Evaluation of MRI Findings in Chronic Painful Knee Joint
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ABSTRACT

BACKGROUND
Any disruption of the intra articular structures of the tri-compartmental knee joint or even extra-articular pathologies related to quadriceps mechanism and synovium can cause painful knee resulting in functional morbidity and disability. To ascertain and manage the root cause various modalities are available today. Magnetic Resonating Imaging (MRI) is an effective and non-invasive imaging modality in diagnosing and classifying the knee pathology. With the introduction of special closely coupled extremity coils, high field systems, open systems, extremity units and other technical advances, MRI has virtually replaced conventional arthrography for evaluation of intraarticular pathologies. It has also decreased both morbidity and costs associated with negative intra articular arthroscopic examinations.

METHODS
The present study was a non-randomized prospective study conducted in Department of Radiodiagnosis and Department of Orthopaedics, Subharti Medical College, Meerut, Uttar Pradesh, India. The study was carried out for a period of three years from September 2015 to September 2018. The study was done on patients presenting in orthopaedics outpatient department, CSS Hospital with knee pain for duration of more than 3 months and subsequent evaluation of the knee joint by using GE SIGNA 1.5 Tesla High gradient MRI Scanner. In each patient T1W, T2W, PD, STIR, GRE and PD-FAT SAT sequences are taken. A total of 100 patients with chronic knee pain i.e. pain for duration of more than 3 months, were studied.

RESULTS
In our study we found that, meniscal tears in young population (age less than 40 years) and meniscal degeneration in patients above 40 years of age is the major finding. Grade 2 medial meniscal tears were most commonly followed by grade 3 medial meniscal tears, followed by lateral meniscal injury. ACL tears were the next most common finding after meniscal injuries or degeneration.

CONCLUSIONS
MRI is an accurate, non-invasive and a cost-effective means to evaluate a painful knee. The high degree of precision in interpretation of MR images and imaging in various planes and positioning the knee in 15-20° of external rotation and 5-10° of flexion aided in delineating the site and the full extent of the lesions.

KEYWORDS
Chronic Knee Pain, MRI, Menisci, Cruciate

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BACKGROUND

The value of magnetic resonance imaging (MRI) for imaging the knee was apparent almost immediately after the introduction of this modality in the early 1980s. With the introduction of special closely coupled extremity coils, high field systems, open systems, extremity units and other technical advances, the utility of MRI in the knee has expanded dramatically.\(^1\) MR examination, a non-invasive modality, is now routinely used to assess a wide spectrum of internal knee derangements and articular disorders and has virtually replaced conventional arthrography in the evaluation of menisci and cruciate ligaments, decreasing both morbidity and costs associated with negative arthroscopic examinations. MR imaging has also proved valuable in the selection of surgical candidates and in preoperative planning.\(^2\) The decrease in the cost of MR knee studies has also contributed to their acceptance by the orthopaedic community as a non-invasive replacement for arthrography and non-therapeutic arthroscopy.\(^3\)

A large number of disorders are best evaluated by MRI, including internal abnormalities such as those of cruciate ligaments and the menisci. Other disorders include abnormalities of patella and quadriceps mechanism, cartilage and synovium. Bone abnormalities such as osteonecrosis and tumours as well as bone contusions and fractures may also be detected. Other advantages offered by MRI examination are the absence of painful after-effects or morbidity.\(^4\) The MRI examination poses almost no risk to the average patient. Fast spin echo imaging, used in conjunction with fat suppression MR technique, has extended the sensitivity and specificity of MR for the detection of articular cartilage injuries. In addition, three-dimensional (3D) volume techniques have demonstrated the versatility of MR imaging in the evaluation of meniscal tears. It can be used to reformate images of meniscal tears in orthogonal and non-orthogonal planes. Additional advantage of MR imaging are multiplanar and thin section capabilities and the ability to evaluate subchondral region and marrow. Chronic knee conditions like synovial arthropathies, synovial neoplasia, synovial osteochondromatosis, rare intra-articular abnormalities like lipoma arborescence etc. can be assessed satisfactorily with MRI as opposed to CT and other modalities.

