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Original Article

Orthopaedics Section

Comparison of Ultrasonographic and Radiographic Findings in Knee Osteoarthritis: A Cross-sectional Study

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ABSTRACT

Introduction: Knee Osteoarthritis (OA) is a prevalent degenerative joint disorder and a major cause of pain and disability among the elderly population. Conventional radiography remains the standard imaging modality for diagnosis and grading; however, it has limited sensitivity in detecting early and soft-tissue changes. Ultrasonography (USG) has emerged as a useful, cost-effective adjunct for evaluating both osseous and periarticular soft-tissue abnormalities. Hence, there is a need to assess its diagnostic efficacy in comparison with radiography.

Aim: To compare the ultrasonographic features with radiographic grading (Kellgren-Lawrence) in patients with knee OA.

Materials and Methods: The present cross-sectional observational study was conducted in the Department of Orthopaedics at SRM Medical College Hospital and Research Institute, Kattankulathur, Chennai, Tamil Nadu, India. from May 2024 to August 2024. A total of 48 patients aged above 50 years fulfilling the American College of Rheumatology (ACR) criteria for knee OA were included. All patients underwent standing anteroposterior and lateral radiographs, graded using the Kellgren-Lawrence (KL) classification, followed by ultrasonographic evaluation using a high-frequency linear probe. Parameters studied included osteophytes, Joint Space Narrowing (JSN), cartilage thickness, joint effusion, Baker's cyst, and meniscal protrusion. Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) software (version 22.0). McNemar's test, Chi-square test, and paired t-test were applied. A p-value of <0.05 was considered statistically significant.

Results: The majority of patients were aged 60-69 years 20 (41.7%) with a female predominance 26 (54.2%). Most cases belonged to Kellgren-Lawrence (KL) Grade 2 18 (37.5%) and Grade 3 16 (33.3%). USG detected osteophytes in 44 (91.7%) of patients compared to 34 (70.8%) on radiography (p=0.004). JSN was observed in 38 (79.2%) by USG and 36 (75.0%) by radiography (p=0.62), showing no significant difference. Ultrasonographic findings such as reduced cartilage thickness 32 (66.7%), joint effusion 20 (41.7%), and meniscal protrusion 12 (25.0%) increased significantly with higher KL grades (p<0.05). Mean medial joint space measurements were comparable between modalities (p=0.48), whereas USG detected significantly reduced lateral joint space compared to radiography (p=0.03).

Conclusion: USG provides improved detection of osteophytes and offers additional information on soft-tissue and early structural changes in knee OA. It associates well with radiographic severity and serves as a valuable, accessible adjunct to conventional radiography for comprehensive evaluation and early diagnosis of knee OA.

Keywords: Diagnostic imaging, Joint space narrowing, Kellgren-Lawrence grading, Osteophytes, Radiography

INTRODUCTION

The OA is the most common joint disorder worldwide and a leading cause of chronic pain and disability, particularly among the elderly population [1]. The knee joint is one of the most frequently affected sites, and the condition is characterised by progressive degeneration of articular cartilage, subchondral bone changes, and varying degrees of synovial inflammation [2-4]. Clinically, patients present with joint pain, stiffness, and functional limitation, significantly impacting quality of life.

Imaging plays a crucial role in the diagnosis and assessment of disease severity in knee OA. Conventional radiography remains the most widely used modality due to its availability, affordability, and ability to demonstrate classical features such as osteophyte formation, JSN, subchondral sclerosis, and cyst formation [5,6]. However, radiographic changes often appear late in the disease process, and several studies have demonstrated a discordance between radiographic findings and clinical symptoms [7-10]. Furthermore, radiography is limited in its ability to assess soft-tissue structures and early cartilage changes.

Magnetic Resonance Imaging (MRI) provides a comprehensive evaluation of both osseous and soft-tissue structures and is considered superior for detecting early osteoarthritic changes. However, its routine use is limited by high cost, longer examination time, and limited accessibility, especially in resource-constrained settings [11]. This highlights the need for a cost-effective and accessible imaging modality that can evaluate both structural and soft-tissue changes.

