Ultrasound imaging for the rheumatologist VI. Ultrasonography of the elbow, sacroiliac, parasternal, and temporomandibular joints

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Received on December 6, 2006; accepted in revised form on December 11, 2006.

Clin Exp Rheumatol 2006; 24: 617-621.

Key words: Elbow, sacroiliac, parasternal and temporomandibular joints, ultrasound, sonography.

ABSTRACT
Ultrasound (US) examination of the elbow and parasternal joints is very useful to detect synovitis, degenerative changes, intrarticular calcification or soft tissue abnormalities. More recently new fields of research involving the sacroiliac and temporomandibular (TM) joints have evolved. Moreover, important information has been obtained about vascularization of the synovial joint in the sacroiliac region and structural modification such as internal derangement in the TM joint.. In this paper, we review and discuss the role of US in the evaluation of elbow, sacroiliac, parasternal and TM joint pathology.

Introduction

Ultrasound (US) is a useful tool for the rheumatologist during consultations with patients presenting elbow symptoms.
In addition the technical improvement over the last few years has led to a growing role for US in the study of sacroiliac (SI), parasternal and temporomandibular (TM) joints which present particular difficulties when imaged sonographically.
In this paper we review and discuss the role of US in the evaluation of elbow, SI, parasternal and TM joint pathology.

Elbow

Indications
US may be successfully used to show joint effusion (1), analyze the features of synovitis in inflammatory diseases (2), assess tendon, bursae (3), ligaments (4) nerves (5, 6) and entheseal (7) involvement in patients with pain and/or swelling of elbow (Table I).

Equipment
The use of high quality equipment is mandatory and high-resolution linear probes (7.5-10 MHz) are recommended (7). Analysing the signs of local hyperemia, colour Doppler (CD) and power Doppler (PD) complete the grey-scale US study.

Scanning technique
The patient is positioned in a chair with the elbow placed on the examination table (8). The joint is kept in full extension with the forearm held in supination whilst performing the anterior scans. The elbow is then flexed to 45° for the lateral scans and 90° for the posterior and medial scans. Dynamic assessment is suggested for a more complete study of elbow pathology.

US imaging of the normal elbow
Joints
Both the humero-radial and humero-ulnar joints are visualized by anterior and posterior scans which show the hyperechoic bony profile of the humerus, radius and ulna (8-10). The capsule bounds the joint cavity and appears as a thin echoic band. A small amount of anechoic synovial fluid is demonstrated within the joint space in healthy subjects. In anterior scans, articular cartilage is visualized as a thin anechoic line with sharp edges bounding the bony surface. Reference ranges are now available in healthy subjects for the bone-capsule distance on multiple scanning planes (11).

Peri-articular tissues
The triceps tendon is visualized by posterior scans. Medial scans show the common flexor tendon and the medial collateral ligament whilst the common

extensor tendon and lateral collateral ligament are visible on lateral scans. The distal biceps tendon and the annular ligament can be clearly depicted on anterior scans (8-10).

In healthy subjects, bursae are visualised with difficulty as two thin hyperechoic parallel lines within the context of the peri-articular tissue, but they are more easily identified when they contain trace amounts of fluid.

The ulnar nerve can be identified clearly by US at the level of the cubital tunnel.

US pathologic findings (Table I)

Joints

Effusion and synovitis are detected by grey scale US which reveals anechoic collections and/or synovial proliferation within the joint cavity. It has been reported that a US distance > 2 mm between the capsule and the bone is a probable sign of joint effusion or synovitis when detected on anterior scans (1). In the presence of active synovitis CD and PD demonstrate increased perfusion in the inflamed synovial tissue.

Intra-articular loose bodies can be identified within the elbow joint cavity by a multiplannar scanning technique.

Irregularities of the bony profile including osteophytes, cortical erosions or fractures may also be identified.

Tendons

Tendonitis (12) of the proximal radial extensors (lateral epicondilitis) and proximal ulnar flexors (medial epicondilitis) are the most frequent soft tissue pathologies of the elbow and are characterized by a thickened and hypoechoic tendon origin, sometimes associated with calcification and cortical bone abnormalities. Both PD and CD are useful for the demonstration of local hyperemia in cases of tendonitis or enthesopathy. Tendinosis (12) and partial or full thickness tendon tears can be identified.

Bursae

In olecranon and cubital bursitis, fluid distension and/or local synovial proliferation are shown (3, 8). In patients with crystal related arthropathies crystalline masses may be demonstrated within the fluid. PD imaging is useful in providing information about active inflammation.

Table I. Pathological findings – elbow joint.

