Cross-Sectional Study

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Comparative evaluation of knee osteoarthritis: radiography vs. ultrasonography in Nepalese population: a cross-sectional study

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Background and objectives: Osteoarthritis (OA) is a degenerative and long-term debilitating disease with rising prevalence, predominantly involving larger joints including the knee joint. While radiography has traditionally been the primary modality for joint evaluation, there is a growing trend towards using ultrasonography (USG) for musculoskeletal disorders, including joint assessment. This study aimed to find the role of USG in the evaluation of OA of knee joints with comparison to the radiographs.

Methods: This was a cross-sectional study done on patients with signs and symptoms of OA of the knee who visited the radiology department for knee radiographs. Kellgren and Lawrence system was used for grading OA in radiographs. USG of knee joints was done with high-frequency probes and searched for joint space width, articular cartilage thickness, marginal osteophytes, meniscal extrusion, and other articular/ extra-articular abnormalities. The USG findings were correlated with findings in anteroposterior and lateral radiographs.

Results: The mean number of osteophytes was higher in USG compared to the radiographs ($P < 0.001$). Mean joint spaces were comparable in both modalities. Meniscal extrusion was seen with USG, which significantly correlated with joint space width and cartilage thickness ($P < 0.005$). USG also detected synovial changes, effusion, and Baker's cyst.

Conclusion: Although radiography is the standard first-line radiological investigation for the diagnosis of OA of the knee joint, USG can be an adjunct as it well correlates with the radiograph findings and can provide more useful information.

Keywords: knee joint, osteoarthritis, radiography, ultrasonography

Introduction

Osteoarthritis (OA) is a degenerative and chronic debilitating disease, predominantly affecting the weight-bearing joints in the elderly, particularly the knee[1]. The prevalence of OA is on the rise and is projected to increase further in the coming years[2]. Plain radiography (X-ray) remains the primary imaging modality, widely evaluated and considered the most reliable diagnostic tool to date. However, musculoskeletal ultrasonography (USG) has garnered significant interest in recent years due to its cost-effectiveness, absence of ionizing radiation, and superior capability in assessing soft tissue structures such as ligaments, tendons, muscles, and synovial linings[3,4]. Early detection of osteophyte formation is possible with USG, which is not typically visible with conventional radiography. Additionally, USG is effective in identifying articular cartilage damage and soft tissue changes, which are not detectable with radiographs[5,6]. Despite these advantages, there is a notable lack of research on the application of USG for knee OA in the Nepalese population. Given the demographic, genetic, and lifestyle differences that may influence the presentation and progression of OA, it is imperative to evaluate the efficacy of USG in this specific population.

This study aims to address this gap by comparing the findings of USG with those of radiography in patients with knee OA in Nepal.

HIGHLIGHTS

- Ultrasonography (USG) outperformed radiography in detecting knee osteoarthritis (OA) abnormalities, including osteophytes and soft tissue changes.
- Higher sensitivity of USG suggests its potential as a cost-effective and radiation-free diagnostic tool for early OA detection.
- This study emphasize the importance of incorporating USG into diagnostic protocols for comprehensive knee OA assessment and management.

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Methods

This was a cross-sectional study done on the patients presenting to the Radiology Department in a Tertiary center for radiographs of the knee with the clinical diagnosis of OA. Ethical clearance for the study was obtained from the Institutional Review Board, reference number (28(6–11) E2/079/080), and informed written consent was obtained from all participating patients after explaining the study to them. The sample size of 136 was determined based on findings from a similar study conducted by Heidari[7] with adjustment of independent variables. All the patients aged 18 or above irrespective of sex, who meet the criteria were included in the study after proper informed consent from the patient. Those who had prior surgical procedures in the knee and those with a recent history of trauma were excluded from the study. This study followed the STROCSS (Strengthening The Reporting Of Cohort Studies in Surgery) 2021 checklist for cross-sectional studies[8]. The study is registered retrospectively in the research registry.

Knee radiographs were done in standing anteroposterior and lateral views. The patients were subsequently taken for USG of the knee joint and the USG operator was blinded with the radiograph findings.

