl PD	2-3 mm	256x256	16cm	40-50
Cor Obl PD	2-3 mm	256x256	16cm	40-50
Flexion	2-3 mm	256x256	16cm	40-50

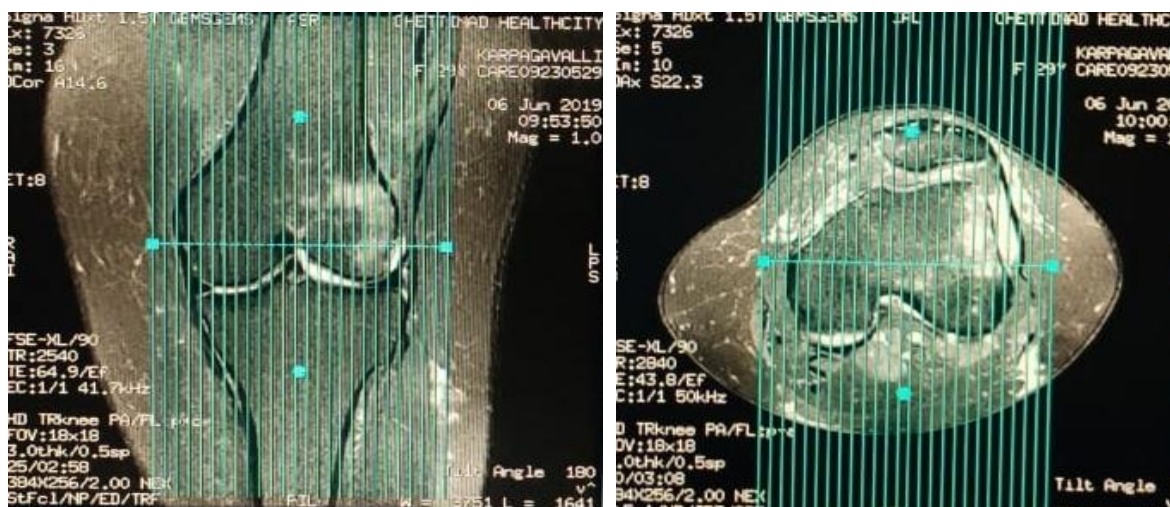


Figure 1: Normal sagittal planning

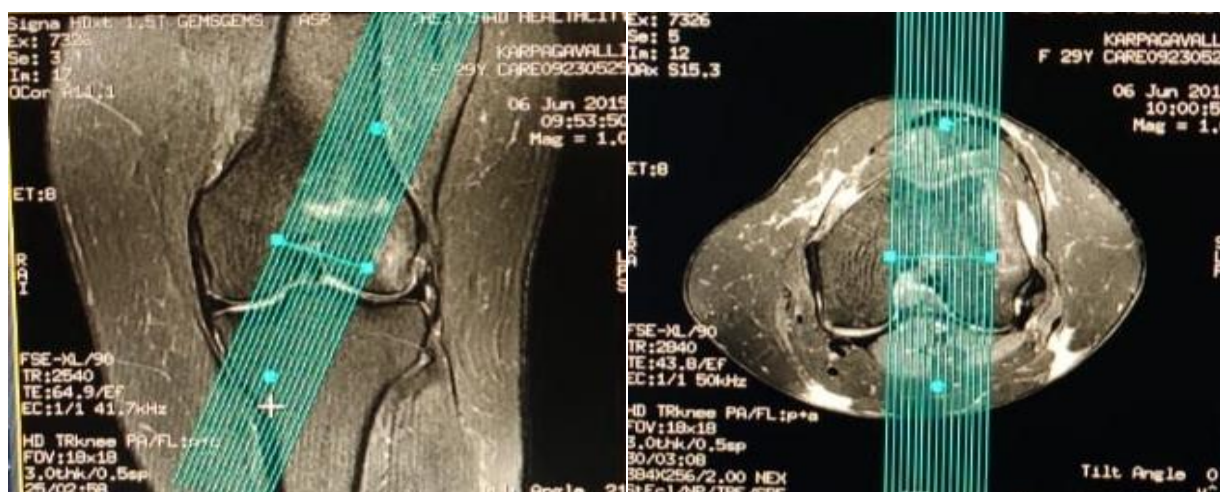


Figure 2: Sagittal oblique planning

Limitations

The limitation of this study is the lack of arthroscopic procedures (as a “gold standard”)

after MR examinations. Another limitation includes mucoid degeneration of ACL; however, it was not diagnosed in this study.



