Ultrasonographic findings in knee osteoarthritis: A comparative study with clinical and radiographic assessment

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Summary

Objective: To compare ultrasonographic (US) findings with clinical and radiographic assessment in knee osteoarthritis (OA).

Methods: Fifty patients with primary knee OA were studied. Clinical assessment of both knees was performed by the same rheumatologist who recorded a visual analogue scale (VAS) for pain (VASP). All patients underwent a US examination of their knees by a second blinded rheumatologist who assessed the Kellgren and Lawrence (K–L) grade, the femorotibial (FT) space width and the presence of patello-femoral degenerative signs.

Results: Forty patients had bilateral symptomatic knee OA and 10 unilateral symptomatic OA. All knees showed radiographic FT degenerative signs. US findings in symptomatic knees were effusion (47%), protrusion of the medial meniscus (MMP) with displacement of the medial collateral ligament (MCLD) (61%) and Baker’s cyst (22%). US effusion, MMP and MCLD were associated with significantly higher VAS score for pain ($P_{<0.05}$). MMP was associated with medial FT space width ($P_{<0.05}$). Patients who had a difference between VAS score for pain in each knee greater than 30 (28 patients) showed significantly more unilateral effusion, MMP, MCLD and worse K–L grade in the more symptomatic knee than those with a difference lesser than 30 (22 patients).

Conclusion: Knee effusion and MMP with MCLD are associated with pain in knee OA. In addition, MMP may contribute to the radiographic medial FT space narrowing. We propose US for assessing periartricular and intraarticular abnormalities involved in the pathophysiology of knee OA.

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Key words: Knee osteoarthritis, Ultrasonography, Effusion, Meniscal protrusion.

Introduction

Osteoarthritis (OA) is the most frequent disease of the musculoskeletal (MSK) system. The knee is one of the most common joint involved in OA. In fact, 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 (PR).

Standard PR is the primary imaging modality used to evaluate OA. Traditionally, it has been considered the gold standard for assessing joint damage in knee OA. PR demonstrates osteoarthritic bony abnormalities and shows indirect signs of articular cartilage lesion. In addition, PR is cheap and widely available. However, this technique is limited by its inability to directly visualize articular cartilage, synovial recesses, menisci and other soft tissues involved in the pathophysiology of OA.

Newer imaging modalities such as magnetic resonance imaging (MRI) and high-frequency MSK ultrasonography (US) offer an overall assessment of the osteoarthritic joint. MRI is accurate and reproducible for evaluating bone, articular cartilage and soft tissues. Advantages of MRI include its non-invasiveness, multiplanar capability and excellent soft tissue contrast. However, MRI is expensive, time consuming and not widely available for routine use in most countries.

High-frequency MSK US effectively depicts superficial periarticular and intraarticular structures involved in rheumatic diseases. This technique has demonstrated accuracy and reliability in the identification of knee effusion and Baker’s cyst as well as higher sensitivity than physical examination for the detection of these pathological findings. Moreover, periarticular tendons, ligaments, bursae and the peripheral aspect of the menisci can be evaluated by US. MSK US has considerable advantages over other imaging modalities including non-invasiveness, quick to perform, relatively low cost, ability to scan multiple joints, repeatability and high patient acceptability. In addition, it can be used routinely to perform dynamic examination.

The aim of this study was to compare US findings with clinical and radiographic assessment in knee OA. To the best of our knowledge, this is the first study that include an overall US assessment of the osteoarthritic knee.

Patients and methods

Fifty consecutive patients (6 males, 44 females) attending the outpatient rheumatologic clinic with unilateral or bilateral primary knee OA, according to ACR criteria were included. Mean age was 64.3 ± 7.9 years (51–78). Median disease duration was 30 months ($p_{25}$–$p_{75}$: 12–70)
(1–120). No patients had clinical history of mechanical knee derangement, fibromyalgia, inflammatory arthritis, microcrystalline arthropathy or knee trauma or surgery. No patient has received arthrocentesis and/or intraarticular steroid injection during the last 3 months. The institutional ethics committee approved the study performed. Consent was obtained from all patients prior to the clinical, US and radiographic evaluation.

