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Role of Magnetic Resonance Imaging in Evaluation of Painful Knee Joint

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Abstract: ***Since its advent, MRI has advanced musculoskeletal imaging. Today, it one of the best modality for assessing the internal structures of the knee, like menisci, cruciate ligaments, and articular cartilage, because of its unparalleled accuracy and non-invasive nature. Purpose: Our aim is to understand the role of MRI in various traumatic and non-traumatic lesions that cause knee discomfort or pain. Materials and methods: Setting: At a tertiary level hospital, patients with painful knee joints who were referred from other hospitals, orthopaedic clinics to the Department of Radiology at SLIMS, Pondicherry. Patients: 70 participants with knee joint discomfort were selected for the study. Investigations: After examining clinically, MRI was performed. Patients who were recommended arthroscopy were followed and observations were corelated. Main Outcome Measures: A variety of MRI findings in various etiologies were studied. MRI was compared with arthroscopy/surgical findings in selected cases. Results: MRI revealed meniscal tears primarily affecting the medial meniscus and the posterior horn. These tears were predominantly reported as grade 3. Among ligament tears, the ACL was most frequently involved. Rest of the chronic causes were minimal. Conclusion: MRI stands out as a precise and non-invasive technology for exploring the soft tissues and osseous structures of the knee. Its high diagnostic accuracy makes it invaluable for identifying and classifying meniscal tears, thus potentially reducing the need for unnecessary arthroscopic procedures. MRI is particularly effective in detecting complete ACL tears and meniscal tears that might be challenging to identify through arthroscopy. Additionally, it provides comprehensive insights into various knee pathologies, aiding in the development of targeted and effective treatment plans. This analysis reinforces the role of MRI as a crucial technique for assessment and management of both traumatic as well as non-traumatic knee conditions.***

Keywords: Magnetic Resonance Imaging (MRI), painful knee joint, meniscal tears, anterior cruciate ligament (ACL) injuries, posterior cruciate ligament (PCL) injuries

1. Introduction

Human knee, a complex and crucial joint, plays an integral role in mobility and weight-bearing activities. However, the prevalence of knee pain has become a significant healthcare concern globally, affecting individuals across various age groups and demographics. Painful knee conditions can arise from a number of factors, such as trauma, inflammation, degenerative changes, and structural abnormalities. Diagnosing the underlying causes of knee pain is a challenging task that demands accurate and detailed imaging methods. MRI has evolved into a crucial tool for assessing and evaluating painful knee joints due to its non-invasiveness and its unique ability to produce high-resolution images of soft tissues. (1)

Our observational study aims to investigate the importance of MRI in the thorough assessment of painful knee joints, highlighting its diagnostic efficacy, strengths, and limitations. (2)

In clinical practice, knee pain is a frequent complaint, leading to a substantial economic burden and compromised quality of life for affected individuals. Although a thorough clinical examination and patient history are essential in the diagnostic process, they may not always provide enough information to accurately identify the underlying causes of knee pain. Radiological imaging, especially MRI, has evolved as an indispensable diagnostic tool for evaluating the complex structures within the knee joint. (3)
Bones, cartilage, ligaments, tendons, and synovial tissues are all part of knee joint, out of these anything can be sources of pain and dysfunction. Trauma, osteoarthritis, rheumatoid arthritis, meniscal tears, ligamentous injuries, and inflammatory conditions are among the pathologies that can afflict the knee joint. Traditional imaging methods like X-rays fall short in capturing soft tissue abnormalities, which makes MRI the most favoured imaging modality for a complete examination of knee joint structure.(4)

MRI has transformed the field of musculoskeletal imaging, providing clinicians with a non-invasive and exceptionally detailed view of the knee's internal structures. Unlike X-rays and CT scans, which are mainly used to visualize bone anatomy, MRI is particularly effective in imaging soft tissues. This makes it the preferred method for assessing synovium, ligaments, tendons and the cartilage of the knee joint. Recent technological advancements, like high-field strength magnets and specialized pulse sequences, have significantly enhanced the diagnostic power of MRI. (5)

MRI's capability to distinguish between different soft tissues enables a thorough evaluation of the knee joint., enabling the identification of subtle abnormalities that may elude other imaging modalities. Furthermore, the absence of ionizing radiation in MRI makes it a safer option for repeated imaging, a crucial consideration in chronic conditions requiring longitudinal assessment.(6)

