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Correlation of MRI-Based MOAKS Grading with WOMAC Clinical Scores in Knee Osteoarthritis: A Cross-Sectional Study

Amit Shankhwar[1], Alka Agrawal[2], Faraz Khan[3], Priya Solanki[4], Priya Singh[3], and Komal Dhayal[3]

[1] Dept of Radiodiagnosis MGM Medical College, Indore, Madhya Pradesh, India, 452001

[2] Dept of Radiodiagnosis, MGM Medical College, Indore, India

[3] Dept of Radiodiagnosis, MGM Medical College, Indore 452001, India

[4] Department of radiodiagnosis, MGM Medical College, MY Hospital, Indore, India

Corresponding author: Priya Solanki, Email: priyasolanki1245@gmail.com

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ABSTRACT

Background: Knee osteoarthritis (OA) is a chronic degenerative joint disease leading to pain, stiffness, and functional limitation. MRI plays a key role in the early detection of joint changes before radiographic signs appear. The MOAKS (MRI Osteoarthritis Knee Score) system provides a structured assessment of bone marrow lesions, cartilage loss, and other structural abnormalities. The WOMAC score is a widely used clinical tool to assess patient symptoms in OA. **Aim:** To evaluate the correlation between MRI-based MOAKS grading and clinical severity assessed using the WOMAC score in patients with primary knee osteoarthritis. **Methods:** A retrospective cross-sectional study was conducted in the Department of Radiodiagnosis, M.G.M. Medical College & M.Y. Hospital, Indore, between November 2023 and November 2024. A total of 110 patients with clinically diagnosed primary knee OA underwent MRI on a 3T system. MOAKS features were scored, and WOMAC scores were documented. Correlations between MRI findings and clinical scores were analysed using Pearson's correlation. **Results:** BML showed the strongest correlation with WOMAC total score ($r = 0.60$, $p < 0.001$). Cartilage loss, meniscal extrusion, and ligament tears showed moderate correlation ($r = 0.45$ 0.48). Osteophytes, synovitis, and effusion showed weaker but significant correlations.

Conclusion: There is a significant association between MOAKS features and WOMAC scores, particularly with BML and cartilage loss. MRI grading helps in understanding clinical severity and can aid in treatment planning.

Keywords: Knee Osteoarthritis, MOAKS, WOMAC, Bone Marrow Lesion, Cartilage Loss.

Introduction

Knee osteoarthritis (OA) is a leading cause of pain and disability in older adults. It affects both quality of life and mobility, especially in overweight and aging populations (1). In India, the prevalence is rising due to a sedentary lifestyle and increasing life expectancy (2). Conventional radiography is commonly used for diagnosis, but it mainly captures late-stage bony changes like joint space narrowing and osteophytes. It fails to detect early and soft-tissue abnormalities that are central to OA progression (1).

Magnetic Resonance Imaging (MRI) provides better soft tissue contrast and is more sensitive to early

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changes in OA, like cartilage damage, meniscal extrusion, bone marrow lesions (BMLs), and synovitis (3). The MRI Osteoarthritis Knee Score (MOAKS) is a validated semi-quantitative tool that evaluates these structural features in subregions of the knee joint (4). It helps track disease burden more comprehensively compared to X-rays.

However, the imaging changes do not always match the severity of patient-reported symptoms. Some patients with severe MRI findings report mild pain, while others with subtle changes have high disability (5). This mismatch has led to the use of clinical scoring tools like the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), which evaluates pain, stiffness, and function from the patient's perspective (6).

Studies have shown that some MOAKS features, especially BMLs, cartilage loss, and meniscus damage, correlate moderately to strongly with WOMAC scores (3,4). Still, most existing research is from Western settings and lacks validation in Indian populations.

This study was conducted to critically evaluate the correlation between MRI-based MOAKS grading and clinical WOMAC scores in Indian patients with knee OA. Understanding this link may improve disease monitoring, guide individualized treatment, and support early intervention.

Material and Methods

This was a time-bound, retrospective, cross-sectional observational study done in the Department of Radiodiagnosis, M.G.M. Medical College & M.Y. Hospital, Indore, Madhya Pradesh, India. Institutional Scientific and Ethics Committee clearance was taken before starting. The study was conducted from November 2023 to November 2024 and included 110 patients who were referred for MRI knee imaging.

Only patients with idiopathic primary osteoarthritis of the knee were included. Cases with secondary arthritis, history of trauma, knee replacement, or absolute contraindications to MRI, like pacemakers or metallic implants, were excluded. After applying the inclusion and exclusion criteria, patients were selected. History was noted in all cases.