METHODS

The present study was a non-randomized prospective study conducted in Department of Radiodiagnosis and Department of Orthopaedics, Subharti Medical College, Meerut, Uttar Pradesh, India for a period of three years from September 2015 to September 2018. The study was done on patients presenting in orthopaedics outpatient department, CSS Hospital, Meerut with knee pain for duration of more than 3 months. These patients were referred to Department of Radiodiagnosis for subsequent MRI examination of the knee joints. MR evaluation was done by using GE SIGNA 1.5 TESLA High gradient MRI Scanner. 100 patients with chronic knee pain i.e. pain for duration of more than 3 months, were studied. In each patient T1W, T2W, PD, STIR, GRE and PD-FAT SAT sequences are taken. Typically, the patient is placed in supine position with the knee placed in a closely coupled extremity coil. The knee was externally rotated 15 degree to 20 degree to facilitate visualization of ACL on sagittal images. The knee was flexed slightly (5 degree to 10 degree) to increase accuracy of assessing the patella-femoral compartment and patellar alignment.

A form of T2 weighting (such as FS proton density (PD) FSE) was used in each of the three acquisition planes (axial, coronal and sagittal), for better visualization of Articular cartilage. A T2 gradient-echo (GRE) sagittal sequence was used to improve the accuracy of detection of meniscal lesions by compensating for blurring inherent in most FSE acquisitions. Addition of short inversion time (TI) inversion recovery (STIR) sagittal acquisitions were also done to improve identification of osseous contusions and muscle trauma. T2 GRE contrast imaging with intra-articular gadolinium was used to differentiate healing from repeated injury after primary meniscal repair or partial meniscectomy. All patients were screened for renal dysfunction by obtaining a history and laboratory kidney function tests before these contrast agents were used. Contrast was also used in suspicion of conditions like rheumatoid arthritis, osteomyelitis and tumours. Delayed gadolinium enhanced MRI cartilage (d GEMRIC) technique was used to identify early chondral lesions by assessing the amount of glycosaminoglycan in cartilage.

Mainly T1W axial, coronal and sagittal images are taken. An acquisition matrix (number of phase encodings) of 256 or higher, a field of view of 12 to 14 cm, and 1 to 2 number of excitations (NEX) were routinely used. GRE images were acquired with an acquisition matrix of 192 or 256. For FS PD FSE images, TE values of 35 to 45 msec were used to maintain a high SNR. Fast recovery FSE techniques were used with TR values of less than 3000 msec without compromising articular cartilage. STIR (fast inversion recovery) were done using a TR of 4000 msec, a TE of 18 msec, a TI of 140 msec and an ETL (echo train length) of 4. Evaluation of neoplastic lesions, both benign and malignant, required a combination of T1, T2 (conventional or FSE), STIR- (FS PD FSE were frequently used in place of STIR because of improved spatial resolution at higher field strengths). FS PD FSE or fast inversion-recovery sagittal or coronal images delineated the proximal-to-distal extent of tumour on one complete image. Multiplanar imaging was done in all the cases and 4-millimeter sections were used for axial and coronal plane images, and 3-to 4-mm thick sections were used for sagittal images. The maximum slice thickness for evaluation of the meniscus was 4mm.

RESULTS

In this study, we studied 100 patients over a period of 2 years. This included 76 men and 24 women, 47 right knee joints and 53 left knee joints. Majority of the patients were in their fourth decade. The patients’ age ranged from 16
years to 66 years with most of the patients in the age group of 31-40 years. (Graph 1)

Out of these 100 patients, 81 patients showed medial meniscal tears, 53 patients showed lateral meniscal tears, 55 patients showed ACL tears and 5 patients showed PCL tears. Following table 2 describes the various pathologies encountered on MR evaluation of the patients.

