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Association of Meniscal Tears and Anterior Cruciate Ligament Tear Using MRI

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HIGHLIGHTS

1. MRI reveals concurrent meniscal and ACL tears.
2. Medial meniscus often involved with ACL.
3. Lateral meniscus tears common in trauma.
4. Chronic ACL tears show degenerative menisci.
5. MRI provides detailed ligamentous and meniscal assessment.
6. Early imaging aids surgical treatment planning.
7. Accurate diagnosis reduces long-term joint degeneration.

Key words:
ACL tears
Meniscal tears
MRI
Knee injuries
Biomechanics
Rehabilitation

ABSTRACT

Introduction: Knee injuries, particularly anterior cruciate ligament (ACL) and meniscal tears, are common in active individuals, significantly affecting mobility and quality of life. ACL injuries often result in secondary meniscal damage due to disrupted knee biomechanics, increasing the likelihood of osteoarthritis. Prompt and accurate diagnosis, supported by advanced imaging techniques like MRI, is critical for guiding individualized treatment strategies to ensure optimal recovery and prevent long-term complications associated with these debilitating conditions. **Objective:** This study aims to investigate the association between ACL and meniscal tears, highlighting the role of magnetic resonance imaging (MRI) in enhancing diagnostic precision and treatment strategies. **Methods:** A cross-sectional study was conducted on 50 patients with suspected knee injuries referred for MRI at Narayana Medical College from January 2022 to October 2023. Clinical presentations and imaging findings were evaluated to identify patterns and correlations between ligamentous and meniscal injuries. **Results:** ACL tears were the most common ligamentous injury (58%), with partial tears (62%) being more prevalent than complete tears. Medial meniscus tears were the most frequent meniscal injuries (53.6%), predominantly affecting the posterior horn. Combined ACL and meniscal injuries were common, particularly in younger individuals involved in high-impact activities. MRI demonstrated exceptional sensitivity and specificity in detecting these injuries, aiding comprehensive treatment planning. **Conclusion:** The study emphasizes the significant association between ACL and meniscal tears, reaffirming MRI's critical role in precise diagnosis and management. Findings underscore the necessity of concurrent evaluation of ACL and meniscal injuries to optimize outcomes and prevent long-term complications. Future research should explore advanced imaging techniques and preventive measures to address these common knee pathologies.

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INTRODUCTION

The knee joint is a vital and intricate structure that plays a crucial role in facilitating movement and supporting weight-bearing activities. It connects the thigh bone (femur), shin bone (tibia), and kneecap (patella) and is supported by a combination of ligaments, tendons, and cartilage that allow for stability and smooth motion [1]. Within this complex system, the menisci are two crescent-shaped fibrocartilaginous structures located between the femur and tibia, designed to enhance joint functionality. The medial meniscus is positioned on the inner side of the knee and is semi-circular, while the lateral meniscus is found on the outer side and is more circular [2]. These structures are critical for maintaining joint integrity by distributing loads, absorbing shocks, stabilizing the knee during movement, and facilitating the lubrication and nutrition of the articular cartilage.

The menisci, despite their durability, are prone to injury, particularly the medial meniscus due to its limited mobility and stronger attachment to surrounding structures. This makes it vulnerable to tears from twisting or pivoting, common in athletic activities [3]. The lateral meniscus, being more flexible, is less prone to such injuries but can still be damaged by high-impact or degenerative conditions. The anterior cruciate ligament (ACL), centrally located in the knee, connects the femur to the tibia and provides stability by preventing excessive tibial forward movement and controlling rotational forces. Its two bundles work together to stabilize the knee during dynamic activities like jumping or rapid directional changes. ACL and meniscal injuries are prevalent in physically active individuals, particularly in sports like soccer and skiing. Women are at greater risk of ACL tears due to anatomical and hormonal differences [4]. Meniscal injuries often accompany ACL tears, with up to 50% of acute cases involving both structures.

The impact of ACL and meniscal injuries extends far beyond immediate pain and discomfort. These injuries significantly affect an individual's mobility and overall quality of life. Symptoms such as swelling, joint instability, and reduced range of motion can impair daily activities and physical performance [5]. Left untreated, these injuries may lead to chronic knee instability, recurrent episodes of giving way, and progressive joint damage. One of the most concerning long-term consequences is the development of post-traumatic osteoarthritis, a condition characterized by the gradual deterioration of cartilage due to altered joint biomechanics and persistent inflammation [6]. Meniscal tears, particularly those involving the weight-bearing zones, exacerbate this degeneration by compromising the knee's ability to evenly distribute loads and absorb shocks during movement [7].

