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Osteoarthritis: research update and clinical applications

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Abstract

Musculoskeletal (MS) ultrasonography (US) offers an overall assessment of the joints in OA. MSUS of the peripheral joints can be carried out at the time of consultation with high patient acceptability. This allows an immediate correlation between imaging findings and clinical data that improves diagnosis and management of patients with OA. The principal indications for MSUS in OA include detection of articular cartilage damage, bone changes, joint inflammation and adjacent soft tissue lesions. The main added value of US over clinical examination and plain radiography is its higher sensitivity for detecting synovitis and bone surface abnormalities, respectively. In addition, MSUS can be routinely used to guide accurate and safe diagnostic or therapeutic injections in the OA joints. The objective of the article is to describe the current applications of MSUS in both clinical practice and research in OA.

Key words: ultrasound, musculoskeletal, osteoarthritis, joint, cartilage, synovitis, osteophytes, erosions, bursitis, meniscal lesions.

Introduction

OA is the most common joint disease and a relevant public health problem [1]. The knee and the hand and foot joints are the most frequently involved peripheral joints in OA [1]. OA is characterized by focal degeneration and progressive loss of articular cartilage and changes in bone, synovium and other soft tissues in the involved joints. Plain radiography is considered the gold standard for assessing OA bony abnormalities and indirectly evaluates articular cartilage damage. However, this technique is limited by its inability to directly visualize articular cartilage, synovial recesses, the peripheral aspect of the menisci and other soft tissues involved in the pathophysiology of OA. High-resolution musculoskeletal (MS) ultrasonography (US) offers an overall assessment and follow-up of the joints in OA. It provides valuable information that bridges the gap between the clinical and the radiological evaluation. MSUS of the peripheral joints can be carried out at the time of consultation as often as necessary. This allows an immediate correlation between imaging findings and clinical data that improves the diagnosis and management of patients with OA.

The articular cartilage, bone contour, synovial recesses, tendons, ligaments, bursae and peripheral aspect of the menisci can be evaluated by US.

At present, the main indications for using US in OA include detection of articular cartilage damage, bone changes, joint inflammation and adjacent soft tissue lesions [1]. The above indications can have clinical and/or therapeutic impact in OA management (Table 1). The main added value of US over clinical examination and plain radiography is its higher sensitivity to detect synovitis (i.e. effusion and synovial hypertrophy) and bone surface abnormalities, respectively. In addition, MSUS can be routinely used to guide accurate and safe diagnostic or therapeutic injections in the OA joints. MSUS provides confirmation of the clinical diagnosis and the indication for injection. Real-time MSUS enables us to correctly place the needle, accurately deliver medication and visualize the drug suspension during and after the procedure [2, 3]. The latter is clinically important in diagnostic IA aspirations or in medication injections that should be strictly IA (e.g. viscosupplementation). On the other hand, some technical limitations of MSUS can reduce its diagnostic capability in OA (Table 1).

This article aims to describe the principal current applications of MSUS in both clinical practice and research in OA.

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Table 1 Indications and limitations for using US in OA

Indications
• Confirmation of joint inflammation (i.e. synovitis)
• Assessment of synovial inflammatory activity
• Detection of subclinical joint inflammation (i.e. synovitis)
• Evaluation of articular cartilage damage
• Detection of early osteophytes or other bone abnormalities present in OA
• Detection or confirmation of the involvement of menisci, ligaments, bursae or other MS structures in the osteoarthritic joint
• Guidance of IA and peri-articular injections
Limitations
• Limited acoustic windows for cartilage and bony cortex assessment in some joints (e.g. hip, glenohumeral)
• Lack of visualization of bone marrow abnormalities
• Low sensitivity of current Doppler modalities in deep/large joints (e.g. hip, glenohumeral)
• Operator dependence

US of the joint in OA

US has many uses in the assessment of patients with OA and, for its ability in evaluating the osteoarthritic joint, has gained increasing and progressive approval among the scientific community.

During the past few years sonography has proved to be a valuable imaging tool for showing different changes related to inflammation and structural damage in early and late OA.

Inflammatory joint findings

US is an excellent imaging modality for evaluating soft tissue abnormalities [4]. Particularly in OA, its use is appropriate for the assessment of joint inflammatory changes such as effusion and synovial hypertrophy. In addition, due to their sensitivity in demonstrating pathological vascularization within the synovial tissue, Doppler modalities can show synovitis and differentiate between active and inactive inflammation [5, 6].