CLINICAL ASSESSMENT

Clinical evaluation of both knees was performed by the same rheumatologist (FC) who recorded from each patient demographic data, duration of symptoms, body mass index (BMI), knee alignment, presence of spontaneous medial knee pain as well as tenderness at the anserin insertion (AI). A visual analogue scale (VAS) (0–100 mm) for knee pain on motion and at rest during the previous week was applied to all patients. Pain was measured by the patient marking a 100 mm VAS between 0 (no pain) and 100 (maximum pain). Tenderness at AI was assessed by applying firm digital pressure at the anteromedial aspect of the proximal tibia, 2.5–3 cm distal to the medial femorotibial (FT) joint line.

Arthrocentesis was performed in one knee of 11 patients with clinically suspected effusion.

US ASSESSMENT

All patients underwent a US examination of the knees by a second blinded rheumatologist experienced in this technique (EN), with a commercially available ultrasound real-time scanner (Logiq 500 CL, General Electric Medical Systems, Japan) using multi-frequency linear transducer (7–12 MHz), within 5 days of the clinical evaluation.

US examination was performed according to standardized scanning method8,9,18. The examination of the knee started on the suprapatellar area, with the patient supine and the knee flexed 30°. 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°. The AI was evaluated by longitudinal and transverse scans in the anteromedial 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 (MCL) and the anterior horn of the medial meniscus were performed, with the patient supine, external rotation of the leg, the knee flexed 10° and mild valgus stress. This latter maneuver 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° 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-semimembranous bursa, posterior menisci horns and posterior cruciate ligament.

US diagnostic criteria for tendon and ligaments lesions, bursitis and panniculitis were based on those widely described in the literature8,9. Effusion was defined as increased hypoechoic or anechoic intraarticular material, within synovial recesses, seen in two perpendicular planes8,9,11,15,16. Knee effusion was considered when maximum anterior–posterior diameter of the suprapatellar recess was greater than 4 mm. Baker’s cyst was identified when the gastrocnemius-semimembranous bursa filled with hypoechoic material showed a transverse diameter greater than 4 mm. The ruptured Baker’s cyst shows a pointed distal aspect. The normal ultrasound appearance of the peripheral aspect of the meniscus is a triangular-shaped hyperechoic structure at the FT joint space8,9. Protrusion of the meniscus was defined as a distance between the peripheral border of the meniscus and the outline of the tibial plateau greater than 2 mm. The measure of meniscal protrusion was also recorded. Normal MCL is seen hyperechoic covering the medial femoral condyle, the outer margin of the medial meniscus and the medial tibial plateau17,18. Distances were measured using electronic calipers.

We performed US scanning of both knees in 10 (2 males, 8 females) asymptomatic healthy volunteers (20 knees). Mean age was 68 ± 9.4 years (54–78).

RADIOGRAPHIC ASSESSMENT

Weight-bearing anteroposterior (AP) and lateral knee radiographs were read by a third rheumatologist (MJP), blinded to the clinical and US findings who assessed the severity of OA on the AP view using the Kellgren and Lawrence (K–L) scale (scores 0–4)19. The FT space width measured at the most peripheral site and the mid-point of the medial compartment (MC) and lateral compartment (LC) and the presence of patello-femoral (PF) degenerative signs.

STATISTICAL ANALYSIS

Statistical analysis was performed using the standard software packages SPSS 8.0 for Windows. Parametric and non-parametric quantitative variables were expressed as mean ± standard deviation (SD) of the mean, interval, and median, percentiles (p), interval, respectively. The chi-square test was applied for comparing qualitative variables. The Student’s t test and the one-way ANOVA test were used to compare means between parametric variables. The Mann–Whitney test and the Kruskal–Wallis test were used to compare means between non-parametric variables. Pearson and Spearman’s correlations were applied for continuous clinical, US and radiographic parameters. Any P value under 0.05 was considered statistically significant.

Results

Forty patients had bilateral symptomatic knee OA and 10 patients unilateral symptomatic OA (90 symptomatic knees). Ten knees of 10 patients were asymptomatic and normal on physical examination. Seventy-three (81.1%) symptomatic knees had spontaneous medial knee pain and 75 (83.3%) symptomatic knees, AI tenderness on physical examination. All symptomatic and asymptomatic knees showed radiographic FT degenerative signs. K–L grade was I in 28 (28%) knees, II in 39 (39%) knees, III in 30 (30%) knees and IV in 3 (3%) knees. PF degenerative signs were detected in 78 (78%) knees. No radiograph showed chondrocalcinosis.
Fig. 1. Knee effusion. Increased hypoechoic fluid within the suprapatellar bursa. F = femur; P = patella; SPB = suprapatellar bursa; LONG = longitudinal.

