



PLAIN RADIOGRAPHIC GRADING OF PRIMARY KNEE OSTEOARTHRITIS USING THE KELLGREN–LAWRENCE SYSTEM AND ITS CORRELATION WITH CLINICAL SEVERITY: A CROSS-SECTIONAL STUDY

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Abstract

Background: Primary knee osteoarthritis (OA) is a leading cause of pain and disability in adults. The Kellgren–Lawrence (KL) system is the most widely used plain-radiographic grading scheme, but the relationship between radiographic grade and clinical severity is variable and clinically important, since management decisions rest on both. **Objectives:** To grade primary knee OA using the KL system and its component radiographic features, and to correlate the radiographic grade with clinical severity (pain and function), at a tertiary care hospital in South India. **Methods:** In this hospital-based cross-sectional study, 250 patients with symptomatic primary knee OA underwent standardised (preferably weight-bearing) radiography of the index knee with KL grading and scoring of individual features (joint-space narrowing, osteophytes, subchondral sclerosis, cysts). Clinical severity was assessed by the visual analogue scale (VAS) for pain and the WOMAC index, and correlated with KL grade. **Results:** The mean age was 57.1 ± 9.3 years (63.6% female), with a mean BMI of 27.8 ± 3.7 kg/m² (78.8% overweight/obese); 50.8% reported occupational squatting/kneeling and 67.2% had bilateral symptoms. KL grade distribution was grade 1 in 10.4%, grade 2 in 38.8%, grade 3 in 33.6% and grade 4 in 17.2%; weight-bearing radiographs were used in 84.4%. Medial joint-space narrowing ($\geq$ grade 1) was present in 96.4% and osteophytes ($\geq$ grade 1) in 96.8%. The mean WOMAC total score was 53.6 ± 15.6 and mean VAS 6.1. Clinical severity rose steadily with radiographic grade: mean WOMAC increased from 32.7 (KL 1) to 46.1 (KL 2), 58.5 (KL 3) and 73.4 (KL 4), and KL grade correlated strongly with WOMAC (Spearman $r = 0.76$, $p < 0.001$) and with VAS ($r = 0.75$). Clinical severity was mild in 10.4%, moderate in 38.8% and severe in 50.8%. **Conclusion:** KL radiographic grade correlated strongly with clinical pain and functional severity in primary knee OA, supporting its role as a simple, informative bedside tool, though the imperfect concordance means that radiographic grade should complement rather than replace clinical assessment.

Keywords: knee osteoarthritis; Kellgren–Lawrence grade; WOMAC; radiographic severity; joint-space narrowing; South India

Introduction

Osteoarthritis of the knee is among the commonest chronic musculoskeletal disorders and a major cause of



pain, functional limitation and disability in middle-aged and older adults. Its prevalence is rising with population ageing and the increasing burden of obesity, and in India it is compounded by lifestyle factors such as floor-level activities involving deep squatting and kneeling. The diagnosis and staging of knee OA rest heavily on plain radiography, which demonstrates the cardinal structural features of the disease—joint-space narrowing reflecting cartilage loss, marginal osteophytes, subchondral sclerosis and cysts, and, in advanced disease, deformity [1].

The Kellgren–Lawrence (KL) system, introduced in 1957, remains the most widely used and internationally accepted scheme for grading the radiographic severity of knee OA, assigning a five-point grade (0–4) based principally on the presence and size of osteophytes and the degree of joint-space narrowing. Despite the emergence of alternative and more granular scoring systems, the KL grade continues to be the reference standard in epidemiological studies, clinical trials and routine practice, and defining OA as KL grade ≥ 2 is a widely used convention [2,5]. Its enduring popularity reflects its simplicity, reproducibility and familiarity, although comparative studies have shown that categorical joint-space-narrowing scores, particularly on semiflexed views, may offer advantages in reproducibility and sensitivity to change [2].