Joints
- Joint effusion: appearance of a hypo-anechoic collection within the joint space and joint capsule distension
- Synovitis: intra-articular synovial proliferation with possible contemporaneous evidence of joint effusion, with or without local increased perfusion (CD or PD)
- Osteophytes: irregularities of the bony profile at the joint margins
- Erosions: cortical defect with an irregular floor (both in longitudinal & transverse scans)
- Intra-articular loose bodies: demonstration of foreign material with variable echogenicity

Tendons
- Partial-thickness tear: discontinuity of fibres with focal hypo-anechoic area and/or focal thinning
- Full-thickness tear: complete hypo-anechoic defect within the tendon, extending entirely through it or absence of the tendon
- Tendinitis: focal or diffuse hypoechogenicity and thickening with or without Doppler signal
- Enthesopathy/enthesitis: entheseal thickening and/or hypoechogenicity and/or Doppler signal and/or calcification

Calcification
- Hyperechoic areas or lines with possible acoustic shadowing

Bursae
- Distension of the wall and presence of fluid collection within
- Synovial proliferation within the bursa with or without local hyperemia (Doppler)

Synovial cysts
- Hypo-anechoic bodies with definite wall often extending on the anterior aspect of the forearm

Nerves
- In neuropathy: swelling; increased diameters/length

Nodules
- Tophi: echoic, heterogeneous oval or round masses with possible internal calcification rheumatoid nodules: echoic, homogeneous masses; sometimes confluent

Nerves

In cubital tunnel syndrome US can visualise swelling (6, 13, 14) and lengthening (5) of the ulnar nerve. Similar findings may be shown in the interosseous nerve in supinator syndrome. US can differentiate between the various causes of ulnar neuropathy at the elbow (*i.e.* retrocondylar compression, tumours, nerve dislocation and hypermobile nerves).

Other findings

The ulnar collateral ligament is frequently the target of pathology and US can demonstrate interruption of the fibres, hypoechoic foci, thickening and calcification.

Subcutaneous nodules (tophi or rheumatoid nodules) may be present in the olecranon region. US can discern their structure, dimensions and relationship to adjacent tissues.

US can assess also fluid content, dimensions and degree of extension of synovial cysts, especially frequent in patients with rheumatoid arthritis or amyloidosis.

Limits

The paucity of acoustic windows (the inner part of the joint is not accessible to the acoustic beam) is the most overriding obstacle to elbow US. This problem is more often evident in patients with disease limiting elbow joint motion and resulting in marked distortion of the local anatomy.

US-guided procedures

US is now an invaluable imaging modality which is enabling the rheumatologist to approach elbow pathology in new and innovative ways, particularly in the execution of fluid aspiration, local therapeutic injections and biopsies. However, to date no standardized method of US guided injection of the elbow have been reported in the literature.

Table II

Pathological findings – sacroiliac joint
- Synovitis: local increased perfusion (using CD or PD)

Pathological findings – parasternal joint
- Joint effusion: appearance of a hypo-anechoic collection within the joint space and joint capsule distension
- Synovitis: intra-articular synovial proliferation with possible associated joint effusion, with or without local increased perfusion (CD or PD)
- Osteophytes: irregularities of the articular bony profile
- Erosions: cortical defect with an irregular floor (both in longitudinal & transverse scans)

Pathological findings – temporomandibular joint
- Joint effusion: appearance of a hypo-anechoic collection within the joint space and joint capsule distension
- Osteophytes: irregularities of the bony profile at the joint margins
- Erosions: cortical defect with an irregular floor (both in longitudinal & transverse scans)
- TMJ derangement: appearance of abnormal disc position
- Masseter muscle edema: appearance of an increased muscle thickness

TMJ: temporomandibular joint.

Sacroiliac joints

Indications

Sacroiliitis is a frequent manifestation of spondyloarthropathy. To date, very few papers on US evaluation of SI joints have been published (15-17). However, the use of contrast enhanced CD US seems to be a very sensitive technique in the detection of active sacroiilitis (15).

Equipment

As for other joints, the use of high quality equipment is mandatory and high-resolution linear probes (7.5-10 MHz) are recommended. CD or PD systems are necessary to obtain information about local vascularization. The CD US is performed using a Doppler frequency of 2.5-5 MHz (16) and microbubble contrast agents for CD US may be used.

Scanning technique

US evaluation is performed with the patient in the prone position, starting with a grey-scale US examination to identify the bony spinous processes in the midline and the posterior part of the SI joints (16). Examination of the contralateral side is recommended.