Fig. 2. Protrusion of the anterior horn of the medial meniscus with distension of the MCL. F = femur; T = tibia; LONG = longitudinal.
The difference between VAS score for pain on motion in each knee was greater than 30 in 28 patients and lesser than 30 in 22 patients. Forty-two patients showed a difference between pain VAS at rest in each knee lesser than 30.

US findings in symptomatic knees were effusion in 42 knees (46.7%), protrusion of the anterior horn of the medial meniscus (MMP) associated with displacement of the medial collateral ligament (MCLD) in 55 knees (61.1%) and Baker’s cyst in 20 knees (22.2%). Sixteen of the 20 Baker’s cysts were ruptured. No knee showed US anserinus tendino-bursitis, tendon lesions, prepatellar or infrapatellar bursitis, ligament rupture, peripheral lateral meniscus abnormalities, lateral collateral ligament lesions or panniculitis of the medial knee fat. Two examples of US effusion and MMP are shown in Figs. 1 and 2.

Effusion, MMP and MCLD were found only in symptomatic knees \( (P < 0.005) \). No asymptomatic knee had Baker’s cyst \( (P > 0.05) \). Symptomatic knees showed a significantly higher \( L \) grade and greater radiographic medial FT space narrowing than asymptomatic knees \( (P < 0.05) \) (Table I). There was no significant difference between symptomatic and asymptomatic knees regarding age, knee involved, BMI, knee alignment, lateral FT space width and presence of radiographic PF degenerative signs (Table II).

The presence of US effusion was associated with MMP, MCLD, Baker’s cyst and a significantly higher VAS score for pain on motion and at rest \( (P < 0.01) \) (Table III). US effusion was not associated with age, disease duration, BMI, \( K \)–\( L \) grade severity, radiographic PF degenerative signs and FT space width (Table II).

Patients with MMP and MCLD showed a significantly higher VAS score for pain on motion and at rest and a lesser medial FT space width than those without these US findings \( (P < 0.01) \). The presence of MMP and MCLD was associated with medial knee pain, \( Al \) tenderness, effusion, Baker’s cyst, longer disease duration, higher BMI and \( K \)–\( L \) grade along with radiographic PF degenerative signs \( (P < 0.05) \) (Table II).

Mean MMP was 6.1 \( \pm \) 1.3 mm (3.3–8.2). The degree of MMP correlated moderately with the radiographic medial FT space width \( (r = –0.4, P = 0.001) \) and did not correlate with age, disease duration and BMI \( (P > 0.05) \). BMI showed a poor correlation with VAS score for pain on motion \( (r = 0.2, P < 0.05) \) and did not correlate with VAS for pain (VASP) at rest and radiographic FT space width \( (P > 0.05) \). However, BMI was associated with the severity of \( K \)–\( L \) grade and the presence of radiographic FP degenerative signs \( (P < 0.05) \).

To further assess the association between effusion, MMP, MCLD and pain intensity, we restricted the sample to patients with \( K \)–\( L \) severity lesser than grade III as all asymptomatic knees had \( K \)–\( L \) grade I or II. Twenty-three symptomatic knees had \( K \)–\( L \) grade I and 34 had grade II. Five asymptomatic knees showed \( K \)–\( L \) grade I and 5, grade II. VAS score on motion and at rest remained significantly higher in knees with effusion (56.5 \( \pm \) 26.9 and 14 (5–37.5), respectively) and knees with MMP/MCLD (56.2 \( \pm \) 22.5 and 17.5 (3.7–37), respectively) than in those without effusion (35 \( \pm \) 28.8 and 5 (0–14), \( P < 0.005 \) and \( P < 0.01 \), respectively) and knees without MMP and MCLD (34.7 \( \pm \) 31 and 5 (0–11), respectively, \( P < 0.005 \)).

Patients who had a difference between VAS score for pain on motion in each knee greater than 30 showed significantly more unilateral effusion, MMP and MCLD and worse \( K \)–\( L \) grade in the more symptomatic knee than those with a difference lesser than 30 \( (P < 0.05) \) (Table III).

Analysis of intraarticular fluid aspirated in 11 knees revealed a leucocyte count from 70 to 980/mm\(^3\). No fluid showed microcrystals.