MRI was performed in supine position using a 3 Tesla (3T) MRI machine with a dedicated knee coil to improve image clarity. It usually took around 30 to 40 minutes for each scan. Standard sequences were used in axial, sagittal, and coronal planes. These included Axial T1 or PD FSE, Axial fat-suppressed PD FSE, Sagittal fat-suppressed PD FSE, Sagittal T2* GRE, Sagittal PD FSE, Coronal T1 or PD FSE, and Coronal fat-suppressed PD FSE.

T2-weighted fat-suppressed PD sequences were most useful to assess cartilage, marrow edema, fluid, and soft tissues. T1-weighted images helped evaluate anatomy, subchondral changes, loose bodies, and bone lesions. Ligaments (ACL, PCL) were best seen in sagittal images, while meniscal pathology was well assessed on sagittal and coronal planes. Patellar cartilage and trochlear groove were better evaluated in axial and sagittal views, respectively.

Technical parameters followed the standard protocol as per ESSR. Slice thickness was 3-4 mm. TR for PD FSE sequences was ~3570 ms, and TE was ~39 ms. Matrix size was generally around 288×384 or 358×512, depending on the sequence.

After image acquisition, findings were graded using MOAKS (MRI Osteoarthritis Knee Score). Clinical severity was evaluated by the WOMAC questionnaire in all cases. Data was entered in Microsoft Excel and analysed using SPSS software version 26. Mean and standard deviation were calculated for continuous data. Pearson correlation coefficient (r) was used to assess the relationship between MOAKS features and WOMAC scores. p-value <0.05 was taken as statistically significant.

Results

The majority of patients belonged to the 40 to 49 years age group (43.64%), followed by 50- 59 years (34.55%). Males were slightly more than females (52.7% vs 47.3%). Overweight was the most common BMI category (50.9%), with obesity seen more in females (19.2%). These demographics reflect a middle-aged population where knee OA burden is high and associated with weight-related joint stress.

Pain score range 5 -9 and 15 -20 was seen in 32 patients each. Lowest pain scores (0- 4) were seen in 18 patients only. The stiffness score of 2-3 was most common (42 patients), followed by 4-5 (28 patients). In function scores, 38 patients had a score range of 17 34, 32 patients had 35 -51, and 25 had 52-68.

Among 32 patients with BML grade 0, the mean WOMAC score was 28.4. Grade 1 seen in 41 patients (mean WOMAC 42.7), grade 2 in 27 patients (mean 53.1), and grade 3 in 10 patients (mean 65.8). Standard deviation increased as grade increased. There was a strong positive correlation between BML grades and total WOMAC scores. As BML severity increased from Grade 0 to 3, the mean WOMAC score rose from 28.4 to 65.8. Pearson's r progressively increased (0.38 to 0.63), all statistically significant ($p \leq 0.001$).

In 43 patients with full-thickness cartilage loss, the mean WOMAC score was 52.6 ± 15.2, whereas in 67 patients without it, it was 34.8 ± 11.7. Partial thickness loss was present in 67 patients had a mean WOMAC of 47.3, and in its absence, it was 32.1 ± 10.4. Patients with full-thickness cartilage loss had significantly higher WOMAC scores (52.6) compared to those without (34.8), with moderate correlation ($r = 0.45$). Similarly, partial loss was also correlated ($r = 0.39$).

BML showed the highest correlation with WOMAC domains ($r = 0.60$ for total score), followed by cartilage loss and meniscus extrusion. Osteophytes showed weaker but still significant associations ($r = 0.30$ for pain). Effusion and synovitis had minimal correlations, suggesting a limited role in symptom burden.

Table 1: Demographic Profile of Study Participants

Characteristic	Category	Frequency (n)	Percentage (%)
Age Group (years)	30- 39	5	4.55%
	40- 49	48	43.64%
	50- 59	38	34.55%
	60- 69	16	14.55%
	≥70	3	2.73%
Gender	Male	58	52.7%
	Female	52	47.3%
BMI Category	Normal (18.5-24.9)	36	32.7%
	Overweight (25-29.9)	56	50.9%
	Obese (≥30)	18	16.4%

Table 2: Distribution of WOMAC score in different domains

WOMAC Domain	Score Range	Common Ranges (%)
Pain	0 -20	5 -9 and 15 -20 (29.09%)
Stiffness	0- 8	2 -3 (38.18%)
Function	0 -68	17- 34 (34.55%)