Accurate diagnosis and appropriate treatment of ACL and meniscal injuries are paramount to preventing these adverse outcomes. Diagnosis often begins with a thorough clinical evaluation, including a detailed history and physical examination to assess joint stability and identify specific injury patterns [8]. Imaging modalities, particularly magnetic resonance imaging (MRI), have revolutionized the diagnostic process for knee injuries. MRI provides unparalleled visualization of soft tissues, allowing for the detection of partial or complete ACL tears, differentiation between degenerative and traumatic meniscal damage, and identification of coexisting injuries such as collateral ligament sprains or bone bruises. Its non-invasive nature, combined with high sensitivity and specificity, has made MRI the gold standard for evaluating knee injuries [9].

Treatment for ACL and meniscal injuries is individualized based on severity, activity level, and goals. Surgical intervention, such as ACL reconstruction using grafts, is often necessary for complete tears in young, active individuals or those with significant instability [10]. Meniscal tears in the outer, vascularized region are typically repaired surgically due to better healing potential, while inner, avascular tears may require partial meniscectomy to alleviate symptoms [11].

Conservative management may be suitable for less severe injuries or less active individuals, focusing on physical therapy to strengthen muscles, improve stability, and enhance proprioception [12]. Bracing can provide additional support during activity. Regardless of the approach, rehabilitation is critical, emphasizing the gradual restoration of range of motion, strength, and functional stability to prevent re-injury and ensure optimal recovery outcomes [13].

The relationship between ACL injuries and secondary meniscal tears underscores the importance of evaluating these structures together. ACL tears disrupt the biomechanics of the knee, leading to increased stress on the menisci. In the acute phase of an ACL injury, the lateral meniscus is more commonly injured due to the rotational forces involved [14]. Over time, chronic ACL deficiency often results in medial meniscal tears as the joint compensates for instability, placing greater loads on the medial compartment. Injury patterns such as the "unhappy triad," which involves simultaneous damage to the ACL, medial

meniscus, and medial collateral ligament, highlight the interconnectedness of knee structures and the need for comprehensive assessment [15].

Concurrent ACL and meniscal injuries complicate treatment and outcomes, often requiring combined ACL reconstruction and meniscal repair for full joint function [16]. Untreated meniscal damage can hinder ACL surgery success and lead to long-term issues. MRI plays a crucial role in identifying complex injury patterns, enabling comprehensive treatment to minimize instability and degeneration while optimizing recovery [17].

ACL and meniscal injuries are common challenges in orthopedics, with potential long-term consequences. Advances in MRI have improved diagnosis and personalized treatment plans, whether surgical or conservative, aiming to restore knee stability and function [18]. Continued research into prevention, surgical techniques, and rehabilitation will further refine care, enhancing outcomes and advancing knee injury management.

The objective of the study is to investigate the association between meniscal tears and ACL injuries, emphasizing the hypothesis of concurrent injuries commonly occurring in these cases. By utilizing MRI, the study aims to explore its role in enhancing diagnostic accuracy, providing detailed visualization of soft tissue structures, and contributing to improved clinical outcomes through precise treatment planning and comprehensive management of knee injuries.

MATERIALS AND METHODS

The study focused on cases of knee injuries with suspected ligament or meniscal injuries referred for MRI at the Department of Radio Diagnosis and Imaging, Narayana Medical College, Nellore. Conducted over a period from January 2022 to October 2023, the study included a sample size of 50 cases. All relevant data were systematically recorded in a structured proforma and later analyzed to derive insights. The study aimed to evaluate the imaging findings and their correlation with clinical presentations, contributing to a better understanding of knee injury patterns and aiding in accurate diagnosis and treatment planning.

