

Ultrasonographic Evaluation of Osteoarthritis-affected Knee Joints: Comparison with Kellgren–Lawrence Grading and Pain Scores

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Abstract

Background: The objective was to compare ultrasonographic findings with clinical and radiographic findings in osteoarthritis (OA)-affected knee joints. **Methods:** This prospective study was conducted in Subharti Medical College, Meerut, after getting clearance from the ethical committee. Eighty-five symptomatic knees fulfilling American College of Rheumatology criteria for OA were included in the study. Patients with trauma, inflammatory, and infective conditions of the knee and with a history of intra-articular interventions and surgery were excluded. Demographic data, body mass index (BMI), visual analog scale (VAS), and Western Ontario and McMaster Universities Arthritis (WOMAC) questionnaire score were obtained. Kellgren–Lawrence (K-L) score was obtained on radiography. Ultrasonographic findings which were recorded include effusion, meniscal extrusion, femorotrochlear cartilage grading, maximum length of osteophytes at medial and lateral compartments, and presence or absence of Baker cyst. **Results:** A total of 85 consecutive symptomatic knees were examined. The male: female ratio was 22:63, with a mean age of 54.52 ± 9.44 years, mean duration of disease of 24.24 ± 19.14 months, mean BMI of 28.91 ± 3.69 kg/m², and mean score of VAS and WOMAC pain scale of 6.27 ± 1.45 and 62.45 ± 10.96 , respectively. K-L grading of 1, 2, 3, and 4 was reported in 12.9%, 21.2%, 25.9%, and 40% of the knees, respectively. The mean VAS score and WOMAC score showed statistically significant correlation with KL grading ($P < 0.05$). Knees with the presence of osteophytes, medial meniscal extrusion, effusion, and medial femoral trochlear cartilage grading showed statistically significant correlation with VAS and WOMAC scores ($P < 0.05$). However, the correlation was not significant for lateral meniscus extrusion and lateral femoral trochlear cartilage grading. **Conclusion:** Our study found that K-L grading and few ultrasonographic criteria showed a significant positive correlation with pain scores, while few other ultrasonographic criteria did not. Both imaging modalities are complementary to each other, rather than one being superior to the other.

Keywords: Cartilage, Kellgren–Lawrence grading, ultrasonography, visual analog scale score, Western Ontario and McMaster Universities Arthritis Scores

INTRODUCTION

Knee osteoarthritis (OA) is one of the most common degenerative joint diseases with a prevalence of 28.7% in India.^[1] Its occurrence increases with advancing age and has a clear female predilection. It is the leading cause of pain and disability in the elderly, reflecting major implications for public health care. Knee OA leads to typical degradation of articular cartilage and soft-tissue structures encircling the knee joint. Though it can be diagnosed clinically, imaging techniques aid specifically in the identification of structures involved, adequacy of treatment planning, and preventing the

factors responsible for progression.^[2,3] In addition, availability of newer nonsurgical and surgical treatment options for knee OA-affected patients demands more precise imaging assessment.^[4,5]

Conventional radiography is the initial imaging investigation in knee OA. It detects bony structural abnormality, but its findings did not show much correlation with the severity

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of pain in knee OA. This could possibly be because of the fact that soft-tissue structures cannot be viewed on radiographs, thus providing only an indirect evidence of cartilage and other soft-tissue damage. Joint space narrowing seen on radiography is considered an indirect indicator of femoro-tibial cartilage loss, however the assessment of actual joint space depends on both cartilage thickness and meniscal integrity, both of which cannot be directly evaluated with the help of radiography.^[6,7] Till date, magnetic resonance imaging (MRI) is considered the most accurate imaging method for quantifying degenerative changes in knee OA. It can evaluate osseous abnormalities as well as soft-tissue changes with high sensitivity and specificity, but it cannot be used as a routine investigation because of its high cost and relatively low availability.^[8] High-frequency ultrasound imaging is a noninvasive, widely available, and relatively inexpensive technique that can be used to reliably assess periarticular and superficial intra-articular abnormalities in knee OA. With time, ultrasonography has become the first-line imaging technique chosen by rheumatologists to obtain real-time imaging information in patients with painful joints.^[9,10] Utility of ultrasound examination in shoulder imaging as well as interventions is well known.^[11,12]