### Table 1. Distribution of Knee Pathologies

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Abnormality</th>
<th>Number of Patients</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Anterior Cruciate Ligament Tears</td>
<td>55</td>
<td>55%</td>
</tr>
<tr>
<td>2</td>
<td>Posterior Cruciate Ligament Tears</td>
<td>55</td>
<td>55%</td>
</tr>
<tr>
<td>3</td>
<td>Medial Meniscal Tears</td>
<td>55</td>
<td>55%</td>
</tr>
<tr>
<td>4</td>
<td>Lateral Meniscal Tears</td>
<td>55</td>
<td>55%</td>
</tr>
<tr>
<td>5</td>
<td>Medial Collateral Ligament Tears</td>
<td>55</td>
<td>55%</td>
</tr>
<tr>
<td>6</td>
<td>Lateral Collateral Ligament Tears</td>
<td>55</td>
<td>55%</td>
</tr>
<tr>
<td>7</td>
<td>Chondromalacia Patellae</td>
<td>55</td>
<td>55%</td>
</tr>
<tr>
<td>8</td>
<td>Osteochondritis Dissecans</td>
<td>55</td>
<td>55%</td>
</tr>
<tr>
<td>9</td>
<td>Osteoarthritis</td>
<td>55</td>
<td>55%</td>
</tr>
<tr>
<td>10</td>
<td>Popliteal Cysts</td>
<td>55</td>
<td>55%</td>
</tr>
<tr>
<td>11</td>
<td>Ossseous Fractures</td>
<td>55</td>
<td>55%</td>
</tr>
<tr>
<td>12</td>
<td>Rheumatoid Arthritis</td>
<td>55</td>
<td>55%</td>
</tr>
<tr>
<td>13</td>
<td>Infections</td>
<td>55</td>
<td>55%</td>
</tr>
<tr>
<td>14</td>
<td>Tumours</td>
<td>55</td>
<td>55%</td>
</tr>
<tr>
<td>15</td>
<td>Medial Patellar Retinaculum Tear</td>
<td>55</td>
<td>55%</td>
</tr>
<tr>
<td>16</td>
<td>Lateral Patellar Retinaculum Tear</td>
<td>55</td>
<td>55%</td>
</tr>
<tr>
<td>17</td>
<td>Joint Effusion</td>
<td>55</td>
<td>55%</td>
</tr>
<tr>
<td>18</td>
<td>Bone Marrow Oedema</td>
<td>55</td>
<td>55%</td>
</tr>
</tbody>
</table>

### Medial Meniscal Tears and Degeneration

Out of 100 patients, 81 patients showed medial meniscal tears and degeneration and 53 patients showed lateral meniscal tears. Of 81 patients with medial meniscal tears and degeneration, 37(45.67%) showed grade II degeneration, 33(40.74%) showed grade III degeneration, 13(16%) showed grade I degeneration, 1(1.23%) showed grade IV tear and 2(2.40%) showed bucket handle tear. Medial meniscal tears and degeneration were more common (81%) which corresponds with Lakkar et al\[8\] who in their study on 115 patients showed medial meniscal tears to be more common than lateral meniscus tears accounting for 36.5% case. Out of 81 medial meniscal tears and degeneration 78 involved the posterior horn and 11 involved the anterior horn. Stoller DW, et al\[8\] in their study also showed posterior horn to be more frequently involved than the anterior horn. Out of 33 patients with grade III, meniscal tear, 30 (90.90%) patients showed tears in posterior horn and 3(9.09%) patients showed tears in anterior horn. In our study, 3 patients showed bucket handle tear, 2 of which were in medial meniscus and 1 in lateral meniscus. This is corresponding with study by Singson et al\[7\] who reported that medial meniscus bucket handle tears are more common than lateral meniscus. Out of three patients with bucket handle tear, two of them showed double PCL sign. Watts et al\[8\] described that double PCL sign is 98% specific but 32% sensitive.

### Medial Meniscus Grade III Tears

- **Grade I**: 13 (16.00%)
- **Grade II**: 37 (45.67%)
- **Grade III**: 33 (40.74%)
- **Grade IV**: 01 (01.23%)
- **Bucket Handle Tear**: 02 (02.40%)

### Lateral Meniscal Tears and Degeneration

Out of 53 lateral meniscal tears and degeneration, 23 (43.39%) showed grade II degeneration, 19(35.84%) showed grade III degeneration, 14 showed grade I degeneration, 01(1.80%) showed grade IV degeneration and 1(1.80%) showed bucket handle tear.

