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Knee Pain Evaluation: MRI's Role in Comprehensive Diagnosis

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ABSTRACT

Introduction: Knee pain is a frequent and disabling issue that impacts people across all age groups, frequently arising from various underlying conditions such as ligament injuries, joint effusion, bone fractures, and osteoarthritis. Precise diagnosis is essential for effective treatment and better patient outcomes.

Aim: The study was aimed to evaluate the different knee joint pathologies.

Materials and Methods: The present study was a hospital based descriptive study conducted in a tertiary care centre in India (n=184). Patients being referred for the evaluation of painful knees were included in the study and evaluated by MRI scans performed using Siemens 1.5 Tesla High gradient MRI scanner. Results were analysed by a descriptive analysis.

Results: A total of 184 patients, including males aged 23-73 (mean age 44.86) and females aged 22-78 (mean age 45.17). Comprehensive medical histories were collected, showing the majority had trauma (n=93) followed by pain (n=82). Few patients were referred for follow- up studies. The study revealed that most patients had ligament injuries with joint effusion (n=42, 22.9%), followed by ligament tears (n=31, 16.84%), knee joint effusion (n=23, 12.5%), chondromalacia patella (n=19, 10.3%), and osteoarthritis (n=18, 9.8%).

Conclusion: MRI is effective in diagnosing knee conditions like ligament injuries, joint effusion, fractures, and osteoarthritis, with significant clinical implications. MRI, being reliable, cost-effective, and non-invasive, provides detailed knee joint evaluations, aiding in surgical decisions and chronic issue assessments without requiring intravenous contrast agents.

Keywords: *Meniscus, Osteoarthritis, ligament, Magnetic Resonance Imaging, Patellar*

1. INTRODUCTION

The evolution of Magnetic Resonance Imaging (MRI) technology has revolutionised knee joint imaging, enabling precise visualisation and assessment of bones, ligaments, tendons, and menisci. MRI has improved diagnosis, management, and monitoring of knee conditions, including osteoarthritis, ligament injuries, and meniscal tears. Its superior spatial resolution and soft tissue contrast facilitate accurate diagnoses and informed treatment decisions, making it an indispensable tool for orthopaedic surgeons and radiologists, particularly in diagnosing and managing knee pain, often caused by osteoarthritis, the most common pain problem among older individuals [1]. Osteoarthritis (OA) affects 22% to 39% of India's population, making it the second most common rheumatologic problem. This degenerative joint disease causes pain, stiffness, and limited mobility, commonly in weight-bearing joints. Factors like ageing, obesity, and lack of physical activity contribute to its high prevalence, emphasising the need for awareness and early diagnosis. [2,3]. Knee pain can stem from various conditions, making accurate diagnosis crucial for effective treatment. A thorough evaluation is essential to identify the root cause, as misdiagnosis can lead to inadequate treatment and prolonged suffering. Globally, 250 million people suffer from knee osteoarthritis, with numbers expected to rise due to an ageing population and increasing obesity rates, highlighting the need for prompt and precise diagnosis to improve quality of life. [4]. Knee pain affects people of all ages and lifestyles, triggered by various factors such as injuries, overuse, or underlying medical conditions. It can be caused by sports injuries, osteoarthritis, poor posture, or weak muscles, and can significantly impact daily life [5]. MRI plays a vital role in the evaluation of knee pain by providing high-resolution, detailed anatomical images that enable clinicians to accurately diagnose and effectively manage a broad range of underlying conditions, including soft tissue injuries, bone-related disorders, and degenerative diseases. By offering a precise, non-invasive, and cost-effective means to evaluate a painful knee, MRI allows clinicians to identify complex conditions, such as ligament sprains, meniscal tears, and osteoarthritis, and develop targeted treatment plans, including surgical interventions, physical therapy, and pain management strategies, to improve patient

