Scholars Journal of Applied Medical Sciences
Abbreviated Key Title: Sch J App Med Sci
ISSN 2347-954X (Print) | ISSN 2320-6691 (Online)
Journal homepage: https://saspublishers.com/journal/sjams/home

OPEN ACCESS

Radiodiagnosis

High-Resolution Ultrasonography in Knee Osteoarthritis

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| **Received:** 10.01.2019 | **Accepted:** 20.01.2019 | **Published:** 28.01.2019
DOI: 10.36347/sjams.2019.v07i01.036

Abstract | **Original Research Article**

Osteoarthritis (OA) is a major health problem in middle aged and older individuals in the form of progressive and disabling joint disease. It is the fourth leading cause of the economic health care burden. Radiographic imaging continues to be most frequently used imaging technique for knee OA, radiographic knee OA changes might be observed only in patients with significant pathological damage in the knee also radiographs are not useful in predicting preclinical OA.MRI becomes the test of choice, because of its capability to directly assess the cartilage and overall structural damage of the knee due to OA but the concern of cost is a major factor in our part of world and hence high-resolution ultrasonography (HRUSG) of knee is desirable method of screening for articular cartilage abnormality and extraarticular abnormalities. Its cost effectiveness, portability, dynamic scanning capabilities make it useful in our settings. Majority of patients in our study were in 4th to 5th decade of life with a mean age of 51 years +/-10.7. Most of the patients were females accounting for 61% of total patients. A large number of patients (52% of total) in our study group were overweight. Osteophyte formation was seen in 153 (76.5%) of total 200 cases followed by joint space reduction in 88 (44%) cases on radiography. K-L grade II, III and IV cases accounted for 88 (44%) of total 200 cases. Meniscal protrusion was the most common abnormality on HRUSG, accounting for 139 (88%) symptomatic cases, followed by articular cartilage abnormality in 128 (81%) cases, joint effusion in 114 (72%) cases and osteophyte formation in 111 (70%) cases. Structural changes were seen in 193 (96.5%) cases on HRUSG in comparison to 153 (76.5%) cases on radiography out of total 200 cases of osteoarthritic knee. HRUSG was capable to detect structural changes in the radiographically normal osteoarthritic knees.

Keywords: Osteoarthritis, High-resolution ultrasonography, Osteophtes, Joint effusion, articular cartilage.

INTRODUCTION

Osteoarthritis (OA) is a major health problem in middle aged and older individuals in the form of progressive and disabling joint disease. According to W.H.O. 10% to 15% of all adults above 60 years age have some degree of osteoarthritis and its prevalence is increasing due to ageing population and increase in related factors such as obesity. It is the fourth leading cause of the economic health care burden [1].The overall prevalence of knee osteoarthritis in India has been reported to be 28.7% by C P Pal *et al*. It was found to be more prevalent in females, obese individuals and sedentary lifestyle [2].

OA is characterized by pain and limited function of the joint. Bone, cartilage, synovium, ligaments and the muscles around the joint are the tissues that change with OA and affect the function of the joint. Diagnosis of OA is mainly based on symptoms. A patient that has reached a certain age and has joint pain, limitation of movement, crepitus and, sometimes effusion in the joint might get the diagnosis of OA. Recommendations for the diagnosis of knee OA were published in 2010 [3].They include three main symptoms: knee pain, short lived morning stiffness and functional limitation in combination with three signs on physical examination crepitus, restricted movement and bony enlargement.

In the knee, the proportion of radiographic OA ranges from 15 to 76% in patients who have knee pain, whereas the proportion of knee pain in people with radiographic knee OA ranges from 15 to 81%.This reflects the discrepancy between clinical and radiographic definition of knee OA. In spite this fact radiographic imaging continues to be most frequently used imaging technique for knee OA, radiographic knee

OA changes might be observed only in patients with significant pathological damage in the knee also radiographs are not useful in predicting preclinical OA. While disease modifying treatments such as exercises, mechanical interventions etc might be more promising in the preclinical stage.

MRI becomes the test of choice, because of its capability to directly assess the cartilage and overall structural damage of the knee due to OA and also it is capable to identify the OA features in preclinical stage. But the concern of cost is a major factor in our part of world and hence high-resolution ultrasonography (HRUSG) of knee is desirable method of screening for articular cartilage abnormality and extraarticular abnormalities. Its cost effectiveness, portability, dynamic scanning capabilities and therapeutic guidance providing capabilities make it useful in our settings. In addition, for some patients sonography may be the test of choice, because of the presence of pacemaker or other absolute or relative contraindication to MRI.