### Lateral Meniscal Grade III Tears

- **Grade I**: 14 (26.91%)
- **Grade II**: 23 (43.39%)
- **Grade III**: 19 (35.84%)
- **Grade IV**: 01 (1.80%)
- **Bucket Handle Tear**: 01 (1.80%)

### ACL Tears and Degeneration

Out of 100 patients, ACL tears were more common (55%) than PCL tears which accounted for only 5%. Michael R Aiello stated that the PCL is twice as strong as the ACL. It contains a larger cross-sectional area and possesses a higher tensile strength, explaining its lower rate of injury. Out of 55 patients of ACL tears, 28 patients (50.90%) had mid substance tears, 21(38.18%) patients had tears at femoral attachment and 6 patients (10.90%) had tear at tibial attachment, on MRI. In this study we found hyper-intensity in the ligament as the most common sign which was seen in 52 patients (94.54%), 29(52.72%) patients showed discontinuity and 1(1%) patients showed non visualization of ACL. In our study we found mid-substance as the most common location of tear and hyper-intensity as the most common sign of ligament tear. JP Singh et al\[8\] in their study also reported mid-substance tear as the most common site and hyper intensity as the most common sign of tear. Out of 55 cases of ACL tear, 32 patients (58.18%) were associated with meniscal tear and 30 patients were associated with PCL buckling. McDaniel et al\[8\] in their study reported that meniscal tear is associated with 85% to 91% of chronic ACL deficient knees. Out of 7 patients with medial collateral ligament tear, 5(71.42%) were found to have ACL tear. Out of 3 patients with lateral collateral ligament tear, 3 (100%) had meniscal tears and 2(66.66%) had PCL tears.
Tears                       Number  Percentage
Complete                    23     41.82%
Partial                     32     58.18%
Total                       55

A: Anterior Cruciate Ligament Tears

ACL Tear                       Number  Percentage
Mid-substance                28     50.90%
Femoral Attachment           21     38.18%
Tibial Attachment            06     10.90%

B: Location of ACL Tear

Signs of ACL Tear                     Number  Percentage
Non-Visualisation              01     1.82%
Hyperintensity                52     94.54%
Discontinuity                 29     52.72%

C: Observed MRI Signs of ACL Tear

Secondary Signs              Number  Percentage
Effusion                      51     92.72%
PCL Buckling                  30     54.54%
Anterior Tibial Subluxation   -     -
Medial Collateral Ligament Tear 03     5.41%
Meniscal Tear                32     58.18%
Bone Bruise/Oedema           15     27.27%
Segond Fracture               -     -
Uncovered Lateral Meniscus    -     -
Deep Femoral Notch            -     -

D: Secondary Signs Associated with ACL Tear

Tears Associated Injuries     Number %
1.                         Meniscal Tears 04 80%
2.                         ACL Tears 05 100%
3.                         Collateral Ligament Tears 02 20%
4.                         Haemarthrosis -
5.                         Bone Contusion/Oedema 02 40%

E: PCL Tears: Distribution of Associated Injuries with PCL

Collateral Ligament Injury     Number of Patients Percentage
Medial Collateral             07     7%
Lateral Collateral            03     3%

A: Distribution of Collateral Ligament Injuries

MCL Tear Associated Injuries  Number Percentage
1.                         Meniscal Tears 05 71.43%
2.                         Bone Oedema 03 42.86%
3.                         Meniscal Tear/Degeneration 06 85.71%
4.                         Fracture Of Tibial Plateau -

B: Distribution of Associated Injuries with MCL Tear

LCL Tear Associated Injuries  Number Percentage
Meniscal Tears               03     100%
PCL Tears                    02     66.66%
Fibular Head Fracture        -

C: Lateral Collateral Ligament Injuries

Patellar Retinaculum         Number Percentage
Medial                      03     75%
Lateral                     01     25%
Total                       04

Table 2. Patellar Retinaculum Tears

Popliteal Cyst               Number Percentage
Unruptured                   7     87.50%
Ruptured                     1     12.50%
Total                       08

Table 3. Popliteal Cysts

PCL tears accounted for a small number of cases 5(5%). Chernye et al11 stated that PCL is twice as strong as the ACL, with a large cross-sectional area and higher tensile strength thus accounting for a lower incidence of rupture of the PCL.