RESULTS

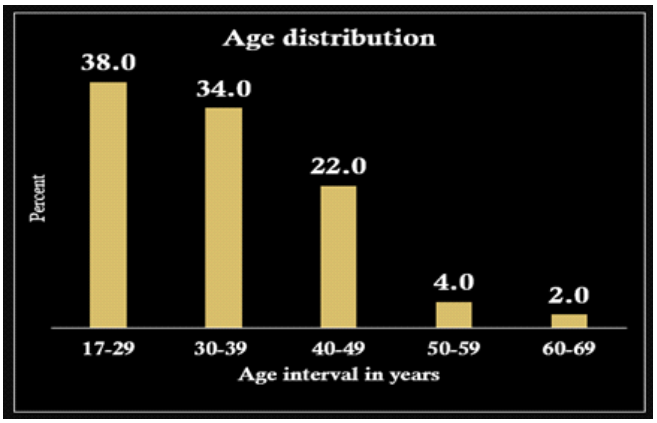

Figure 1: Age Distribution Across Different Age Groups

The bar chart depicts the age distribution of individuals in various age groups. The majority (38%) belong to the 17-29 age group, followed by 34% in the 30-39 age group. The 40-49 age group comprises 22% of the population, while smaller proportions are observed in the 50-59 (4%) and 60-69 (2%) age groups. The data indicates a predominantly younger population, with a significant decline in representation in the older age intervals, suggesting a skew towards youth.

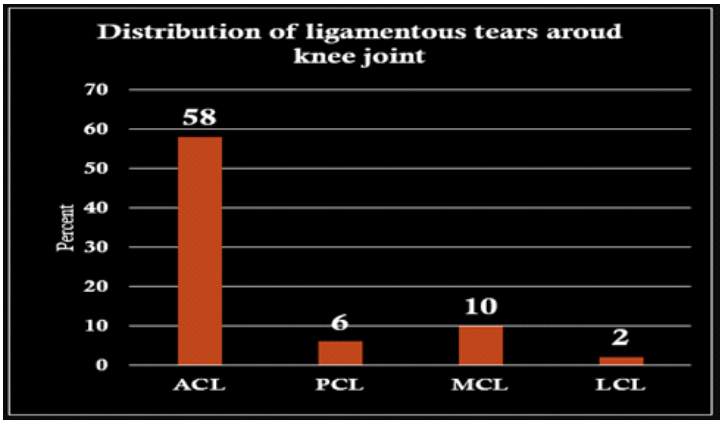

Figure 2: Distribution of Ligamentous Tears Around the Knee Joint

Cruciate Ligament (ACL) tears are the most common, accounting for 58%, followed by Medial Collateral Ligament (MCL) tears at 10%. Posterior Cruciate Ligament (PCL) tears occur in 6% of cases, while Lateral Collateral Ligament (LCL) tears are the least frequent, at just 2%.

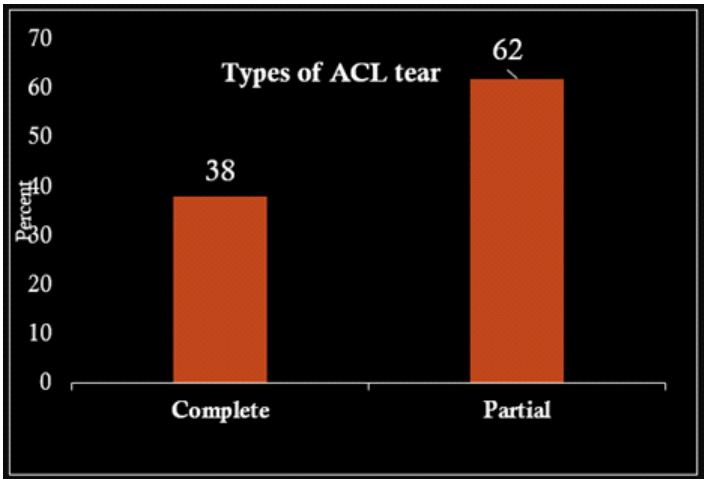

Figure 3: Distribution of Complete and Partial ACL Tears

The bar chart shows the distribution of types of ACL tears. Partial tears are more prevalent, comprising 62% of cases, while complete tears account for 38%. This indicates that partial tears are significantly more common than complete tears among individuals with ACL injuries.