Synovitis has typically an episodic course in OA and usually contributes to the presence and aggravation of pain and other symptoms [4]. In osteoarthritic joints with synovitis, both components (i.e. joint effusion and synovial hypertrophy) usually appear and can be detected by B-mode US. OMERACT definitions for the components of synovitis in RA, which are represented by SF (abnormal hypoechoic or anechoic IA material that is displaceable and compressible but does not exhibit Doppler signal) and synovial hypertrophy (abnormal hypoechoic IA tissue that is non-displaceable and poorly compressible and which may exhibit Doppler signal), may be applied also in OA as well as in other rheumatic diseases [7]. US depicts even minimal abnormalities related to synovitis with high sensitivity [4]. Fluid can be either homogeneously anechoic or hypoechoic, depending on its composition; the presence of local debris and proteinaceous or calcified material contributes to the inhomogeneous aspect of it [4].

Development of high-resolution probes and high-tech equipment has recently rendered US an emerging and widely used modality to detect and visualize a wide set of abnormalities in fine detail in both early and late disease [4, 6]. In particular, the use of high-end machines and high-resolution transducers in addition to the applications of high-sensitivity Doppler modalities and correct machine settings are fundamental aspects for optimizing tissue visualization, studying joint abnormalities and detecting even the smallest and infinitesimal changes [5].

In addition, in patients with OA, US can be used for the guidance of needles for joint fluid aspiration and local drug injections [4]. US can therefore be used as a useful bedside modality in the detection of inflammatory aspects in osteoarthritic patients and is an excellent tool for monitoring disease progression and assessing response to local and systemic treatments [5].

An in-depth knowledge of the scanning technique with application of standard scanning protocols at different joint sites is mandatory to correctly evaluate patients with OA. This includes multi-planar, dynamic and bilateral assessments of the examined joint and extensive study of the various structures involved [8].

Structural damage findings

The most representative abnormality in OA is represented by progressive joint degeneration with loss of cartilage and hypertrophy of the subchondral bone and joint margin [4]. US is able to demonstrate the signs of structural damage involving the hyaline cartilage and the bony cortex at joint margins.

Hyaline cartilage

A fundamental requisite for imaging articular cartilage by US is represented by the correct use of appropriate acoustic windows at different joint sites. Indeed, with the joint either in maximal flexion (hand and knee), in extension (elbow, wrist, ankle and foot) or in intra-rotation/extra-rotation (hip and shoulder), hyaline cartilage is

visualized in most articular sites and in normal subjects typically appears as a homogeneously anechoic band with curvilinear shape [4]. In some joints lacking acoustic windows, only a limited portion of cartilage can be imaged that cannot be considered representative of the complete layer [4]. With a correct, perpendicular insonation of the structure by the US beam, in healthy joints the cartilage typically has a well-defined anechoic echotexture with sharp, regular and continuous margins. The anterior interface, localized between cartilage and soft tissues, is thinner than the posterior edge, visualized between cartilage and bony cortex. According to the size of the joint, the thickness of the cartilage varies between 0.1 and 0.5 mm (hand and foot) and 3 mm (knee) and is accurately measured with current high-tech equipment that allows even submillimetre measurements. Assessment of the contralateral site to perform complete comparisons is always recommended [4].

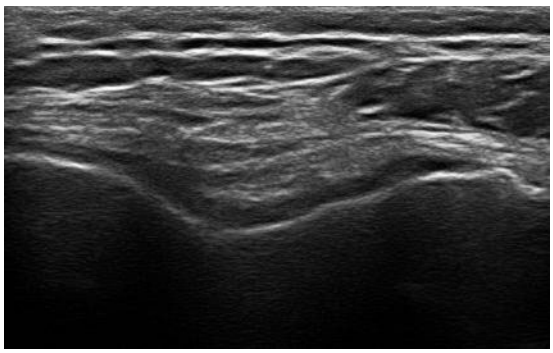
US is able to demonstrate a wide set of cartilage abnormalities in OA (Fig. 1). In early disease, loss of sharpness and irregularities of surfaces are imaged and initially involve the superficial edge [4, 5]. These abnormalities, which correspond to tissue degeneration and cleft formation, are followed by echotexture changes with inhomogeneous hypoechogenicity, and, later on, by focal and asymmetric thinning up to the complete absence of the cartilaginous layer that is related to cartilage breakdown and bony denudation [9].