A recurring and clinically important question is how closely radiographic severity corresponds to the patient's symptoms and function. The relationship is known to be imperfect: many individuals with marked radiographic change have modest symptoms, while others with severe pain have relatively mild radiographic disease, and cartilage degeneration seen at arthroscopy correlates only moderately with radiographic grade [3,4]. Pain and disability in knee OA are multifactorial, influenced by structural severity but also by body weight, muscle strength, joint laxity, comorbidity, psychological factors and pain sensitisation [4]. Nonetheless, several studies have documented significant positive associations between KL grade and validated measures of pain and function such as the WOMAC index and the visual analogue scale, and between KL grade and biological markers of disease activity [6,7]. Understanding the strength of this radiographic–clinical correlation in a given population is important because it informs how much weight to place on the radiograph when making management decisions.

The clinical value of a radiographic–clinical correlation is twofold. First, when the two are concordant, the KL grade offers an objective anchor for staging disease, counselling patients about prognosis, and selecting management along the conservative-to-surgical continuum—from weight reduction, physiotherapy and analgesia in earlier disease to consideration of arthroplasty in advanced, symptomatic disease. Second, when they are discordant, the mismatch itself carries information, prompting a search for other contributors to pain—inflammation, referred pain, periarticular pathology or central sensitisation—that a radiograph alone cannot capture. A quantitative understanding of how strongly grade and symptoms travel together therefore helps clinicians calibrate the weight they place on the film.

The present study was therefore undertaken to grade primary knee OA using the KL system and its component radiographic features, and to correlate the radiographic grade with clinical severity, at a tertiary care hospital in South India.

Materials and Methods

Study design and setting

This was a hospital-based, descriptive cross-sectional study conducted in the Departments of Orthopaedics and Radiodiagnosis, a tertiary care teaching hospital, South India. The study was approved by the Institutional Ethics Committee.

Participants



Two hundred and fifty patients with symptomatic primary knee OA were included. Patients with secondary OA (inflammatory arthropathy, post-traumatic or septic sequelae) were excluded. Demographic, anthropometric (BMI) and risk-factor data (occupational squatting/kneeling, prior knee injury, family history), symptom duration and laterality were recorded.

Radiographic assessment

Standardised radiographs of the index knee—preferably weight-bearing anteroposterior views together with lateral and, where available, skyline projections—were obtained and graded using the KL system (grades 0–4). Individual radiographic features were scored separately: medial and lateral joint-space narrowing, osteophyte grade, subchondral sclerosis, subchondral cysts, bony deformity, patellofemoral OA and chondrocalcinosis. A proportion of films underwent a second independent reading.

Clinical assessment and definitions

Clinical severity was assessed using the visual analogue scale (VAS, 0–10) for pain, morning stiffness duration, and the WOMAC index (pain, stiffness and function subscales and total score), together with a clinical examination (crepitus, joint-line tenderness, bony enlargement, deformity, effusion, quadriceps wasting, range of motion). A composite clinical severity category (mild, moderate, severe) was derived. Radiographic–clinical correlation was assessed between KL grade and WOMAC/VAS.

Statistical analysis

Data were summarised using descriptive statistics; categorical variables were expressed as frequencies and percentages and continuous variables as mean $\pm$ standard deviation. The correlation between KL grade and clinical scores was assessed using the Spearman rank correlation coefficient.

Results

Demographic and clinical profile

The 250 patients had a mean age of 57.1 ± 9.3 years, with a female predominance (63.6%). The mean BMI was 27.8 ± 3.7 kg/m², and 78.8% were overweight or obese. Occupational squatting or kneeling was reported by 50.8%, a family history of knee OA by 38.4% and prior knee injury by 20.4%; symptoms were bilateral in 67.2%, with a mean symptom duration of 38 months (Table 1). On examination, crepitus was present in 71.6%, varus deformity in 54.0%, quadriceps wasting in 39.6% and effusion in 34.0%.

Radiographic grading

Weight-bearing radiographs were used in 84.4% of patients. The KL grade of the index knee was grade 1 in 26 patients (10.4%), grade 2 in 97 (38.8%), grade 3 in 84 (33.6%) and grade 4 in 43 (17.2%) (Figure 1). Individual radiographic features were common: medial joint-space narrowing of at least grade 1 was present in 96.4%, osteophytes of at least grade 1 in 96.8%, subchondral sclerosis in 58.0%, subchondral cysts in 30.8% and patellofemoral OA in 46.4% (Table 2).