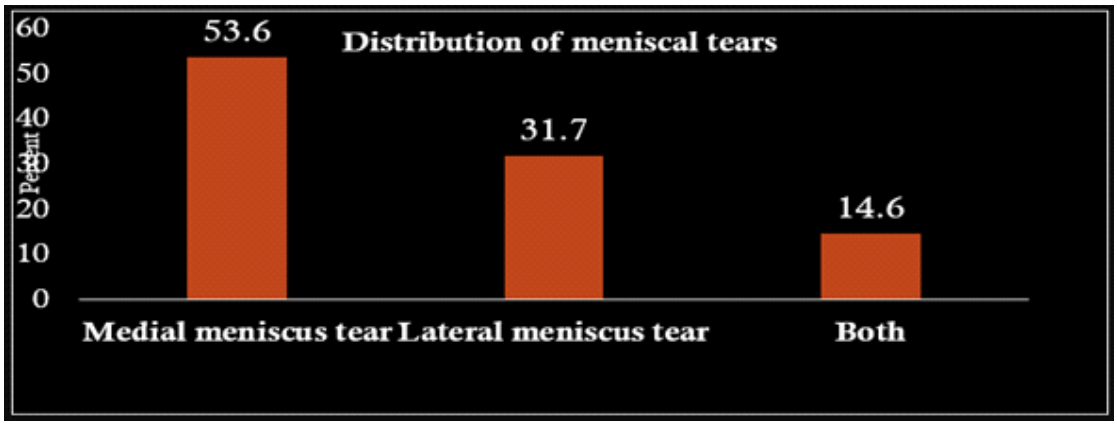

Figure 4: Distribution of Meniscal Tear Types

The bar chart highlights the distribution of meniscal tears. Medial meniscus tears are the most common, accounting for 53.6% of cases, followed by lateral meniscus tears at 31.7%. Combined tears involving both the medial and lateral menisci are observed in 14.6% of cases. This data indicates a higher prevalence of isolated medial meniscus injuries compared to other types.

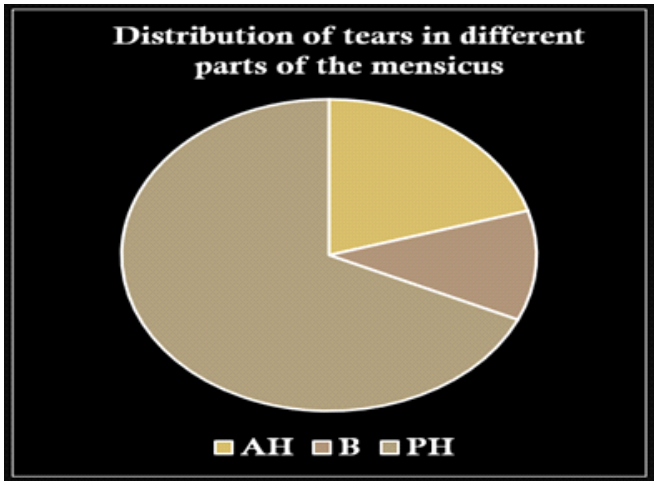

Figure 5: Distribution of Tears in Different Parts of the Meniscus

The pie chart illustrates the distribution of tears in different parts of the meniscus. Tears are categorized into three regions: anterior horn (AH), body (B), and posterior horn (PH). The chart indicates a variation in the occurrence of meniscal tears across these parts, with the posterior horn (PH) typically being the most frequently affected region.

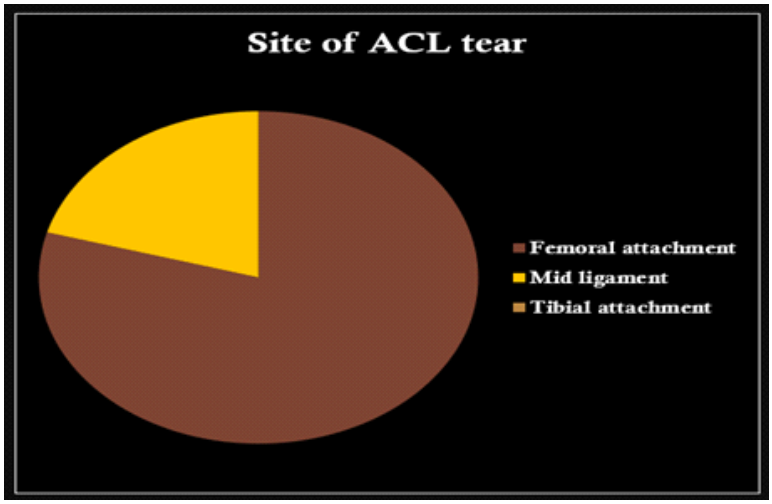

Figure 6: Site Distribution of ACL Tears

The pie chart illustrates the distribution of ACL tears based on their site. Tears are categorized into femoral attachment, mid-ligament, and tibial attachment regions. The femoral attachment is the most commonly affected site, followed by the mid-ligament region. The tibial attachment is the least frequently involved site, indicating a variation in the distribution of injury locations along the ACL.

