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Comparative Evaluation of Knee Osteoarthritis: Radiography vs. Ultrasonography in Nepalese Population: A Cross-Sectional Study

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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.

Conflicts of interest

None

Author contributions

Sundar Suwal: Conceptualization, as mentor and reviewer for this original article and for data interpretation

Bibek K.C: Conceptualization and reviewer for this case.

Shailendra Katwal: Contributed in performing literature review and editing

Dinesh Chataut: Reviewer and data interpretation

Benu Lohani: Contributed in performing literature review and editing

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2. Unique identifying number or registration ID: researchregistry10278

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Declaration of competing interest

All the authors declare that they have no competing interest

Highlights

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

Abstract:

Background and Objectives:

Osteoarthritis 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 for musculoskeletal disorders, including joint assessment. This study aimed to find the role of ultrasonography in the evaluation of osteoarthritis of knee joints with comparison to the radiographs.

Methods:

This was a cross-sectional study done on patients with signs and symptoms of osteoarthritis of the knee who visited the radiology department for knee radiographs. Kellgren and Lawrence system was used for grading osteoarthritis in radiographs. Ultrasonography 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 ultrasound findings were correlated with findings in anteroposterior and lateral radiographs.

Results:

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

Conclusion:

Although radiography is the standard first-line radiological investigation for the diagnosis of osteoarthritis of the knee joint, ultrasonography 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 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 ultrasonography, which is not typically visible with conventional radiography. Additionally, ultrasonography 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 ultrasonography for knee osteoarthritis 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 ultrasonography in this specific population.

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

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 osteoarthritis. 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 et al. with adjustment of independent variables (7). All the patients aged 18 or above irrespective of gender, 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 ultrasonography of the knee joint and the ultrasound 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 (Figure 1)(10).

The knee ultrasonography (USG) procedure commenced at the suprapatellar region, with the patient positioned supine and the knee flexed at 30 degrees. 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 (Figure 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 ultrasound 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 ultrasound 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.

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 kilograms respectively. Most of the patients were working as a farmer (Table 1).

Most of the patients had KL grade II and III osteoarthritis (34.56% each) and only 8.09% had KL grade IV OA. Subchondral sclerosis was seen in 50% of the patients. Ultrasound 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) (Figure 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.

Discussion

Osteoarthritis 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.'s 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 osteoarthritis 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 osteoarthritis according to the KL grading system (P<0.001) which aligns with the study by Riecke et al (5). Additionally, a statistically significant reduction (P<0.001) in mean joint space width measurements was noted bilaterally with increasing osteoarthritis severity, as per the KL grading system. Sugiyanto et al. similarly reported these findings in 40 osteoarthritis patients, where they observed significant differences in joint space width between KL grades I and II (p=0.047 and p<0.005)(18). Takahashi et al. also reported a significant relationship (P=0.003) between reduced joint space width and increasing KL grade (19).

Our study demonstrated that osteophyte detection was more successful using ultrasound compared to radiography. This finding is consistent with previous research by Oo et al. and Mathiessan et al., which showed that ultrasound sensitivity is comparable to MRI and superior to radiography (20,21). Brom et al. reported a sensitivity of 95% and specificity of 86% for ultrasound in detecting osteophytes (16). Similarly, Keen et al. found that ultrasound detected 30% more osteophytes than radiography (22). The increased detection of osteophytes via ultrasound is partly due to its ability to identify early changes not visible on X-ray (16). Ultrasound also offers the advantage of real-time evaluation with imaging in a 360-degree 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 ultrasound. However, the measurement of lateral joint space width on ultrasound was significantly lower compared to radiography (P=0.001). This finding aligns with Keen et al.'s study (22). Majdi et al. reported high sensitivity and specificity for ultrasound (90.4% and 75.8%) compared to radiography (73% and 88%), with MRI as the gold standard (23). Both Guermazi et al. and Hayashi et al. have recommended the use of ultrasound 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 osteoarthritis, 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 osteoarthritis(26). Ch et al. also concluded that meniscal extrusion is a prominent feature of osteoarthritis, detectable by ultrasound before signs appear on radiography (27).

In our study, we successfully identified additional soft tissue changes using ultrasound, including joint effusion, Baker's cyst, and synovitic changes, all of which are part of the spectrum of osteoarthritis. Ultrasound proved to be superior to radiography in detecting soft tissue changes associated with osteoarthritis, such as joint effusion, synovitis, Baker's cyst, bursitis, and meniscal pathology. Additionally, ultrasound 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 ultrasonography for knee osteoarthritis assessment, providing valuable insights into the diagnostic capabilities of both modalities in a Nepalese population. We recommend integrating ultrasonography into knee osteoarthritis 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 ultrasound (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 ultrasound and radiography in osteoarthritis. The smaller study group and hospital-based setting limit population representation, and non-randomization and lack of gold standard comparison may affect standardization. Future research should include larger, diverse population studies and longitudinal analyses to assess osteoarthritis progression, compare imaging modalities, and explore ultrasonography's cost-effectiveness and accessibility in resource-limited settings.