outcomes [6,7]. Magnetic Resonance Imaging (MRI) stands out as the premier diagnostic tool for evaluating soft tissue structures within the knee joint, offering unparalleled contrast resolution for ligaments, tendons, cartilage, muscles, and synovial tissue. This exceptional capability makes MRI the gold standard for diagnosing acute traumatic knee pain, as it enables clinicians to rapidly and definitively identify injuries, thereby facilitating timely and effective treatment. In many cases, MRI can even replace more invasive techniques like arthroscopy or surgical exploration, to diagnose knee injuries, making it a safer and more efficient option for patients. Magnetic Resonance Imaging has gained popularity as a diagnostic tool of the musculoskeletal disorders, especially for the knee joint which is the most frequently examined joint and vulnerable to trauma in cases of accidents, sports related injury, fall on ground, twisting injury etc [8,9]. MRI is perfect for evaluating knee pain because it's safe, non- invasive, and provides very detailed images. This precision helps doctors make an accurate diagnosis and develop an effective treatment plan, leading to better care for patients with knee pain.[10]. MRI of the knee can play a crucial role in the surgical process, extending its utility beyond pre-operative diagnosis to intra-operative guidance and post-operative monitoring. MRI can be used to track the healing progress after surgery, allowing doctors to assess the effectiveness of the procedure, detect any postoperative complications, and optimise rehabilitation protocols. By doing so, MRI can help ensure optimal surgical outcomes, reduce the risk of complications, and facilitate a faster and more effective recovery for patients undergoing knee surgery [11].

2. MATERIAL AND METHODS

This study was a hospital based prospective, diagnostic descriptive study conducted in the tertiary centre in Hyderabad India. The study was carried out among 184 patients referred for MRI knee due to various clinical history of knee pain over a period of 7 months. The ethical clearance from the Institute was obtained before starting the study and written informed consents were taken before enrolling the patients.

Inclusion Criteria: All patients referred for MRI knee of either one or both knees having a clinical history of knee joint pain, fall injury, road traffic accident (R.T.A) and old history of trauma were included in this study

Exclusion Criteria:

- Patients contraindicated for MRI due to cardiac pacemakers and other metallic implants.
- Claustrophobic patients and post-operative patients.
- History of knee surgery or joint replacement
- Patients with known joint disease e.g.: Neoplasm, inflammatory or infectious disorder. **MRI Protocol**: MR scans were carried out GE Excite Sigma 1.5 Tesla MRI scanner using an eight-channel phased-array volume knee coil. Patient was placed in supine position with feet first orientation in MRI Scanner, and the knee to be imaged was approximately externally rotated 15-20-degree in for imaging anterior cruciate ligament in the sagittal plane. Localizers were taken in three different planes after positioning the patient. The MRI protocol consisted of sagittal T2W,T2 WFFE, PDSPIR sequences; coronal PD, T2W, STIR sequences. The parameters included slice thickness of 4 mm, slice gap of 0.5 mm, Field of View (FOV) as 150mm and a matrix size of 212 x 168 matrix were taken.

Data Collection and Data Analysis: A detailed data of a patient including Age, Gender, Body weight, Clinical History and MRI findings were tabulated. MR findings were recorded in a Performa and correlated with clinical observations/ other radiological investigations. Descriptive Analysis was used for analysing the data.

3. RESULTS

This prospective study was conducted over a period of 7 months at a private hospital in Hyderabad, India. The primary objective of our study was to investigate the role of Magnetic Resonance Imaging (MRI) in evaluating various knee pathologies, including the diagnosis and underlying causes of knee pain. A total of 184 patients were included in this study, all of whom presented with knee-related symptoms such as knee pain, trauma, walking difficulties, or required follow-up investigations. These patients were referred for MRI knee examinations, which provided a comprehensive evaluation of their knee joint. By analysing the MRI findings of these patients, we aimed to gain a deeper understanding of the diagnostic capabilities of MRI in knee pathology and its potential to inform treatment decisions. The majority of the patients in this study were male (n=127, 69.02 %) and a lesser number of female patients were reported for the study(n=57, 30.98%) (Figure 1).

