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NEW INTERPRETATION OF THE PLAIN RADIOGRAPHY IN LIGAMENTOUS & SOFT TISSUE INJURIES OF THE KNEE

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ABSTRACT: AIMS: The primary aim was to identify and establish new signs in plain radiography of the knee joint that could indicate soft tissue abnormalities that are established on Magnetic Resonance Imaging (MRI). To correlate the plain radiographic features to that of the MRI findings which is the gold standard in the evaluation of the knee disorders? **MATERIAL AND METHODS:** A prospective cross sectional study was done on a total of 60 patients including both the sexes and of all age groups who presented with knee joint pain and subsequently underwent plain radiographic evaluation followed by MRI of the knee joint. The data is analyzed and the findings on plain radiographs correlated with that of MRI. **RESULTS:** The most common soft tissue injuries as identified on MRI of the knee joint were that of Anterior Cruciate Ligament (ACL) and medial meniscus (MM). Knee joint effusion was found to be a common occurrence in cases of trauma. These findings were also identified on plain radiographs. **CONCLUSION:** Signs (sign complexes) on plain radiograph with regard to joint space, inter condylar region of tibia, tibial plateaus, soft tissue planes at the tibio femoral joint, supra and infra patellar regions on lateral radiograms, and calcifications in soft tissue planes indicate various soft tissue injuries of the knee as detected and confirmed on MRI. Thus plain radiograph stands as a primary imaging modality in diagnosing not only the osseous abnormalities of the knee joint but also soft tissue abnormalities in comparison to MRI.

KEYWORDS: Soft Tissue knee injuries, Plain radiography, Sign complexes, MRI.

INTRODUCTION: Knee joint is particularly vulnerable to injury because of its unique architectural arrangement of bony, muscular, ligamentous, and meniscal structures and its key role in ambulation and support. Rotational, compressive and transaxial forces may act together or separately to produce knee injuries. Radiography is the first step in the evaluation of the knee joint disorders. It is universally available, quick and inexpensive and can yield many diagnostic clues. It can readily reveal fractures, osteochondral defects, bony lesions, joint effusions and joint space narrowing and bone mal-alignment. In cases in which fractures are involved, the radiographic diagnosis is frequently obvious. However, some fractures and most soft tissue injuries about the knee have subtle radiographic findings and may be difficult to detect even with optimal radiographic views. While radiography may not always identify the cause for changes, but may help in further management. Due to certain limitations of the plain radiography in evaluation the soft tissues, it is superseded by other imaging modality like the MRI. Radiographic features of several subtle, yet detectable knee injuries are studied, with a goal to emphasize the analysis of plain radiographic findings and correlation of radiographic results with those of magnetic resonance imaging (MRI).¹ In the recent days MRI is the gold standard in imaging soft tissues of

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the knee. It provides high resolution images with detailed information concerning the bone marrow, cortex, cartilage, menisci, ligaments, tendons and surrounding synovium. It enables multiplanar imaging and many a times obviates the need for invasive procedures like arthroscopy.² Therefore the objectives of the present study was to identify the plain radiographic signs and correlate with MRI findings in knee joint disorders. This study was performed to identify and establish new sign complexes in plain radiography that could indicate soft tissue abnormality that are established on MRI.

MATERIALS & METHODS: The present cross sectional study included 60 out-patients visiting our medical institute with knee pain and subjected to investigations of plain radiography and MRI were included in the study. The study was approved by the institutional ethical committee. The study included patients belonging to all ages and both sexes. Patients with bony ankylosis, fibrous ankylosis, frank fractures of the bones of knee joint and bone tumors of the knee were excluded from the study.

Plain radiograph of the knee joint is performed using a 500mA Siemens machine using a 24 x 30cm computer radiography cassette with 58kV and 6mAs. Antero-posterior (A-P) view in standing position is taken for both the knee joints. Subsequently, A-P supine and trans-lateral views are taken for the affected knee joint.