MATERIALS AND METHODS

Study Population

This prospective, observational study was carried out in department of Radiodiagnosis in a tertiary care hospital. The study population consisted of 100 patients (i.e. 200 knees) with primary knee osteoarthritis referred for radiograph of knee. No patient had clinical history of mechanical knee derangement, fibromyalgia, inflammatory arthritis, microcrystalline arthropathy, knee trauma or surgery. No patient has received arthrocentesis and / or inter-articular steroid injection during the last three months. We have grouped the cases into 'symptomatic' and 'asymptomatic' knee osteoarthritis. The 'symptomatic knee osteoarthritis' was defined as the presence of two mandatory symptoms(knee pain in the absence of any recent trauma or injury and very short joint stiffness, lasting for less than 10 min, when starting movement) even in the absence of risk factors. 'Asymptomatic knee osteoarthritis' was defined as radiographic osteoarthritis without symptoms. In our study population 58 patients had bilateral symptomatic knee OA and 42 had unilateral symptomatic OA. Thus, total of 158 symptomatic knees and 42 asymptomatic knees become part of our study. All symptomatic and asymptomatic knees with prior radiographic examination were subjected to HRUSG assessment after taking written informed consent. No ethical issues were there in the study and study was carried out after approval from institutional research and ethical committee.

Study Design

Informed consent was obtained from all patients taking part in the study. Detailing of the imaging procedures is as follows:

Radiography

Weight-bearing A.P (Antero-posterior) and lateral radiographs of bilateral knee were obtained on the same day as the HRUS examination. The X-ray beam was kept horizontal and centred midway between the knees for A.P. and it was centred to the midpoint of the palpable superior border of the medial tibial condyle for lateral radiographs. The limbs were rotated slightly medially to allow for the obliquity of x-ray beam on AP view. All theradiographs were examined by the same radiologist for osteophytes, joint space narrowing and Kellgren-Lawrence grades. Osteophytes were graded as follows: Grade 0 = no osteophyte, Grade 1 = marginal osteophyte, Grade 2 = obvious osteophyte. Medial and lateral Joint spaces were defined separately either normal or narrowed. The total Kellgren-Lawrence grade (K-L grade) was calculated for medial and the lateral compartment of the knee joint separately. The radiologist was blinded to clinical and US findings.

High-resolution ultrasonography (HRUSG)

An HRUSG examination of both the knees was performed on Philips iU22 machine using a high frequency linear probe of 5-12 MHz. The examination was performed by a single radiologist with expertise on musculoskeletal US. The radiologist was blinded to the clinical and radiographic findings. US examination was performed according standardized scanning method as described in literature [4].The examination of the knee started on the suprapatellar areas, with the patient supine and knee flexed 30 degrees. In the suprapatellar anterior aspect of the knee, longitudinal and transverse scans of the quadriceps tendon, suprapatellar bursa and prepatellar bursa were performed. In the infrapatellar anterior knee, the patellar tendon and infrapatellar superficial and deep bursae were scanned longitudinally and transversely, with the patient supine, the knee flexed 45 degrees. The anserine insertion was evaluated by longitudinal and transverse scans in the antero-medial portion of the proximal tibia, with the patient supine, the knee in full extension. In the medial knee, longitudinal and transverse scans of the medial collateral ligament and anterior horn of the medial meniscus were performed, with the patient supine, external rotation of the leg, the knee flexed in 10 degree and mild valgus stress. This latter manoeuvre opens the joint space and allows a better examination of the meniscus. Longitudinal and transverse scans of the lateral collateral ligament, anterior horn of the lateral meniscus, iliotibial band and biceps femoris tendon were performed in the lateral aspect of the knee, with the patient supine, internal rotation of the leg, knee flexed 10 degree and mild varus stress. The examination of the posterior aspect of the knee was performed with the patient prone and the knee in full extension, and included longitudinal and transverse scans of the gastrocnemius-semimembranosus bursa, posterior menisci horns and posterior cruciate ligament. Osteophytes were evaluated with patient supine and knee fully extended (Fig.1). For the evaluation of

femoral cartilage, the knee was flexed as much as possible (Fig.2). Meniscal protrusion was measured as a perpendicular distance in mm between the most distant meniscus border and line connecting the femoral and tibial bone ends and more than 3 mm was defined as meniscal protrusion (Fig.3) [5]. Effusion was defined as at least 4 mm thickness of fluid in suprapatellar fossa (Fig.4) [4].The femoral cartilage structural changes were recorded as 1. Normal (a homogenous anechoic band having a sharp soft tissue- cartilage interface), 2. Mild erosion (in the form of loss of the normal sharpness of soft tissue-cartilage interface), 3. Obvious cartilage thinning and 4. Total loss of cartilage [6].Distances were measured using electronic callipers.

