

## Original Research Article

# Indirect signs of anterior cruciate ligament tear on MRI knee: a retrospective study

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**Received:** 09 November 2022

**Revised:** 06 December 2022

**Accepted:** 27 January 2023

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### ABSTRACT

**Background:** Anterior cruciate ligament is the most common ligament tear in knee and its primary role is to provide stability to the knee joint. Aim of study is to describe various secondary signs that are helpful in diagnosing partial/complete ACL tear. MRI offers distinct advantages over arthroscopy as a means of evaluating the ACL. MRI evaluation is effective in preventing unnecessary arthroscopy by assessing the severity of ACL tear and coexisting injuries.

**Methods:** In this retrospective study 30 cases of partial/complete ACL tear were studied over a period of six months using Siemens Magnetom Essenza 1.5T MRI scanner in Srinivas institute of medical sciences and research centre, Mangalore.

**Results:** To establish the sensitivity and specificity of indirect signs at MR imaging of Anterior Cruciate Ligament in 30 patients (18 with complete and 12 with partial thickness tear). The indirect signs were as follows: Bone Contusions (70%); Buckling of PCL (72%); Posterior displacement of lateral meniscus (54%); Anterior displacement of tibia (28%); pericruciate fat pad (86%); Wavy patellar tendon sign (28%) and associated joint effusion (90%).

**Conclusions:** ACL ligament is the most commonly disrupted ligament in knee seen in radiology and orthopedic practice. A significant percentage of partial tears will progress to a functionally complete ACL tear. MRI helps guide the treatment decision process by demonstrating the extent of ACL injury and secondary signs make the accuracy of diagnosis stronger.

**Keywords:** Anterior cruciate ligament, Ligaments, ACL tear

### INTRODUCTION

Direct evidences of ACL tear are often confounding, posing difficulty in arriving at a conclusive diagnosis in those cases various indirect evidences are of great value. The indirect signs of ACL tear, when properly evaluated prove additive, adjunctive and complementary to the diagnosis. Many clinical studies done so far establishes the role of occult fractures, bone contusion patterns, PCL line, anterior translation of tibia, etc in the diagnosis of partial and complete tears of ACL.<sup>1-5</sup>

### METHODS

#### *Study design, duration and location*

A retrospective study of 30 patients with ACL tear. (12 Full thickness ACL tear and 18 Partial thickness ACL tear) from a period of March 2022 to August 2022 was performed. MRI knee of all patients was done using 1.5T Siemens Essenza MR scanner in the Department of Radiodiagnosis, Srinivas Institute of Medical Sciences and Research Centre, Mangalore, Karnataka.

**Inclusion and exclusion criteria**

Patients of all ages and both sexes were included in the study. Patients with underlying bony fractures, inter-articular infections and post-operative patients were excluded from the study.

**RESULTS**

In order to establish the sensitivity and specificity of indirect signs at MR imaging of anterior cruciate ligament we took MR images of 30 patients (12 with complete thickness ACL tear and 18 with partial thickness tear) with demographic representation depicted in (Table 1-2).

**Table 1: Age group distribution.**

Age group (years)	N (%)
0-10	0 (0)
11-20	3 (10)
21-30	9 (30)
31-40	7 (23.3)
41-50	6 (20)
51-60	4 (13.3)
61-70	1 (3.3)

**Table 2: Sex wise distribution.**

Sex	N (%)
Male	19 (63.3)
Female	11 (36.3)

