Imaging the hip joint in osteoarthritis: A place for ultrasound?

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Abstract

Osteoarthritis has traditionally been imaged with conventional radiographs; this has been regarded as the reference technique in osteoarthritis for a long time. However, in recent years, innovative imaging techniques such as ultrasonography have been used to obtain a better understanding of this disease. This is mainly due to tremendous technical advances and progressive developments of ultrasound equipment occurring over the past decade. Ultrasonography has been demonstrated to be a valuable imaging technique in the diagnosis and management of osteoarthritis of the hip joint. Application of this imaging methodology for osteoarthritis has improved the understanding of the disease process and may aid in the assessment of the efficacy of future therapies. The execution of ultrasound-guided procedures with safety and reliability has a relevant significance in patient management of osteoarthritis of the hip joint. This paper reviews the use of ultrasound as an imaging technique for the evaluation and treatment of osteoarthritis hip joint.

Keywords

Musculoskeletal ultrasound, hip joint, osteoarthritis, osteophytes, synovitis, ultrasound-guided interventional procedures

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Introduction

Osteoarthritis (OA) has traditionally been imaged with plain radiographs; this has been considered as the reference technique in OA for a long time.¹ However, more recently, innovative imaging techniques such as ultrasonography have been widely applied to obtain a better understanding of this disease.² This is mainly due to technological developments of ultrasound (US) equipment occurring over the past decade. US has the ability to highlight different anatomic structures in fine detail and detect minute particulars of tissue change.³

OA is a very common rheumatic disorder affecting synovial joints. The main pathological findings are represented by progressive degeneration with loss of cartilage and hypertrophy of the subchondral bone, joint margin and capsule. The most frequent findings are synovial proliferation, joint effusion and bursitis.^{3,4} OA usually appears and worsens with the advance of old age. However, it may sometimes occur earlier in life. In those cases, disability and work impairment usually

appear prematurely, due to joint use-related pain, swelling, stiffness, deformity and reduced joint motion.⁴

Technique, equipment and appearance

The clinician's ability to evaluate the hip joint for OA pathology depends on having an expert knowledge of the scanning technique, the various anatomic areas to be examined, as well as the US equipment requirements. A standard scanning protocol, including multi-planar, dynamic and bilateral assessment is recommended good practice and should always be followed to perform a complete study of the various anatomic structures around the hip joint.⁵ The use of

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Figure 1. Longitudinal view of anterior hip joint.

A: acetabulum; arrow head indicates anterosuperior labrum; star indicates anterior joint recess; FH: femoral head; FN: femoral neck.

generous amounts of US gel is necessary for improving the visualisation of the structures included in the target area and to reduce the occurrence of artefacts.

Correct patient positioning is fundamental for the best visualisation of joint tissues, as shown in Figure 1. In particular, for the imaging of the hyaline cartilage, the hip joint should be kept in well-defined and standardised positions to enable the US beam to penetrate through the most suitable acoustic windows.^{1,6}

General rules on US assessment of the hip joint OA pathology include:

- Hip joint OA pathology scanning is conventionally limited to the anterior surface of the joint;⁶
- Choosing a lower frequency linear or curvilinear probe for optimal penetration that allows the visualisation of deeper tissue;⁷
- Patient lying in supine position with heels together and hip externally rotated. Place the transducer in an oblique longitudinal plane over the femoral neck to examine the anterior synovial recess using the femoral head as a landmark;⁷
- Cranial to the anterior recess, the fibrocartilaginous anterosuperior labrum of the acetabulum can be detected as a homogeneously hyperechoic triangular structure;⁷
- Joint capsule should be followed from the acetabulum to the point of its fixation to the neck;⁷
- Over the joint space and the femoral head, the iliopsoas muscle is identified lateral to the femoral neurovascular bundle;⁷
- The iliopsoas tendon is found in a deep eccentric position within the posterior and medial part of the muscle belly and lies over the iliopectineal eminence;⁷
- The iliopsoas bursa lies between the tendon and the anterior capsule of the hip joint: in normal state, it is collapsed and cannot be detected with US.⁷

Using the correct probe ensures greater visualisation of the structures involved in the area under assessment. In obese patients, lower frequency probes may help the examination.⁸ After B-mode evaluation by using the most appropriate probe frequency and correct machine setting, colour/power Doppler modalities are then applied to assess synovial vascularity. This may be increased in cases of active inflammation within the joint and other synovial periarticular structures.^{1,8,9} In hip joint OA, as well as in inflammatory arthritis, Doppler techniques are capable of demonstrating local hyperaemia due to active synovial inflammation.^{10,11} However, it is challenging to exclude hyperaemia of synovial tissue arising from the hip joint due to the depth of effected structures.