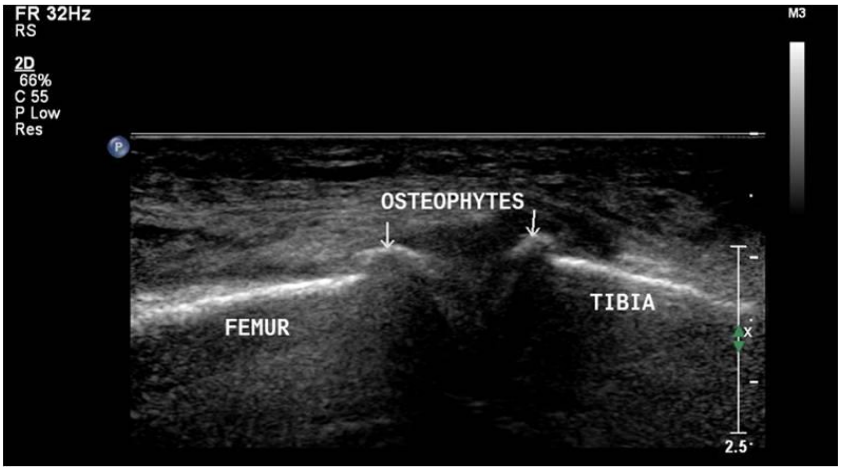

Fig-1: HRUS image of knee joint showing prominent osteophytes at lower end of femur and upper end tibia

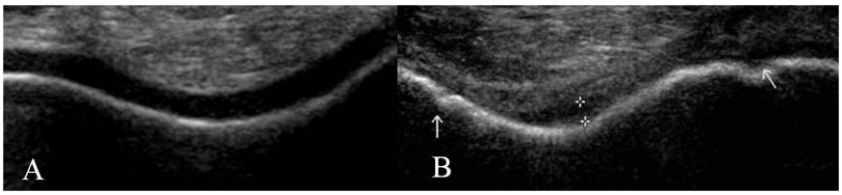

Fig-2: HRUS image of Knee joint showing (A) normal articular cartilage (B) reduced cartilage thickness with bone erosion

Fig-3: Coronal HRUS image of knee joint demonstrating medial meniscus subluxation

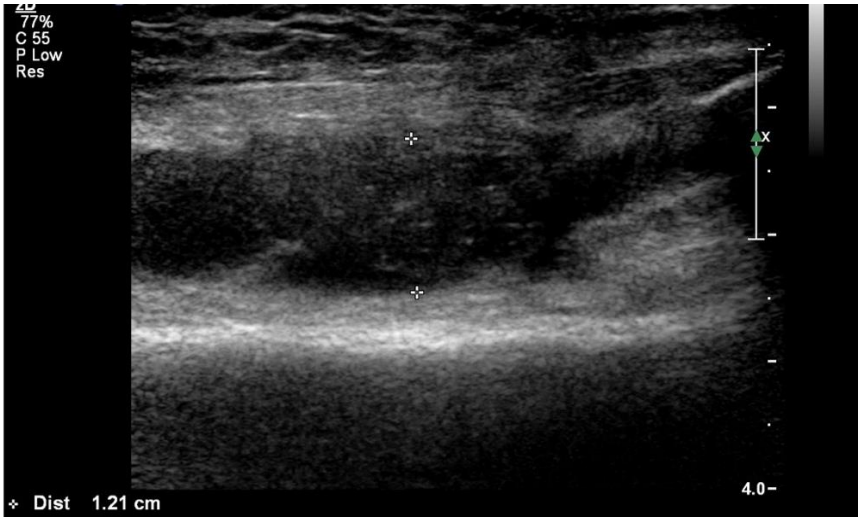

Fig-4: Frontal longitudinal section HRUS, knee joint demonstrating effusion

Statistical Evaluation

Continuous variables are represented as Mean +/- S.D. Categorical variables is represented as numbers with percentage. A comparison between diagnostic performance of radiography and HRUSG in OA knee was assessed. The chi square test was applied for comparing qualitative variables. *p*-value of<0.05 is considered statistically significant.

RESULTS

Out of total 200 cases, 158 symptomatic knees and 42 asymptomatic knees become part of our study. Majority of patients in our study were in 4th to 5th decade of life with a mean age of 51 years +/-10.7 (Table-1). Most of the patients were females accounting for 61% of total patients (Table-2). A large number of patients (52% of total) in our study group were overweight (Table-3).The most common presenting complaint was pain on walking and pain on stair climbing (Table-4).