Numerous studies have documented the superior diagnostic accuracy of MRI in detecting and characterizing a spectrum of knee pathologies. In cases of ligamentous injuries, MRI not only identifies the presence of tears but also provides crucial information in terms of span and location of the injury, aiding

in surgical planning. Meniscal tears, common contributors to knee pain, are well-delineated on MRI, facilitating timely intervention and preventing further joint damage.[7,8]

With continues technological advancement, The MRI of knee in future holds promising developments. Emerging techniques like magnetic resonance arthrography and quantitative MRI aim to deliver even more detailed information about the knee joint, further enhancing diagnostic accuracy. Moreover, efforts to address the challenges of accessibility and cost may broaden the applicability of MRI in diverse healthcare settings.[9]

In conclusion, this observational study strives to deliver comprehensive insights into the essential importance of MRI in the diagnosis and assessment of painful knee joints. By examining the historical evolution, diagnostic efficacy, and challenges associated with MRI, we aim to foster a deeper understanding of its place in clinical practice. [10]

2. Aims & Objectives

Aim
To study and analyse the role of MRI in the assessment of painful knee joints.

Objectives
1) To analyse the different kinds of traumatic and non-traumatic lesions that are producing knee discomfort.
2) To pinpoint the common lesions that frequently impact the knee joint.
3) To assess the types of knee joint abnormalities identified by MRI, aiding in accurate diagnosis.

3. Methods

Study Design
This was a cross-sectional observational study conducted over a two-year period in the Department of Radiology, Sri Lakshmi Narayana Institute of Medical Sciences, Puducherry.

Study Population
Seventy patients aged between 14 and 65 years, presenting with knee pain of varying durations, were recruited. Patients were referred from orthopedic clinics, general practitioners, and tertiary care centers.

Inclusion Criteria
- Individuals aged 14 years or older with symptomatic knee pain.
- Patients who consented to MRI evaluation.

Exclusion Criteria
- Contraindications to MRI, such as pacemakers or metallic implants.
- Pregnant individuals.
- Patients with knee surgery within six months or known knee joint infections.

MRI Protocol
MRI scans were performed using a Siemens Magnetom Essenza 1.5T unit. The imaging protocol included:

- **T1-weighted sequences** for anatomical detail and bone marrow evaluation.
- **T2-weighted and proton density (PD)-weighted images** for soft tissue and cartilage assessment.
- **Fat-suppressed sequences** to highlight bone marrow edema and fluid collections.
- Multiplanar imaging in sagittal, coronal, and axial planes for comprehensive evaluation.

Data Collection
Patient demographics, clinical history, and MRI findings were documented. A subset of 30 patients underwent arthroscopy for comparative analysis. Data were recorded in a structured format to facilitate correlation and statistical analysis.

Statistical Analysis
The diagnostic accuracy of MRI was calculated by comparing imaging findings with arthroscopy results. Descriptive statistics were used to summarize patient demographics, and imaging findings were expressed as percentages.

4. Results

This study consists of 70 patients, the age of the patient who presented with knee pain ranged from 14 to 65 years of age, with a mean age of 35.03 years. Most of the patients who were affected were between 21 to 40 years of age **(Figure 1).** Out of 70 patients, 39 were males and 31 were females, which is 55.7 % and 44.2 % respectively **(table 1, Figure 2)**. There were 40 meniscal tears in 34 (48.5%) patients out of which, 22 (64.7%) patients had isolated medial meniscal tear, 6 (17%) patients had isolated lateral meniscus and 6 (17 %) patients had tear of both the menisci **(table 2, Figure 3)**. Out of 40 meniscal tears, 30 (75%) tears involved the posterior horns, 4(10 %) tears involved the anterior horns, and 6 (15%) tears involved the body of the meniscus **(Figure 4)**.

In this study, 28 out of 40 meniscal tears were medial meniscal tears, in which Grade I tears were 3, Grade II were 9 and Grade III were 16 in number. Posterior horn was involved in 23 tears of medial meniscus and 5 tears involved the body of the meniscus **(Figure 5)**.