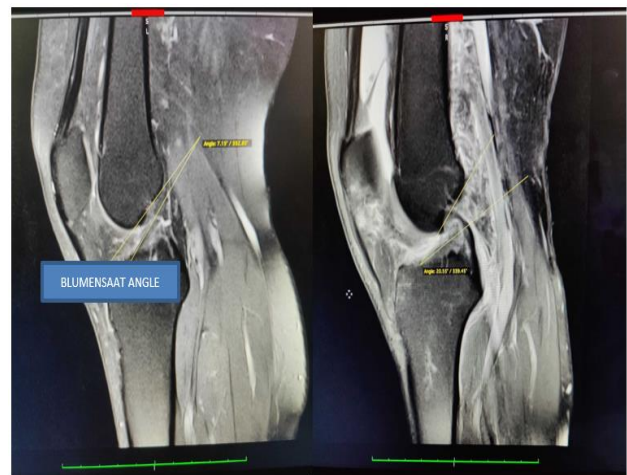
**Table 3: Indirect signs of ACL tear included in study.**

Variables/groups		Group 1 (Full thickness tear) (N=12), Frequency (%)	Group 2 (Partial thickness tear) (N=18), Frequency (%)
Bony contusions	Yes	8 (66.6)	11 (61.1)
	No	4 (33.3)	7 (38.8)
Medial meniscus tear	Yes	6 (50)	12 (66.6)
	No	6 (50)	6 (33.3)
Wavy patellar tendon sign	Yes	3 (25)	3 (16.6)
	No	9 (75)	15 (68.1)
Anterior translation of the tibia	Yes	4 (33.3)	0
	No	8 (66.6)	18 (100)
Pericruciate fat pad	Yes	10 (83.3)	16 (88.8)
	No	2 (16.6)	2 (11.1)
Associated joint effusion	Yes	9 (75)	14 (77.7)
	No	3 (25)	4 (22.2)
PCL buckling	Yes	8 (66.6)	15 (83.3)
	No	4 (33.3)	3 (16.6)

Majority of patients were males in the age group of 21-40 years of age. Bone contusions in lateral compartment were present in 66% and 61% patients amongst full and partial thickness tear respectively; buckling of PCL was present in 66.6% and 83.3% patients respectively amongst full and partial thickness tear respectively. Anterior displacement of tibia is seen in 33% patients with full thickness tear and nil in partial thickness tear; pericruciate fat pad is seen in 83.3% and 88.8% patients in respective groups; wavy patellar tendon sign is seen in 25% and 16.6% patients in respective groups; associated joint effusion is seen in approximately 75% patients in both groups.

**DISCUSSION**

Anterior cruciate ligament (ACL) is the most commonly injured ligament in the knee. It is intracapsular but extra-synovial. It is composed of 2 bundles, Anteromedial bundle (AM) and Posterolateral bundle (PL). Attachments of ACL are to the inner aspect of the lateral femoral condyle and the intercondylar eminence of the tibia distally. The primary role of ACL is to provide stability to the knee joint. It resists anterior translocation and internal rotation of the tibia over the femur. It also limits hyperextension of the knee. ACL injury is associated with anterolateral instability of the knee.



**Figure 1: Blumenfaat’s angle measurement in sagittal view.**

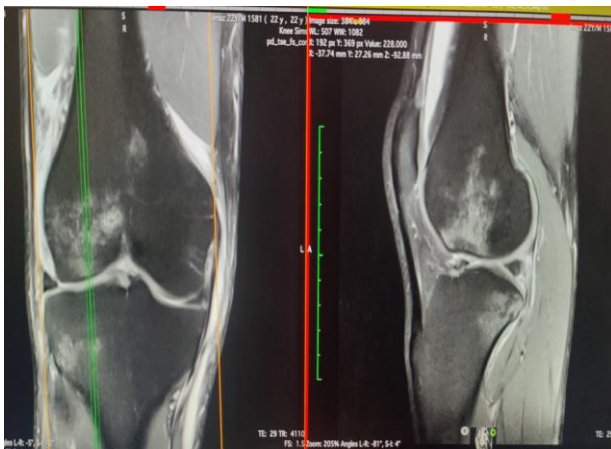
**ACL imaging**

Why imaging?: clinical examination depends on the ability to demonstrate anterior tibial motion relative to a fixed femur (Lachman test, anterior drawer test and pivot shift test). However, these have very low sensitivity and specificity and are difficult to perform because of pain and guarding. MRI is the main imaging modality used to visualize ACL injury. It can diagnose sprain of ACL, partial/complete tears, site of ACL tear, congruity of fibres, evaluation of ACL graft reconstruction with a detailed anatomical detail of the surrounding structures. Direct signs of ACL tear on MR imaging were; Discontinuity of the fibres (focal or diffuse), T2 high