### Table I

<table>
<thead>
<tr>
<th>Clinical findings</th>
<th>Symptomatic knees (n= 90)</th>
<th>Asymptomatic knees (n= 10)</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years) (mean, SD)</td>
<td>64 ( \pm ) 7.6</td>
<td>67.6 ( \pm ) 9.9</td>
<td>n.s.</td>
</tr>
<tr>
<td>Knee involved</td>
<td></td>
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<tr>
<td>Right knee (n, %)</td>
<td>43 (47.7%)</td>
<td>7 (70%)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Left knee (n, %)</td>
<td>47 (52.2%)</td>
<td>3 (30%)</td>
<td>n.s.</td>
</tr>
<tr>
<td>BMI (mean, SD)</td>
<td>31.8 ( \pm ) 5.1</td>
<td>29.2 ( \pm ) 3.9</td>
<td>n.s.</td>
</tr>
<tr>
<td>Knee alignment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal (n, %)</td>
<td>75 (83.3%)</td>
<td>8 (80%)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Genu varus (n, %)</td>
<td>11 (12.2%)</td>
<td>0</td>
<td>n.s.</td>
</tr>
<tr>
<td>Genu valgus (n, %)</td>
<td>4 (4.4%)</td>
<td>2 (20%)</td>
<td>n.s.</td>
</tr>
<tr>
<td>US findings</td>
<td></td>
<td></td>
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<tr>
<td>Effusion (n, %)</td>
<td>42 (46.7%)</td>
<td>0</td>
<td>(&lt; 0.005)</td>
</tr>
<tr>
<td>MMP with MCLD (n, %)</td>
<td>55 (61.1%)</td>
<td>0</td>
<td>(&lt; 0.001)</td>
</tr>
<tr>
<td>Baker’s cyst (n, %)</td>
<td>20 (22.2%)</td>
<td>0</td>
<td>n.s.</td>
</tr>
<tr>
<td>Radiographic findings</td>
<td></td>
<td></td>
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<tr>
<td>( K )–( L ) grade</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade I (n, %)</td>
<td>23 (25.5%)</td>
<td>5 (50%)</td>
<td>(&lt; 0.05)</td>
</tr>
<tr>
<td>Grade II (n, %)</td>
<td>34 (37.7%)</td>
<td>5 (50%)</td>
<td></td>
</tr>
<tr>
<td>Grade III (n, %)</td>
<td>30 (33.3%)</td>
<td>0</td>
<td></td>
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<tr>
<td>Grade IV (n, %)</td>
<td>3 (3.3%)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>FT space width</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peripheral MC (mm) (mean, SD)</td>
<td>6.7 ( \pm ) 2.7</td>
<td>8.1 ( \pm ) 1.5</td>
<td>(&lt; 0.05)</td>
</tr>
<tr>
<td>Mid-point MC (mm) (mean, SD)</td>
<td>5.6 ( \pm ) 2</td>
<td>7.2 ( \pm ) 1.4</td>
<td>(&lt; 0.05)</td>
</tr>
<tr>
<td>Peripheral LC (mm) (mean, SD)</td>
<td>9.4 ( \pm ) 1.7</td>
<td>9.4 ( \pm ) 1.8</td>
<td>n.s.</td>
</tr>
<tr>
<td>Mid-point LC (mm) (mean, SD)</td>
<td>6.7 ( \pm ) 1.5</td>
<td>7.1 ( \pm ) 2</td>
<td>n.s.</td>
</tr>
<tr>
<td>Radiographic FP degenerative signs (n, %)</td>
<td>71 (78.8%)</td>
<td>7 (70%)</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

MCLD: medial collateral ligament displacement; n.s.: not significant.
In control subjects, US mean maximum anterior–posterior diameter of the suprapatellar bursa was 2.3 ± 0.7 mm (1–3.7) and mean distance from the peripheral border of the medial meniscus to the edge of the tibial plateau was 0.5 ± 0.3 mm (0–1). Anterior–posterior diameter of the suprapatellar bursa did not correlate with age. The distance from the peripheral border of the meniscus to the tibial plateau showed a moderate positive correlation with age (r = 0.5, P = 0.001). None of the control subject had Baker’s cyst or other US knee abnormalities.

### Discussion

Pain is the predominant symptom of OA. However, the cause of pain in knee OA is poorly understood. Although articular cartilage is considered the major structure involved in OA, hyaline cartilage has no nervous fibers. Then, pain may arise from other periarticular and/or intraarticular structures such as the joint capsule, synovium, periosteum, bone, tendons, bursae, ligaments or menisci.

