# Imaging

# Ultrasound imaging for the rheumatologist VIII. Ultrasound imaging in osteoarthritis

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**ABSTRACT**

*The present review provides an update of the available data and discusses research issues relating to ultrasound (US) imaging in osteoarthritis (OA). Currently, the principal indications for using US in OA include: delineation of changes within articular cartilage (AC) and demonstration of synovial and adjacent soft tissue pathology together with injection into OA joints under US guidance. US has been proposed as a possible imaging tool for following the progression of OA.*

*The main priorities requiring the attention of researchers include: addressing difficulties surrounding consensus on definitions of pathology in OA, charting the natural history of AC change in site specific OA, investigation of the link between inflammation and OA and the use of three-dimensional (3D) US in OA.*

## Introduction

Musculoskeletal ultrasound (US) has rapidly come to the fore in recent years as one of the most important tools of investigation for rheumatologists (1-5). Throughout Europe and beyond, rheumatologists are increasingly performing US themselves. Both the research available and training required has predominantly concentrated on the exploration of inflammatory disease. There has, however, been increasing interest in the use of US to image and investigate structural change in osteoarthritis (OA) (6-8).

Plain radiography has been the standard imaging technique for many years to both diagnose and quantify OA. This has inherent limitations including the indirect visualisation of the articular cartilage (AC) and inability to image co-existent soft tissue pathology. US can reliably quantify changes both in AC and soft tissues and would appear to be a neglected imaging modality in OA to date.

Research in the area has centred upon knee OA in particular and has attempted to address the following: comparison between US and plain radiography, correlation of US changes in AC with histomorphometry and the causes of pain in knee OA (9, 10).

This review aims to highlight the current use of US in OA and discuss the available literature surrounding the topic.

## Clinical applications

The principal indications for using US in OA include: delineating progressive changes in AC, demonstrating synovial changes within joints and the visualisation of adjacent soft tissue pathology (6, 11). In addition, US can identify bony changes including osteophytosis and in rare clinical circumstances bone erosion as seen in erosive OA (6, 12, 13).

Grey scale US using high quality, high frequency linear transducers are required for imaging the finest details within AC. Classically the normal anatomical details of AC are seen best at lower levels of power and gain (6). Power Doppler has limited use in OA to demonstrate hypervascularity of the synovial linings of joints and the investigation of the putative link between inflammation and OA (14, 15).

The application of US in OA also extends to the guidance of needles for intra-articular injection of various joints and soft tissues (16-20).

## Sonographic findings

The main pathological features detected by US in patients with OA are those related to cartilage damage, joint inflammation, and osteophyte formation (Table I) (Fig. 1).

**Table I.** Pathological conditions and corresponding US findings.

| Pathologic condition | US findings |
|---|---|
| Joint effusion | Increased hypoechoic or anechoic intraarticular material, within synovial recesses, seen in two perpendicular planes (7).<br>Hypoechoic or anechoic anteroposterior distention of the joint capsule (9).<br>An anechoic area within the joint cavity (10). |
| Synovitis | Hypoechoic synovial hypertrophy with diffuse or nodular appearance (10). |
| Popliteal cyst in patients with knee OA | Mono or bilobed anechoic or hypoechoic area (6).<br>Gastrocnemious-semimembranous bursa filled with hypoechoic material showing a transverse diameter greater than 4 mm. The ruptured Baker's cyst may show a pointed distal aspect (7). |
| Mucous cyst in patients with Heberden's nodes | Sharply defined anechoic area over the distal interphalangeal joint (12). |
| Osteophyte | Irregularity of the bone contour (6). |
| Cartilage damage | Loss of sharpness of the cartilage margins (6).<br>Loss of homogenenicity of the cartilage layer (6).<br>Cartilage thinning (focal or extend to the entire cartilaginous layer) (6). |

Normal AC has characteristic sonographic features. It is bounded by an outer well-defined chondro-synovial margin which is thinner than its equally sharp, deeper osteo-chondral counterpart. The echotexture is characteristically homogeneously anechoic or hypoechoic depending on the level of gain. The thickness of AC not unnaturally varies according to the articular surface being examined (0.1 mm at the proximal phalanx to 2.6 mm at the medial femoral condyle) (6, 11).