Out of 40 tears, 12 were lateral meniscal tear in which it was found that Grade III tear were 11 and Grade I tear was seen in 1 patient only. Posterior horn was involved in 7 cases while anterior horn and body was involved in 4 and 1 tears respectively **(Figure 6)**.

In our study, we were able to classify 36 out of 40 tears into types which involved vertical tears, horizontal tears, bucket handle tears. While remaining were complex tears **(Figure 7)**. 3/5 bucket handle tears involved medial meniscus, while the other 2 involved lateral meniscus. **(Figure 8)**

25 out of 70 patients had ACL pathologies and in these 25 patients, 21 had ACL tears, out of these 21 patients, 16 had acute complete tear, 3 had acute partial tear, 2 had chronic ACL tears and 4 had myxoid degeneration**. (Figure 9)**

Our study had only 3 (out of 70) patients with PCL tear, 1 had a partial tear and the other 2 had complete PCL tear. **(Table 3)**
20 patients presented with medial collateral ligament tear (MCL) and among these 20 patients, 4 (20 %) had Grade I tear, 7 (35%) had grade 2 tears and 9 (45%) had grade 3 tears. **(Figure 10)**

3 patients presented with LCL tears and among these patients, 2 had Grade 1 sprain and 1 patient had grade II sprain.

9 out of 70 patients were reported of having bone contusion and out of these, 7 patients also had an acute ACL tear. It was seen that femur (9) had more common occurrence of bone contusion as compared to tibia (4). The antero-lateral femoral condylar contusions (8) were more common in occurrence than medial femoral condyle (1). Antero-lateral femoral condylar contusions (8 out 13) were most involved followed by posterolateral tibial condylar contusion (4/13). 5 patients out of 9 patients with bone contusion also had MCL tears.

9 patients reported to have 11 bone fractures, in which 6 fractures were involving the tibia, 2 fractures involved the femur, 1 fracture was observed in the fibular head and the patella was involved in 2 fractures **(Figure 11).**

There were only 3 patients who presented with chondromalacia patella. Out of these, 2 were males and 1 was a female. 1 patient showed grade I and 2 patients showed grade II.

The present study had 8 patients with a total of 8 cysts. Out of these, 2 patients were reported to have baker's cyst, 2 patients had para-meniscal cyst, and 4 patients had ganglion cysts. Both of the two para-meniscal cysts involved the medial meniscus and were associated with horizontal meniscal tears **(Figure 12)**.

3 out of 70 patients were reported to have a neoplastic lesion. A giant cell tumour, a synovial sarcoma and a patient was suspected to have chondrosarcoma.

10 out of 70 patients showed changes suggestive of osteoarthritis on MRI, among the 10 patients medial compartment was involved in 5 patients, lateral compartment was involved in 2 patients, and both the compartments were involved in 3 patients **(Table 4)**.

5 out of 70 patients had synovial hypertrophy including 1 patient with nodular hypertrophy.

In our study 30 out of 70 patients were followed up with arthroscopy. In these 30 patients, a total of 44 tears were noted on MRI. Out of these, 19 were ACL tears, 13 were medial meniscus tears,10 were lateral meniscus tears and 2 were PCL tears. In the 19 reported cases of ACL tears on MRI when followed on arthroscopy only 15 were confirmed. Majority of the cases corelating with arthroscopy were complete ACL tears. In 2 reported case of PCL on MRI both were confirmed on arthroscopy.

Medial meniscal tear was seen in 13 patients on MRI out of them 11 patients correlated on arthroscopy. Grade III tear was most common in these patients.

Lateral meniscal tear was seen in 10 patients on MRI out of them 8 patients correlated on arthroscopy. 36 out of 44 tears were corelated on arthroscopy.

