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IMAGING CHARACTERISTICS OF KNEE OSTEOARTHRITIS ON 3.0 TESLA MRI: A CROSS-SECTIONAL STUDY IN VIETNAM

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ABSTRACT: This study aim to investigate and characterize the imaging features of knee osteoarthritis (OA) using high-field 3.0 Tesla Magnetic Resonance Imaging (MRI) in a cohort of patients at Thong Nhat Hospital. A cross-sectional descriptive study was conducted on 156 patients with radiographically confirmed knee OA who underwent 3.0T MRI between November 2024 and May 2025. Pathologies of the menisci, cruciate ligaments, collateral ligaments, subchondral bone and joint space were systematically evaluated. Univariable and multivariable logistic regression analysis was employed to identify imaging features associated with OA. The study included 156 patients (mean age 55.8±10.6 years; 73 males). The majority of patients were classified radiographically as Kellgren-Lawrence (KL) grade I (n=99, 63.46%). Despite the prevalence of early-stage radiographic disease, 3.0T MRI revealed a high burden of soft-tissue pathology. The most common ligamentous injury was a partial tear of the anterior cruciate ligament (ACL) in 42 patients (27%), while medial meniscal tears were identified in 56 patients (35.9%). Mild joint effusion was a frequent finding, present in 107 patients (68.6%). In the multivariable model, age (Odds Ratio 1.03, 95% Confidence Interval [CI] 1.02–1.04), ACL injury (OR 1.14, 95% CI 1.02–1.28), posterior cruciate ligament (PCL) injury (OR 1.24, 95% CI 1.02–1.50), collateral ligament injury (OR 1.23, 95% CI 1.02–1.49) and lateral meniscal injury (OR 1.14, 95% CI 1.00–1.29) were identified as significant independent predictors of OA. High-field 3.0T MRI is a pivotal tool for the comprehensive assessment of knee OA, detecting a wide spectrum of radiographically occult soft tissue and bone marrow pathologies. These findings, particularly those related to ligamentous and meniscal integrity, are critical to understanding the disease's biomechanical underpinnings and may be present despite minimal radiographic changes.

Keywords: Knee Osteoarthritis, Magnetic Resonance Imaging (MRI), 3.0 Tesla, Meniscus, Cruciate Ligament, Kellgren-Lawrence Grade.

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1. INTRODUCTION

Knee osteoarthritis (OA) is one of the most common long-term musculoskeletal disorders in the world, characterized by a progressive degradation of articular cartilage, pathological changes in the subchondral bone and the formation of osteophytes [1, 2]. As a leading cause of pain and disability, particularly in aging populations, knee OA imposes a substantial burden on individuals and healthcare systems worldwide [3, 4]. The World Health Organization (WHO) estimates that 9.6% of men and 18.0% of women over 60 years are affected by symptomatic OA, with the knee being one of the most commonly involved joints [5, 6]. The clinical symtoms including chronic pain, joint stiffness and reduced mobility, significantly impair quality of life and increase the risk of comorbidities such as depression and physical incapacitation. The primary objectives of OA management are to alleviate symptoms, improve joint function and critically to slow the progression of structural damage, thereby delaying or obviating the need for total knee arthroplasty—a major surgical intervention with considerable costs and risks [7-10].