Table 3: Correlation Between BML Grade and WOMAC Total Score

BML Grade	Frequency (n)	WOMAC Mean ± SD	Pearson's r	p-value
0	32	28.4 ± 10.2	-	-
1	41	42.7 ± 12.6	0.38	≤ 0.001
2	27	53.1 ± 14.3	0.51	≤ 0.001
3	10	65.8 ± 16.1	0.63	≤ 0.001

Table 4: Correlation Between Cartilage Loss and WOMAC Scores

Cartilage Type	Present WOMAC Mean ± SD	Absent WOMAC Mean ± SD	Pearson's r	p-value
Full-thickness Loss	52.6 ± 15.2	34.8 ± 11.7	0.45	≤ 0.001
Partial-thickness Loss	47.3 ± 14.9	32.1 ± 10.4	0.39	≤ 0.001

Table 5: Summary of correlation between MOAKS and WOMAC score

MOAKS Feature	WOMAC Domain	Pearson's r	p-value	Sensitivity (%)
Bone Marrow Lesion	Pain	0.55	<0.001	80
	Function	0.58	<0.001	82
	Total	0.60	<0.001	85
Cartilage Loss	Pain	0.45	0.001	72
	Function	0.50	<0.001	75
Osteophyte	Pain	0.30	0.02	60
	Stiffness	0.25	0.04	55
Meniscus Extrusion	Pain	0.40	0.003	70
	Function	0.48	0.001	78
Effusion	Pain	0.35	0.008	65
	Stiffness	0.32	0.001	62
Synovitis	Pain	0.38	0.005	68
Meniscus Tear	Function	0.42	0.002	72
Ligament Tear (ACL/PCL)	Function	0.47	0.001	76

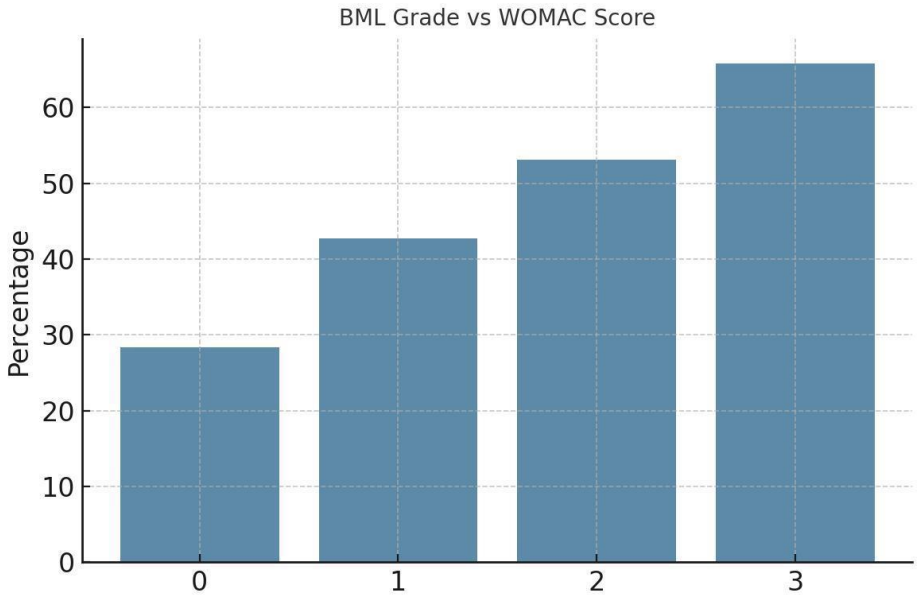

Figure 1: Stepwise Increase in WOMAC Scores with Higher MOAKS BML Grades Among Knee OA Patients