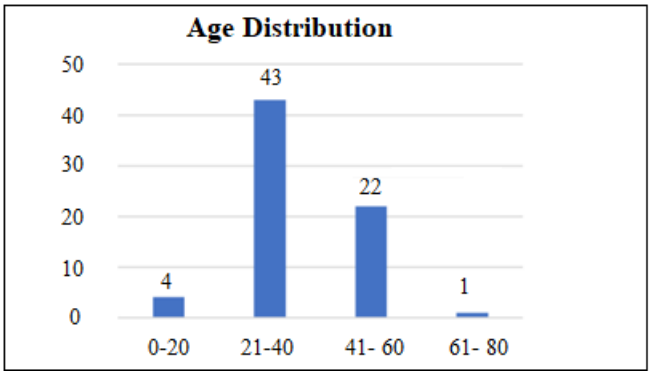

Figure 1: This chart represents age distribution of the patients with painful knee joints

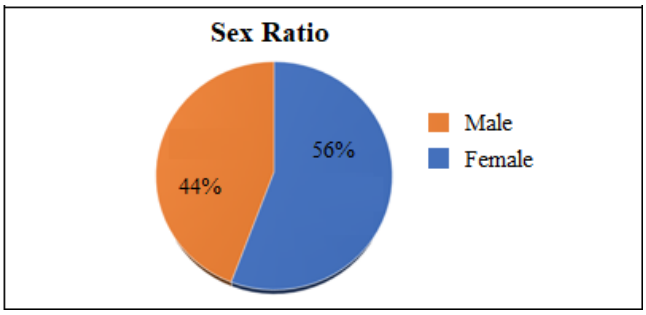

Figure 2: This pie chart is a representation of percentage of male and female in the study population

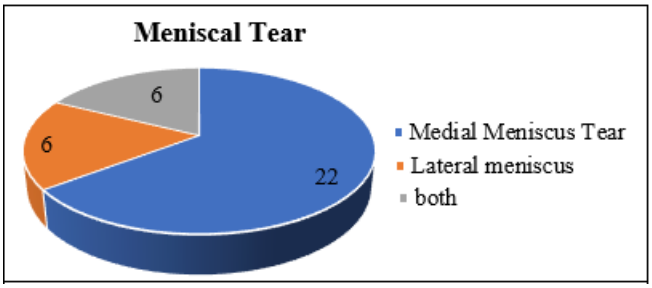

Figure 3: This pie chart is displaying the distribution of tears between the Medial and Lateral Meniscus

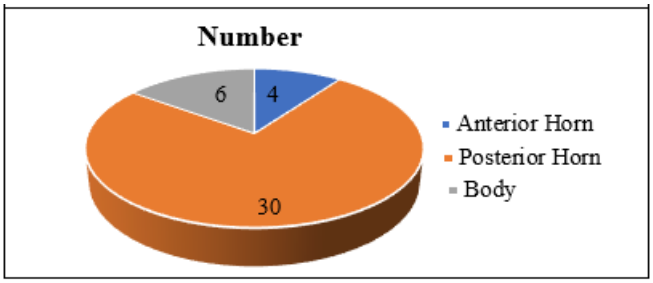

Figure 4: This pie chart is a depiction of distribution of tears of the anterior, posterior horn and body of the meniscus

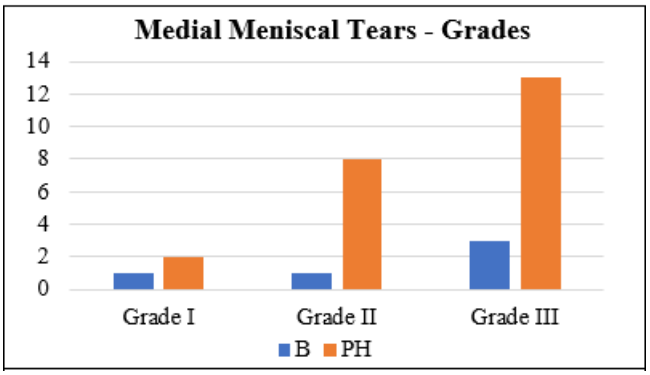

Figure 5: This chart is a depiction of Distribution of grades of meniscal tears among the different parts of medial meniscus

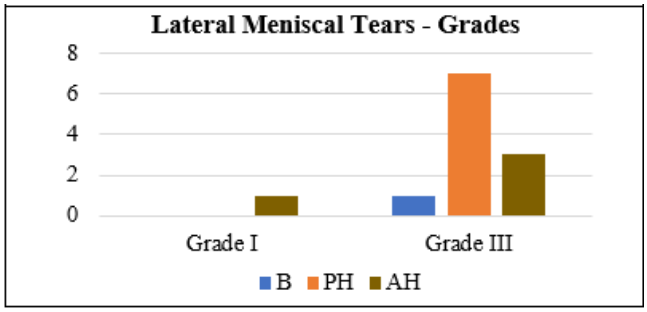

Figure 6: This chart is a depiction of Grades of meniscal tears distributed among the different regions of the lateral meniscus