A spectrum of change within AC can be charted with US. The earliest morphostructural changes seen with US include loss of the sharp definition of the outer chondro-synovial margin and micro-cleft formation. This progresses to the loss of transparency of the normally homogeneous AC layer itself, sometimes mistaken for anisotropy or inappropriate setting of the machine. Inflammatory expansion of the AC can sometimes be detected in the early phases of OA but pseudo-widening of the joint space should be corrected by pressure applied by the probe over the area to disperse fluid to more accurately assess the thickness of the AC layer. In the later stages of OA the progressive thinning of the cartilaginous layer is easily detected with US leading to eventual complete denudation of bone. There is some debate about the significance of an inflammatory process in OA (14). Certainly, US is able to depict even minimal joint effusion, most commonly in the knee joint (10). Typically the fluid is anechoic although in OA it may appear inhomogeneous with particulate matter (possibly due to proteinaceous material, debris or calcified fragments), which may create posterior acoustic shadowing. Power Doppler rarely captures any significant indication of hyperaemia in these circumstances but this will require further study in large cohorts of OA patients. Small fluid collections can also be depicted in the distal inter-phalangeal joints in hand OA – perhaps indicating a mild degree of synovitis (12). In erosive hand, OA erosions similar to those seen in rheumatoid arthritis can be detected with varying degrees of clarity related to the interposition of osteophytes which may limit the width of the acoustic window (13).

One of the hallmark features of OA on plain radiography is the appearance of osteophyte at the joint margins. US can also depict these irregularities of the bony contour. It should be remembered that the hyperechoic rim of an osteophyte will create acoustic shadowing and therefore obscuration of the adjacent bone surface. There appears to be excellent correlation of osteophytosis between US and plain radiography (6, 7).

The full US assessment of any joint affected by OA should also include assessment of the adjacent soft tissues and occasionally abnormalities are visualised. Around the knee in particular, US can frequently demonstrate the presence of Baker's cysts (19) and additionally bursitis: superficial and deep infra-patellar and anserine with characteristic hypoanechoic enlargement

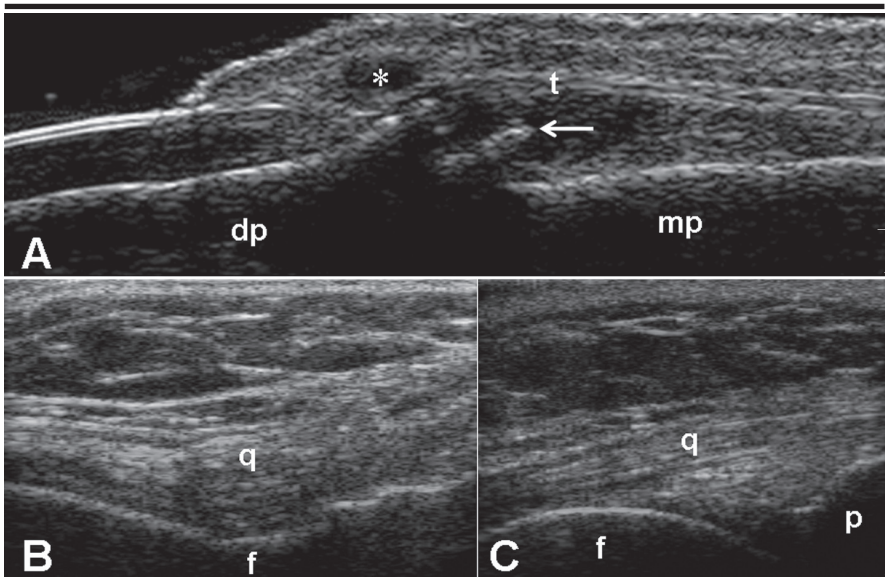


**Fig. 1**. Osteoarthritis. **A**. Hand. Distal interphalangeal joint. Heberden's node. Dorsal longitudinal view showing an osteophyte (**arrow**) on the head of the middle phalanx (**mp**) and a mucous cyst (*) on the dorsal aspect of the basis of the distal phalanx (**dp**). **B**-**C**. Knee. Marked thinning of the articular cartilage of the femoral condyle (**f**) on suprapatellar transverse (**B**) and longitudinal (**C**) views. **p** = upper pole of the patella; **q** = quadriceps tendon. Image **A** taken with a Technos MPX (Esaote Biomedica, Genova, Italy) using a 10-14 MHz linear probe. Images **B** and **C** taken with a Diasus (Dynamic Imaging, Livingstone, UK) with a linear 5-10 MHz probe.
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of the bursal sac. Meniscal lesions can also be depicted with extrusion of the meniscal horns beyond the joint line.