Bony cortex

Bony cortex is imaged by US as a hyperechoic, regular and continuous surface. It has a linear shape that becomes curvilinear at the joint margins. Osteophytes are characteristic findings in OA and are imaged by US as a step-up of the bony prominence at the end of the normal bone contour, or at the margins of the joint seen in two perpendicular planes, with or without acoustic shadow [4].

The high sensitivity of US in showing bony cortex changes has been widely reported and, in erosive hand OA, erosions are imaged as IA discontinuities of the bone surface visible in two perpendicular planes [10]. Even in this case, OMERACT definitions for erosions in RA can be applied also in OA. They can be detected with varying degrees of clarity related to the interposition of osteophytes, which may determine narrowing of the acoustic window [10].

Fig. 1 US assessment of the femoral condylar cartilage in a patient with knee OA (suprapatellar transverse scan).



Loss of sharpness and irregularities of surfaces, inhomogeneous hypoechoic echotexture and asymmetric thinning are shown.

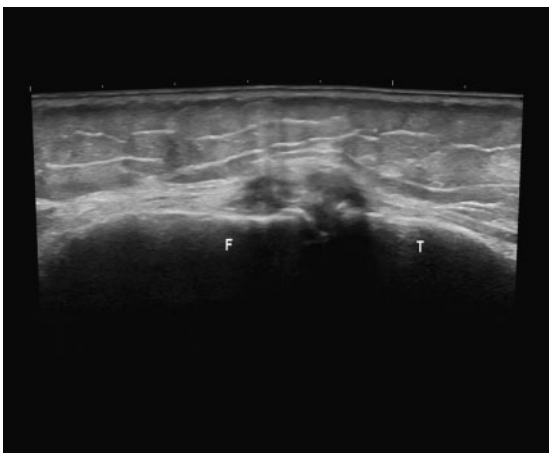
US assessment of other MS structures involved in OA

It is widely accepted that OA is a disorder of the whole joint and clinical symptoms are multifactorial. The involvement of joint structures such as ligaments and menisci or periarticular bursae may play a clinical role and thus may be possible treatment targets in OA. The above structures and their principal abnormalities can be evaluated by MSUS.

Meniscal degeneration, degenerative meniscal tears and parameniscal cysts are common findings in knee OA that can contribute to the clinical manifestations. Protrusion of the medial meniscus of the knee with displacement or distension of the medial collateral ligament and the medial joint capsule are frequently detected by MSUS in patients with medial femorotibial OA (Fig. 2). These findings have been associated with global pain, pain in the medial compartment and anserine insertion tenderness in knee OA [11, 12]. Likewise, in acromioclavicular OA, the IA meniscus is usually seen bulging from the joint space and displacing the joint capsule away from its normal anatomic location.

The presence of iliopsoas, trochanteric, infrapatellar and anserine bursitis can be detected with MSUS in hip and knee OA patients. However, the prevalence and the relation between these bursitides and OA severity has not

Fig. 2 US longitudinal image of the medial femorotibial space of an osteoarthitic knee.



The medial meniscus appears inhomogeneous and protruded and the medial collateral ligament displaced from the joint space. Osteophytes are seen at both sides of the joint space. F: femur; T: tibia.

been established; in particular, anserine bursitis has been infrequently found in patients with knee OA and medial knee pain [13]. Nevertheless, US-guided aspiration and steroid injection are clearly indicated in symptomatic periarticular bursitis.

Baker's cyst is commonly found in knee OA. It results from pathological fluid distension of the gastrocnemious-semimembranous bursa that communicates with the knee joint in adults. Baker's cyst can be symptomatic by itself, independently of the degree of accompanying knee synovitis, and has been associated with knee pain in OA [12, 14]. Baker's cysts are easily identified and their aspiration and injection can be safely guided with MSUS [15].

In conclusion, US allows us to accurately assess the periarticular and IA structures involved in the osteoarthritic joint in clinical practice. Technological development (e.g. USd fusion imaging, new Doppler software) will probably enhance the role of US in the assessment of cartilage, bony cortex and inflammation in both clinical practice and research.

Rheumatology key messages

- MSUS offers an overall joint assessment in OA.
- US provides valuable information on cartilage damage, bone changes, joint inflammation and adjacent soft tissue lesions.

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