MRI knee was done using a 1.5 Tesla Philips Achieva machine. Proton density weighted sequence in saggital plane (PDW-sag), PDW-m spin gradient inversion recovery in saggital plane (SPIR-sag), short T1 inversion recovery in coronal plane (STIR-coronal), T2-coronal, T1-coronal, T1-axial, STIR-axial, STIR-axial sequences with thin sections were obtained for evaluation.

Statistical Analysis: The data is analyzed by proportions and chi square test.

RESULTS: The present study consisted of 50 males and 10 female patients. It was observed that the maximum number of patients (29 cases) belonged to the age group of 21-30 years followed by the age group of 31-40 which consisted of 15 cases.

Out of 60 cases, 45 (75% of 60) of them had abnormal ACL on MRI whereas 41(91% of 45) revealed signs of ACL injury on plain radiographs (Fig. 1a & b).



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Fig. 1(a) MRI of a 24 year old male patient showing ACL strain revealing the abnormal contour of the ACL (arrow) and the corresponding AP view of plain radiograph is shown in Fig. 1(b) AP view of plain radiograph of a 24 year old male patient showing prominence of medial intercondylar eminence (arrow).

Fourteen (23.3% of 60) cases had abnormal contour without discontinuity of the ligament fibres on MRI, out of which 12 were identified on plain radiograph, accounting for 85% of that identified on MRI. It was observed that 23 (38% of 60) cases had discontinuity of ACL fibres on MRI, out of which 20 (87% of 23) cases revealed the features on plain radiographs. Of the 60 cases, 8(13%) of them had discontinuity of ACL fibres with buckling of posterior cruciate ligament (PCL) on MRI and all these cases were also identified on plain radiographs indicating a statistically significant correlation (Fig. 2a, b). Eleven patients who presented with only PCL buckling on MRI, only 2 of them (18.18%) were identified on plain radiograph which was not statistically significant. (Table 1)

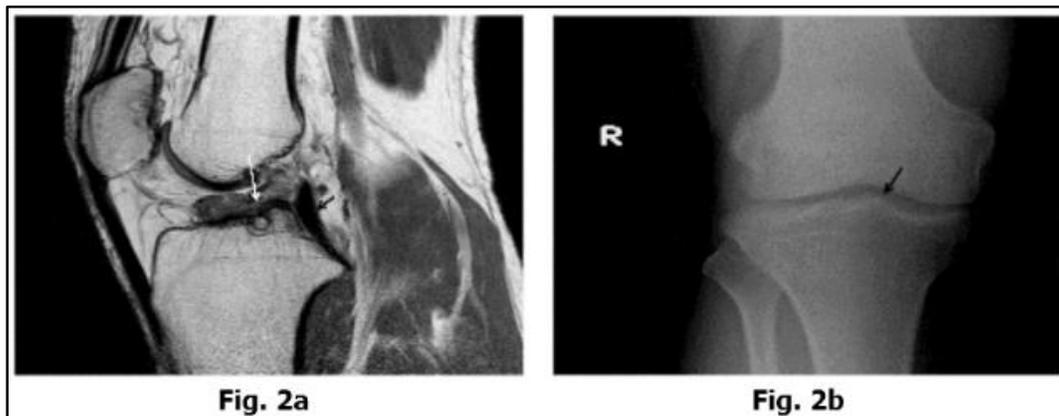


Fig. 2(a) MRI of a 56 year old male showing complete ACL tear (discontinuity of the fibres as shown by the white arrow) with PCL buckling (black arrow) and the corresponding plain radiograph is shown in Fig. 2(b) plain radiograph showing prominence of medial ICE with sclerotic margin with osteopenia underneath.

Table 1: Tabulation of all the soft tissue structures of the knee joint (of the 60 cases studied) correlating the features identified on MRI and those cases in which the same was identified in the plain radiographs.