Table-1: Age-wise distribution of cases.

S.No.	Age Groups	No. Of Patients	% Of Patients
1.	35-45 yrs	36	36%
2.	46-55yrs	29	29%
3.	56-65yrs	27	27%
4.	> 66 yrs	08	8%
Total		100	100%

Table-2:Gender-wise distribution of cases.

S.No.	Gender	No. Of Patients	% Of Patients
1.	Male	39	39%
2.	Female	61	61%
Total		100	100%

Table-3: Distribution of cases on basis of 'Body Mass Index'.

S.No.	BMI (kg/m2)	No. Of Patients	% Of Patients
1.	Underweight (<18.5)	12	12%
2.	Normal (18.5 – 24.9)	22	22%
3.	Overweight (25 – 29.99)	52	52%
4.	Obese (>_ 30)	14	14%
Total		100	100%

Table-4: Distribution of patients on basis of presenting symptoms

S.No.	Presenting Symptoms	% Of Patients
1.	Pain on walking	78
2.	Pain on stair climbing	84
3.	Pain on lying	12
4.	Pain on sitting	16

Osteophyte formation was seen in 153 (76.5%) of total 200 cases followed by joint space reduction in 88 (44%) cases on radiography (Table:5). K-L grade II, III and IV cases accounted for 88 (44%) of total 200 cases (Table:6).

Table-5: Distribution of cases on basis of radiographic findings in symptomatic and asymptomatic knee OA (n=200)

S.No.	Radiographic findings	Symptomatic (n=158)	Asymptomatic (n=42)
1.	Joint space reduction	72 (46%)	16 (38%)
2.	Osteophyte formation	111 (70%)	42 (100%)
3.	Subarticular sclerosis	46 (29%)	0 (0%)
4.	Geode formation	13 (8%)	0 (0%)
5.	Loose bodies	34 (18%)	34 (18%)
6.	Deformity of bone ends	14 (9%)	0 (0%)
7.	Normal	47 (30%)	0 (0%)

Table-6: Distribution of cases on basis of K&L grading (n=200)

S.No.	K&L Grading	Symptomatic (n=158)	Asymptomatic (n=42)
1.	Grade 0	47 (30%)	0 (0%)
2.	Grade I	39 (25%)	26 (62%)
3.	Grade II	26 (16%)	16 (38%)
4.	Grade III	32 (20%)	0 (0%)
5.	Grade IV	14 (9%)	0 (0%)
	Total	158 (100%)	42 (100%)

Meniscal protrusion was the most common abnormality on HRUSG, accounting for 139 (88%) symptomatic cases, followed by articular cartilage abnormality in 128 (81%) cases, joint effusion in 114 (72%) cases and osteophyte formation in 111 (70%) cases (Table:7).

Table-7: Distribution of sonographically detected abnormality in symptomatic and asymptomatic OA knee (n=200)

S.No.	HRUSG findings	Symptomatic (n=158)	Asymptomatic (n=42)	*p*-value
1.	Articular cartilage abnormality	128 (81%)	32 (76%)	0.6331
2.	Osteophyte formation	111 (70%)	42 (100%)	<0.0001
3.	Meniscal protrusion	139 (88%)	4 (9%)	<0.0001
4.	Synovial hypertrophy	26 (16%)	0 (0%)	0.0105
5.	Joint effusion	114 (72%)	2 (5%)	<0.0001
6.	Popliteal cyst	18 (11%)	1 (2.3%)	0.1404
7.	Bony acoustic irregularity (erosion)	38 (24%)	0 (0%)	0.0009
	Normal	7 (4%)	0 (0%)	

Structural changes were seen in 193 (96.5%) cases on HRUSG in comparison to 153 (76.5%) cases on radiography out of total 200 cases of osteoarthritic knee. HRUSG was capable to detect structural changes in the radiographically normal osteoarthritic knees (Table-8).

Table-8: Distribution of cases on the basis of presence or absence of structural changes in OA knee on Radiography vs HRUSG (n=200)

Structural changes	Present	Absent
Radiography	153 (76.5%)	47 (23.5%)
HRUSG	193 (96.5%)	7 (3.5%)

DISCUSSION

Symptomatic knee OA has been reported in 6-10% of the adult population. The diagnosis of knee OA is established by clinical evaluation, usually supplemented by plain radiography. Pain is the predominant symptom of OA knee and is the main reason for medical consultation. The OA knee pain is described to be of two types- 1.Mechanical pain and 2.Inflammatory pain. Mechanical pain is associated with joint movements such as walking and stair

climbing. Whereas resting OA knee pain is more likely inflammatory pain.