Collateral Ligament Injuries

Out of 7 patients with medial collateral ligament tear, 5 (71.42%) cases were found to have ACL tear. Turek SL13 stated that complete MCL rupture may be associated with tears of ACL.

Medial Collateral Ligament Injuries

Out of 7 patients with medial collateral ligament tear, 5 (71.42%) cases were found to have ACL tear. Turek SL13 stated that the lateral collateral ligament injury or disruption is less common than the injury to medial collateral ligament.

Lateral Collateral Ligament Injuries

Out of 3 patients with lateral collateral ligament tear, 3 (100%) had meniscal tears and 2 (66.66%) had PCL tears. According to Stoller D. W.14 injury or disruption of the LCL is significantly less common than the injury to the MCL. Also, he stated that LCL injuries may be seen in conjunction with an either ACL or PCL injury.

Chondromalacia Patellae

Plain radiographs of the knee cannot assess for chondral changes, and can only demonstrate features of osteoarthritis involving the patellofemoral joint in end-stage disease. In our study of 100 patients, 3 (3%) patients had chondromalacia patellae. The findings on MRI were articular cartilage defects in medial patellar facet, with exposed subchondral bone and underlying fluid, appearing hypointense on T1WI and hyperintense on FS-PD weighted images and STIR images. Barry S. Yulish et al15 in their study described that MR imaging is an accurate means of examining the posterior patellar cartilage and should be considered as an alternate to diagnostic arthroscopy when chondromalacia patellae is suspected.
Osteochondritis Dissecans
In our study of 2 (2%) patients showed osteochondritis dissecans. The findings on MRI were hypointense signal on T1W, T2W and PDW images and hyperintense on STIR images, in subchondral region of anteromedial portion of medial femoral condyle. In their study, BN Lakhkar et al also revealed that focal defects in the femoral condyle in osteochondritis dissecans were well demonstrated on coronal T2W1. Osteonecrosis is well depicted on MR imaging earlier than radiographic appearance.

Osteoarthritis
Out of 100 patients, 30 (30%) patients had changes of osteoarthritis and showed reduction in the medial compartment of the joint space, remodelling of the tibial and femoral condyle. Osteophytic changes were also seen in patella, at femoral and tibial condyle along with tibial spiking. Krishanu B et al described various MR findings in osteoarthritis of knee. Our findings correlated with these; however chondral fragments and loose bodies were not seen. Also, other abnormalities associated with osteoarthritis were bone marrow oedema, meniscal tears, effusion, baker cyst. This correlated with the study conducted by Peter R. Kornaat.16

Rheumatoid Arthritis
In our study, one patient presented with rheumatoid arthritis. The plain radiograph findings were osteoporosis, bony ankylosis between femur and tibia and a sclerotic band involving proximal shaft of tibia. MRI findings were severe degree bony ankylosis with wasting of surrounding muscles, non-visualisation of ACL, medial and lateral menisci, thinning of MCL and LCL and medial and lateral retinaculum. According to Gerhard Adam et al.17 radiographs depict bony changes directly whereas disease of the articular cartilage, menisci, ligaments and synovium are identified only indirectly. MR imaging has been proved to be useful in evaluating rheumatoid arthritis. Because of its high soft tissue contrast, MR demonstrates cartilaginous, soft tissue and bone marrow abnormalities.