Soft tissue injury of the knee joint	MRI		Plain Radiograph		Correlation between the observations on MRI and Plain radiographs (%) *Statistically significant
	Cases	%	Cases	%	
Anterior cruciate ligament (ACL)	45	75	41	68	95*
Posterior cruciate ligament (PCL)	11	18	2	3.3	18.18

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Medial meniscus (MM)	43	71	33	55	76.74*
Lateral meniscus (LM)	19	31	10	16.66	52.63
Medial collateral ligament (MCL)	3	5.1	3	5.1	100*
Lateral collateral ligament (LCL)	13	21.7	12	20	92.30*
Joint space	30	50	32	52	--
Moderate effusion	14	23.33	14	23.33	100*
Severe effusion	3	5	3	5	100*
Mild effusion	30	50	22	36.66	73.33*
Marrow edema in femur	5	10	0	0	12
Changes in tibia	22	36.66	16	26.66	72.72*

Table 1

Medial meniscus (MM) injury was detected in 43(71% of 60) cases on MRI of which, 33(76.74% of 43cases) had evidence detectable on plain radiographs. Evidence of grade II injury to the posterior horn of MM was detected in 24(40% of 60) cases on MRI of these 18(75% of 24) cases were identified on plain radiographs. 17 cases revealed grade II signal intensity changes in the posterior horn on MRI, of which 14(83%) had signs suggestive of the same on plain radiographs. One case showed grade III tear of the anterior as well as posterior horn of medial meniscus on MRI, which was also identified on the plain radiograph (Fig. 3a & b). But one patient, who showed evidence of grade I injury to the posterior horn on MRI, was not identified on plain radiograph.

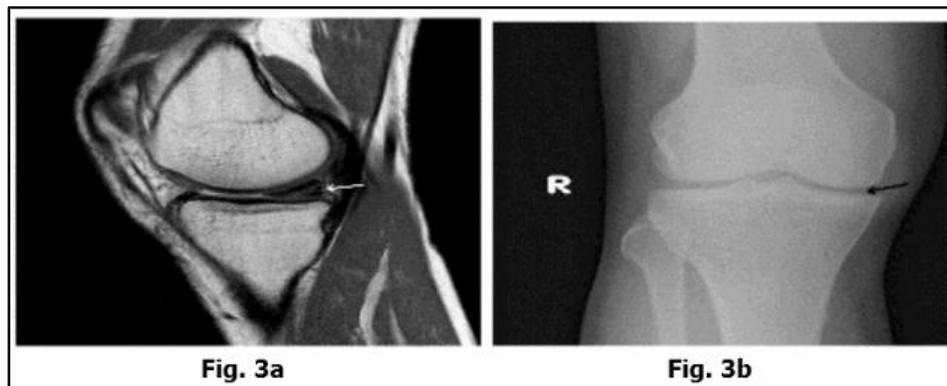


Fig. 3(a) MRI of 51 year old male patient showing grade III medial meniscus, posterior horn tear (arrow) Fig 3(b) The plain radiograph of the same patient shown in Fig. 3(a) showing reduced medial tibio femoral joint space with sclerosis of the medial tibial plateau (arrow)

Injury to lateral meniscus (LM) was evident in 19(31% of 60) patients on MRI whereas plain radiographic signs indicating injury to LM are identified in 10(52.3% of 19) cases which was statistically significant. Seven (11.7% of 60) cases were identified having grade III tear of posterior horn of LM on MRI. The plain radiographic signs revealing the same were identified in 3 (42.8%) cases. Five (8.3%) patients revealed grade II signal intensity change of posterior horn

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on MRI, whereas changes on plain radiograph revealing the same was identified in 3(60% of 5) of the cases. Four (6.8%) cases revealed tear in both the anterior and posterior horns of varying grades on MRI and all (100%) of them are identified on the plain radiographs. Three (5.0% of 60) cases revealed grade III tear on MRI of which none were identified on plain radiographs (Fig 4a & b).