The knee radiographs thus obtained were classified according to Kellgren and Lawrence (KL) classification[9]. The KL classification includes five grades: Grade 0 being no changes detected in X-ray; Grade 1 being doubtful joint space narrowing and osteophyte lipping; Grade 2: definite osteophyte and possible joint space narrowing; Grade 3: moderate multiple osteophytes with definite narrowing of the joint space, sclerosis, and deformity of bone ends; and Grade 4: large osteophytes, marked narrowing of joint space, severe sclerosis, and definite deformity of bone ends. A manual count of osteophytes was performed as a bony projection seen arising from the end of the bones in the anteroposterior views. Measurements of the medial and lateral knee joint space were performed in the console with 100% magnifications. The maximum perpendicular distance between the femoral and tibial ends was recorded as the measurements of the knee joint spaces (Fig. 1)[10].

The knee USG procedure commenced at the suprapatellar region, with the patient positioned supine and the knee flexed at 30°. The widest space of the knee joint was located, and a static image was captured. An inflection point on the femoral aspect of the knee joint, where the femoral condyle begins its round contour, was identified. The most distal end of the tibia was also marked. A perpendicular line was drawn between these points, and the distance measured as the joint width (Fig. 2). Similar techniques were applied to both the medial as well as lateral sides of the knee joint[11]. The hypoechoic strip at the end of the hyperechoic bone cortex was identified as cartilage covering the joint, and the maximum perpendicular distance between the cartilage layers in millimeters was recorded as the knee joint space width. Thickness of the medial meniscal cartilage was recorded in the same plane[9]. Osteophytes were manually counted by sweeping a linear probe longitudinally across the knee joint space. Knee effusion was diagnosed if the maximum anterior-posterior diameter of the suprapatellar recess exceeded 4 mm. Baker's cyst was identified by the presence of hypoechoic material within the gastrocnemius-semimembranosus bursa with a transverse diameter greater than 4 mm. The normal USG appearance of the peripheral menisci is a triangular hyperechoic structure at the joint space. Meniscal protrusion was defined as the distance between the peripheral border of the meniscus and the tibial plateau outline exceeding 2 mm[6]. The USG examinations were conducted by two experienced radiologists, each performing an average of 600 examinations annually, ensuring proficiency with the technique. Regular meetings and continuous quality control monitoring were conducted. Both patients and the public were involved in the study, participating in meetings, providing feedback, and disseminating knowledge.

Figure 1. Joint space measurement in in radiograph of knee. A tangent line is drawn at the very end of the femur and another at the end of the tibia. Distance between the lines is taken as joint width[10].

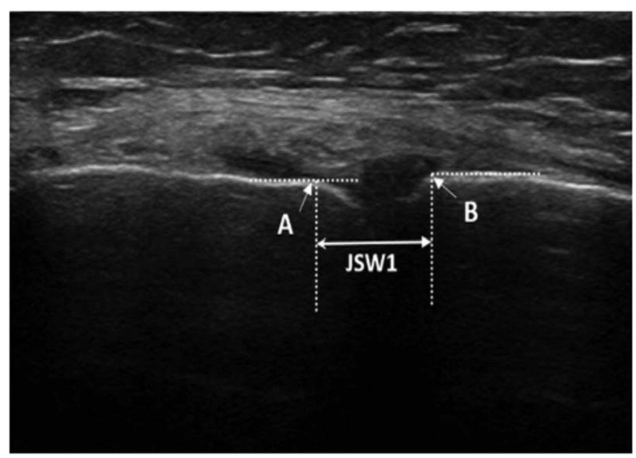

Figure 2. Method of joint space measurement on Ultrasound. Point A refers to the point of infliction in the femoral condyle and point B refers to the tibial end. JSW refers to the joint space width[11].

Statistical analysis

The data obtained were entered in the proforma. Data analysis was done with SPSS version 25. A comparison of the means of both modalities was done with the Box and Whisker plot. Differences in the mean calculated as *P*-value were obtained for different groups classified according to the KL grading system in the plain radiographs. Comparative analysis was done with paired *t*-test and ANOVA test.

Results

Among 136 patients enrolled in the study, 61% were female. The age range of the patients was 31–86 years. The mean age and mean weight of the patients were 55.7 ± 12 years and 66.6 ± 10.95 kg, respectively. Most of the patients were working as a farmer (Table 1).

Most of the patients had KL grade II and III OA (34.56% each) and only 8.09% had KL grade IV OA. Subchondral sclerosis was seen in 50% of the patients. USG detected a greater number of osteophytes as compared to the radiographs (mean of 2.34 ± 1.3 and 4.04 ± 1.96 in radiographs and USG, respectively), which was statistically significant (*P*-value <0.001) (Table 2). There was a linear relationship between the number of osteophytes to KL grading in radiographs. A greater number of osteophytes were seen with higher KL grade (*P*-value <0.001) (Fig. 3) (Table 3). There was an equal distribution of subchondral sclerosis among the participants.