Many studies have been performed to establish the possible correlations between ultrasonographic findings and knee OA symptoms. Recent studies have indicated that ultrasonography is a useful and reliable method for identifying knee osteophytes, medial meniscal protrusion, and morphological changes in the cartilage in the medial femoral condyle, but no clear conclusions were drawn. All the authors underlined the need for more work in this field.^[13-23] Due to paucity of literature in India, this study was undertaken to find out the possible correlation between knee pain scores and radiographic as well as ultrasonographic findings in knee OA and to further explore, if ultrasonographic findings presented better association with knee pain scores than conventional radiography.

MATERIALS AND METHODS

This prospective study was conducted in the Department of Radio-diagnosis, Chattrapati Shivaji Subharti Hospital and Subharti Medical College, Meerut, India. Approval from the institutional ethical committee was obtained (IEC16547). Eighty-five adult patients fulfilling American College of Rheumatology criteria for OA, referred to radiology department for radiographic study, were recruited.^[24] Patients with a prior history of trauma, surgery, and intra-articular interventions in relation to knee were excluded. Patients not giving informed consent and having inflammatory and infective conditions of the knee were also excluded. Informed consent of all the participants was obtained after explaining the procedure. Convenient sampling method was used, and data were collected on a preformed structured interviewer-administered questionnaire. More symptomatic knee of the patient was examined. A flowchart describing the selection of symptomatic patients is shown in Figure 1.

Demographic data included age, sex, height, weight, and body mass index (BMI). Patients were then asked to score their average knee pain during the past month on a 100-mm visual analog scale (VAS) from 0 to 100 mm, where 0 mm represented no pain, while 100 mm represented extreme pain. Patients were then asked to self-complete Western Ontario and McMaster Universities Arthritis (WOMAC) questionnaire.^[25] The questionnaire was translated in local language and patients were assisted by one of the investigators.

Weight-bearing anteroposterior and lateral knee radiographs of all the patients were taken. The radiographs were interpreted for severity of knee OA using Kellgren–Lawrence (K-L) score by a radiologist (blinded to the clinical and ultrasonographic findings).^[26]

Ultrasonographic examination was performed by a radiologist having 5 years of experience in doing musculoskeletal ultrasonography (blinded to clinical and radiographic findings). All ultrasonographic examinations were performed on Samsung Madison HS70A machine (company-Samsung; Meerut, Uttar Pradesh, India) using a high-frequency linear probe. Ultrasound examination was performed with the patient lying in supine position and knee flexed to 20°–30° with a pillow under the knee for comfort. After applying abundant gel over the supra-patellar region, scanning was commenced in longitudinal and transverse planes applying minimal pressure over the area so as to avoid displacing the effusion sideward. Presence of effusion and synovial hypertrophy was noted. Quadriceps/patellar tendons and prepatellar/infrapatellar bursa were also evaluated.

Scanning in coronal planes over the medial and lateral aspects of the joint was done in longitudinal and transverse planes, and the status of menisci, collateral ligaments, Pes anserine bursitis, and iliotibial tract insertional tendinitis was noted. Maximum length of the osteophytes (bone step-ups) located at the edges of the medial and lateral joint surfaces was measured. Extrusion of menisci was also noted (defined as distance between the peripheral border of meniscus and outline of tibial plateau > 3 mm).^[27]

Patients were then asked to flex the joint completely, and a probe was placed over trochlear notch for evaluation of the femorotrochlear articular cartilage degeneration. The degeneration was graded as: “Grade 0 – normal, Grade 1 – loss of the normal sharpness of cartilage interfaces and/or increased echogenicity of the cartilage, Grade 2A – Grade 1 with clear local thinning (<50%) of the cartilage, Grade 2B – local thinning of the cartilage of more than 50% but < 100%, and Grade 3 – 100% focal loss of cartilage thickness.”^[28] Patients were then asked to lie prone, and the posterior aspect of the knee joint was scanned in longitudinal and transverse planes. The distension of semimembranosus-medial head of gastrocnemius bursa was evaluated. Posterior joint recess was also evaluated for the presence of loose bodies. Tibial attachment of posterior cruciate ligament was also seen for any abnormality.