USG has emerged as a valuable imaging tool in the evaluation of knee OA. It allows real-time visualisation of periarticular soft-tissues, synovium, cartilage surface, joint effusion, and osteophytes, while being safe, inexpensive, and widely available [12,13]. Previous studies have demonstrated that USG is a reliable modality with good validity and reproducibility in assessing osteoarthritic changes.

Recent studies have further highlighted the advantages of USG over conventional radiography. USG has been found to be more effective in detecting osteophytes and soft-tissue abnormalities, supporting its role as a complementary imaging modality in knee OA [14,15].

Despite these findings, there remains a paucity of studies that comprehensively associate detailed ultrasonographic findings such as cartilage thickness, joint effusion, and meniscal protrusion-with standardised radiographic grading systems like the Kellgren-

Lawrence classification. Additionally, limited data are available from Indian clinical settings, where demographic and disease patterns may vary [16,17].

The authors compared ultrasonographic features with radiographic grading (Kellgren-Lawrence) in patients with knee OA. The present study aimed to provide a comprehensive assessment of both osseous and soft-tissue changes and to highlight the complementary role of USG in the evaluation and early detection of knee OA.

MATERIALS AND METHODS

The present study was designed as a cross-sectional study to evaluate and compare ultrasonographic and radiographic findings in patients with knee OA. The study received Institutional Ethics Committee approval from SRM Medical College Hospital & Research Centre, Kattankulathur, Chennai, Tamil Nadu, India. (Ethics Clearance No: SRMIEC-ST0226-7096; Reg No: EC/NEW/INST/2022/2933). The study was carried out in accordance with the ethical principles outlined in the Declaration of Helsinki. Written informed consent was obtained from all participants prior to inclusion in the study. Patient confidentiality and anonymity were strictly maintained throughout the study, and no identifying information was disclosed.

Patients presenting to the Orthopaedics Outpatient and Inpatient Departments with clinically suspected knee OA were screened for eligibility. The study procedures were conducted in accordance with the ethical standards of the responsible committee on human experimentation.

Sample size calculation: The sample size was calculated using a prevalence-based formula yielding a total sample size of 48 patients. The calculation was performed using OpenEpi software (Version 3.01) based on the findings of a similar study by Suwal S et al., assuming a confidence level of 95% (Z=1.96) and absolute precision of 5% [15]. The calculated sample size was 48.

Inclusion criteria: Patients aged more than 50 years fulfilling the American College of Rheumatology (ACR) clinical criteria for knee OA, including morning stiffness lasting less than 30 minutes, crepitus on knee movement, bony tenderness, bony enlargement, and absence of palpable warmth [16].

Exclusion criteria: Patients with a history of prior knee surgery, recent trauma to the knee, or fracture or dislocation involving the knee joint were excluded from the study.

Study Procedure

Clinical evaluation: All patients underwent detailed clinical assessment based on ACR criteria for knee OA before imaging investigations [16]. Demographic (age, sex), clinical (pain, stiffness), radiographic (KL grade, osteophytes, JSN), ultrasonographic (osteophytes, cartilage thickness, effusion, meniscal protrusion, Baker's cyst, joint space), and outcome variables were collected.

Radiographic assessment of the knee: Conventional radiography of the knee was performed using standing anteroposterior and lateral views to assess JSN and osteophyte formation.

Kellgren-Lawrence grading system: Radiographic severity of knee OA was graded according to the Kellgren-Lawrence classification system [17]. The Kellgren-Lawrence grading system classifies knee OA radiographically from Grade 0 (normal) to Grade 4 (severe disease), based on progressive findings of osteophyte formation, JSN, subchondral sclerosis, and bony deformity [1].

Ultrasonographic assessment of the knee: USG of the knee was performed in all patients using a high-frequency linear probe.

Ultrasonographic parameters evaluated: USG evaluation included assessment of osteophytes, joint space, cartilage thickness, knee effusion, Baker's cyst, and meniscal protrusion.

Comparison of USG findings with radiographic findings: Ultrasonographic findings were compared with radiographic findings across different Kellgren-Lawrence grades.

Outcome measures: The outcome measures included detection of osteophytes, assessment of JSN, evaluation of cartilage thickness, joint effusion, meniscal protrusion, and comparison of mean joint space measurements between radiography and USG.