Popliteal Cysts
Plain radiograph showed soft tissue swelling on the posterior aspect. In this study of 100 patients, 8 (8%) of them showed popliteal cysts out of which, one was a ruptured cyst. These were associated with meniscal tears, joint effusion and osteoarthritis. In a study conducted by John R Handy, of 400 patients, 77 (19%) were found to have popliteal cysts and a statistical correlation existed with effusion, meniscal tears, or “degenerative” arthropathy, or a combination of these 3 maladies.18

Tumours
In our study, two patients of tumours were studied, of which one was synovial sarcoma and the other was osteogenic sarcoma. Plain radiograph of osteogenic sarcoma revealed ill-defined lesion involving distal shaft of femur and adjacent soft tissue with destruction of cortex and few radio dense areas within it s/o calcification. Plain radiograph of synovial sarcoma revealed irregular soft tissue mass with few radiodense areas within it on antero-superior aspect of patella medially. D S Shetty et al in their study of 115 patients found tumour in five patients and found that MR demonstrates internal haemorrhage, intraarticular, marrow and soft tissue extension, with a great degree of accuracy.

Osseous Fractures
In this study, 2 (2%) patients had fracture of intercondylar tibial tubercle. Stoller DW et al19 in their study showed that fractures about the knee can involve the femoral condyle, tibial plateau and patella. However tibial plateau fractures are the most commonly seen.

Joint Effusion
Out of 100 patients, 87 (87%) cases had fluid accumulation in the central joint space and suprapatellar recess. Out of these cases, 48 (55.17%) cases showing accumulation in the suprapatellar recess. This was consistent with the findings of Kaneko K, et al20 stated that fluid preferentially accumulates in the suprapatellar recess and central portions of the joint in the traumatized knee.

Medial and Lateral Patellar Retinaculum Tears
In this study, 2 (2%) patients had medial patellar retinaculum tear and none had lateral patellar retinaculum tear. This corresponds with study conducted by Stephen F. Quinn, et al21 who in their study on 17 patients, found medial patellar retinaculum tear in 16 patients and lateral patellar retinaculum tear in 1 patient.

Osteomyelitis
In our study, there was one case of chronic osteomyelitis. Ali Nawaz Khan et al in their study showed that sensitivity and specificity of MRI are higher than those of plain radiography and CT; MRI is particularly good at depicting bone marrow abnormalities. On MRI, marrow signal abnormality is more sensitive than lytic changes on plain images, and findings become positive earlier in the disease process with MRI than with radiography. Intramedullary bone pathology may be directly visualized with MRI; in marrow with osteomyelitis, these findings may precede bone changes.

DISCUSSION

MRI is an accurate, non-invasive and a cost-effective means to evaluate a painful knee. The high degree of precision in interpretation of MR images and imaging in various planes and positioning the knee in 15-20° of external rotation and 5-10° of flexion aided in delineating the site and the full extent of the lesions. Out of 100 patients, 74 were men (74%) and 26 women (26%). 47 (47%) had derangements of the right knee while 53 (53%) had left sided derangements. The maximum numbers of patients were between 31-40 years (32%) of age. Of all patients, the commonest observed pathology was medial meniscal tears (80%) followed by anterior cruciate ligament tears (55%).
MRI has been proven to be effective in defining the various knee structures such as ligaments, tendons, menisci, cartilage, musculature and soft tissues and has proved to be an imaging modality of choice in defining damage to these structures thus providing an aid in planning the treatment if needed. Additional advantage of MR imaging is multiplanar and thin section capabilities and the ability to evaluate subchondral region and marrow. As a result, MR imaging is recommended instead of plain radiograph and CT for evaluation of occult knee fractures, including tibial plateau fractures of the knee. The utility of MRI is enhanced by confirming that it is the appropriate imaging modality and that it is interpreted correctly. Judicious use of MRI also requires asking if there is another more cost-effective means to reach a diagnosis and if the results of MRI are likely to change the management of problem. MRI has also proved beneficial in selection of the patients, in preoperative planning, as it accurately delineates the extent and severity of lesion, the degree of tear of meniscal lesions, the exact site of the pathology and also it detects the associated secondary signs with lesion. MRI also helps in diagnosis and in improving patient doctor communication (resulting in more meaningful informed consent). Magnetic Resonance Imaging (MRI) offers ever increasing options for diagnostic imaging of the knee. MRI is the modality of choice for diagnosing and characterizing various knee pathologies.

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