The examination findings paralleled the radiographic and symptomatic severity. Crepitus, present in nearly three-quarters of patients, is an expected accompaniment of cartilage loss and surface incongruity, while quadriceps wasting and effusion—each present in a substantial minority—reflect the disuse and low-grade synovitis that accompany symptomatic disease and that themselves contribute to pain and functional limitation. Varus deformity in over half of patients is in keeping with the medial-compartment predominance typical of this population.



Clinical severity and correlation with radiographic grade

The mean WOMAC total score was 53.6 ± 15.6 , the mean VAS 6.1 and the mean morning stiffness 20 minutes. Clinical severity increased consistently with radiographic grade: the mean WOMAC total score rose from 32.7 at KL grade 1 to 46.1 at grade 2, 58.5 at grade 3 and 73.4 at grade 4, and the mean VAS from 4.0 to 5.4, 6.9 and 7.6 across the same grades (Table 3; Figure 2). KL grade correlated strongly and significantly with the WOMAC total score (Spearman $r = 0.76$, $p < 0.001$) and with the VAS ($r = 0.75$). Overall, clinical severity was categorised as mild in 10.4%, moderate in 38.8% and severe in 50.8% (Table 4).

Table 1: Demographic, anthropometric and clinical characteristics (N = 250).

Variable	Value
Age (years), mean $\pm$ SD	57.1 ± 9.3
Female	159 (63.6%)
BMI (kg/m^2), mean $\pm$ SD	27.8 ± 3.7
Overweight/obese	78.8%
Occupational squatting/kneeling	50.8%
Family history of knee OA	38.4%
Prior knee injury	20.4%
Bilateral symptoms	67.2%
Symptom duration (months), mean	38
Crepitus	71.6%
Varus deformity	54.0%
Quadriceps wasting	39.6%
Effusion	34.0%

Table 2: Radiographic grading and features.

Variable	Category	n (%)
KL grade (index knee)	1	26 (10.4)
	2	97 (38.8)
	3	84 (33.6)
	4	43 (17.2)
Weight-bearing radiograph	Yes	211 (84.4)
Medial joint-space narrowing ≥ 1		96.4%
Osteophytes ≥ 1		96.8%
Subchondral sclerosis		58.0%



Subchondral cysts		30.8%
Patellofemoral OA		46.4%

Table 3: Clinical severity by KL grade.

KL grade	Mean WOMAC total	Mean VAS (0–10)
Grade 1	32.7	4.0
Grade 2	46.1	5.4
Grade 3	58.5	6.9
Grade 4	73.4	7.6
Overall	53.6 ± 15.6	6.1

Spearman correlation: KL grade vs WOMAC total $r = 0.76$ ($p < 0.001$); KL grade vs VAS $r = 0.75$.

Table 4: Overall clinical severity category.

Severity	n (%)
Mild	26 (10.4)
Moderate	97 (38.8)
Severe	127 (50.8)