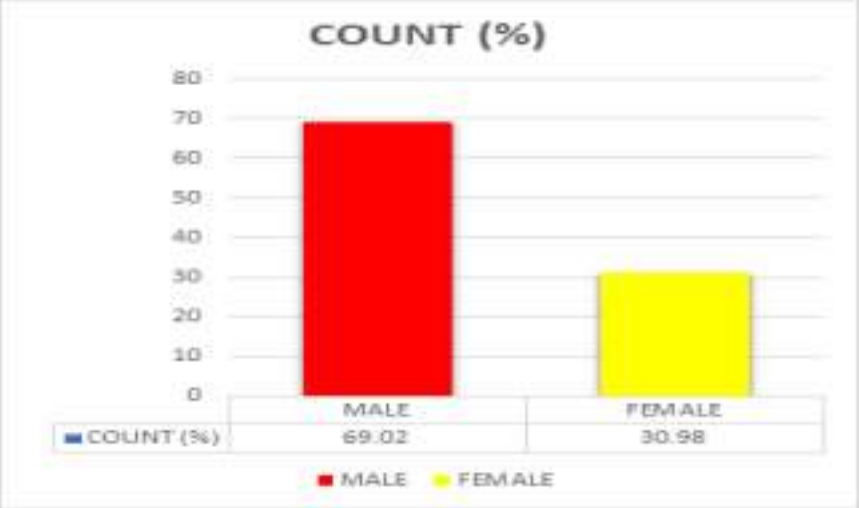

Figure-1 Graph showing the distribution of patient based on gender

A sample size of 184 was selected, comprising male patients between the ages of 23 and 73 years, with a mean age of 44.86 years, and female patients between the ages of 22 and 78 years, with a mean age of 45.17 years. This age range was chosen to ensure a diverse representation of adults across different stages of life, from young adulthood to older adulthood, allowing for a more comprehensive understanding of the research topic. (**Table 1)**.

GENDER	**Minimum age (in years)**	**Maximum age (in years)**	**Mean (in years)**
Male	23	73	44.86
Female	22	78	45.17

Table-1: Age Distribution of Patients

During the data collection process, we gathered comprehensive medical histories from the

patients who underwent examination, revealing that the majority of patients (n=93) had a history of trauma, followed closely by those experiencing pain (n=82). In contrast, a relatively small number of patients were referred for follow-up studies. Notably, the disproportionately high ratio of trauma patients in our sample suggests that the hospital has a significant role in providing emergency care, with a substantial volume of patients presenting with acute injuries or traumatic events. (Figure-2).

Figure-2 Graph showing the distribution of patients based on clinical history.

Our study showed that majority of the patient had ligament injury with joint effusion followed by ligament tear, Knee Joint Effusion, Chondromalacia Patella and Osteoarthritis at a rate of n= 42; 22.9%, n= 31; 16.84%, n= 23; 12.5%, n= 19; 10.3% and n= 18; 9.8% respectively as shown in **Table 2.**

Pathology	**No of patients**	**Percentage (%)**
Ligament Tear	31	16.84
Ligament Tear with knee joint effusion	42	22.9
Bone Fracture	8	4.3
Synovial Chondromas	18	9.8
Osteoarthritis	18	9.8
Patellar Pathologies	31	16.84
Bony Bruise and Edema	13	7.06
Knee Joint Effusion	23	12.5
Total	**184**	**100**

Table 2: Distribution of patients according to knee pathology

4. DISCUSSION

This study was an observational analysis of the various knee pathologies detected by MR imaging. A total of 184 patients were included, having a history of knee pain, trauma and follow up. Knee joint pain is a common symptom among the elderly patients whereas trauma occurs mostly in the people who are physically active. Majority of our study participants were males (69.02%) and the most common history was found to be trauma which indicated that there was a major contribution of traumatic patients in the study. Through the course of time the detection of Knee joint pathologies has been advanced as per the need of the patient. Initially the knee joint was examined using X-ray instrumentation, meanwhile it was replaced by CT scan in case of bone traumas and MRI for the detection of soft tissue anomalies. Using MRI we could easily examine the pathologies of the ligaments which includes Anterior Cruciate Ligament(ACL), Posterior Cruciate ligament(PCL), lateral collateral Ligament(LCL) and medial collateral ligament (MCL).Apart from that the joint space in the knee is also clearly evaluated using different sequences. Mostly the ligament injury is visualised using T2 weighted sequence in the knee protocol which is followed by proton density weighted sequence also used in examining the Knee Effusion. The present study aimed to investigate the role of MRI in evaluating various knee pathologies in a diverse sample of adults, consisting of 184 patients with a majority being male (69.02%) and a lesser number of female patients (30.98%), with an age range spanning from 22 to 78 years, chosen to ensure a representative sample of adults across different stages of life. Our findings highlight the importance of MRI evaluation in detecting a range of knee injuries and conditions, which can inform treatment decisions and improve patient outcomes.

The findings of our study, which revealed a high incidence of ligament injuries, with a notable predominance of Anterior Cruciate Ligament (ACL) tears (51.6% of 31 patients), are in line with the existing studies done by Johnson et al. and Kaplan

et al., which has reported a similar pattern of ligament injuries in knee (12,13).The majority of ligament tears in our study involved the posterior horn of the meniscus (74.2 % of 31 patients), a finding that demands further discussion. This may be attributed to the unique anatomical structure of the knee joint, which renders the posterior horn more susceptible to injury due to its critical role in load transmission, shock absorption, and joint stability, as well as its proximity to the tibial plateau and posterior cruciate ligament (PCL).