For decades, the diagnostic approach for knee OA has been anchored in conventional radiography. The Kellgren-Lawrence (KL) classification system established in 1957 is still the most used method for grading radiographic severity based on indirect signs of cartilage loss, like narrowing of the joint space, subchondral sclerosis and the presence of osteophytes [11]. However, this technique has limitations that curtail its utility, especially in the early stages of the disease. Radiographs are insensitive to direct changes in articular cartilage and are incapable of visualizing crucial soft-tissue structures, including the menisci, ligaments and synovium. As a result, a radiographic diagnosis often reflects late-stage, irreversible structural damage, leaving a critical window for early intervention largely unaddressed [12, 13]. Ultrasonography is beneficial for examining superficial soft tissues, synovitis and joint effusions, its ability to evaluate deep intra-articular structures is limited. Magnetic Resonance Imaging (MRI) has become the foremost non-invasive technique for the thorough, multi-compartmental evaluation of the knee joint. Its superior soft-tissue contrast allows for the direct visualization and characterization of pathologies within the articular cartilage, menisci, ligaments, subchondral bone marrow and synovium. The advent of high-field 3.0 Tesla (3.0T) MRI systems has further advanced diagnostic capabilities. By providing a higher signal-to-noise ratio (SNR) and improved spatial and contrast resolution compared to conventional 1.5T systems, 3.0T MRI enhances the detection of subtle and early-stage pathologies [14-16]. Kijowski et al. demonstrated that 3.0T MRI has significantly higher specificity and accuracy ($p<0.05$) for detecting articular cartilage lesions compared to 1.5T MRI [17]. Furthermore, advanced quantitative MRI techniques feasible at 3.0T, such as T2 mapping, can detect early biochemical changes in cartilage composition before morphological defects become apparent, offering a window into the preclinical phase of OA [18].

Knee OA is a major and growing public health problem in Vietnam. Although 3.0T MRI systems are becoming more accessible, there is a relative paucity of systematic research characterizing the spectrum of imaging findings in the Vietnamese population with knee OA. This lack of knowledge may lead to an over-reliance on insensitive radiographic methods and a potential underestimation of the true burden of structural disease. This study was therefore initiated to address this gap. A fundamental premise of this study is the exploration of the frequent discordance between structural damage visible on MRI and the assigned radiographic grade. It is common for patients with early radiographic disease (e.g., KL grade I) to harbor significant soft-tissue injuries, like tears in the meniscus or ligaments, that are major causes of joint instability and disease progression. An evaluation based solely on radiography may misclassify such patients as having "mild" disease, leading to suboptimal management strategies. This study aims to provide a detailed characterization of 3.0T MRI findings to: 1) describe the comprehensive spectrum of imaging findings (meniscal, ligamentous, osseous and synovial) in patients with knee OA and 2) analyze the correlation between specific MRI-detected pathologies and the radiographic severity of OA.

2. MATERIALS AND METHODS

2.1. Study Design

This investigation was conducted as a prospective, cross-sectional descriptive study at the Department of Diagnostic Imaging, Thong Nhat Hospital in Ho Chi Minh City, Vietnam. The study protocol was approved by the institutional review board and data collection from November 2024 to May 2025.

The study cohort consisted of patients referred for knee imaging with clinical symptoms suggestive of OA. The inclusion and exclusion criteria were defined as follows:

Inclusion Criteria: Patients aged 40 years or older who presented with clinical symptoms of knee OA (e.g., pain, stiffness, limited motion) and had a radiographic diagnosis of OA according to the Kellgren-Lawrence criteria were eligible for inclusion. All included patients subsequently underwent a 3.0T MRI of the symptomatic knee.

Exclusion Criteria: Patients were excluded if they had a diagnosis of other inflammatory arthropathies (e.g., rheumatoid arthritis), a history of prior surgery on knee or any contraindications to MRI, such as the presence of metallic implants or claustrophobia.

2.2. Image Interpretation and Data Collection

All participants underwent standard radiography and a non-contrast 3.0 Tesla MRI (Siemens MAGNETOM Lumina). The MRI protocol included Proton Density (PD), T2-weighted fat-suppressed (T2W-FS) and T1-weighted sequences in axial, coronal and sagittal planes. Two experienced musculoskeletal radiologists, blinded to clinical data, independently reviewed all images, with discrepancies resolved by consensus.

2.3. Statistical Analysis

All collected data were entered into a exel database and analyzed using R software (version 4.1). Descriptive statistics were used for patient characteristics and univariable and multivariable logistic regression analyses were performed to assess associations between MRI findings and OA, with a p-value < 0.05 considered significant.