Conclusion

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

Table 1: Clinico-demographic distribution of the patients.

Table 2: Number of osteophytes seen in radiographs and ultrasonography (n = 136).

Table 3: Difference between means with various Kellgren Lawrence (KL) grades in X-ray. (ANOVA test) (n=136)

Table 4: Comparison of X-ray and Ultrasound findings (paired T-test) (n=136).

Table 5: Correlation of Meniscal extrusion with osteophytes, knee joint spaces, and cartilage thickness on ultrasonography (n = 136).

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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).

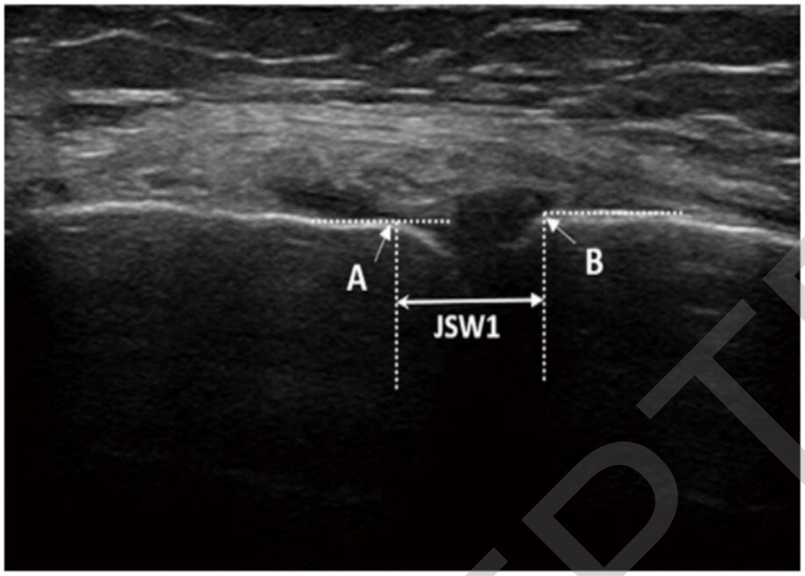
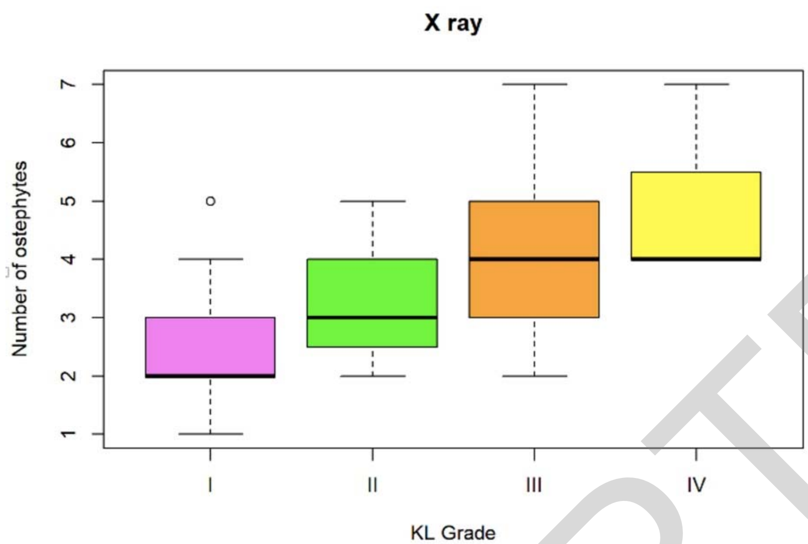


Figure 3: Box and Whisker plot showing the distribution of the number of osteophytes according to KL grading.



Characteristics	Frequency (N)	Percentage (%)
Gender		
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 1: Clinico-demographic distribution of the patients

Characteristics	Radiographs		Ultrasonography	
	Number (N)	**Percentage (%)**	**Number (N)**	**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	

Table 2: Number of osteophytes seen in radiographs and ultrasonography (n = 136)

Characteristics	KL grade I mean	KL grade II mean	KL grade III mean	KL grade IV mean	F value	P value
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**

Table 3: Difference between means with various KL grades in X-ray. (ANNOVA test) (n=136)

KL: Kellgren Lawrence

Characteristics	X ray Mean (sd)	USG Mean (sd)	t value	df	p-value
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 4: Comparison of X-ray and USG findings (paired T test) (n=136)

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 value
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