Ligament Tear- In our study, MRI scans of the knee revealed ligament tears in 16.84% of patients. Specifically, 51.6% of these tears were isolated ACL tears, 25.8% were PCL tears, and 22.6% were MCL tears. The posterior horn was affected in 74.2% of the tears, while the anterior horn was affected in 25.8%. This analysis suggests that the posterior horn is more commonly involved in ligament tears of the knee, with ACL and PCL tears being more prevalent than MCL tears.

Ligament tear with Knee Joint Effusion- In addition to ligament tears, 42 patients (22.9% of the total sample) were found to have ligament tear with knee joint effusion, a condition characterised by an abnormal accumulation of fluid in the knee joint. Of these, 33 patients (78.6%) had mild joint effusion, while 9 patients (21.4%) had severe joint effusion with ligament tears. A distinct group comprising 23 patients was diagnosed exclusively with knee joint effusion. This indicates that, in addition to other conditions observed, there was a notable subset of patients who only exhibited fluid accumulation within the knee joint.

Bone Fractures- In addition to ligament tears and knee joint effusion, our study also identified a smaller but significant number of patients with bone fractures. Specifically, 8 patients (4.3% of the total sample) were diagnosed with bone fractures, highlighting the importance of comprehensive evaluation of the knee joint. Upon further analysis, we found that the fracture sites varied among these patients. The most common site of fracture was the tibia, which was affected in 4 patients (50% of bone fractures). The patella was the second most common site, with 3 patients (37.5% of bone fractures) experiencing fractures in this area. Finally, 1 patient (12.5% of bone fractures) had a fracture in the femur. Bony bruises were observed in 13 patients, accounting for 7.06% of the study population. These bruises were specifically located in the intercondylar region, which is the area between the condyles of the tibia and femur. This finding highlights a relatively small but significant portion of patients with injuries in this critical joint region.

Osteoarthritis- We investigated the presence of osteoarthritis (OA) in the knee joint using MRI. Notably, 9 patients (15% of the total sample) exhibited MRI changes suggestive of osteoarthritis. A closer examination of these patients revealed that the medial compartment was the most commonly affected area, with 5 patients (55.50% of OA cases) showing signs of OA in this region. In contrast, only 1 patient (11.11% of OA cases) had OA involvement in the lateral compartment. Interestingly, 1 patient (11.11% of OA cases) had bilateral compartment involvement, highlighting the complexity of OA in some cases. Furthermore, our analysis showed that the patellofemoral compartment was involved in 6 patients (66.66% of OA cases), which is a common site for OA to occur. In fact, the patellofemoral joint is a common area where OA can develop, leading to pain and stiffness in the front of the knee. To illustrate these findings, we have included an MR image of a study patient showing patello-femoral arthritis,

which demonstrates the characteristic features of OA in this compartment. It's worth noting that when we expanded our analysis to the entire sample, we found that 18 patients (9.8% of the total sample) exhibited MRI changes suggestive of osteoarthritis.

Patellar Pathologies: A total of 31 patients were diagnosed with various patella-related pathologies. Among these patients, Chondromalacia patellae was identified in 19 individuals, representing 10.3% of the study population. This means that approximately 1 in 10 patients had this condition, which involves the softening and breakdown of the cartilage on the underside of the patella classified into grades based on their severity. Of the 19 patients with Chondromalacia patellae, 11 had Grade 1, indicating mild cartilage damage, 5 had Grade 2, indicating moderate damage, and the remaining 3 had Grade 3, signifying more severe cartilage deterioration. Synovial Chondromas were found in another 18 patients, accounting for 9.8% of the overall patient population. This condition involves the formation of benign cartilaginous nodules within the synovium of the knee joint and affects nearly 10% of the patients studied.

The mechanisms of injury contributing to posterior horn tears are multifaceted, including sudden deceleration or twisting movements that can cause the meniscus to become trapped between the femoral condyle and tibial plateau, leading to tears, as well as the posterior horn's vulnerability to injury in cases of PCL tears or avulsions. Notably, the posterior horn's role in load transmission and joint stability makes it prone to injury due to significant stress and strain, particularly in cases of repetitive trauma or chronic joint instability, where it may be repeatedly subjected to excessive stress, ultimately leading to tears or degenerative changes. The presence of joint effusion, particularly mild joint effusion, was also common in our study, a finding that validates the existing study and reinforces the notion that joint effusion is a frequent accompaniment to meniscal tears, as demonstrated by numerous prior investigations that have similarly reported a high incidence of joint effusion in patients with meniscal pathology(14). The connection between ligament tears and joint effusion shows that doctors need to do a thorough check of the knee joint to make sure they find all the problems and treat them correctly. The fact that we found bone fractures(7.06%), bony bruises(4.3%), and osteoarthritis (15%) in our study reveals a limitation of relying solely on physical examination and X-rays to diagnose knee problems. However the number of patients were not significant. These