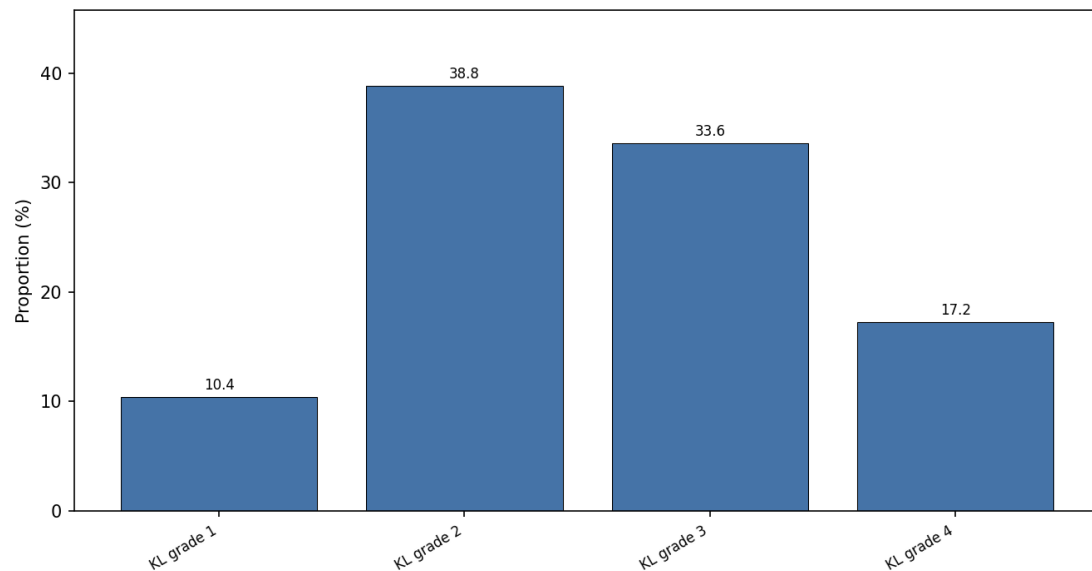


Figure 1: Distribution of Kellgren–Lawrence grade of the index knee (%).

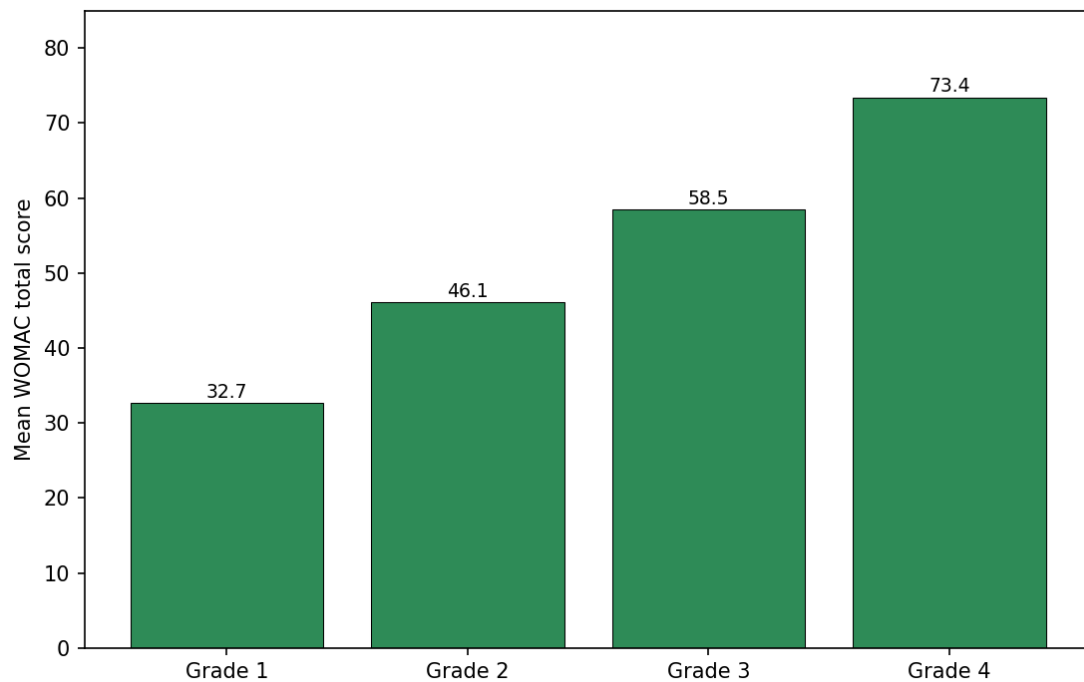


Figure 2: Mean WOMAC total score by Kellgren–Lawrence grade.

Discussion

This cross-sectional study demonstrates a strong positive correlation between the KL radiographic grade and clinical severity—both pain and function—in patients with symptomatic primary knee OA, with the mean WOMAC score more than doubling from KL grade 1 to grade 4 and a Spearman correlation of 0.76 with WOMAC and 0.75 with VAS. This finding supports the clinical utility of the KL grade as a simple, inexpensive and widely understood summary of structural severity that tracks meaningfully with how the patient feels and functions, and it accords with studies reporting significant associations between KL grade and validated symptom and biomarker measures [6,7].