**Literature review**

To date much of the focus for rheumatology sonographers has been in the exploration of the capability of US in inflammatory arthritis and soft tissue pathology. Relatively little has been published on OA, although it would appear that this imbalance is slowly being redressed.

The largest cohort of patients with primary OA to be studies with US was a pan-European venture investigating knee OA (10). The study involved 600 patients and was designed to assess patients with a flare of knee pain within 72 hours of onset with US. Primarily the group aimed to ascertain the involvement of an inflammatory component to these flares. The investigators devised their own definitions for knee synovitis and joint effusion. Power Doppler was not used owing to the difficulties in standardising machine settings between centres. Inflammation was found to be present in 46.3% of cases (2.7% synovitis alone, 14.2% synovitis and effusion and 29.5% effusion alone). The remaining 53.7% of patients had no US explanantion for their pain although alternative sources of pain in adjacent soft tissues was not sought.

A sub-set of this large group of knee OA patients were further investigated with US by a Spanish group during this initial study to look for other possible explanations for pain otherwise unexplained by joint inflammation (9). They found in their 81 patients that US pathology frequently co-existed with primary joint pathology: 45.7% with meniscal lesions, 37% with Baker's cysts, 8.6% with infra-patellar bursitis and 6.2% with anserine bursitis.

Further investigation of pain in knee OA using US has demonstrated several features which also appear to correlate with pain including medial meniscal protrusion and medial collateral ligament displacement (7). Medial meniscal protrusion also appeared to correlate with the degree of narrowing of the medial compartment of the knee ($p < 0.5$).

The lack of any agreed standardised scoring system for degenerative change within AC has hampered investigators but recently a semi-quantitative grading system has been proposed by a Danish group who looked at both inter and intra-observer variability in assessing cartilage damage in 100 patients with hip OA (21). They produced very encouraging kappa values indicative of good levels of agreement between investigators.

Quantifying changes in AC in OA have also been the subject of various investigators (22). These have invariably been *in vitro* studies using surgical specimens and correlating with histological findings. Whilst there are obvious putative benefits from these studies to *in vivo* scenarios, further investigation in living subjects is required.

Some preliminary work has been done comparing the changes seen in OA using US and magnetic resonance imaging (MRI). Whilst the data is encouraging this came from one small study performed in knee OA (23).

US has been shown to be of great clinical benefit in injecting joints, particularly the hip in OA and for accurate placement of steroid injection in the soft tissues surrounding joints affected by OA. Some studies have also employed US as a tool for verification of correct placement of corticosteroids in challenging joints and soft tissues.

**Research agenda**

The main priorities requiring the attention of investigators are listed in Table II.

Consultation of the current literature will make it clear that the sonographic investigation of inflammatory arthritis and soft tissue disorders occupy the minds of most investigators. Fortunately this imbalance has already begun to be corrected. The scope for further research using US in OA is therefore infinite.

Perhaps the greatest difficulty encountered by sonographers keen to further our knowledge of OA is the lack of any international consensus on definitions of pathology commonly seen in OA eg. synovitis and synovial hypertrophy in knee OA (10, 24). Individual investigators have therefore had to adopt their own dimensions thereby limiting reproducibility between some studies. Certainly this area will require different centres to collaborate and focus upon agreement, particularly for those keen to explore the links between inflammation and OA.

Furthermore, the increasing interest in using US as a tool to investigate structural change in AC will require long range cohort studies in large numbers of patients with OA at multiple sites to permit the natural US history of site specific OA to be charted. It is also likely that such studies will need comparator imaging modalities such as plain radiography and MRI to verify the changes. The advent of 3D US is also likely to stimulate great interest as a possible alternative to MRI in OA studies, particularly those concentrating on therapeutic effects of new interventions on AC (25).

Other exciting areas for future research include the use of US to investigate the link between calcium pyrophosphate deposition disease and OA, particularly at the knee joint. US would seem to be a very promising imaging tool to enable such studies to take place (26).

The shift towards investigating AC, coupled with the expansion in the use of US by rheumatologist worldwide will hopefully galvanise into exciting research for the future.

**Table II**. US imaging in OA: research agenda.

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| International consensus on validity issues in OA |
| The role of inflammation in OA |
| US imaging of the natural history of OA |
| Quantitative change in AC with 3D US |
| Calcium pyrophosphate deposition disease and OA |

**Link**

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