A fundamental aspect when using Doppler modalities is the application of the optimal setting (image size and depth, gain, focus positioning) which markedly improves the ability of US to detect increased flow of synovium in inflammatory pathological conditions.¹² In particular:

- the use of the correct Doppler frequency (high frequencies for superficial tissues and low frequencies for deep structures);
- the application of the lowest possible pulse repetition frequency without excessive artefact should be used and may be stored as a specific preset;
- the positioning of the focus by the area of interest and the correct regulation of the colour box size represent all the fundamental aspect to be considered.^{11,12}

Main indications for using US in OA hip

In hip joint OA, sonography has shown its capability to detect and evaluate a wide spectrum of abnormalities

Figure 2. US images of different pathologies indicated in Table 1. (a) Osteophyte of neck of femur; (b) Paralabral cyst of acetabular labrum; (c) Iliopsoas bursitis; (d) Synovial thickening.

involving the anterosuperior part of articular cartilage, bony cortex and synovial tissue. Examples of different pathologies are shown in Figure 2. Signs of inflammation, such as joint effusion, are not revealed by physical examination, due to the depth of the hip joint. However, with sonography even small intra-articular effusion of the hip joint can be detected by measuring the distance between the neck of the femur and the joint capsule. In addition, osteophytes appear as cortical protrusions at the joint margin.^{13,14} General indications for using US in the hip joint OA are reported in Table 1.

US evaluation of hip OA and appearance

US assessment of the OA hip focuses on the presence of effusion or synovitis by assessing the collum-capsule distance (CCD), condition of the bone and the presence of osteophytes.^{14,15} Despite the fast growing availability and interest in musculoskeletal US, there remain concerns about the subjectivity of the US evaluation and the lack of standards for the procedures and diagnostic

Table 1. General indications for using US in hip joint OA

Detection of joint effusion
Detection of synovial thickening and hypertrophy
Assessment of cartilage lesions
Evaluation of osteophytes and bony cortex involvement
Assessment of periarticular soft-tissue abnormalities in OA (bursitis)
Therapeutic and diagnostic US-guided procedures
Follow-up of the response to local and systemic therapies

terminology.¹⁶ However, in 2006, a study conducted by Qvistgaard et al.¹⁵ addressed these concerns and successfully showed that US could be a reproducible method for the assessment of changes in the osseous

Figure 3. Examples of osteophyte score. (a) Score 0, no visible osteophyte; (b) Score 1, irregularity on the cartilage–bone transition is just visible (arrow); (c) Score 2, well-defined osteophytes, shelf formation or irregularities on the femoral neck. There is one large osteophyte ({} with shelf formation (arrows), which is an ultrasound discontinuity between the distal border of the osteophyte and the femoral neck; (d) Score 3, involvement of the whole femoral neck including shelf formation. There is one large osteophyte ({} with shelf formation (horizontal arrows). The femoral head is seen between the two vertical arrows. (From Qvistgaard et al.,¹⁵ reproduced with permission).

surface and synovium-related inflammation. Examples of different parameters defined in Quistgaard et al.¹⁵ study are shown in Figures 3 to 5.

The CCD is the longest ultrasonic intra-articular distance between the lower edge of the capsule and the upper edge of the femoral cortex as shown in Figure 5.^{14,15} In normal adults, the average CCD measurement is 0.30–0.40 mm.¹³ An ultrasonic distance of 7 mm or more, or a difference between both hips of 1 mm or more are considered as intra-capsular ‘effusion’ in the hip joint.^{13,17}

Advantages and disadvantages of different imaging modalities used in OA hip

Plain radiography is the imaging modality most frequently used for assessing joint involvement. However, plain radiographs do have some limitations. They do not adequately visualise the hyaline cartilage and other soft tissues, which are frequently involved in OA hip joint disease progression.^{18,19} In addition, plain

radiographs have low sensitivity in demonstrating minimal cartilage involvement in early disease. Common radiological findings are joint space narrowing, osteophytes, sclerosis and deformity.⁴ However, these features sometimes appear only in moderate to advanced disease and may also be present in older, asymptomatic people thus generating doubts about their real role and importance as radiographic characteristics of the disease.

Among other imaging modalities, magnetic resonance imaging (MRI) has been demonstrated to be a sensitive and non-invasive technique for evaluating musculoskeletal disease and has been used as the reference tool in the assessment of criterion validity of US in OA hip joint, demonstrating excellent soft-tissue contrast.^{18,20,21} Several studies have demonstrated its accuracy and reliability; however, the high costs and low availability of MRI equipment limit its routine use.^{1,18} Arthroscopy is a gold standard tool for evaluating most OA changes, particularly for direct visualisation of cartilage surface alterations, but its invasiveness limits its use in daily clinical practice.¹⁸

Figure 4. Examples of femoral head score. (a) Score 0, round femoral head; (b) Score 1, slightly flattened femoral head; (c) Score 2, very flattened femoral head (}); (d) Score 3, no obvious contour – the femoral head (}) cannot be identified. [From Qvistgaard et al.,¹⁵ reproduced with permission].

Figure 5. Examples of joint effusion score. (a) Score 0, no fluid; The synovial space is uniformly hypoechoic, without areas suggesting the presence of fluid; (b) Score 1, fluid is perhaps present (arrow); (c) Score 2, fluid is present (}). [From Qvistgaard et al.,¹⁵ reproduced with permission].