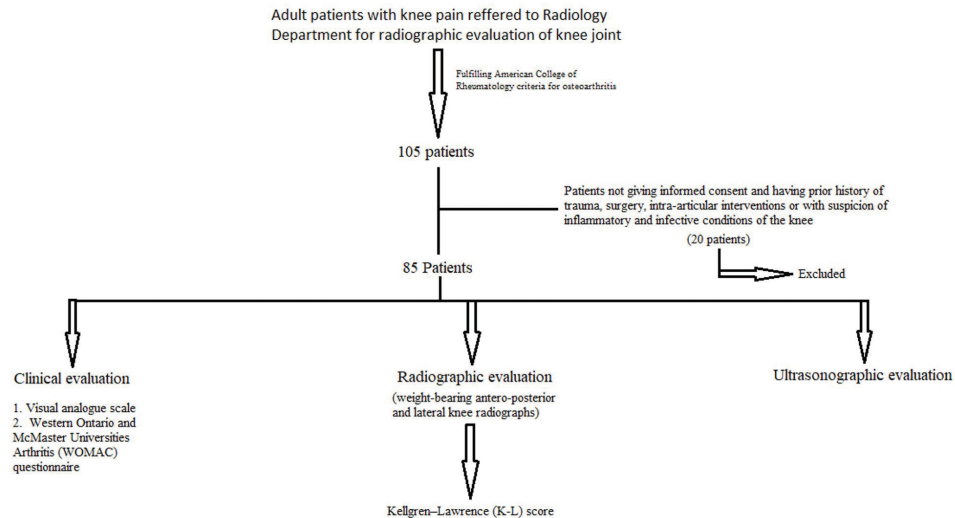


Figure 1: Flowchart showing selection of symptomatic patients and their clinical, radiographic, and ultrasonographic evaluation

The data collected were tabulated in an Excel Sheet. Statistical analysis was performed using SPSS 22.00 for Windows; SPSS Inc., Chicago, IL, USA.

RESULTS

Eighty-five symptomatic knee OA cases were examined and analyzed. The study population included 63 (74.1%) females and 22 (25.9%) males, with a mean age of 54.52 ± 9.44 years. The mean duration of the symptoms was 24.24 ± 19.14 months. The mean BMI, VAS, and WOMAC scores were 28.91 ± 3.69 kg/m², 6.27 ± 1.45 , and 62.45 ± 10.96 , respectively. K-L grading of 1, 2, 3, and 4 was reported in 12.9%, 21.2%, 25.9%, and 40% of the knees, respectively. The mean VAS score and WOMAC score increased with increase in K-L grading with statistically significant correlation ($P < 0.05$) [Table 1]. Weight-bearing frontal conventional radiographs of OA affected knee joints showing different K-L grading are shown in Figure 2.

On ultrasonography, the most prevalent imaging finding was osteophytosis followed by medial meniscal extrusion, effusion, and lateral meniscal extrusion seen in 75 (88%), 57 (67.1%), 44 (51.8%), and 43 (50.6%) patients, respectively. Presence of medial meniscus extrusion, lateral meniscus extrusion, and joint effusion reported an increase in mean VAS and WOMAC scores, however statistically significant correlation was present with medial meniscus extrusion and effusion but not with lateral meniscus extrusion. Medial meniscus was not visualized in two cases. The mean length of osteophyte was greater at medial tibiofemoral joint space with a value of 3.91 ± 1.78 mm as compared to lateral tibiofemoral joint space with a value of 2.80 ± 1.74 mm. Pain scores increased with increasing length of osteophytes, and the findings were statistically significant.