Joint space measurements in radiographs and USG were similar (mean of medial joint 2.38 ± 0.9 mm and 2.44 ± 0.93 mm, respectively; mean of lateral joint 3.21 ± 0.76 and 3.02 ± 0.78 mm, respectively). There was a linear relationship of joint space with KL grade in both medial and lateral joint spaces. More reduced joint spaces are seen with higher KL grade (*P*-value <0.001 in both medial and lateral joint spaces) (Table 4). There was no significant difference between the mean measurements of the medial knee joint space between both modalities. A statistically significant difference ($P = 0.001$) in the mean measurement of the lateral joint space is seen between the two modalities.

The mean medial femoral condyle cartilage thickness measured with USG was 0.78 ± 0.5 mm. The cartilage thickness was found lower in participants with meniscal extrusion. Meniscal extrusion was seen in 15% of the patients. Meniscal extrusion was seen more in patients with a greater number of osteophytes, reduced knee joint spaces, and reduced medial femoral cartilage thickness, which were statistically significant (*P*-value <0.05) (Table 5).

Knee joint effusion was seen in 41%, with the predominance of mild joint effusion (29%). Baker's cyst was seen in 0.7% of the patients. Synovial hypertrophy was seen in 15% of the patients with increased vascularity.

Table 1

Clinico-demographic distribution of the patients

Characteristics	Frequency (*M*) (Percentage (%))
Sex	
Male	53 (38.97)
Female	83 (61.03)
Occupation	
Army	2 (1.47)
Business	11 (8.09)
Driving	2 (1.47)
Farming	25 (18.38)
Finance	2 (1.47)
Household	56 (41.18)
Lawyer	1 (0.74)
Marketing	2 (1.47)
Musician	1 (0.74)
Officer	3 (2.21)
Police	2 (1.47)
Retired	10 (7.35)
Security	2 (1.47)
Services	6 (4.41)
Tailor	2 (1.47)
Teaching	9 (6.62)
Total	136 (100)

Table 2

Number of osteophytes seen in radiographs and ultrasonography ($n = 136$)

	Radiographs	Ultrasonography
Characteristics	Number (*M*) (Percentage (%)	Number (*M*) (Percentage (%)
Number of osteophytes		
0	5 (3.68)	1 (0.74)
1	31 (22.79	9 (6.62)
2	48 (35.29)	16 (11.76)
3	30 (22.06)	32 (23.53)
4	13 (9.56)	30 (22.06)
5	5 (3.68)	23 (16.91)
6	4 (2.94)	13 (9.56)
7	0 (0)	5 (3.68)
8	0 (0)	3 (2.21)
9	0 (0)	3 (2.21)
13	0 (0)	1 (0.74)
Mean ± SD	2.34 ± 1.3	4.04 ± 1.96

Discussion

OA is a degenerative disorder that primarily affects the large weight-bearing joints of the body. Our study, involving 136 patients, found that OA was more prevalent in females than males. Similar results were reported in studies conducted by Hame *et al.* and Hanne *et al.*[12,13]. This difference could be attributed to hormonal factors, variations in knee anatomy, and kinematics. Poor joint congruence, coupled with a higher mechanical workload during walking, is considered a contributing factor to OA development through cartilage tear, as evidenced by Peshkova *et al.* study[14]. In a study of the Chinese population by Li *et al.*[15], the prevalence of OA was highest in the age group above 70 with linear growth after 40 years. Our findings align with this, as the majority of cases in our study fell within the age range of 31–86 years, with 16% of cases above 70. Although a larger population was over 40 years, fewer patients were over 70 years in our study, which could be due to differences in life expectancy between Nepal and China.