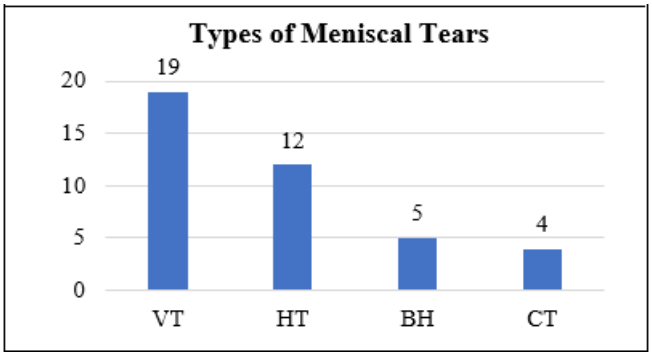

Figure 7: This chart is a depiction of meniscal tears distributed in different types

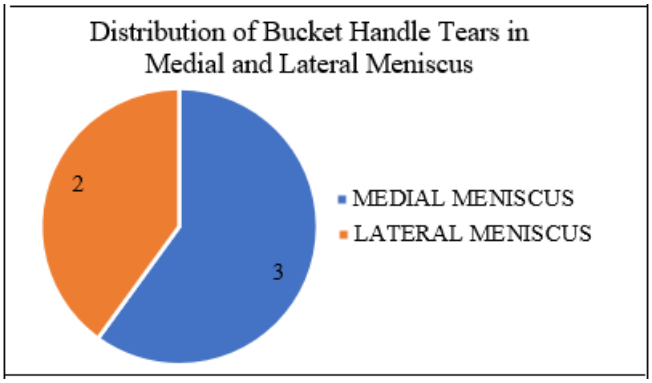

Figure 8: This pie chart depicts involvement of medial and lateral meniscus in case of bucket handle tear

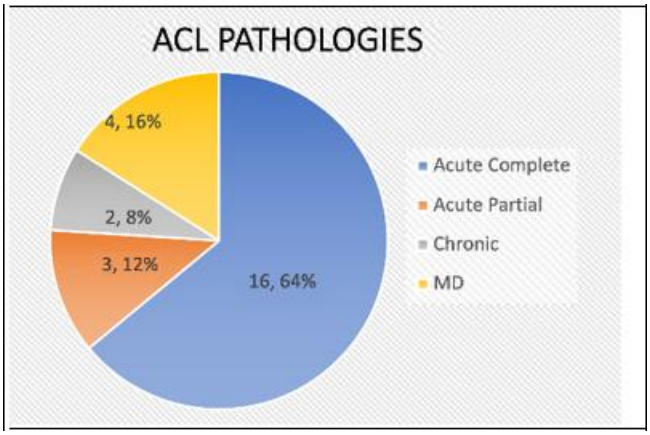

Figure 9: This pie chart depicts different ACL pathologies distribution

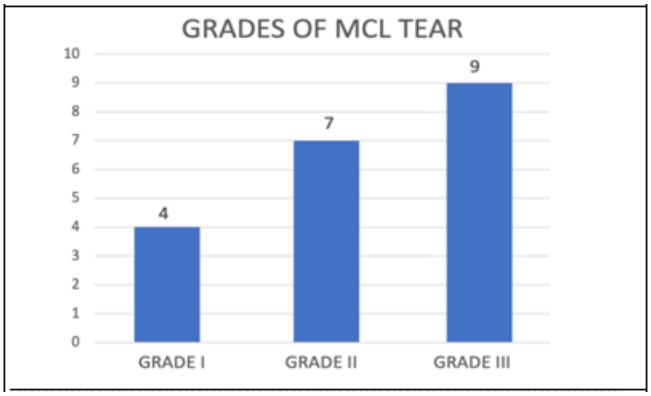

Figure 10: This bar diagram is a representation of different MCL tear grades.