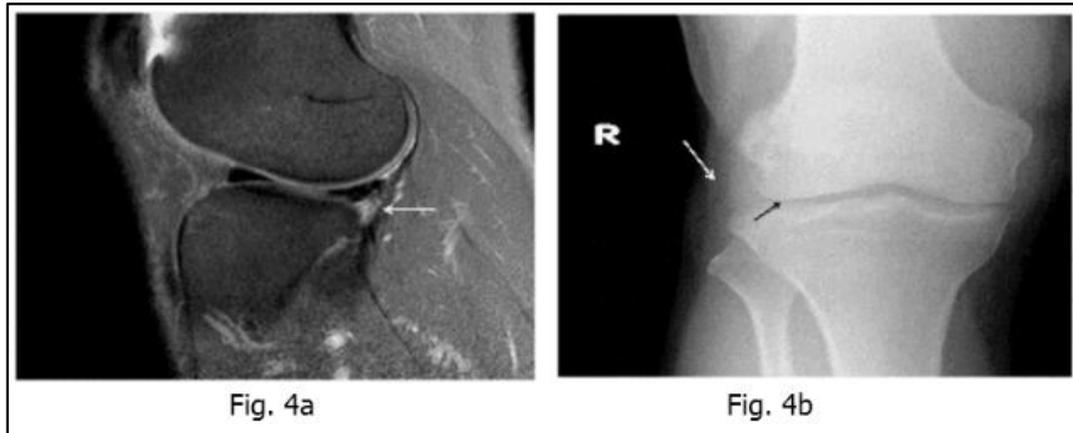


Fig. 4(a) MRI of 26 year old male patient showing grade III tear of lateral meniscus posterior horn (arrow) Fig. 4(b) The plain radiograph of 26 year old male patient showing grade III tear of lateral meniscus posterior horn on the MRI (Fig. 4(a)) shows decreased lateral tibio femoral joint space (black arrow), with indistinct lateral fat planes (white arrow)

Out of 60 cases 3(5%) cases revealed injury to the medial collateral ligament (MCL) on MRI of which all 3(100% of those identified on MRI) cases had signs indicating the same on plain radiographs (Fig. 5a & 5b) which was statistically significant.



Fig. 5(a) MRI of 26 year old male patient showing medial collateral ligament injury (arrow), whereas the corresponding plain radiograph (b) showing calcification at the attachment of MCL to the medial femoral condyle (Pellagrini steida syndrome) Fig. 5(b) The plain radiograph of 26 year old male patient showing calcification at the attachment of MCL to the medial femoral condyle (Pellagrini Steida Syndrome)

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On MRI 13(21.66% of 60) cases revealed injury to the lateral collateral ligament of which 12(92.3% of 13) cases were detected on plain radiographs which was statistically significant.

Among 60 patients in the study, 30(50%) cases revealed reduction in the joint space on MRI, whereas 32(52%) cases showed reduced joint space on plain radiographs which was statistically significant. Reduction in the tibio femoral joint space medially was noted in 27(45% of 60) patients on MRI, whereas 29(48.3% of 60) cases showed the same on plain radiographs. One case each revealing a reduction in the joint space medially and bilaterally on MRI was also identified as such on plain radiographs.

Knee joint effusion was noted in 47(78%) cases of 60 patients on MRI, of which 39(83% of 47) cases were also detected on plain radiographs which was statistically significant. Moderate and massive joint effusion was noted in 14 and 3 patients respectively, was also detected on plain radiographs (Fig. 6a, b & c). On the contrary 30(50% of 60) patients who revealed minimal joint effusion on MRI only in 22(73.3% of 30) patients revealed the signs on plain radiographs.