In our study, medial femoral trochlear cartilage of Grade 1, Grade 2A, Grade 2B, and Grade 3 was reported in 2.4%, 23.5%, 40%, and 34.1%, of the patients, respectively. Lateral femoral

Table 1: Correlation of Kellgren-Lawrence grading with visual analog scale and Western Ontario and McMaster Universities Arthritis score

KL Grading	Distribution, n (%)	VAS, mean ± SD	WOMAC, mean ± SD
Grade 1	11 (12.9)	5.22±0.82	56.45±6.83
Grade 2	18 (21.2)	5.57±1.19	57.94±9.25
Grade 3	22 (25.9)	5.89±1.29	59.38±8.58
Grade 4	34 (40)	6.21±1.04	62.93±8.19
ANOVA test**		4.89	4.97
P		<0.04*	<0.04*

KL Grading: Kellgren–Lawrence grading, VAS: Visual analog scale, WOMAC: Western Ontario and McMaster Universities Arthritis, n: Number of knees, SD: Standard deviation, ANOVA: Analysis of variance, *: Statistically significant

trochlear cartilage of Grade 1, Grade 2A, Grade 2B, and Grade 3 was reported in 7.1%, 40%, 50.6%, and 2.4% of the patients, respectively. The mean VAS score and WOMAC score increased with increase in femoral trochlear cartilage grading and was found maximum in Grade 3 trochlear cartilage both medially and laterally. When mean VAS and WOMAC scores were compared with the grading of femoral trochlear cartilage degeneration, it was found to be statistically significant (as $P < 0.05$) for both medial and lateral positions [Table 2].

Medial and lateral collateral ligaments were intact in all the patients, Thickening, hypoechogenicity and loss of fibrillar pattern are ultrasonographic features of collateral ligament degeneration and these findings were seen in MCL in 77.5% cases and in LCL in 41.8% cases. Both degenerated medial and lateral collateral ligaments were associated with increase in pain scores, but statistically significant correlation was found in relation with medial collateral ligament only. Baker’s cyst was present in 9.4% and iliotibial tract insertional tendinopathy was seen in 11.6% of cases, and their presence was associated with higher VAS and WOMAC pain scores. The findings were not

statistically correlated due to small sample size. Para-meniscal cyst and pes anserine bursitis were not seen in any case.

On applying Pearson’s correlation, positive and statistically significant correlation was found between K-L grading and pain scores. Similar positive and statistically significant correlation was reported for medial sided osteophytes, medial meniscal extrusion, medial femorotrochlear cartilage grading, medial collateral ligament degeneration, and effusion in relation to VAS and WOMAC score. However, significant correlation was not found with lateral-sided osteophytes, lateral meniscus extrusion, and lateral femorotrochlear cartilage grading. High-frequency ultrasonographic images of the OA-affected knee joints in different patients are shown in Figures 3-5.

DISCUSSION

Our study comprised 85 patients with OA-affected knee joints, examined clinically, radiographically, and ultrasonographically. Comparison of the demographic and radiographic findings in our study with the published literature is shown in Table 3. The average age, sex ratio, and BMI of the patients in our study were comparable to those of the previous studies as shown in Table 3. The mean VAS and WOMAC scores in our study were 6.27 ± 1.45 and 62.45 ± 10.96 , respectively. Serban *et al.*^[16] reported similar mean score of VAS (6.58 ± 2.08), but low mean score of WOMAC (54.9 ± 16.7) in their study.

As far as K-L grading is considered, 40% of the knees were in Grade IV, which differed from that of previous published literature. This difference in K-L grading might be due to the fact that demography of the patients in surrounding area is rural and they involved in agricultural and strenuous work who seeks

medical attention late in the disease course. The mean pain scores increased with increase in K-L grading. A positive and significant correlation was found between K-L grading and VAS as well as WOMAC scores. Therefore, it can be said that with increase in K-L grading, pain also increases, which is in line with a recent systematic review that higher Grade of OA (K-L 3 or above) is a stronger predictor of pain than lower Grades (K-L 2 or less). Serban *et al.*^[16] also revealed significantly higher VAS and WOMAC scores as the K-L score increased.

A positive and significant correlation was reported for effusion in relation to VAS as well as WOMAC scale. Similarly, Hill *et al.*^[29] reported a strong association between effusion and pain in knee OA. Naredo *et al.*^[19] found a strong association between effusion and pain in knee on motion as well as rest, and this finding was independent of radiographic OA severity, age, disease duration, and BMI. However, Serban *et al.*^[16] did not find any correlation between effusion and pain scores.