STATISTICAL ANALYSIS

The parameters studied included osteophytes, JSN, cartilage thickness, joint effusion, meniscal protrusion, Baker's cyst, and joint space measurements. Statistical analysis was performed using SPSS software (version 22.0). McNemar's test, Chi-square test, and paired t-test were applied as appropriate. A p-value <0.05 was considered statistically significant.

RESULTS

Demographic Characteristics of Study Participants

The total sample size of the study was 48 patients with mean age of 62.8±7.5 years. Among the 48 study participants, most were aged 60-69 years (41.7%), followed by those aged 50-59 years (37.5%), while individuals aged ≥70 years comprised 20.8% of the cohort. Females constituted a slightly higher proportion than males (54.2% vs. 45.8%), indicating a modest female predominance in knee OA [Table/Fig-1].

Variables	n (%)
Age (years)	
50-59	18 (37.5)
60-69	20 (41.7)
≥70	10 (20.8)
Sex	
Male	22 (45.8)
Female	26 (54.2)

[Table/Fig-1]: Demographic characteristics of study participants (N=48).

Distribution of Kellgren-Lawrence (KL) Grades on Radiography

Regarding the radiographic severity of knee OA based on the Kellgren-Lawrence grading system, the majority of patients were classified as Grade 2 (37.5%), indicating the presence of definite osteophytes with possible JSN. This was followed by Grade 3 (33.3%), characterised by moderate JSN and subchondral sclerosis. A smaller proportion of patients were observed in Grade 4 (16.7%), representing advanced disease with severe JSN and bony deformity. The least number of cases belonged to Grade 1 (12.5%), where only doubtful osteophytes were present [Table/Fig-2].

KL Grade	Radiographic features	n (%)
Grade 1	Doubtful osteophytes	6 (12.5)
Grade 2	Definite osteophytes, possible Joint Space Narrowing (JSN)	18 (37.5)
Grade 3	Moderate JSN, sclerosis	16 (33.3)
Grade 4	Severe JSN, deformity	8 (16.7)

[Table/Fig-2]: Distribution of Kellgren-Lawrence (KL) Grades on radiography (N=48).

Ultrasonographic Findings in Patients with Knee Osteoarthritis (OA)

Regarding spectrum of ultrasonographic findings observed in the 48 patients with knee OA, osteophytes were the most frequent ultrasonographic finding, present in 91.7% of patients. Reduced cartilage thickness was observed in 66.7%, while joint effusion was seen in 41.7%, indicating associated inflammatory changes. Meniscal protrusion was detected in 25.0% of cases, and Baker's cyst was the least common finding, occurring in 12.5% of patients [Table/Fig-3].

USG finding	n (%)
Osteophytes	44 (91.7)
Reduced cartilage thickness	32 (66.7)
Joint effusion	20 (41.7)
Meniscal protrusion	12 (25.0)
Baker's cyst	6 (12.5)

[Table/Fig-3]: Ultrasonographic findings in patients with knee Osteoarthritis (OA) (N=48).

Comparison of Osteophyte Detection by Radiography and Ultrasonography (USG)

Regarding the detection of osteophytes using radiography and USG, osteophytes were identified in 70.8% of patients on radiographs, whereas USG detected osteophytes in a significantly higher proportion (91.7%). This difference was statistically significant (p=0.004), demonstrating the superior sensitivity of USG in detecting osteophyte formation compared to conventional radiography [Table/Fig-4]. Normality is not applicable as McNemar's test was used for paired categorical (binary) data.

Osteophyte detection	Radiography n (%)	Ultrasonography (USG) n (%)	p-value
Present	34 (70.8)	44 (91.7)	0.004*
Absent	14 (29.2)	4 (8.3)	

[Table/Fig-4]: Comparison of Osteophyte detection by radiography and Ultrasonography (USG) (N=48).
Statistical test: McNemar's test; *Statistically significant (p<0.05)

Comparison of Joint Space Narrowing (JSN) Detected by Radiography and USG

On comparison of JSN as detected by radiography and USG, JSN was observed in 75.0% of patients on radiographs and 79.2% on USG. The difference between the two imaging modalities was not statistically significant (p=0.62), indicating comparable performance of radiography and USG in assessing JSN [Table/Fig-5].