3. RESULTS

3.1. Patient Cohort Characteristics

During the study period from November 2024 to May 2025, a total of 156 patients met the inclusion criteria and were enrolled in the study. The demographic and baseline characteristics of the cohort are summarized in [Table 1]. The study population consisted of 73 males (46.8%) and 83 females (53.2%). The mean age of the patients was 55.8±10.6 years, with no statistically significant difference in age between male (56.7±10.5 years) and female (54.7±10.6 years) participants ($p>0.05$). The left knee was more frequently affected (n=92, 59%) than the right knee (n=64, 41%), though this difference was not statistically significant ($p>0.05$).

3.2. Radiographic Findings

Based on the Kellgren-Lawrence (KL) classification, the majority of patients presented with early-stage radiographic OA. KL Grade I was the most common finding, observed in 99 patients (63.46%), followed by KL Grade II in 31 patients (19.87%). Advanced radiographic changes were less frequent, with KL Grade III identified in 10 patients (6.41%) and KL Grade IV in 6 patients (3.85%). Ten patients (6.41%) had no definitive radiographic signs of OA and were classified as KL Grade 0.

Table 1. Demographic and Radiographic Characteristics of the Study Population

Characteristic	Value
Total Patients (N)	156
Age (years)	
Mean ± SD	55.8±10.6
Gender	
Male, n (%)	73 (46.8%)
Female, n (%)	83 (53.2%)
Affected Knee	
Right, n (%)	64 (41.0%)
Left, n (%)	92 (59.0%)

Characteristic	Value
Kellgren-Lawrence Grade	
Grade 0, n (%)	10 (6.41%)
Grade I, n (%)	99 (63.46%)
Grade II, n (%)	31 (19.87%)
Grade III, n (%)	10 (6.41%)
Grade IV, n (%)	6 (3.85%)

3.3. MRI Findings

Despite the predominance of early radiographic OA, 3.0T MRI revealed a high prevalence of significant intra-articular pathologies, as detailed in [Table 2].

3.4. Meniscal Injuries

Lesions of the medial meniscus were identified in 105 patients (67.3%), which was more frequent than lesions of the lateral meniscus, found in 68 patients (43.6%). The most common type of injury for both menisci was a tear. A medial meniscal tear was present in 56 patients (35.9%), while a lateral meniscal tear was observed in 34 patients (21.9%).

3.5. Cruciate and Collateral Ligament Injuries

Pathology of the anterior cruciate ligament (ACL) was observed in 63.5% of the cohort (n=99). The most common ACL finding was a partial tear (n=42, 26.92%), followed by a complete tear (n=35, 22.44%). Mucoid degeneration of the ACL was noted in 22 patients (14.1%). Injuries to the posterior cruciate ligament (PCL) were substantially less common, affecting only 14.7% of patients (n=23), with partial tears being the most frequent type (n=17, 10.9%). Collateral ligament sprains were very common, with the vast majority being Grade I injuries (n=107, 68.59%), characterized by edema and increased signal in the soft tissues surrounding the ligament on fat-suppressed sequences.

Table 2. MRI Findings of Meniscal and Ligamentous Structures

Category	N	%
Medial Meniscus		
Total Lesions	105	67.30%
Degeneration	37	23.70%
Tear	56	35.90%
Complex Tear	12	7.70%
Lateral Meniscus		
Total Lesions	68	43.60%
Tear	34	21.90%
Anterior Cruciate Ligament (ACL)		
Normal	57	36.54%
Mucoid Degeneration	22	14.10%
Partial Tear	42	26.92%
Complete Tear	35	22.44%
Posterior Cruciate Ligament (PCL)		
Normal	133	85.26%
Mucoid Degeneration	1	0.64%
Partial Tear	17	10.90%
Complete Tear	5	3.21%
Collateral Ligaments		
Normal	7	4.49%
Grade I Sprain	107	68.59%
Grade II Sprain	38	24.36%
Grade III Sprain	4	2.56%

3.6. Synovial and Other Findings

Mild joint effusion was the single most frequent finding on MRI, observed in 107 patients (68.6%). Synovial cysts were identified in 28 patients (17.95%). These cysts were located in various characteristic locations, including the popliteal fossa (Baker's cyst), adjacent to the cruciate ligaments and at the proximal tibiofibular joint.