At the same time, the correlation, though strong, is not perfect, and this incompleteness is itself clinically instructive. A substantial literature documents discordance between radiographic and symptomatic severity: cartilage degeneration at arthroscopy correlates only moderately with KL grade [3], meniscal tears are highly prevalent on MRI across all radiographic grades yet do not reliably explain pain [4], and in end-stage disease self-reported disability is driven as much by pain, body weight and joint laxity as by radiographic grade [8]. Pain in knee OA is a multidimensional phenomenon reflecting not only structural damage but inflammation, peripheral and central sensitisation, muscle weakness, psychological state and comorbidity. The practical implication is that the radiograph should inform, but not dictate, management: a patient with severe symptoms and modest radiographic change deserves the same careful assessment and treatment as one whose grades are concordant.

The demographic and risk-factor profile of the cohort—middle-aged, predominantly female, overweight or obese, with frequent occupational squatting and a high rate of bilateral disease—reflects the recognised risk factors for knee OA and, in the Indian context, the contribution of floor-level activities and rising obesity. The very high prevalence of joint-space narrowing and osteophytes on radiographs confirms that these features underpin the KL grade, while the appreciable rates of subchondral sclerosis, cysts and patellofemoral involvement illustrate the multi-compartment nature of the disease. Varus deformity in over



half of patients is consistent with the predominance of medial-compartment OA and has implications for load redistribution and surgical planning, although alignment is better regarded as a marker of established disease severity than as an independent initiator [5].

Methodologically, the study reaffirms the central role of standardised, preferably weight-bearing, radiography in the assessment of knee OA. Weight-bearing (and ideally semiflexed) views improve the detection and reproducibility of joint-space narrowing, the feature most sensitive to change, and comparative work by the OARSI–OMERACT group has shown that categorical joint-space-narrowing scoring on semiflexed views offers the best reproducibility and sensitivity to change among common schemes [2]. Nonetheless, for routine clinical grading and communication, the KL system remains the pragmatic standard, and its strong correlation with clinical severity in this cohort supports its continued everyday use. Advanced imaging such as MRI adds sensitivity for early cartilage and meniscal change but, as the evidence on incidental meniscal tears shows, must be interpreted cautiously and is not required for routine staging [4].

From a management standpoint, the strong grade–symptom correlation observed here has practical value in a busy clinic. A plain radiograph, obtainable at low cost almost anywhere, provides an immediate, reproducible estimate of structural severity that—because it tracks WOMAC and VAS—helps triage patients toward appropriate intensity of treatment and toward timely surgical referral when high radiographic grade coincides with severe, refractory symptoms. Equally, the concentration of severe clinical disease (half the cohort) among the higher radiographic grades supports the pragmatic use of KL grade as one criterion, alongside symptom burden and functional limitation, in prioritising patients for interventions such as total knee arthroplasty.

It is also important to place these findings within the limitations of radiographic staging itself. Plain radiographs image bone and infer cartilage status indirectly from joint-space width; they are relatively insensitive to early cartilage and meniscal change and are influenced by knee positioning, beam angle and weight-bearing status. This explains why some patients with early symptomatic disease have low grades and why standardisation of technique is essential for reliable grading and for any longitudinal comparison [2,3]. The measured associations should therefore be understood as reflecting established, symptomatic disease in a clinic population rather than the full spectrum of OA in the community.

Conclusion

In this South Indian cohort with symptomatic primary knee OA, the Kellgren–Lawrence radiographic grade correlated strongly with clinical pain and functional severity, with WOMAC and VAS rising steadily across grades. The KL grade is therefore a simple, informative bedside indicator of disease severity and a valuable adjunct to clinical assessment. Because the radiographic–clinical concordance is strong but incomplete, however, the grade should complement rather than replace a thorough clinical evaluation, and management should be guided by the patient’s symptoms and function as well as by the radiograph.

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