signal intensity (Intrasubstance or as surrounding mass) and abnormal contour of the ACL-Wavy or  $>+15^\circ$  angle to the Blumensaat's line (Figure 1). These direct signs are usually sufficient and have both high sensitivity and specificity for accurate diagnosis of ACL tear.

**Pitfalls in direct ACL evaluation**

Exact location and grading of tear are frequently not possible on MRI because ACL is obscured by post trauma hemorrhage or adjacent edema. A ganglion cyst of the ACL, thought possibly to represent the result of remote trauma, will cause intrasubstance high signal and mass effect and thus mimic a tear. If an effusion is present, Fluid may track between the anterior and posterior bands of an intact ACL, producing apparent intrasubstance high signal intensity suggestive of a tear. Inaccurate scanning techniques (especially the oblique sagittal images) by the radiology technician is also common. The use of secondary (indirect) signs of ACL team has been advocated to improve accuracy. Numerous indirect signs have been described. These include orientation of the ACL.<sup>6,7</sup> Bony contusions and osteochondral fractures, Posterior cruciate ligament (PCL) line<sup>8</sup>, PCL angle<sup>8</sup>, PCL bowing<sup>8</sup>, deep lateral femoral sulcus, anterior drawer sign<sup>9</sup> and posterior displacement of the lateral meniscus. The purpose of this study was to compare the sensitivity and specificity of indirect signs of ACL tear.



**Figure 2: Bony contusions in distal femur and proximal tibia on coronal and sagittal views.**

**Secondary signs included in the study**

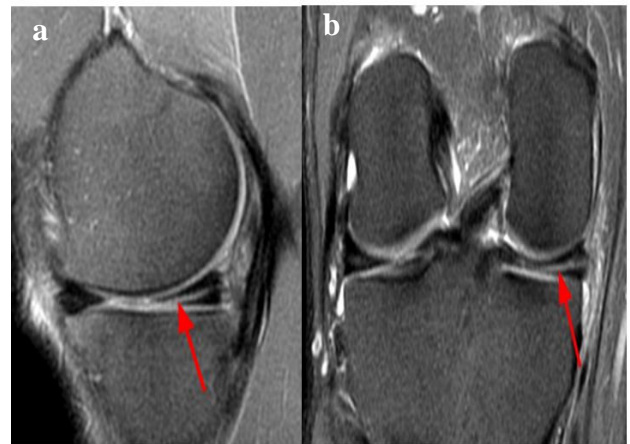
Secondary signs included were; osseous contusions (postero-lateral tibial plateau is most specific), posteromedial tibial plateau contusion or fracture, complete tear or signal in medial meniscus, anterior translation of tibia, uncovered posterior horn of lateral meniscus, pericruciate fat pad sign, wavy patellar tendon sign. Other signs like PCL buckling sign, associated Segond's fracture and joint effusions have also been mentioned. ACL injury can be associated with MCL injury and medial meniscus tear; termed as unhappy O'Donoghue triad.