DISCUSSION

The knee joint, a vital structure for movement and weight-bearing, is supported by ligaments, tendons, and cartilage, including the menisci, which distribute loads, absorb shocks, and stabilize the knee. Medial meniscus tears are more common due to its limited mobility, while the lateral meniscus is less prone to injury. ACL injuries, prevalent in athletes, destabilize the knee by impairing rotational control and forward motion. These injuries, if untreated, can lead to joint instability, reduced mobility, and post-traumatic osteoarthritis. MRI is essential for diagnosing ACL and meniscal injuries, offering detailed visualization of soft tissues and guiding treatment. This study explores the association between ACL and meniscal tears and highlights MRI's role in improving diagnostic accuracy and treatment outcomes [19].

Our study aligns with findings by Gupta R (2021) and Venkataraman S (2022), highlighting the correlation between age and ACL or meniscus injuries. Gupta R reported a mean age of 25.32 ± 7.12 years for partial ACL tears and 28.64 ± 10.84 years for complete ACL tears, emphasizing a younger demographic. Venkataraman S categorized participants into age groups, with average ages for hyperplasia have much lower SWE values (8.54 ± 2.50 kPa and 5.48 ± 3.11 kPa, respectively). Liver parenchyma SWE values are generally lower, except in focal nodular hyperplasia (22.05 ± 32.30 kPa). These findings highlight the potential of SWE in differentiating between lesion types.

Our findings contrast with studies by Gupta R (2021) and Jog AV et al. (2020), which observed complete ACL tears as significantly more prevalent than partial tears. In contrast, our study identifies partial tears as more common than complete tears. These differences may arise from variations in diagnostic methods, study populations, or injury mechanisms, highlighting the need for further research to better understand the distribution of ACL tear types and their contributing factors [21,22].

Our findings align with studies by Mansori AE (2018) and Espejo-Reina A (2019), emphasizing the predominance of medial meniscus (MM) tears, particularly vertical and bucket-handle types, and the posterior horn as the most common tear location. Mansori AE highlighted MM tears as more prevalent than lateral meniscus (LM) tears, with vertical tears being the most common type across both. Espejo-Reina similarly observed a higher prevalence of MM tears, often associated with specific injury patterns. Both studies reinforce our observation of medial meniscus tears as the most frequent, followed by lateral and combined meniscal injuries, with posterior horn involvement dominating [23,24].

Our findings align with studies by Mansori AE (2018) and Espejo-Reina A (2019), emphasizing the predominance of meniscal tears in the posterior horn (PH) for both medial and lateral menisci. Mansori AE

highlighted the PH as the most frequent site, followed by tears involving the entire meniscus, with anterior tears being least common. Similarly, Espejo-Reina reported the PH as the most affected region (54.1%), followed by the middle third and miscellaneous segments. These patterns underscore the vulnerability of the posterior horn across all meniscal tears, consistent with our observations of tear distribution across different anatomical regions of the meniscus [23,24].

Our findings align with those of Jog AV (2020) and Gupta R (2021), highlighting the distribution of ACL tear sites and associated meniscal injuries. Jog AV observed that partial ACL tears predominantly involved the posterolateral bundle, while complete tears were more frequent overall. Gupta R emphasized the posterior horn as the most common site for meniscal tears in both medial and lateral menisci, often involving adjacent regions like the body. Similarly, our study shows the femoral attachment as the most affected site in ACL tears, followed by the mid-ligament and tibial attachment, reflecting variations in injury patterns across studies [21,22].

CONCLUSION

The study highlights the significant association between anterior cruciate ligament (ACL) tears and meniscal injuries, emphasizing the importance of simultaneous evaluation for accurate diagnosis and treatment planning. Magnetic resonance imaging (MRI) emerges as a crucial tool in detecting these injuries, offering detailed visualization of soft tissue structures and enabling tailored therapeutic approaches. The findings demonstrate a predominance of partial ACL tears and medial meniscal injuries, with posterior horn tears being the most common. These insights underscore the role of MRI in optimizing clinical outcomes, supporting comprehensive management, and informing strategies to mitigate long-term complications in knee joint pathologies.

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