Table 3. Univariable and Multivariable Logistic Regression Analysis of Factors Associated with Knee Osteoarthritis

Variables	Univariable		Multivariable	
	OR (95% CI)	p	OR (95% CI)	p
Age	1.04 (1.02-1.05)	<0.001	1.03 (1.02 - 1.04)	<0.001
Gender	1.24 (0.95- 1.63)	0.105	1.11 (.87 - 1.41)	0.398
ACL Injury	1.18 (1.05 - 1.35)	0.006	1.14 (1.02-1.28)	0.020
PCL Injury	1.33 (1.08- 1.66)	0.008	1.24 (1.02-1.50)	0.028
Collateral Ligament Injury	1.19 (.96 - 1.46)	0.113	1.23 (1.02-1.49)	0.027
Medial Meniscal Injury	1.05 (.92 - 1.21)	0.443	1.01 (.89-1.14)	0.930
Lateral Meniscal Injury	1.23 (1.07 - 1.41)	0.005	1.14 (1.00 - 1.29)	0.048
Joint Effusion	1.25 (.99 - 1.57)	0.065	1.10 (0.90 -1.36)	0.326

3.7. Logistic Regression Analysis

The results of the univariable and multivariable logistic regression analyses are presented in [Table 3]. In the univariable analysis, age, ACL injury, PCL injury and lateral meniscal injury were significantly associated with the presence of knee OA. After adjusting for confounding variables in the multivariable model, several factors remained as strong, independent predictors of OA. Each additional year of age increased the odds of OA by 3% (OR 1.03; 95% CI 1.02–1.04; p<0.001). The presence of an ACL injury (OR 1.14; 95% CI 1.02–1.28; p=0.020), PCL injury (OR 1.24; 95% CI 1.02–1.50; p=0.028), collateral ligament injury (OR 1.23; 95% CI 1.02–1.49; p=0.027) and lateral meniscal injury (OR 1.14; 95% CI 1.00–1.29; p=0.048) were all significantly associated with increased odds of OA. In contrast, gender, medial meniscal injury and the presence of joint effusion did not demonstrate a statistically significant association in the final multivariable model.

4. DISCUSSION

This study provides a comprehensive characterization of 3.0T MRI findings in a cohort of Vietnamese patients with symptomatic knee OA. The principal finding of this investigation is the high prevalence of significant intra-articular soft-tissue and osseous pathology, particularly meniscal and ligamentous injuries, in a population with predominantly early-stage radiographic disease (KL grades I and II). This highlights the critical role of high-field MRI in revealing the true extent of structural damage that is occult on conventional radiographs.

A central theme emerging from our results is the profound discordance between radiographic severity and the burden of structural damage identified by MRI [19]. Over 83% of our cohort was classified as KL grade II or lower, a category often considered "mild" in clinical practice . However, MRI showed that 63.5% of patients had a medial meniscal lesion and 63.5% had an ACL injury. This discrepancy underscores the well-documented limitations of radiography, which mainly shows secondary bone changes rather than the main pathologies in cartilage, menisci and ligaments that initiate and drive the degenerative cascade. This finding has significant clinical implications. A patient presenting with knee pain and a KL grade I radiograph may be treated with basic analgesics and physical therapy under the assumption of mild disease. However, our data suggest this same patient has a high probability of harboring a significant biomechanical derangement, like a degenerative meniscal tear or a partial ACL tear. This evidence supports a lower threshold for utilizing MRI in symptomatic patients with minimal radiographic findings to diagnosis and targeted early intervention.