**Bony contusion**

More common in posterior femoral condyle and postero-lateral part of intercondylar notch of tibia, Contusions in both these areas are highly specific for ACL tear. Contusion in the lateral femoral condyle and posterior aspect of the tibial plateau is a pattern often described with pivot shift injuries, a common mechanism of ACL injury (Figure 2).<sup>10</sup>

**Complete tear or signal in medial meniscus**

Meniscal tears are described as the most common injury associated with ACL tears in adults with rates of 40–70% (Figure 3).<sup>11</sup>



**Figure 3: Horizontal tear of medial meniscus on; a) sagittal and b) coronal view.**



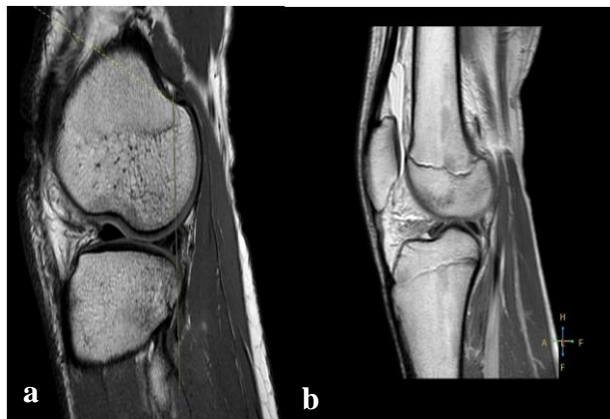
**Figure 4: Sagittal images showing anterior translation of tibia on femur.**

**Anterior translation of tibia**

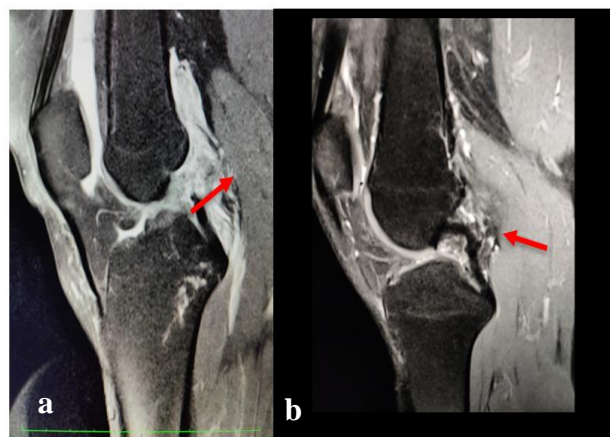
Anterior tibial translation was measured by placing vertical lines tangent to the posterior aspect of the ossified lateral femoral condyle and the lateral tibial plateau. A distance between the two lines of greater than 5 mm was considered abnormal (Figure 4).<sup>12,13</sup>

### Uncovered posterior horn of lateral meniscus and wavy patellar tendon sign

Uncovering of the posterior horn of the lateral meniscus was defined by a vertical line drawn tangent to the posterior cortex of the ossified lateral tibial plateau. If this line passed through any part of the posterior horn of the lateral meniscus, this sign was present (Figure 5).<sup>14</sup>



**Figure 5: Uncovered posterior horn of lateral meniscus a) wavy patellar sign, b) on sagittal images.**



**Figure 6: Pericruciate fat pad sign; a) buckling of PCL, b) on sagittal image.**

### Pericruciate fat pad sign and PCL buckling sign

PCL buckling was defined, as reported by Mc Cauley et al. by measuring an angle created by lines placed parallel to the femoral portion of the PCL and tibial portion of the PCL. An angle of less than 105° was considered abnormal (Figure 6).<sup>15</sup>

### Limitations

Limitations of current study were; post operative patient with MR non-compatible metallic implant in-situ/cardiac pacemaker and claustrophobia.

### CONCLUSION

Secondary signs of ACL tear described were found to have variable sensitivity on MR images. Presence of bony contusions, pericruciate fat pad hyperintensity and joint effusion were found to have a high sensitivity for both partial and full thickness ACL tears. However, Pericruciate fat pad signal and joint effusion are nonspecific findings. Therefore, these can be used to suspect an underlying ACL abnormality to facilitate rescanning in PD FAT SAT sagittal sequence or a follow up scan to rule out ACL injury in cases of adjacent edema or hemorrhage. Rest of the indirect signs have moderate sensitivity in both partial and full thickness ACL tears. The presence of these secondary signs increases the confidence of diagnosis. In almost all cases of ACL tear, these secondary signs are present in different combinations. Hence together they can significantly indicate an underlying ACL tear/sprain. However, rarely ACL tear can even present with no indirect signs. Therefore, these secondary signs should be used as an adjunct to direct signs of ACL tear.