US imaging of the normal sacroiliac joint

With the probe in transverse position, the posterior contour of the sacrum is visualized as an echogenic line, while the sacral spinous process is shown as a concave curve at the midline, with sacral wings, represented by a regular echogenic line laterally. The SI joint is visualized as a hypoechoic cleft between two echogenic lines (sacrum and iliac bone) (16, 17).

US pathologic findings (Table II)

Joints

Increased perfusion is detected by CD US (16) and contrast enhanced CD US is significantly better than an unenhanced technique to diagnose active sacroiliitis (15). Arslan *et al.* used unenhanced CD US to demonstrate perfusion around or inside the SI joint in 48% of patients with sacroiliitis, but also in some patients with osteoarthritis and in controls (16).

Limits

SI joints are examined in a very incomplete manner because their anatomical configuration does not allow good US beam penetration.

US-guided procedures

Local therapeutic injections may be executed under US guidance. Pekkafali *et al.* (17) described a US guided technique which allowed them to have a 76.7% of success in positioning the needle in the sacroiliac joint (increased to 93.5% in the last injections).

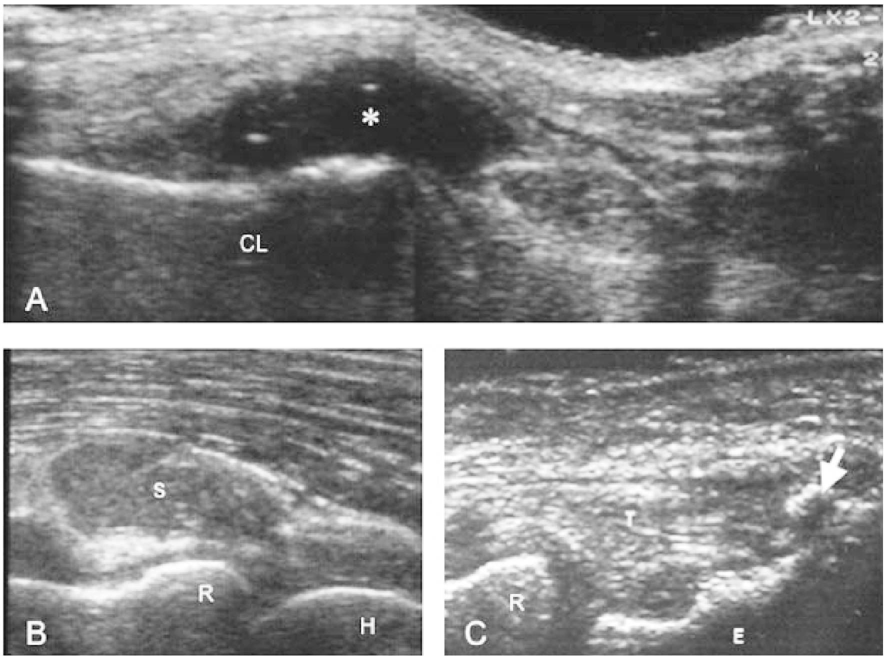

Fig. 1. Representative examples of sterno-clavicular and elbow joint US pathological findings.
A. Early arthritis. Extended view of the sterno-clavicular joint on anterior longitudinal scan. Marked joint cavity widening due to an increased amount of synovial fluid (*).
B. Rheumatoid arthritis. Proliferative synovitis of the elbow joint on lateral longitudinal view.
C. Calcific epicondilitis. Hypoechoic thickening of the entheseal region with an intratendineous calcification appearing as an hyperechoic line with posterior acoustic shadow (arrow).
*: effusion; CL: clavicle; S: synovial proliferation; R: radius; H: humerus; T: common extensor tendon; E: lateral epicondyle.
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Parasternal joints

Indications

US examination of the parasternal joints allows the rheumatologist sonographer to identify the disorders (inflammatory or degenerative) affecting the articular and peri-articular soft tissues of the joint.

Equipment

The parasternal joints are superficial so high quality equipment and high-resolution linear probes (7.5-13 MHz) are recommended. The US study, initially performed in the grey-scale, may be completed with CD US or PD US for the analysis of local hyperemia.

Scanning technique

The patient is in a sitting or supine position, the probe placed over the parasternal joint, performing longitudinal and transversal scans over the clavicle or the costal axis. Controlateral comparative examination is recommended.

US imaging of normal parasternal joints

The sternoclavicular joint is identified lateral to the manubrium sternum and both the sternum and the clavicle are visualized as hyperechoic lines with posterior acoustic shadowing. The medial part of the clavicle is positioned more anterior and superior with respect to the sternum and has a rounded configuration. A hypoechoic space between the two bony structures represents the joint space (18).