Our logistic regression analysis's findings support the biomechanical theory of OA progression. The disease process is highlighted by the strong, independent

association between OA and injuries to the ACL, PCL, collateral ligament and lateral meniscal. Ligamentous insufficiency and meniscal dysfunction alter joint kinematics, leading to abnormal load distribution across the articular cartilage and subsequent chondral wear and degeneration. An ACL tear is a well-established risk factor for post-traumatic OA, with studies showing that up to 50% of patients develop radiographic OA within 10-15 years of injury [20]. Our results demonstrate that even in a non-traumatic, degenerative OA population, the integrity of these stabilizing structures is a powerful determinant of disease status. The finding that lateral meniscal injury, but not medial, was a significant predictor in the multivariable model is intriguing and warrants further exploration. Although medial meniscal tears were more common, this finding might be due to specific biomechanical factors in our study population, or it could be that lateral tears are a greater contributor to rotational instability.

Our study also provides a detailed look at the spectrum of ligamentous pathology. In addition to simple tears, we found ACL mucoid degeneration in 14.1% of patients. This condition, characterized by the deposition of glycosaminoglycan-rich mucoid material between intact ligament fibers, represents a distinct degenerative entity. On MRI, it typically presents as a thickened, ill-defined ACL with increased signal intensity. Mucoid degeneration is not a tear, but it can cause pain by mechanically impinging on the ligament because it is thicker. It is thought to be part of the degenerative continuum and may be a sign of "pre-failure". Its identification is important to avoid misdiagnosis as a ligament tear which would have different management implications.

Finally, the high prevalence of joint effusion (68.6%) and synovial cysts (17.95%) serves as a marker of active intra-articular inflammation or synovitis. These findings are not passive; they indicate an active biological process occurring within the joint. A Baker's cyst forms when increased intra-articular pressure, often from synovitis or a meniscal tear, forces synovial fluid through a one-way valve mechanism into the gastrocnemius-semimembranosus bursa. Therefore, the presence of a Baker's cyst is an important indirect sign of underlying intra-articular pathology and active inflammation, which are increasingly recognized as key therapeutic targets in OA management.

Several limitations of this study should be acknowledged. First, its cross-sectional design precludes any conclusions regarding causality or the temporal progression of the observed pathologies. Second, the MRI findings were not correlated with an arthroscopic gold standard. Lastly, the study did not collect detailed clinical outcome data. Future research should include longitudinal studies to track the history of these MRI-detected lesions and their impact on clinical and structural progression over time.

5. CONCLUSION

In comparison to traditional radiography, high-field 3.0T MRI offers a thorough and detailed evaluation of the pathological alterations in knee osteoarthritis. Our findings demonstrate a high burden of significant intra-articular pathology, including ligamentous injuries, meniscal tears and markers of synovitis, even in patients with early-stage radiographic disease. These pathologies, particularly those contributing to biomechanical instability, are strongly associated with the presence of OA. The comprehensive anatomical data yielded by 3.0T MRI is essential for accurate diagnosis, risk stratification and the development of individualized treatment strategies aimed at modifying the course of this debilitating disease.

REFERENCES

[1] Aslan A. Hip and Knee Osteoarthritis: An Overview. Acta Medica Alanya. 2022;6(3):223-4.

[2] Engİnar AÜ. AB1203 EVALUATION OF THE URIC ACID AND HEMATOLOGICAL PARAMETERS IN PATIENTS WITH NODAL HAND OSTEOARTHRITIS. Annals of the Rheumatic Diseases. 2023;82:1830.

[3] Rwebembera J, Marangou J, Mwita JC, Mocumbi AO, Mota C, Okello E, et al. 2023 World Heart Federation guidelines for the echocardiographic diagnosis of rheumatic heart disease. Nature Reviews Cardiology. 2024;21(4):250-63.

[4] Fragoulis GE, Evangelatos G. Immunoglobulin G4–related disease: is it all the same? : Oxford University Press; 2020. p. 2195-6.