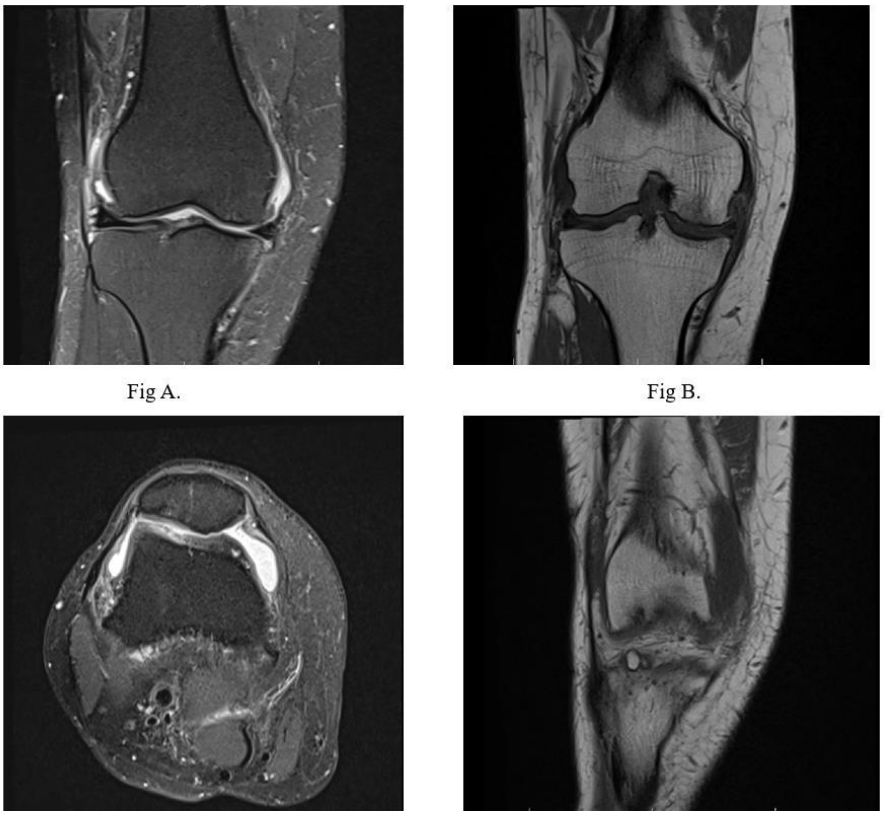

Fig A. Fig B.

Figure 2: MRI Findings in a 47-Year-Old Male with Moderate Knee Osteoarthritis Symptoms (WOMAC Score 47/98)

FIG A. Coronal MRI image shows joint space reduction
FIG B. Coronal MRI image shows anterior femur osteophyte (MOAKS Grade 1)
FIG C. Axial MRI shows mild knee joint effusion (MOAKS grade 2)
FIG D. Coronal MRI image shows a small popliteal cyst.

Discussion

In our study of 110 Indian patients, most were aged between 40 - 59 years (78.2%) and slightly more were men (52.7%), while half of them were overweight (BMI 25–29.9 kg/m²). WOMAC pain scores showed a clear bimodal pattern: 29.1% had mild pain (5–9), and another 29.1% severe pain (15–20). Stiffness was generally mild (scores 2–3 in 38.2%), and functional limitation settled mostly in the moderate range (17–34 in 34.6%) (Table 2). Such wide variation, even among similar age and weight groups, reflects patterns seen in an observational cohort where different pain phenotypes correspond to distinct MRI-detected structural changes (3,7).

We found a strong positive correlation between bone marrow lesion (BML) grade and total WOMAC score ($r = 0.60$, $p < 0.001$), with a mean WOMAC rising from 28.4 in BML grade 0 to 65.8 in grade 3 (Table 3). Conversely, a UK-VIDEO trial showed no correlation between total subchondral BML volume and WOMAC domains ($b = 0.3$ WOMAC units per mm³, $p > 0.05$), though only the cystic component of BMLs was linked to pain ($b = 51.8$, 95% CI 14.2–89.3), suggesting lesion composition matters more than size alone (8,9).

Cartilage loss showed moderate links to patient symptoms, with full-thickness defects correlating with WOMAC scores ($r = 0.45$) and partial-

thickness lesions at r = 0.39 (both $p \leq 0.001$, Table 4). Halmandge et al. similarly found a moderate positive correlation between medial femorotibial cartilage defects and WOMAC pain ($r \approx 0.42$), reinforcing that focal cartilage breakdown drives clinical burden (3). Colak et al. reported that a simpler Outerbridge clinical grading predicted arthroscopic outcomes just as well as MOAKS (AUC 0.695 vs. 0.683) and with better inter-reader agreement (80.8% vs. 65.0%, p = 0.012), suggesting ultra-detailed MRI scoring may not always improve clinical discrimination (2,9). More quantitatively, Zhou and Shen showed that T2 relaxation times, a direct measure of cartilage matrix integrity, correlated inconsistently with WOMAC (r = 0.282–0.636), indicating that advanced imaging metrics can diverge from symptom profiles and need further standardization before routine use (1,10).