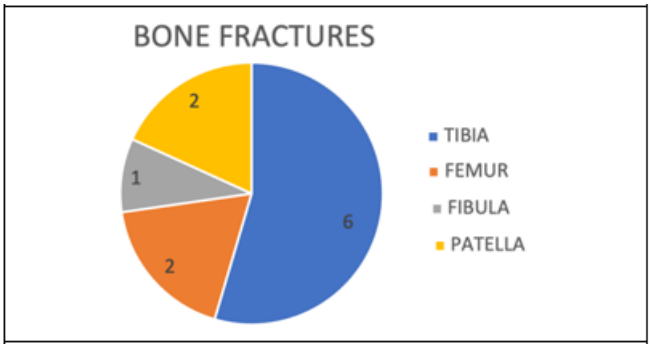

Figure 11: This chart represents fracture distribution in bones around the knee joint

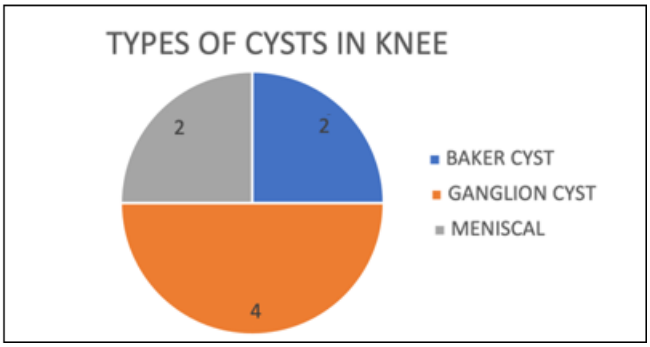

Figure 12: Shows the Variety of Cysts Distribution

Table 1: Table on sex distribution

Sex	Number of Patients
Male	39 (56 %)
Female	31(44 %)
Total	70

Table 2: Table showing percentage of involvement of meniscal tears.

Tear	Number and Percentage
Medial Meniscus	28(70 %)
Lateral Meniscus	12(30 %)
Total	40

Table 3: Showing prevalence and percentage of different types of PCL tear

PCL Tear	Number and Percentage
Partial	1(33%)
Complete	2(66%)
Total PCL Tear	3
Total Number of Patients in this Study	70
Prevalence of PCL Tear in this Study	4%

Table 4: Arthritis cases number and prevalence

Arthritis	Number and Percentage
Medial Compartment	5/10(50 %)
Lateral Compartment	2/10(2%)
Both Compartment	3/10(30%)
Total Arthritis Cases	10
Total Number of Cases	70
Prevalence In This Study	10/70(14.2 %)

5. Discussion

Anatomy of the knee is quite complex; the involvement of several structures makes imaging of the knee particularly challenging for diagnosing knee disorders. Most components of the knee—ligaments, menisci, and articular cartilage—can be injured or might be affected by disease processes; hence, they might lead to significant morbidity and disability because of painful knee conditions. The knee is a complex joint; thus, in the past, it used to be examined with multiple imaging techniques to assess abnormalities. These included conventional radiography, scintigraphy, CT scan, planar tomography, and arthrography.

The introduction of MRI has revolutionized the imaging of the knee. Unlike other imaging modalities, this high-resolution view of bony and soft tissue structures can be visualized through an MRI in a non-invasive manner without the use of intra-articular or intravenous contrast injection, joint manipulation, or causing discomfort to the patient, thus emerging as a much more superior modality of imaging for knee pathology. Quite a few studies opposed to arthroscopy supported the clinical usefulness of MRI. Such comparisons are singled out specifically as very useful when investigating injuries in the menisci and ligaments, which are known to be common causes of knee pain. Other than traumatic injuries, MRI is also functional in diagnosing several acute and chronic disorders of the knee.

MRI of the knee is indicated for various conditions, including traumatic injuries, meniscus tears, ligament tears, and joint overstrain injuries. This imaging technique is highly effective in diagnosing a wide range of issues such as cysts, chondromalacia patellae, and osteonecrosis. It is also valuable for identifying chronic conditions like osteochondritis dissecans, arthritis, and synovial hypertrophy, as well as pathological conditions such as infections, synovial chondromatosis, pigmented villonodular synovitis, and loose bodies. It has made MRI an invaluable diagnostic and management tool in knee disorders because it can give a composite view of knee structures and pathologies. The high accuracy of MRI coupled with high non-invasiveness makes it the best modality for evaluation of the knee among various techniques in radiology for imaging and, therefore effectively answers to the limitations of these techniques in helping appropriately plan for treatment so that patients can realize better outcomes.