Fig. 6(a) MRI showing knee joint effusion in a 48 year old female patient which appears as hyperintense areas (arrows) on T2 image (b) plain radiograph showing fullness/ increased density in the supra patellar region on lateral projection (arrow) and (c) lateral displacement of the soft tissues at the tibio femoral joint on AP view of a 40 year old female patient (area of increased density shown by an arrow)

Eight (13.3%) cases out of 60 revealed changes in the femur on MRI. Of the above mentioned 8 cases, 5(10%) revealed medial condyle marrow edema on MRI, of which none of them revealed the signs on plain radiograph indicating the same. Similarly, 2(3.4% of 60) cases having geodes in the lateral condyle on MRI were inconspicuous on plain radiographs. Among the 60 cases, 22(36.7%) had changes in tibia on MRI whereas 17(77.27% of 22) cases showed changes in tibia on plain radiographs.

The osteophytes in the medial and lateral condyle of the femur and tibia were identified on both MRI and plain radiography and had a strong statistical significance. Similarly two (3.4%) cases showed fracture lateral tibial condyle on MRI which was identified on plain radiograph.

Nine (15% of 60) patients revealed geodes in medial condyle of tibia on MRI, out of which 7(78% of 9) were identified on plain radiographs and the remaining 2 cases being inconspicuous. In 3(5% of 60) cases bone marrow edema/contusion, was identified on MRI whereas none of them were identified on plain radiographs.

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The changes in joint space were clearly depicted in 17 cases (28.7%) in the plain radiography which were less obvious on MRI due to the supine positioning of the patient during the procedure.

DISCUSSION: Radiography is the first step in the evaluation of the knee joint disorders. It is universally available, quick and inexpensive and can yield many diagnostic clues. It can readily reveal fractures, osteochondral defects, bony lesions, joint effusions, joint space narrowing and bone mal-alignment. While radiography may not always identify the cause for knee pain it is useful in excluding serious problems such as fractures, advanced degenerative changes and neoplasms and may help direct further management.

The knee is the largest, complex, bicondylar, synovial joint in the body.³ It is composed of two condylar joints between the femur and tibia, tibiofemoral joints and a sellar joint between the patella and femur, the patella femoral joint. A number of stabilizing factors counter the considerable biomechanical demands that are imposed upon the joint: most important is a complex arrangement of intra capsular and extra capsular ligaments.

The soft tissues around the knee comprise: fibrous capsule, menisci, cruciate ligaments, collateral ligaments and medial and lateral stabilizing structures of the knee. The injuries involving these structures along with bone and bone marrow are well identified on the MRI. In order to evaluate internal derangement adequately, the axial, coronal and sagittal planes using thin sections (3mm thick) with a combination of T1- and T2- weighted sequences, short tau inversion recovery (STIR) or T2 –weighted image with fat suppression are required.⁴ Tears in the structures or discontinuity in the fibres, edema/contusion or effusion in the joint space, sclerosis, geodes, cysts, osteophytes and fracture can all be appreciated on MRI. Similarly on the plain radiographs, the displacement of synovial fluid, spiking of the intercondylar eminence, displaced soft tissue planes, indistinct fat planes, enlargement of joint space, compression fractures can be appreciated.

The sagittal plane is most important plane in assessing the menisci, with a coronal plane providing supportive rather than new information and the axial plane increasing the accuracy of the sagittal and coronal planes when combined.⁵⁻⁷ The medial and lateral menisci, the transverse ligament, and the menisco femoral ligament appear homogeneously dark on all pulse sequences. The vascular and avascular zones cannot be distinguished on MRI.⁸ The vascularized zone does not demonstrate enhancement with intravenous gadolinium.

In primary healthcare setups where MRI facility is not available, the plain radiography becomes the key in analyzing the changes in the soft tissues along with the well-established changes in the hard bony tissues. MRI is an expensive, not readily available investigation at the level of primary health care centres. However MRI is a noninvasive gold standard investigation in establishing soft tissue injuries of the knee joint.

The objective of our study was to establish new signs on plain radiography of the knee joint that would indicate soft tissue injury, thereby obviating the need for expensive, not readily available investigations like MRI at a primary level. On reviewing the literature it was found that our study is first of its kind (unique) in establishing signs on plain radiography that indicate soft tissue injury of the knee joint.