Joint Space Narrowing (JSN)	Radiography n (%)	Ultrasonography (USG) n (%)	p-value
Present	36 (75.0)	38 (79.2)	0.62
Absent	12 (25.0)	10 (20.8)	

[Table/Fig-5]: Comparison of Joint Space Narrowing (JSN) detected by radiography and USG (N=48).
Statistical test: McNemar's test; *p>0.05 considered not statistically significant

Association of Ultrasonographic Findings with Kellgren-Lawrence Grades

Comparison of ultrasonographic findings with radiographic severity revealed that patients with higher Kellgren-Lawrence grades (3-4) had a significantly greater prevalence of USG abnormalities, including osteophytes (100%), reduced cartilage thickness (83.3%), joint effusion (58.3%), and meniscal protrusion (33.3%), compared with those having lower grades (1-2). All associations were statistically significant (p<0.05), indicating a progressive increase in ultrasonographic abnormalities with disease severity [Table/Fig-6].

USG Parameters	KL Grade 1-2 n (%)	KL Grade 3-4 n (%)	p-value
Osteophytes	20 (83.3)	24 (100)	<0.001*
Reduced cartilage thickness	12 (50)	20 (83.3)	0.002*
Joint effusion	6 (25)	14 (58.3)	0.006*
Meniscal protrusion	4 (16.7)	8 (33.3)	0.03*

[Table/Fig-6]: Association of ultrasonographic findings with Kellgren-Lawrence Grades (Percentages were calculated using the respective KL grade subgroup denominator (n=24 in each group) N=48.
Statistical test: Chi-square test; *Statistically significant

Mean Joint Space Measurement: Radiography vs USG

On comparison of mean joint space measurements obtained by radiography and USG, the mean medial joint space measurements were similar between radiography (2.4±0.9 mm) and USG (2.5±0.8 mm), with no statistically significant difference (p=0.48). In contrast, the mean lateral joint space was significantly lower when measured by USG (3.0±0.8 mm) compared to radiography (3.2±0.7 mm) (p=0.03), suggesting that USG may be more sensitive in detecting subtle lateral compartment joint space reduction. [Table/Fig-7].

Parameters (mm)	Radiography (Mean±SD)	USG (Mean±SD)	p-value
Medial joint space	2.4±0.9	2.5±0.8	0.48
Lateral joint space	3.2±0.7	3.0±0.8	0.03*

[Table/Fig-7]: Mean joint space measurement: Radiography vs USG (n=48).
Statistical test: Paired t-test; *Statistically significant

DISCUSSION

The present study compared USG with conventional radiography in evaluating knee OA in 48 patients. USG demonstrated better detection of osteophytes and additional soft-tissue abnormalities, with findings consistent with radiographic severity. It serves as a valuable adjunct imaging modality for comprehensive assessment of knee OA.

The present study found that the majority of patients were aged 60-69 years (41.7%), followed by 50-59 years (37.5%) and ≥70 years (20.8%). As cartilage, subchondral bone, and periarticular tissues degenerate with time, OA prevalence increases with age. Oyamakinde SO et al., and Brom M et al., found similar age clustering, with OA prevalence rising after the fifth decade and peaking in the sixth and seventh decades [18,19].

The present study cohort had a little female predominance (54.2%), consistent with epidemiological research showing knee OA is more common in women, especially after menopause. Hormones, knee biomechanics, cartilage thickness, and postural alignment may contribute. Nigerian and South American populations have similar female preponderance, demonstrating this pattern is persistent across ethnic and geographic groups [18,19].

Most Kellgren-Lawrence (KL) Grade 2 (37.5%) and Grade 3 (33.3%) patients had mild to moderate OA on radiographs. Advanced OA (Grade 4) was 16.7% and early disease 12.5%. This distribution shows that many patients seek medical assistance in the early-to-moderate stages of disease, when structural damage is evolving but not quite end-stage. Oyamakinde SO et al., and Suwal S et al., both found KL Grades 2 and 3 to be the most common radiographic classifications. Radiographic characteristics such as JSN and osteophyte formation generally arise after severe cartilage loss, limiting its early illness identification [15,18].