Our study population includes 158 symptomatic OA knees. The mean age of our study population was 51 years with female preponderance. A large number (52%) of patients were overweight. Female preponderance in our study is probably attributable to sedentary lifestyle and lack of exercise in our ethnic background. This along with fact that most of the household work is being done in squatting position leads to early and increased involvement of tibio-femoral compartment of knee joint in OA. Recent lifestyle changes may be the reason behind younger population being overweight and long working hours leading to inadequate exercises even in male population. In all compartments overweight is a risk factor for osteophytes formation. Overweight is a risk factor that may influence the knee joint not only via mechanical loading but also via biochemical pathways and is a risk factor for all compartments and many types of OA-related damage. As overweight is a modifiable risk factor, losing weight is advised as treatment for symptomatic OA also it might prevent progression or onset of OA.

In our study, 16% of cases complained of rest pain. No attributable cause was identified on radiography in these patients while on HRUSG synovial thickening was found to be in 16% of symptomatic cases and this correlation was statistically significant (*p*-value 0.01) and correlated well with the inflammatory nature of pain in these cases.

Majority of cases complained of pain on walking/stair climbing (84%), i.e. pain related to joint movement (mechanical pain).Most common findings on radiography were osteophyte formation in 70% cases followed by joint space reduction in 46% cases. On HRUSG the most common findings were meniscal protrusion in 88%, followed by articular cartilage abnormality in 81% and joint effusion in 72% cases of symptomatic knee OA. Statistically significant correlation was observed between meniscal protrusion and joint effusion with symptomatic OA (*p*-values <0.0001).Meniscal protusion and joint effusion have also been attributed as cause of mechanical pain in the literature (4,5). In our study no statistical significant correlation was observed between articular cartilage abnormality and symptomatic OA (*p*-value=0.63) with articular cartilage abnormality present in 76% of asymptomatic knees also. This finding is in concordance with literature that articular cartilage abnormality is probably not related to pain in the OA knee. Thus in our study the findings on HRUSG are better correlating with the mechanical pain in symptomatic knees in comparison to radiography.

HRUSG is considered better for soft tissue abnormalities in the joint, but it was found equally better for identification of osteophytes in our study population. The HRUSG was able to detect all the radiographically detected osteophytes. In our study meniscal protrusion, joint effusion and popliteal cyst were also observed in few of the asymptomatic knee OA cases (<10%).Articular cartilage abnormality was present in 76% cases of asymptomatic knee OA.

Radiography detected structural changes in 76.5% cases of the total 200 OA knees, while HRUSG was able to detect structural changes in 96.5% cases. Thus HRUSG scores over radiography in cases of knee osteoarthritis and this association was statistically extremely significant (*p*-value <0.0001).Early detection of OA will be helpful in patient management as disease modifying regimens like exercises and drug may help to prevent and postpone the symptom. We propose routine use of HRUSG in clinically diagnosed osteoarthritis cases of knee in place of radiography. As it is not only having better yield, but also its cost effectiveness, dynamic scanning capabilities and therapeutic guidance providing abilities make it useful in our settings. It is safe and repetitive examinations can be performed, as no ionizing radiation is involved. Its portability makes it score over even MRI and it can become the only choice in cases where MRI is contraindicated.

There are also limitations that wait to be overcome including: the lack of a standardized method for measuring of cartilage thinning and joint space narrowing and the lack of a validated scoring system for the US findings indicative of OA. In addition, ultrasound has been viewed as one of the most operator-dependent imaging techniques. A strict standardization of scanning technique and diagnostic criteria are necessary to perform reliable US assessment.

CONCLUSION

Conventional radiography is the current standard for osteoarthritis imaging in routine practice. However, radiographic features of OA do not concord with the symptoms of OA. Given the discordance between radiographic structural changes and symptoms in OA, the importance of high-resolution ultrasound detected changes in terms of therapeutic interventions needs to be established. HRUS can detect various manifestations of OA including articular cartilage abnormalities, effusion, synovitis, erosions, osteophtes, meniscal changes, bursitis and tendon and ligament abnormalities. It provides unique information that bridges gap between the clinical and radiologic evaluation. Structural modification is now an aim in clinical trials of drugs therapy in OA. Ultrasonography is an imaging technique that may be useful in the diagnosis and management of osteoarthritis, both in clinical trials and in practice.

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