The current study had 70 patients with knee pain, of which 30 were left knee MRIs, and 40 were right knee MRIs. All the scans for the current study were obtained with 1.5 Tesla Siemens MRI machine.

Individuals whose age range from 14 to 65 years with a mean age of 35.03 years were included for the study. Most patients referred for an MRI of the knee due to pain were aged between 21 and 40 years. Additionally, the incidence of cases was found to be higher in males with knee pain, at 56%. The results of this study align with those reported by Yadav et al [(11)], in which the average age was 36.70±14 years, and male preponderance was noticed by them (Yadav and Kachewar, 2013). A similar trend of male preponderance was reported in the studies conducted by Gimhavanekar et al [(12)]. (2016), Mansour et al. (2015) [(13)], and Singh et al. (2004) [(14)].

In this study, 48.5% of patients who underwent MRI for painful knee joints were found to have meniscal tears. Among these patients, 64.7% had only medial meniscal tears, 17% had only lateral meniscal tears, and another 17% had both medial and lateral meniscal tears. Similarly, Rana S et al., in their study of painful knee joints MRI findings in 77 patients, reported meniscal tears in 53.2% of cases affecting the medial meniscus and 16.8% the lateral meniscus.

There were 40 meniscal tears reported in 70 patients, the posterior horn was involved in 30 tears (75%) , the anterior horn was involved in 4 tears (10%), and 6 tears (15%) noted in the body. In the medial meniscus posterior horn was a common site for tears. These findings align with those reported in earlier studies (Bansal et al., 2018 [(15)]; Pasupuleti et al., 2015 [(16)]; Kelly, 2006[(17)]; Crues et al., 1990 [(18)]; Pame et al., 2017) [(19)].

The lateral meniscus had been reported to be involved in 12 meniscal tears, Out of which 1 tear was a grade I tear, while 11 tears were grade III tear. This finding aligns with the study conducted by Silva et al[(20)], which examined 44 individuals with meniscal tears and found that majority of tears were of IIIrd Grade, with the fewest tears classified as grade I.

Among the medial meniscal tears noted, Grade I were 3 in number, Grade 2 were 9 in number, and Grade 3 were 16 in number. A similar pattern was observed in the study by Silva et al [(20)]., which also found that Grade III was noted in majority of medial meniscus tears. Amongst 40 meniscal tears, 36 were categorized by type: 19 were vertical, 12 were horizontal, and 5 were bucket handle tears. Among the 19 vertical tears, 10 patients had a history of associated trauma. Kelly EA[(17)] also noted in his study that most vertical tears are caused by trauma.

This study had 5 patients with bucket handle tears, amongst them medial meniscus was involved in 3 (60%) and 2 (40%) involved the lateral meniscus. In the study of Wright et al [21]., there were 39 patients with bucket handle tears, it was seen that the medial meniscus was affected in 82% of cases, while the lateral meniscus was involved in 18% of cases. The observations of the current study aligned with that of Wright et al [21], likely due to the smaller sample size in this study.

Among the 70 patients, 25 had anterior cruciate ligament (ACL) tears. Of these, 16 (64%) had acute complete tears, 3 (12%) had acute partial tears, 2 (8%) had chronic tears, and 4 (16%) exhibited myxoid degeneration. To be classified as acute ACL tear the criteria was, if the MRI was conducted before six weeks of the injury and as chronic if the MRI was conducted after six weeks post-injury, this criteria was established by Vahey et al. [22]

Posterior cruciate ligament (PCL) tears were observed in 3 patients, with complete tears in 2 patients and partial tear in 1 patient. The PCL tears' incidence in this study was 4%. Sonin et al.[23] reported a similar incidence of 3% in their study, where only 10 out of 350 cases of knee injury involved a PCL tear.