Meniscal pathology, extrusion, and tears showed moderate correlations with WOMAC pain and function in our cohort (r = 0.40–0.48; Table 5). Perry et al. demonstrated that patients treated with platelet-rich plasma had significant reductions in meniscal extrusion scores alongside parallel improvements in WOMAC pain and function ($p < 0.05$), suggesting that restoring meniscal anatomy can relieve symptoms (8). However, Halmandge et al. found a high prevalence of meniscal extrusion and tears without any corresponding rise in WOMAC scores, indicating that meniscal changes may not always drive symptoms uniformly across populations or disease stages (11). This discrepancy might reflect differences in how extrusion is measured, the influence of coexisting cartilage loss, or variations in individual biomechanics.

Osteophyte formation, effusion, and synovitis showed weaker yet significant links with WOMAC domains in our cohort (r = 0.25–0.38 in Table 5). Jaremko et al. found that even low-grade effusions (MOAKS ≥1) were associated with nearly double the baseline WOMAC pain score (4.8 vs. 2.4; $p < 0.001$) and increased odds of steroid injection, highlighting that minimal effusion still matters clinically (12). Using the WORMS system, Bilgici et al. observed even stronger effusion–pain ($r = 0.601$; $p < 0.001$) and effusion-related disability correlations ($r = 0.626$, $p < 0.001$), suggesting whole-organ scoring may more sensitively capture fluid's impact on symptoms (13). In contrast, Halmandge et al. reported no significant relationship between osteophyte size or synovitis–effusion grades and WOMAC scores, indicating these features may be less symptom-driven in some Western cohorts (11). Also, Fan et al. showed that osteophyte burden predicted pain progression only when baseline BML or effusion synovitis was present (RR 1.15 per grade increase, $p < 0.01$), whereas without these accompanying lesions, osteophytes did not affect symptom change, demonstrating how multiple lesion types interact to drive clinical severity (14).

Beyond lesion-specific correlations, the reliability and granularity of MRI scoring systems themselves shape the strength of MRI clinical links. Maksymowych et al. showed that the KIMRISS method achieved much higher inter-reader reliability (ICC > 0.80 for both BML and effusion) compared to MOAKS, which often fell below this mark for some features (6).

This better reproducibility may partly explain why studies using MOAKS without rigorous reader calibration sometimes report weaker or inconsistent correlations. Furthermore, the predictive models by Peng and Sun demonstrated that integrating multiple semi-quantitative features of bone marrow lesions, cartilage morphology, and osteophytes into multivariate scores yielded AUCs of 0.74–0.80 for different pain types, suggesting composite scoring can improve MRI phenotyping's clinical usefulness (8). As MRI assessment evolves, standardizing scoring protocols and blending semi-quantitative with quantitative metrics will be essential for reliably linking structural pathology to patient-reported outcomes.

Our study's primary strength is that it is the first to validate MOAKS & WOMAC correlations using high-field 3T MRI in an Indian cohort, filling an important gap in ethnicity-specific data. But the retrospective, single-center design limits causal inference and may introduce referral bias, and reliance on subjective WOMAC assessments can be swayed by psychosocial factors beyond joint pathology. Although MOAKS provides a comprehensive semi-quantitative grading framework, its only moderate inter-reader reliability for some features highlights the need for more reproducible scoring systems.

Future work must focus on prospective, longitudinal cohorts to see if baseline MRI features such as cystic versus non-cystic BMLs and cartilage integrity, plus markers like synovial osteopontin, actually predict symptom trajectories and structural worsening. Additionally, multi-centre studies of the region with standardized calibration of advanced scoring systems and incorporation of quantitative tools (such as T2 mapping or Dual-energy CT virtual non-calcium) will improve reproducibility and clarify how different imaging methods can be used for truly personalised OA management.

Taken together, the work shows that subchondral bone marrow lesions and cartilage loss are the primary MRI features driving clinical severity in knee osteoarthritis, whereas meniscal pathology, osteophytes, and inflammatory markers have a more secondary impact. By improving imaging phenotyping with more reliable scoring systems and combining these with molecular markers, we can precisely target the key structural drivers of pain and dysfunction and thereby optimise patient outcomes in knee OA.

Conclusion:

Our study highlights that subchondral bone marrow lesions and cartilage loss are the most symptom-relevant MRI features in knee OA, showing the strongest correlation with WOMAC scores. Meniscal extrusion, osteophytes, and synovitis had weaker associations, suggesting a more secondary contribution to clinical severity. Future multicenter, prospective studies using standardized and quantitative imaging tools are necessary to validate these links and personalize OA care.

Conflict of interest: NIL

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