Figure 3: Anterior cruciate ligament (ACL) sagittal-oblique T2 FSE image.



Figure 4: Anterior cruciate ligament (ACL) in flexion MRI technique.

Results

In 30 subjects who presented with symptoms of ACL injury selected for this study 22 (73.3%) were male and 8 (26.7%) female. (Table 1) The number of patients with age 20-30 years was 6 (20%), 31-40 years was 8 (26.7), 41-50 was 12 (40%) and 51-60 years was 4 (13.3%). (Table 2)

Table 1: Patient’s distribution based on sex of patients

	Frequency	Percent
Male	22	73.3
Female	8	26.7
Total	30	100.0

Table 2: Patient’s distribution based on age of patients

	Frequency	Percent
20 - 30 yrs	6	20.0
30 - 40 yrs	8	26.7
40 - 50 yrs	12	40.0
50 - 60 yrs	4	13.3
Total	30	100.0

In routine sagittal imaging of knee 9 patients (30%) were found to have normal ACL, 8 (26.6%) had partial tear and 13 (43.3%) had complete tear of ACL. Additional sagittal-oblique and flexion imaging were added. On sagittal-oblique view 13

(43.3%) patients had partial tear of ACL. In 4 cases partial tear was missed on routine sagittal imaging. Flexion technique also showed the same result as oblique sagittal technique. The percentage of complete tear using standard sagittal imaging was 43.3% (13 patients). Both flexion and sagittal oblique imaging showed the same number of complete ACL tear as compared to sagittal technique. The percentage of partial tear of ACL using standard sagittal MR protocol was statistically significantly lower ($p < 0.01$) than in oblique sagittal and flexion techniques. (Table 3)

Table 3: Standard sagittal knee MR protocol, sagittal-oblique and flexion MR technique findings of anterior cruciate ligament (ACL)

	Sagittal	Sagittal-Oblique	Flexion
Normal	9 (30%)	4 (13.3%)	4 (13.3%)
Partial tear	8 (26.6%)	13 (43.3%)	13 (43.3%)
Complete tear	13 (43.3%)	13 (43.3%)	13 (43.3%)
Total	30 (100%)	30 (100%)	30 (100%)

Discussion

Sagittal-oblique imaging clearly depicts a partial rupture because of its double angulation in two planes with two phases of sagittal and paracoronal and approximate orientation of external rotation of foot which follows the specific course of the ligament. Complete tear of ACL does not cause a diagnostic problem for the standard MP protocol of knee. This technique can be performed easily and faster as it does not require repositioning of the patient as in flexion technique.

The major diagnostic problem in diagnosing partial ACL tear with standard MR protocol is due partial volume effect of intercondylar fossa of ACL. This can be avoided by using flexion technique. In this technique the ligament remains unstretched which makes it wider and thus can be accurately assessed. Flexion technique is however time consuming as the patients knee has to be repositioned for a new scout.

In this study the standard procedure was proved to be statistically significant than sagittal-oblique and flexion techniques that showed the whole course of ACL.

These approaches can therefore reduce the risk of invasive diagnostics and the treatment cost.

Conclusion

The ACL ligament is structurally important and is the frequently injured structure in case of trauma. MR Imaging has improved the accuracy of assessment of injuries and other conditions affecting ACL as well. In this study the addition of sagittal-oblique and flexion imaging has proved the diagnostic accuracy of ACL lesions as compared to standard MR imaging when ACL lesion is suspected.

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