Bone bruises were found in 9 out of 70 patients in this study. Predominant involvement was observed in the femur, with the lateral femoral condyle affected in 8/13 bruises and the medial femoral condyle in 1/13 bruises. Additionally, lateral tibial condyle was affected in 4/13 bruises, while there were no cases of involvement associated with the medial tibial condyle.

Bone bruising were most typically connected with ACL and MCL damage.

Acute ACL tears were frequently linked with bone bruises, with 3 cases showing associated posterolateral tibial bruises and 7 cases showing associated lateral femoral bruises.

In this study, 5 patients had bone bruises associated with MCL tears. This is consistent with the findings of Yoon KH et al.[24], who investigated 86 patients with arthroscopically confirmed ACL tears. They reported bone contusion rates of 68% in the lateral femoral condyle, 73% in the lateral tibia, 24% in the medial femoral condyle, and 26% in the medial tibial plateau. Additionally, they found that 22% of these patients had MCL injuries.

Chondromalacia patellae was a cause of knee discomfort in 3 out of 70 patients, including 1 female and 2 males. Among these 3 patients, 1 had grade I chondromalacia patellae and 2 had grade II. Kelly EA[17] also noted in their observation that chondromalacia was involving men more frequently as compared to women. Similarly, Rose et al. noted in their study that mostly patients with chondromalacia patellae were in the early stages of the disease (stage 1 and stage 2). In line with these findings, the patients in this study exhibited MR features of chondromalacia patellae corresponding with early stages.

This study had 8 out of 70 patients with cystic lesions detected on MRI.

Out of these 8 cases, 2 were with Baker's cysts, resulting in an incidence of 2%. These 2 patients with Baker's cysts also had associated joint effusion, ACL tears, and MCL tears. Fielding et al., in their analysis on Baker's cysts using MRI, found an incidence of 5%. They also reported an association between popliteal cysts and both medial meniscal tears and ACL tears.

Additionally, meniscal cysts were observed in 2 patients, both involved the MM and none involved the LM. Horizontal tears of the meniscus, specifically involving the posterior horn were associate with these cysts. This finding is in the same line as that obtained by Burk et al. [25], where it was seen that meniscal cysts were usually associated with horizontal tears of which most arise from the posterior horn of the meniscus.

Features of arthritis were observed in 10 out of the 70 patients. Among these 10 patients with osteoarthritis, the medial compartment was involved in 5 patients, the lateral compartment in 2 patients, both compartments in 3 patients. In the analysis by Joshi et al[26] with 128 patients, in their observation they also found that the medial tibiofemoral joint was more commonly affected than the lateral tibiofemoral joint.

Arthroscopy follow-up was possible in 30 of the 70 patients. Of these, 15 out of 19 patients who were diagnosed with ACL tear on MRI showed confirmed tears of the ACL by arthroscopy. Most of the cases confirmed were actually a complete tear of the ACL. Medial meniscus injury: 11 / 13 diagnosed meniscal tears with MRI were also confirmed with arthroscopy, in which most of them were Grade III tears. In lateral meniscal tears, 8 / 10 detected through MRI were arthroscopically proven. Posterior horn radial and grade I as well as II tears were difficult to assess by arthroscopy.

6. Conclusion

MRI has proven to be an excellent technique for evaluating the soft tissue and bony contents of the knee. It is a cost-effective tool, particularly valuable for patients suffering from knee discomfort. In the context of traumatic knee injuries, MRI stands out as the preferred method for diagnosing meniscal and ligament tears due to its high precision. Although a thorough understanding of normal knee anatomy and common pitfalls can mitigate interpretative errors, they cannot be completely avoided. Therefore, MRI reports must provide comprehensive descriptions of any detected tears to better inform treatment strategies for meniscal and ligament injuries. The accuracy of MRI in detecting meniscal tears, especially lateral ones, may be reduced, in cases of ACL tear, it still surpasses the reliability of physical examinations. MRI is particularly useful in cases with ambiguous clinical presentations, allowing for better patient stratification and more informed surgical management decisions. This study underscores the invaluable role of MRI in diagnosing a large number of chronic knee conditions. MRI offers a detailed view of the anatomy with no need for intravenous contrast or joint manipulation. Its high diagnostic accuracy for meniscal tears and ACL assessments makes MRI an indispensable tool in the thorough evaluation and management of knee disorders.

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