In keeping with our results, effusion, MMP and Baker’s cyst have been the principal findings in MRI and US studies of knee OA. The role of joint effusion in the pathophysiology of OA is controversial. Mild synovitis with secondary effusion has been described in knee OA. Hill et al. reported a strong association between effusion and pain in knee OA. We found that effusion was associated with pain intensity on motion and at rest independently of radiographic OA severity, age, disease duration and BMI. Although Baker’s cyst was detected only in symptomatic knees, this US finding did not show statistic significance probably due to the smaller number of cases.

Joint space narrowing is a primary radiographic feature of OA. Arthroscopic studies have found a moderate correlation between radiographic joint space narrowing and loss of hyaline articular cartilage. Mazzuca et al. demonstrated that increase in knee pain and/or inflammation may affect the ability to fully extend the knee, thus reducing the apparent radiographic thickness of the articular cartilage. Other studies have shown that menisci can contribute to joint space width and meniscal protrusion or displacement away from their normal anatomic location may cause radiographic FT space narrowing independently of cartilage thinning in knee OA. More recent study demonstrated that increase in knee pain and/or inflammation may affect the ability to fully extend the knee, thus reducing the apparent radiographic thickness of the articular cartilage. Other studies have shown that menisci can contribute to joint space width and meniscal protrusion or displacement away from their normal anatomic location may cause radiographic FT space narrowing independently of cartilage thinning in knee OA.

MMP and MCLD were associated with clinical and radiographic advanced OA. However, when considering only knees with early K–L grades, pain intensity on motion and at rest were significantly higher in those with MMP and MCLD than in knees without these findings. Our data are in accordance with Gale et al. who reported that meniscal subluxation on MRI was highly associated with symptomatic knee OA and severity of K–L grade and medial FT space narrowing on weight bearing knee radiographs. In addition, as we found, the degree of MMP did not correlate with age or weight.

Since joint space narrowing is an essential component of the K–L scale, it is expected that the presence of MMP was associated with worse K–L grade. However, because joint space width is a primary outcome measure for knee OA in clinical practice and investigative trials, the contribution of meniscal protrusion in this radiographic parameter is of great interest. The physiopathologic meaning of meniscal protrusion in the development of knee OA is unknown. Meniscal displacement away from the tibial articular cartilage may be considered a condition similar to meniscectomy that has been shown to predispose to OA in clinical practice and experimental models. Longitudinal studies would clarify whether meniscal protrusion has an etiologic role in knee OA or it is a secondary phenomenon.
MMP with MCLD were clearly associated with medial knee pain and anserin insertion (AI) tenderness. These frequent clinical features of knee OA are thought to be due to anserinus tendinitis and/or bursitis in many patients. Uson et al. found US anserin lesions in a small percentage of patients with this clinical diagnosis. MMP is accompanied by displacement and probably distension of the MCL and the medial joint capsule. The close anatomic relationship between the tibial insertion of the MCL and the pes anserinus makes difficult clinical differential diagnosis between MCL and AI involvement.

Some limitations of our study should be mentioned. Firstly, we used the conventional standing AP knee radiograph whereas a semiflexion AP view would be more accurate for studying the FT space. Moreover, we did not use an axial view for evaluating the PF space. Nevertheless, we performed the routine views mostly used in daily clinical practice for radiologically assessing severity and progression of knee OA.

Secondly, the US inter-observer reliability was not studied. US has been viewed as one of the most operator-dependent imaging technique. This fact is partly due to the intrinsic real time nature of US images acquisition. The recorded US images largely display the subjective findings observed by the individual performing the examination. However, in our study all the US examinations were performed by the same rheumatologist who has 9 years of experience in MSK US. In addition, the recent study by Scheel et al. has revealed an excellent inter-observer reliability (kappa value of 1) between 14 experts in MSK US for the US detection of knee pathological findings including effusion, bone surface abnormalities, tendon lesions, bursitis and Baker’s cyst. In the same study, the overall sensitivity and specificity of US compared with MRI for diagnosing knee abnormalities were 90.5% and 87.5%, respectively.

**Conclusion**

Our results suggest that knee effusion as well as MMP and/or MCLD are associated with mechanical pain and pain at rest in knee OA. In addition, MMP and/or MCLD may be related to medial knee pain and AI tenderness and MMP can correlate with radiographic medial FT space narrowing. MSK US is a non-invasive diagnostic tool for evaluating periarticular and intraarticular abnormalities involved in knee OA.

**References**