A positive and significant correlation was reported for medial meniscus extrusion in relation to VAS as well as WOMAC score. Kijima *et al.*^[30] found correlation between pain with medial meniscus extrusion (the higher the extrusion degree, the higher the level of pain). However, Serban *et al.*^[16] did not find any correlation between the medial meniscal extrusion and pain scores. A positive correlation was reported for lateral meniscus extrusion in relation to VAS as well as WOMAC scale, however the results were statistically insignificant.

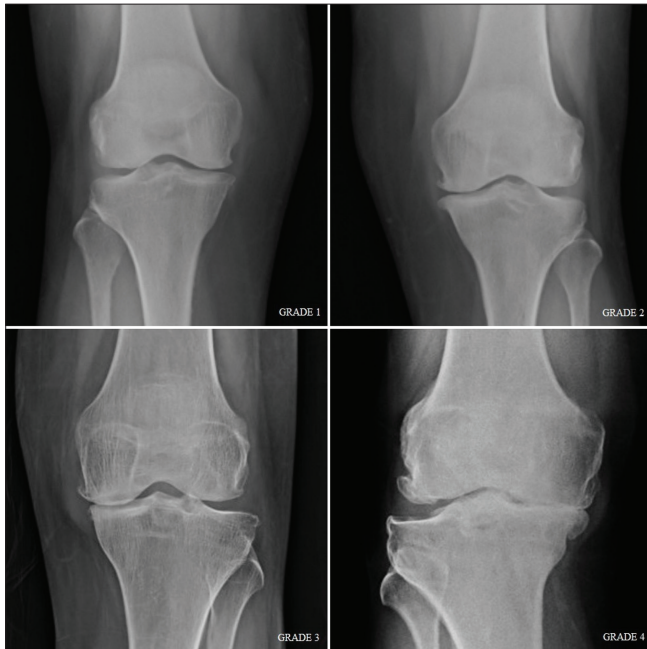


Figure 2: Radiographic grading of osteoarthritis in knee joint using Kellgren–Lawrence score

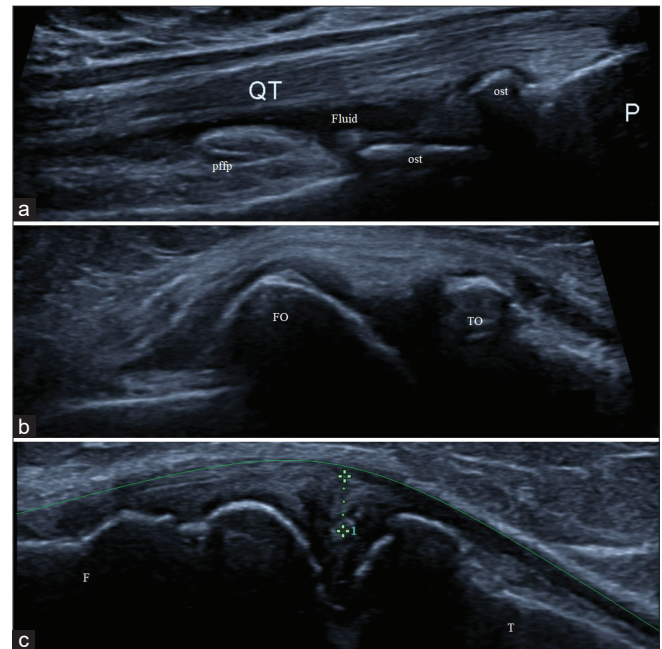


Figure 3: High-frequency ultrasonographic evaluation of osteoarthritis-affected knee joint showing; (a) presence of minimal effusion (fluid) in the supra-patellar recess and multiple osteophytes (ost) at patello-femoral joint; (b) presence of femoral and tibial osteophytes at joint margins (FO and TO); and (c) evidence of medial meniscal extrusion (calipers) causing displacement of medial collateral ligament (green line). F: Femur, T: Tibia, QT: Quadriceps tendon, pffp: Prefemoral fat pad and P: Patella

Similar findings were noted by Serban *et al.*,^[16] who did not find lateral meniscus extrusion to be an independent predictor of VAS score, however they found it to be an independent predictor of WOMAC score.