The main limitation of US in OA hip evaluation is its partial accessibility to the inner joint structures. This is due to the inability of the US beam to penetrate bony cortex, resulting in frequent difficulties in the complete visualisation of the hyaline cartilage. In addition, US is

viewed as an operator-dependent imaging technique. This is due to the intrinsic real-time nature of US image acquisition and interpretation.^{8,22} However, the recent technological development of new high-quality equipment has partially solved this particular problem,

Table 2. Advantages and disadvantages of different imaging modalities used in OA hip joint

	Advantages	Disadvantages
X-ray	Low cost, reference technique Wide equipment availability Base line assessment	Radiation, limitations in imaging soft tissue structures.
MRI	Sensitive, non-invasive technique, no radiation burden, excellent soft tissue contrast High accuracy and reliability	High costs and low availability Not dynamic
Arthroscopy	Gold standard, direct visualisation of soft tissues, cartilage surface	Invasive, not readily available expensive
Ultrasound	Safety, non-invasiveness No radiation burden, low running cost, absence of contra-indications, accuracy Repeatability over the time Wide equipment availability Bedside procedure Optimal patient acceptance Monitoring of disease progression US-guided procedures	Limited number and width of acoustic windows Operator dependency Long learning curve Lack of standardised definitions and scoring systems for all findings.

MRI: magnetic resonance imaging; OA: osteoarthritis.

facilitating the visualisation of joint structures and the detection of their possible involvement.⁸

Another issue with US is operator dependency, especially amongst novice users. There is a tendency to over diagnose pathology (reporting normal structures as abnormal) which could potentially result in unnecessary medical or surgical interventions and subsequent legal and clinical implications.²³ To minimise this, the Society of Radiographers advocates appropriate and robust training for all US operators to provide accurate diagnosis in conjunction with clinical findings.²⁴ The main advantages and disadvantages of different imaging modalities used in OA hip joint are reported in Table 2.³

Role of US in OA hip joint management

Intra-articular hip injections have been successfully used to diagnose and treat a wide range of hip pathologies including OA.^{25,26} Hip joint injections are technically challenging because of the joint's deep location and the proximity of the adjacent femoral neurovascular bundle.^{25,26} Needles placed using only surface landmarks accurately enter the hip joint only 52% to 80% of the time and may pass within 4.5 mm of the neurovascular structures, posing undue risk of damage or irritation.^{26,27} During the last few decades, fluoroscopy has been the most commonly used image guidance modality for these injections, but this still does not

visualise the vessels or nerves.^{28,29} CT-guided injections are expensive and time-consuming. These techniques expose the patient and staff to radiation, iodinated contrast with associated reactions, and use cumbersome equipment.³⁰

US is becoming an increasingly available imaging modality within many outpatient clinics with several studies confirming the accuracy of US-guided intra-articular hip injections. US enables safe, accurate and inexpensive joint injection with real-time visualisation of soft-tissue structures.^{28–31}

Technique and appearance

Performing an US-guided intra-articular hip injection requires an intermediate level of skill at minimum. Several different approaches have been described to access the hip joint using US guidance.^{28–30}

The patient is placed supine. The leg is held in slight external rotation and abduction thereby reducing tension on the capsular structures and moving the iliopsoas tendon and bursa medially out of the intended needle path. Preferably, a 5–3.5 MHz curved array transducer is used, which provides the necessary penetration depth. Usually a 21-gauge needle with a length of 9 cm is used for the average adult. In smaller adults or children a 23-gauge, 5 cm hypodermic needle might be used. The needle is advanced at a caudo-cranial angle along the long axis of the transducer aiming for

Figure 6. Ultrasound guided intra-articular hip injection: The needle is advanced at a caudo-cranial angle along the long axis of the transducer aiming for the anterior recess near the junction of the femoral neck with the femoral head.

the anterior recess near the junction of the femoral neck with the femoral head as shown in Figure 6(a) and (b).

Conclusion

Ultrasonography has been demonstrated to be a valuable imaging technique in the diagnosis and management of OA of hip joint.²⁰ It shows different changes resulting from inflammation and structural damage. These changes mainly consist of the appearance of joint effusion and synovial hypertrophy in the presence of inflammation and osteophytes. Application of this imaging methodology in the assessment and treatment of OA has improved the understanding of the disease process as well as the relationship between structure and symptoms and may support in the assessment of future therapies. US-guided hip joint injections with their excellent safety and reliability profile have a significant value in patient management.

Future improvements in US research on OA with the execution of studies investigating new aspects of the disease and using innovative US tools such as 3D-US, fusion imaging and elastography will hopefully strengthen the diagnostic quality of sonography, analysing early and late disease with more accuracy. In conclusion, this review demonstrates there is sufficient evidence to support the use of US for diagnostic and therapeutic purposes, due to the fact it is a safe, non-invasive, inexpensive modality that supports findings of physical examination and clinical reasoning. However, subjectivity of the US evaluation and the lack of standards for the procedures and diagnostic terminology warrant future work.

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