Radiography revealed JSN in 75.0% of patients and USG in 79.2% (p=0.62). Radiography and USG assess joint space reduction similarly, especially in the medial compartment. Radiography is the standard for JSN evaluation since it shows cartilage degeneration and meniscal extrusion. USG directly visualises cartilage thickness and meniscal location, adding pathophysiological insights. Majidi H et al., and Suwal S et al., observed no significant variation in mean medial joint space measures between radiography and USG, confirming USG's reliability in joint space evaluation [14,15].

Another notable finding of the present study was that USG (91.7%) detected osteophytes more often than radiography (70.8%) (p=0.004). USG is more sensitive at detecting marginal osteophytes, especially in early and mild OA. USG can detect tiny, non-ossified osteophytes that radiography cannot, according to several studies [18]. USG can detect femoral and tibial osteophytes with sensitivities above 90%, according to Oyamakinde SO et al., and Brom M et al., found osteophytes in radiographed KL 0 knees. These findings suggest that USG can diagnose OA early when radiographic abnormalities are missing [18,19].

The USG showed a wide range of OA anomalies in this investigation. The most common findings were osteophytes (91.7%), reduced

cartilage thickness (66.7%), joint effusion (41.7%), meniscal protrusion (25.0%), and Baker's cyst (12.5%). USG is better at assessing knee joint osseous and soft-tissue components, according to these data. Previous investigations have found similar prevalence rates of effusion, meniscal protrusion, and Baker's cyst, demonstrating that OA is a "whole-joint disease" rather than a cartilaginous problem [18]. High-resolution USG can identify synovial inflammation, effusion, and periarticular cysts-features not visible on conventional radiography -which may contribute to pain and functional impairment [19].

Higher KL grades (3-4) were linked to more USG abnormalities, such as osteophytes (100%), reduced cartilage thickness (83.3%), joint effusion (58.3%), and meniscal protrusion (33.3%) ($p<0.05$). Higher radiographic disease severity was associated with increased frequency and severity of ultrasonographic abnormalities. These findings are consistent with Brom M et al., who found USG anomalies in radiographically normal knees and increased cartilage involvement and osteophytes with KL grades. This suggests USG can identify subclinical and preradiographic OA alterations [19].

Mean medial joint space measurements were similar across radiography (2.4±0.9 mm) and USG (2.5±0.8 mm), with no significant difference ($p=0.48$). USG detected minor lateral compartment constriction better than radiography ($p=0.03$), as mean lateral joint space was considerably reduced. In the Nepalese investigation by Suwal S et al., lateral joint space measurements differed significantly between the two modalities, probably due to USG's greater cartilage margin and meniscal extrusion visibility. USG may be useful in detecting early or asymmetric compartmental involvement, which normal radiographs may miss [15].

The present study highlights the important complementary role of USG in the evaluation of knee OA. While radiography remains essential for grading disease severity, USG provides additional insights into soft-tissue and early structural changes, enhancing overall diagnostic assessment. Its accessibility and safety make it a practical tool in routine clinical practice, especially in resource-limited settings.

Limitation(s)

Being a single-centre study, the results may not be representative of the broader population. Additionally, USG is operator-dependent, which may affect reproducibility, and the lack of comparison with MRI, considered the gold standard, limits comprehensive validation of the findings.

CONCLUSION(S)

The USG demonstrated superior detection of osteophytes and provided additional information on soft-tissue abnormalities, including cartilage changes, joint effusion, and meniscal protrusion, which are not adequately visualised on conventional radiography. Both modalities showed comparable assessment of JSN, while ultrasonographic findings increased significantly with higher Kellgren-Lawrence grades, indicating good association with radiographic severity. These findings highlight that USG serves as a valuable and accessible adjunct to radiography, enabling a more comprehensive evaluation of knee OA, particularly for early and soft-tissue changes.

Authors' contribution: Conceptualisation and study design were carried out by RRR and EDKN; Data collection was performed by RRR, EDKN, GN and S; Data analysis and interpretation were conducted by GN and S; The first draft of the manuscript was written by RRR; Critical revision of the manuscript for important intellectual content was performed by RRR and EDKN. All authors read and approved the final manuscript and agree to be accountable for all aspects of the work.

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