Table 2: Correlation of ultrasound findings with visual analog scale and Western Ontario and McMaster Universities Arthritis score

Variables	Distribution, n (%)	VAS, mean±SD	WOMAC, mean±SD
Medial meniscus extrusion			
Yes	57 (67.1)	6.53±1.44	64.58±10.49
No	26 (30.6)	5.58±1.21	56.42±9.16
Not visualized	2 (2.4)	8±1.41	80±2.83
ANOVA test		5.89	9.01
P		0.004*	<0.01*
Lateral meniscus extrusion			
Yes	43 (50.6)	6.44±1.32	63.37±9.09
No	42 (49.4)	6.10±1.57	61.50±12.64
T-test		1.22	0.62
P		0.27	0.43
Effusion			
Yes	44 (51.8)	6.75±1.16	65.86±9.13
No	41 (48.2)	5.76±1.56	58.78±11.67
T-test		11.17	9.79
P		0.001*	0.002*
Medial trochlear cartilage			
Grade 1	2 (2.4)	4±0.71	46.50±2.12
Grade 2A	20 (23.5)	5.15±1.23	54.20±9.56
Grade 2B	34 (40)	6.32±1.29	62.76±9.09
Grade 3	29 (34.1)	7.14±1.13	68.86±9.57
ANOVA test		12.96	11.78
P		<0.01*	<0.01*
Lateral trochlear cartilage			
Grade 1	6 (7.1)	4.67±1.63	50.17±8.91
Grade 2A	34 (40)	5.97±1.34	59.71±10.06
Grade 2B	43 (50.6)	6.63±1.29	65.74±10.19
Grade 3	2 (2.4)	8.50±0.71	75±7.07
ANOVA test		6.41	6.44
P		0.001*	0.001*

*Statistically significant. VAS: Visual analog scale, WOMAC: Western Ontario and McMaster Universities Arthritis, n: Number of knees, SD: Standard deviation, ANOVA: Analysis of variance

The mean length of osteophytes was greater at medial tibiofemoral joint space (3.91 ± 1.78 cm) as compared to lateral tibiofemoral joint space (2.80 ± 1.74 cm), which may be due to the fact that medial compartment of knee is a weight-bearing part and exposed to greater stress as compared to the lateral compartment. Significant Pearson's correlation was found with pain scores and medial osteophytes but not with lateral osteophytes. Chan *et al.*^[15] and Serban *et al.*^[16] also found similar correlation.

When mean VAS and WOMAC scores were compared statistically with grades of trochlear cartilage damage medially and laterally, it was found to be statistically significant as $P < 0.05$. These results were in accordance with the study done by Serban *et al.*^[16] Similar findings of association of the hyaline cartilage damage or loss, with pain scores, have also

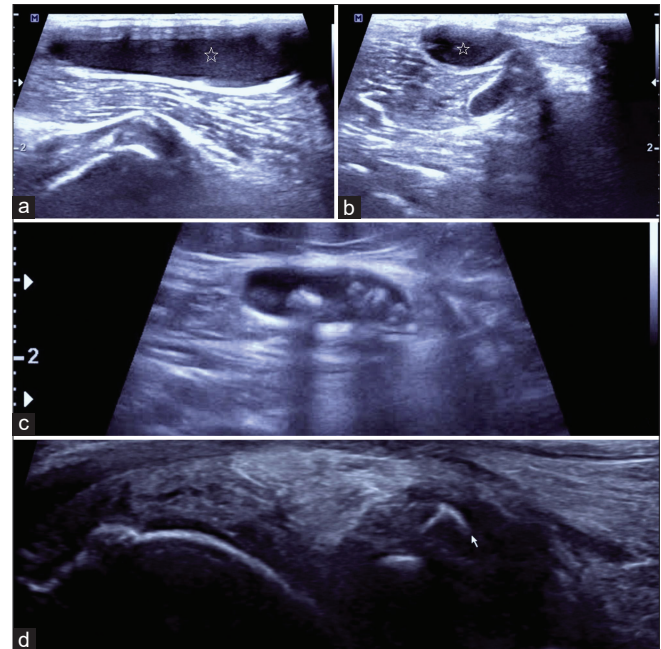


Figure 4: High frequency ultrasonographic evaluation of different patients with osteoarthritis affected knee joints showing (a,b) semimembranosus/medial gastrocnemius bursal distension also known as Baker cyst (star); (c) presence of multiple loose bodies present within the Baker cyst; and (d) presence of loose bodies (arrow) in the posterior joint recess