[5] Cross M, Smith E, Hoy D, Nolte S, Ackerman I, Fransen M, et al. The global burden of hip and knee osteoarthritis: estimates from the global burden of disease 2010 study. Annals of the rheumatic diseases. 2014;73(7):1323-30.

[6] Palazzo C, Ravaud J-F, Papelard A, Ravaud P, Poiraudeau S. The burden of musculoskeletal conditions. PloS one. 2014;9(3):e90633.

[7] Tăng TH, Huỳnh TH. TÌNH HÌNH THOÁI HOÁ KHỚP GỐI VÀ MỘT SỐ YẾU TỐ LIÊN QUAN Ở BỆNH NHÂN CAO TUỔI ĐIỀU TRỊ NGOẠI TRÚ TẠI BỆNH VIỆN ĐA KHOA CÀ MAU. Tạp chí Y học Việt Nam. 2023;531(1B).

[8] Vos PA, DeGroot J, Barten-van Rijbroek AD, Zuurmond AM, Bijlsma JW, Mastbergen SC, et al. Elevation of cartilage AGEs does not accelerate initiation of canine experimental osteoarthritis upon mild surgical damage. Journal of Orthopaedic Research. 2012;30(9):1398-404.

[9] Neogi T. The epidemiology and impact of pain in osteoarthritis. Osteoarthritis and cartilage. 2013;21(9):1145-53.

[10] McAlindon TE, Bannuru RR, Sullivan M, Arden N, Berenbaum F, Bierma-Zeinstra S, et al. OARSI guidelines for the non-surgical management of knee osteoarthritis. Osteoarthritis and cartilage. 2014;22(3):363-88.

[11] Peterfy C, Guermazi A, Zaim S, Tirman P, Miaux Y, White D, et al. Whole-organ magnetic resonance imaging score (WORMS) of the knee in osteoarthritis. Osteoarthritis and cartilage. 2004;12(3):177-90.

[12] Cioroianu GO, Florescu A, Simionescu CE, Sas TN, Tarniță DN, Rogoveanu OC. The therapeutic benefits of NSAIDs and physical therapy in knee osteoarthritis. Romanian Journal of Morphology and Embryology. 2024;65(2):217.

[13] Niedermeier M, Pap T, Korb A. Therapeutic opportunities in fibroblasts in inflammatory arthritis. Best Practice & Research Clinical Rheumatology. 2010;24(4):527-40.

[14] Guermazi A, Niu J, Hayashi D, Roemer FW, Englund M, Neogi T, et al. Prevalence of abnormalities in knees detected by MRI in adults without knee osteoarthritis: population based observational study (Framingham Osteoarthritis Study). Bmj. 2012;345.

[15] Gold GE, Chen CA, Koo S, Hargreaves BA, Bangerter NK. Recent advances in MRI of articular cartilage. American Journal of Roentgenology. 2009;193(3):628-38.

[16] Roemer FW, Demehri S, Omoumi P, Link TM, Kijowski R, Saarakkala S, et al. State of the art: imaging of osteoarthritis—revisited 2020. Radiology. 2020;296(1):5-21.

[17] Kijowski R, Blankenbaker DG, Davis KW, Shinki K, Kaplan LD, De Smet AA. Comparison of 1.5-and 3.0-T MR imaging for evaluating the articular cartilage of the knee joint. Radiology. 2009;250(3):839-48.

[18] Wong S LF, Cristea A, Steinbach L, Neu C, Zhao J.. T2 mapping of articular cartilage of the knee at 3T. Radiol Res Pract. 2011;2011:525891.

[19] Kornaat PR, Bloem JL, Ceulemans RY, Riyazi N, Rosendaal FR, Nelissen RG, et al. Osteoarthritis of the knee: association between clinical features and MR imaging findings. Radiology. 2006;239(3):811-7.

[20] Barenius B, Ponzer S, Shalabi A, Bujak R, Norlén L, Eriksson K. Increased risk of osteoarthritis after ACL reconstruction–a 14-year follow-up study of a randomized controlled trial. Arthroscopy. 2013;29(10):e80-e1.