Most of the patients in our study had KL Grade II and III OA which was similar to the study done by Brom *et al.* and Carou *et al.*[16,17]. Our study observed a significant increase in osteophyte count corresponding to the severity of OA according to the KL grading system ($P < 0.001$), which aligns with the study by

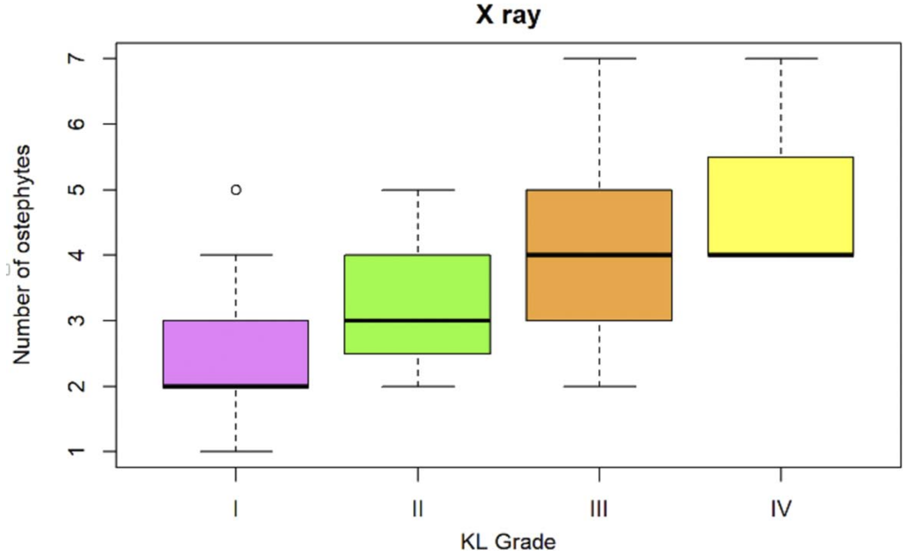

Figure 3. Box and Whisker plot showing the distribution of the number of osteophytes according to KL grading.

Riecke *et al.*[5]. Additionally, a statistically significant reduction ($P < 0.001$) in mean joint space width measurements was noted bilaterally with increasing OA severity, as per the KL grading system. Sugiyanto *et al.*(18) similarly reported these findings in 40 OA patients, where they observed significant differences in joint space width between KL grades I and II ($P = 0.047$ and $P < 0.005$). Takahashi *et al.*[19] also reported a significant relationship ($P = 0.003$) between reduced joint space width and increasing KL grade.

Our study demonstrated that osteophyte detection was more successful using USG compared to radiography. This finding is consistent with previous research by Oo *et al.* and Mathiessan *et al.*, which showed that USG sensitivity is comparable to MRI and superior to radiography[20,21]. Brom *et al.*[16] reported a sensitivity of 95% and specificity of 86% for USG in detecting osteophytes. Similarly, Keen *et al.*[22] found that USG detected 30% more osteophytes than radiography. The increased detection of osteophytes via USG is partly due to its ability to identify early changes not visible on X-ray[16]. USG also offers the advantage of real-time evaluation with imaging in a 360° plane and axis, minimizing the chances of bony projection overlap.

In our study, there was no significant difference in the measurement of medial joint space between radiography and USG. However, the measurement of lateral joint space width on USG was significantly lower compared to radiography ($P = 0.001$). This finding aligns with Keen *et al.*[22]. Majdi *et al.*[23] reported high sensitivity and specificity for USG (90.4 and 75.8%) compared to radiography (73 and 88%), with MRI as the gold standard. Both Guermazi *et al.* and Hayashi *et al.* have recommended the use of USG and other imaging modalities over radiography due to radiography's lack of reproducibility and inability to detect early changes[24,25].

In our study, a significant difference ($P = 0.004$) was observed in the mean width of the medial joint space and the extrusion of the medial meniscus, indicating a high likelihood of reduced joint space width with positive meniscal extrusion. Additionally, a significant difference in the mean thickness ($P = 0.003$) of the medial femoral cartilage and the extrusion of the meniscus was noted, suggesting a lower thickness of the medial femoral cartilage with a higher probability of meniscal extrusion.

Our findings are consistent with those of Arno *et al.*, who concluded that cartilage loss in the medial aspect predominantly occurs in areas not contacting the meniscus. Moreover, in severe OA, individuals with more cartilage loss exhibited higher rates of meniscal tear and extrusion. Furthermore, the more pronounced the meniscal loss, the less effective it was in preventing the progression of OA[26]. Ch *et al.*[27] also concluded that meniscal extrusion is a prominent feature of OA, detectable by USG before signs appear on radiography.