Table 3: Comparison of the demographic and radiographic findings of the patients in our study with that of the published literature

Study	Age (years)	Female:male ratio	BMI (kg/m ²)	Duration (months)	KL Grading (%)			
					I	II	III	IV
Present study	54.52±9.44	63:22 (2.86)	28.91±3.69	24.24±19.14	12.9	21.2	25.9	40
Naredo <i>et al.</i> ^[19]	64±7.6	Not assessed	31.8±5.1	Not assessed	25.5	37.7	33.3	3.3
Chan <i>et al.</i> ^[15]	59.0±13.9	143:50 (2.86)	24.9±4.1	Not assessed	17.1	22.3	22.3	16.6
Bevers <i>et al.</i> ^[22]	57±9.2	120:60 (2.00)	28.8±7.4	103±114	23.9	38.9	17.8	8.3
Podlipská <i>et al.</i> ^[20]	59.9±7.8	49:30 (1.63)	29.1±4.3	Not assessed	26.6	24.1	25.3	21.5
Serban <i>et al.</i> ^[16]	63.44±9.49	33:19 (1.73)	31.73±6.42	Not assessed	41.5	31.7	24.4	2.4

BMI: Body mass index, KL grading: Kellgren–Lawrence grading

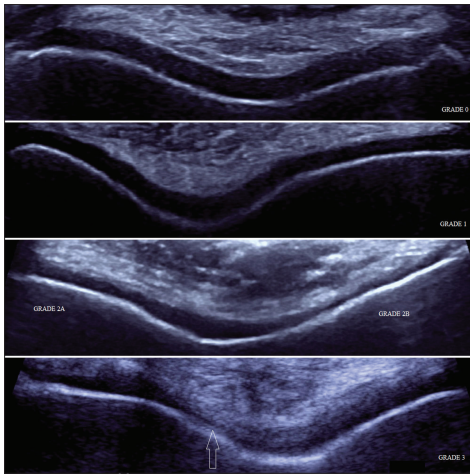


Figure 5: High-frequency ultrasonographic evaluation of osteoarthritis-affected knee joints showing different grading of femorotrochlear articular cartilage degeneration

been demonstrated in ultrasound study by Chan *et al.*^[15] and MRI study by Yusuf *et al.*^[31]

Limitations

Some of the limitations of our study should be taken into account. First, we did not compare the symptomatic patients with the control group. Second, ultrasound findings were not compared with MRI and scoring system was not used for different ultrasound features. Third, data of patient's treatment were not taken into account. A lack of standardization and validation over the definition and scoring system for different ultrasonographic signs in OA-affected knee joint definitely exists. These constraints can be sorted by conducting a multicentered study involving larger sample size and including controls as well. Newer ultrasonographic techniques such as elastography and three-dimensional/four-dimensional ultrasound and use of ultrasound contrast agents will also help in understanding the pathophysiology of OA in a better way.

CONCLUSION

This was the first study in the Indian scenario comparing high-frequency ultrasonographic evaluation of OA-affected knee joints with K-L grading and pain scores. The present study revealed that findings of conventional radiography (K-L grading) and few ultrasonographic criteria such as medial tibio-femoral osteophyte, medial meniscal extrusion, medial femorotrochlear cartilage grading, medial collateral ligament degeneration, and effusion showed a significant positive correlation with pain scores of the knees. Hence, it can be said that although conventional radiography and musculoskeletal ultrasound measure different structural tissues of the osteoarthritic knee, both imaging modalities are complementary to each other, rather one being superior to other.

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Conflicts of interest

There are no conflicts of interest.

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