methods can miss important details, such as tiny cracks in the bone, bleeding or bruising within the bone, or wear and tear on the joints. MRI scans, on the other hand, offer a more detailed and accurate view of the knee's internal structures, allowing doctors to detect these subtle but important issues. The high number of osteoarthritis cases we found in the medial compartment of the knee is not surprising, given what previous research has already shown (15). The medial compartment is the part of the knee joint that is located on the inside of the knee, closest to the other leg. This medial compartment bears more weight and stress than other parts of the knee joint, making it more susceptible to

damage and osteoarthritis. Our study found a high number of cases of Chondromalacia patellae and Synovial Chondromas, highlighting the need for thorough examination of the patella and surrounding tissues. Chondromalacia patellae is a condition where the cartilage on the underside of the patella becomes damaged, causing knee pain and stiffness. Synovial Chondromas are benign tumours that grow in the knee joint lining. Both conditions can be easily missed during routine exams or X-rays, but can have significant consequences if left untreated. If not properly diagnosed and treated, they can lead to chronic pain, limited mobility, and even osteoarthritis. Our study highlights the need for a comprehensive approach to evaluating and treating knee injuries and conditions. The high prevalence of ligament injuries and joint effusion emphasizes the importance of MRI evaluation in patients with knee trauma or pain, as early diagnosis is crucial for appropriate treatment and preventing long-term complications. Comprehensive evaluation of the entire knee joint is also necessary to identify all potential injuries or conditions and develop an effective treatment plan. Furthermore,

evaluation of the patella and surrounding soft tissues is important to identify conditions that can be easily missed, such as Chondromalacia patellae and Synovial Chondromas.

5. CONCLUSION

Our study provides compelling evidence for the diagnostic utility of MRI in knee pathology, encompassing a range of conditions including ligament injuries, joint effusion, bone fractures, and osteoarthritis. The results of this study have significant implications for clinical practice, as they can inform treatment decisions and ultimately improve patient outcomes. As such, we emphasise the importance of incorporating MRI evaluation into the management of knee related symptoms, enabling healthcare providers to deliver high-quality, personalised care to their patients. Magnetic Resonance Imaging (MRI) has become the most commonly used diagnostic tool for evaluating knee problems. MRI is a reliable, cost-effective, and non invasive technique that provides a comprehensive assessment of the knee joint. MRI offers a non- invasive and non-ionizing alternative that can provide detailed information about the surface and internal abnormalities of ligaments and menisci. The anterior cruciate ligament and medial meniscus are the most commonly injured structures, and MRI is highly accurate in diagnosing meniscal tears and ACL pathologies. By describing the morphology and location of meniscal tears, MRI can help orthopaedic surgeons decide whether to perform primary repair or partial meniscectomy. Furthermore, MRI can guide surgical management in cases with indeterminate clinical findings and is particularly useful in evaluating chronic knee abnormalities unrelated to acute trauma. Overall, MRI is an accurate, cost-effective, and non

invasive modality that provides valuable information about the anatomy of the knee joint without the need for intravenous contrast agents.

6. LIMITATIONS

While this study demonstrates the diagnostic capabilities of MRI in knee pathology, several limitations are acknowledged below:

1. **Sample size:** Although our study comprised 184 patients, a larger sample size may have provided more robust results and increased the generalizability of our findings. 2. **1.5**

Tesla MRI setup: The use of a 1.5 Tesla MRI setup may have limited the resolution and sensitivity of the images obtained, potentially affecting the accuracy of diagnoses. Future studies using higher-field strength MRI machines (e.g., 3.0 Tesla) may provide more detailed images and improved diagnostic capabilities.

3. **Limited generalizability:** Our study was conducted in a single centre, which may limit the generalizability of our findings to other populations and healthcare settings. Future studies should aim to recruit patients from diverse backgrounds and settings. 4. **Cost and accessibility:** The use of MRI may not be feasible or accessible in all

healthcare settings due to cost and resource constraints. Future studies should consider the cost-effectiveness and accessibility of MRI in different healthcare contexts.

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