In our study, we successfully identified additional soft tissue changes using USG, including joint effusion, Baker's cyst, and synovitic changes, all of which are part of the spectrum of OA. USG proved to be superior to radiography in detecting soft tissue changes associated with OA, such as joint effusion, synovitis,

Table 3

Difference between means with various KL grades in X-ray

Characteristics	KL grade I mean	KL grade II mean	KL grade III mean	KL grade IV mean	F value	P
Number of osteophytes	2.35	3.04	3.94	4.82	21.78	**< 0.001**
Medial knee joint space	3.33	2.50	1.98	0.95	50.58	**< 0.001**
Lateral knee joint space	3.81	3.24	2.90	2.77	13.25	**< 0.001**

(ANNOVA test) ($n = 136$).
KL, Kellgren Lawrence.

Table 4

Comparison of X-ray and USG findings (paired *T*-test) (*n* = 136)

Characteristics	X-ray Mean (sd)	USG Mean (sd)	t value	df	*P*
Number of osteophytes	2.34 (1.3)	4.04 (1.96)	− 15.93	135	< 0.001
Medial knee joint space in mm	2.38 (0.9)	2.44 (0.93)	− 0.9	135	0.37
Lateral knee joint space in mm	3.21 (0.76)	3.02 (0.78)	3.28	135	0.001

Table 5

Correlation of meniscal extrusion with osteophytes, knee joint spaces and cartilage thickness on ultrasonography (*n* = 136)

USG characteristics	No meniscal extrusion mean	Meniscal extrusion mean	T value	*P*
Number of osteophytes	3.9	4.81	− 2.47	0.02
Medial knee joint space	2.53	1.93	3.1	0.004
Lateral knee joint space	3.07	2.78	2.09	0.04
Medial femoral cartilage thickness	0.83	0.5	3.19	0.003

Baker's cyst, bursitis, and meniscal pathology. Additionally, USG findings of joint space narrowing and synovitis demonstrated a stronger correlation with pain compared to structural damage[16].

This study's strength lies in its comprehensive comparison of radiography and USG for knee OA assessment, providing valuable insights into the diagnostic capabilities of both modalities in a Nepalese population. We recommend integrating USG into knee OA diagnostic protocols by using it alongside radiography for initial assessments, monitoring disease progression, and evaluating soft tissue structures, enhancing overall diagnostic accuracy in resource-limited settings.

In our study, radiographs were obtained in a weight-bearing standing position, while USG was performed in a supine position with 30° joint flexion. We did not correlate imaging findings with patients' pain perception or body morphology. The primary focus was comparing USG and radiography in OA. The smaller study group and hospital-based setting limit population representation, and nonrandomization and lack of gold standard comparison may affect standardization. Future research should include larger, diverse population studies, and longitudinal analyses to assess OA progression, compare imaging modalities, and explore USG's cost-effectiveness and accessibility in resource-limited settings.

Conclusion

Our study demonstrates the superiority of USG over radiography in assessing knee OA, particularly in detecting osteophytes and soft tissue changes. This emphasizes the importance of incorporating USG into diagnostic protocols for more comprehensive evaluation and management of knee OA in clinical practice.

Ethical approval

We have conducted an ethical approval base on the Declaration of Helsinki with registration research at the Institutional Review Committee (IRC) of the Institute of Medicine (IOM), Tribhuvan University, Nepal, Reference number: 28(6–11) E^2/079/080.

Consent

Written informed consent was obtained from the patient for the publication of this case report and the accompanying images. A copy of the written consent is available for review by the Editor-in-chief of this journal on request.

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None.

Author contribution

S.S.: conceptualization, as mentor and reviewer for this original article and for data interpretation; B.K.C.: conceptualization and reviewer for this case; S.K.: contributed in performing literature review and editing; D.C.: reviewer and data interpretation; B.L.: contributed in performing literature review and editing. All authors have read and approved the manuscript.

Conflicts of interest disclosure

The authors declare that there is no conflict of interest regarding the publication of this article.

Research registration unique identifying number (UIN)

1. Name of the registry: researchregistry.
2. Unique identifying number or registration ID: researchregistry 10278.
3. Hyperlink to your specific registration (must be publicly accessible and will be checked): https://www.researchregistry.com/browse-the-registry#home/registrationdetails/663c47f03ceee70028533d8a/.

Guarantor

Shailendra Katwal is the person in charge of the publication of our manuscript.

Data availability statement

The materials datasets used and/or analyzed during this study are available from the corresponding author upon reasonable request.

Provenance and peer review

Not commissioned, externally peer-reviewed.

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