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Plain radiographs are 91% sensitive and 86% specific for osteoarthritis when combined with criteria indicating osteoarthritis, including any of the following: age more than 50 years, crepitus and morning stiffness of 30 minutes or less.⁹

Lateral condylar depression and widening, as measured on plain radiographs was helpful in identifying the soft tissue injury and planning open or arthroscopic treatment methods in centres with limited availability of MRI.¹⁰

Multiple studies have been conducted in assessing the sensitivity of MRI in evaluating the soft tissue changes when compared to the plain radiographs. Localized development of knee osteoarthritis can be predicted from MR imaging a decade earlier.¹¹ Study to correlate the clinical assessment, radiographic and MRI findings revealed that MRI was far superior to plain radiography and better than clinical assessment and has a high sensitivity, accuracy and positive predictive value.¹²

But the studies to indicate the valuability of the plain radiography in assessing the soft tissue injuries of knee have not been widely conducted. A study by Ian G. Stiell et al.¹³ have indicated that the use of radiography for acute knee injuries is not efficient. Nevertheless in our study the plain radiography with all its limitations in diagnosing soft tissue injury of the knee joint has proven to be a valuable tool in diagnosing the changes that are established on MRI, if the following six signs are meticulously appreciated.

The six sign complexes that were observed on plain radiography would be of great value in diagnosing soft tissue pathologies where the MRI facility is not available. They are:

1. **ACL:** Signs on plain radiogram that indicate ACL injury are spiking of intercondylar eminence, with either sclerotic margin or irregular margin with or without underlying osteopenia, fracture of intercondylar eminence indicates ACL injury.
2. **Medial meniscus injury/tear:** Signs on plain radiogram that indicate medial meniscus injury/tear are reduced tibio-femoral joint space medially, sclerosis of medial tibial plateau, with laterally displaced soft tissue planes.
3. **Lateral meniscus:** Signs on plain radiogram that indicate lateral meniscus injury/tear are sclerosis of lateral tibial plateau, lateral tibial condyle, fracture, laterally displaced soft tissues at the tibio-femoral joint and decrease in lateral tibio-femoral joint space.
4. **Medial collateral ligament:** Signs on plain radiogram that indicate injury to medial collateral ligament are displacement of medial soft tissue planes at medial tibio-femoral joint, calcification at medial femoral condyle at the site of attachment of medial collateral ligament.
5. **Lateral collateral ligament:** Signs on plain radiogram that indicate injury to lateral collateral ligament are indistinct lateral fat planes at the tibio-femoral joint, laterally displaced lateral soft tissue planes.
6. Signs on plain radiogram that indicate joint effusion are increased density in the suprapatellar and infrapatellar regions on lateral x rays. Also laterally displaced fat planes with increased density on AP films.

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CONCLUSION: Knee joint pain is a common complaint patients present with, especially in middle and old ages. The causes can be various being bony or soft tissue injuries. Radiology plays a major role in diagnosing the cause of pain and thereby in its management. The present study was done to identify signs on plain radiography that indicate soft tissue injuries of the knee joint that are otherwise established on MRI and thus correlate signs on plain radiographs with that of MRI. Specific observations regarding the knee joint space, tibial inter condylar eminence, the bone density, soft tissue planes at the tibio femoral joint medially and laterally, density at the suprapatellar and infra patellar region, compression fractures of the tibial plateaus / femoral condyles/ inter condylar eminence reveal invaluable signs revealing injury to the menisci, cruciate ligaments, collateral ligaments, knee joint effusion when carefully assessed and interpreted on the plain radiographs. Thus though MRI today is the standard modality to diagnose soft tissue injuries of the knee joint, plain radiography a readily and universally available investigation at all levels of health care systems certainly does reveal certain signs that indicate injury to the soft tissues of the knee.

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