The appearance of the sternocostal joint is quite similar to the sternoclavicular joint but the costal cartilage is normally viewed as a homogeneously hypoechoic oval-shaped area without posterior acoustic shadows in longitudinal scans, while in transverse scans it appears as a ribbon-shaped homogeneous hypoechogenicity (19).

US pathologic findings (Table II)

Joint

Effusion is detected as an anechoic or hypoechoic intracapsular collection (12) and synovitis as echogenic tissue proliferating within the joint cavity. PD US may demonstrate an increased perfusion in the inflamed synovial tissue.

Degenerative changes, due to osteoarthritis, may be detected by showing joint space narrowing, osteophyte formation and articular bony surface irregularity. Cortical erosions, fractures, sternoclavicular dislocation or neoplasms may also be identified.

In Tietze's syndrome, a disease characterized by pain and tenderness of the parasternal joints, the inflamed costal cartilage is increased in size compared to the controlateral one and it appears more echogenic with dot-like hyperreflective echos and intense broad posterior acoustic shadowing (19).

Limits

Because of their anatomical configuration, only a restricted area of the parasternal joints can be imaged by US, thus resulting in incomplete joint evaluation.

Sonography guided procedures

No data are published about US guided procedures in parasternal joints.

Temporomandibular joint

Indications

Sonographic examination has been widely used in the study of 'internal derangement' of the TM joint. This term refers to an abnormal position of the articular disc relative to the mandibular condyle and the articular eminence (20-25). In addition osteoarthritic changes (23, 26-28) and those found in rheumatoid arthritis (RA) (29, 30) have been investigated using US.

The results of the study published by Melchiorre *et al.* and Manfredini *et al.* in RA and psoriatic arthritis patients emphasize that TM joint US evaluation may play a role in the clinical assessment of rheumatic patients, most of all in the assessment of joint effusion.

Equipment

US TM joint examination requires high quality equipment and high-resolution linear probes (7.5-15 MHz) (20-23, 25, 30).

Scanning technique

Different positions are described in the US assessment of TM joint, with the patient sitting in an upright position with the head in the natural position (23, 29, 30) or supine on the examination table (25, 27, 28).

The transducer is placed against the patient's face, overlying the zygomatic arch and the TM joint, parallel to the long axis of the mandibular ramus and then tilted until the optimal visualization is obtained (23, 24, 26-28). The scans are obtained both in the open-mouth and in close-mouth positions.

Transverse and longitudinal scans are recommended and dynamic assessment is suggested in the study of the disc displacement.

US imaging of normal temporomandibular joint

Joint

The mandibular condyle and articular eminence are identified as hyperechogenic lines, the articular capsule is shown as a hyperechoic line running parallel over the mandibular condyle. The articular disc, better visible in the closed-mouth position (20), appears as a thin iso-hyperechoic line with a subtle hyphoechoic halo, just above the condylar line. Because of the echogenicity of the articular disc, being similar to that of the articular capsule, it is very difficult to distinguish between the disc and the capsule. The course of the disc is shown by slightly moving the patient's mandible.

Muscles

US has been used for the measurement of masseter muscle thickness, defined as the maximal distance between the outer fascia of the muscle and the lateral surface of the mandibular ramus, both during rest and maximum contraction (31).

US pathologic findings (Table II)

Joint

Effusion is detected as an anechoic collection within the articular capsule. It has been reported that a US distance >2 mm between the capsule and the bone is a probable sign of joint effusion (32).

Irregularities of the bony profile including osteophytes or cortical erosions may also be identified.

Recent studies show a high concor-

dance between US and magnetic resonance imaging for TM joint effusion (29) and degenerative changes (22).
Disc position may be abnormal with displacement at closed-mouth and/or at open-mouth position, with or without reduction of the internal derangement.

Muscles
An increment in muscle thickness has been described in patients with temporomandibular disorder, probably due to muscle edema (31).

Limits
The size of the acoustic window is perhaps the greatest obstacle to TM joint US. The medial part of the joint is not accessible to the acoustic beam and therefore medial disc displacements cannot be visualised.
The disc is always difficult to see, and during static scanning, the US beam must be kept in exactly the same orientation to the discal surface to prevent discal anisotropy (24, 28). Finally, the upper TM joint compartment may be filled with fluid or fibrous tissue (maximally in long-time disc displacement), resulting sometimes in difficulties differentiating between disc displacement and fibrous structures.

US-guided procedures
Intrarticular injections of TM joint are usually performed but no data are reported about US-guided procedures into such joints.

Link
For further ultrasound images, go to: www.clinexprheumatol.org/ultrasound

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