*Funding: No funding sources*

*Conflict of interest: None declared*

*Ethical approval: The study was approved by the Institutional Ethics Committee*

### REFERENCES

1. Kaplan PA, Walker CW, Kilcoyne RF, Brown DE, Tusek D, Dussault RC. Radiology flpcemhor 1QQd fracture patterns of the knee associated with anterior cruciate ligament tears: assessment with MR imaging. *Radiology*. 1992;183:835-8.
2. Murphy BJ, Smith RL, Uribe JW, Janecki CJ, Hechtman KS, Mangasarian RA. Bone signal abnormalities in the posterolateral tibia and lateral femoral condyle in complete tears of the anterior cruciate ligament: a specific sign? *Radiology*. 1992; 182:221-4.
3. Sanders TG, Medynski MA, Feller JF, Lawhorn KW. Bone contusion patterns of the knee at MR imaging: footprint of the mechanism of injury. *Radio Graphics*. 2000;20:S135-51.
4. Schweitzer ME, Cervilla V. Kursunoglu Brahme S, Resnick D. The PCL line: an indirect sign of anterior cruciate ligament injury. *Clin Imaging*. 1992;16:43-8.
5. Vahey TN, Hunt JE, Shelbourne KD. Anterior translocation of the tibia at MR imaging: a secondary sign of anterior cruciate ligament tear. *Radiology*. 1993;187:817-9.
6. Fitzgerald SW, Remer EM, Friedman H, Rogers LF, Hendrix RW, Schafer MF. MR evaluation of the anterior cruciate ligament: value of sagittal images with coronal and axial images. *AJR* 1993;16:1233-7.
7. Robertson PL, Schweitzer ME, Bartolozzi AR. Anterior cruciate ligament tears: MR imaging evaluation. *Radiology*. 1994;193:829-34.

8. McCauley TR, Moses M, Kier R, Lynch JK, Barton W, Joki P. MR diagnosis of tears of anterior cruciate ligament of the knee: importance of ancillary findings. *AJR.* 1994;162:115-9.
9. Chan WP, Fritz RC, Stoller DW, Cenant HK. MR “anterior drawer” sign: a useful sign in the diagnosis of complete anterior cruciate ligament tear (abstr). *Radiology.* 1991;181:178-9.
10. Craf BK, Cook DA, De Smet AA, Keene JS. ‘Bone bruises’ on magnetic resonance imaging evaluation of anterior cruciate ligament injuries. *Am j Sports Med.* 1993;21:220-3.
11. Stoller DW. Magnetic resonance imaging in orthopedics and sports medicine, 2nd ed. Philadelphia: Lippincott-Raven; 1997:311-31.
12. Chan WP, Peterfy C, Fritz RC, Cenant HK. MR diagnosis of complete tears of the anterior cruciate ligament of the knee: importance of anterior subluxation of the tibia. *AJR.* 1994;162:355-60.
13. Vahey TN, Junt JE, Shelbourne KD. Anterior translocation of the tibia at MR imaging: a secondary sign of anterior cruciate ligament tear. *Radiology.* 1993;187:817-9.
14. Tung GA, Davis LM, Wiggins ME, Fadale PD. Tears of the anterior cruciate ligament: primary and secondary signs at MR imaging. *Radiology.* 1993;188:661-7.
15. McCauley TR, Moses M, Kier R, Lynch JK, Barton JW, Joki P. MR diagnosis of tears of anterior cruciate ligament of the knee: importance of ancillary findings. *AJR.* 1994;162:115-9.

**Cite this article as:** Sandhir G, Rahman S. Indirect signs of anterior cruciate ligament tear on MRI knee: a retrospective study. *Int J Res Med Sci* 2023;11:936-40.