11 How to scan in the context of inflammatory joint disease

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Introduction

High resolution Ultrasound (US) is an important tool in the diagnosis and follow-up of various rheumatologic diseases. Advances in technology such as high-end machines, probes with high frequencies and increased sensitivity of flow imaging techniques have contributed to the importance of US in the field of inflammatory joint disease.

In this article we will mainly discuss the most frequently affected joints in the context of arthritis which are the small joints of the hands and feet. For scanning these joints, linear or hockey-stick transducers with frequencies of 12-18 Mhz are used.

The scope of this article is to highlight the tips of the scanning technique, the indications, pitfalls and limitations of US in the context of arthritis.

How to scan

The 3 following scanning technique rules can ensure optimal imaging:

- Hold the transducer with three fingers, make small movements with the probe and use generous qualities of coupling jelly **(Fig.1)**.

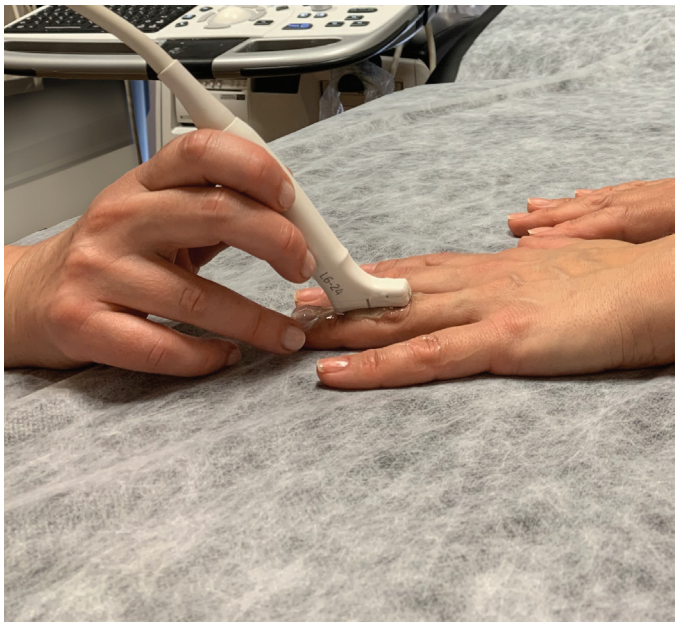

Figure 1: *Scanning technique (Rule I). Hold the transducer with three fingers, use generous qualities of coupling jelly.*

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- Don't use a lot of pressure. It is important to apply minimal probe pressure so that the effusion or synovitis are not squeezed away **(Fig.2a-2b)**.
- Use flow imaging techniques such as Color Doppler, Power Doppler and new sensitive techniques that detect blood flow in small vessels. Flow imaging techniques are very important as they can depict neovascularity in the thickened synovium which is a sign of disease activity **(Fig.2c, 2d, 2e)**.

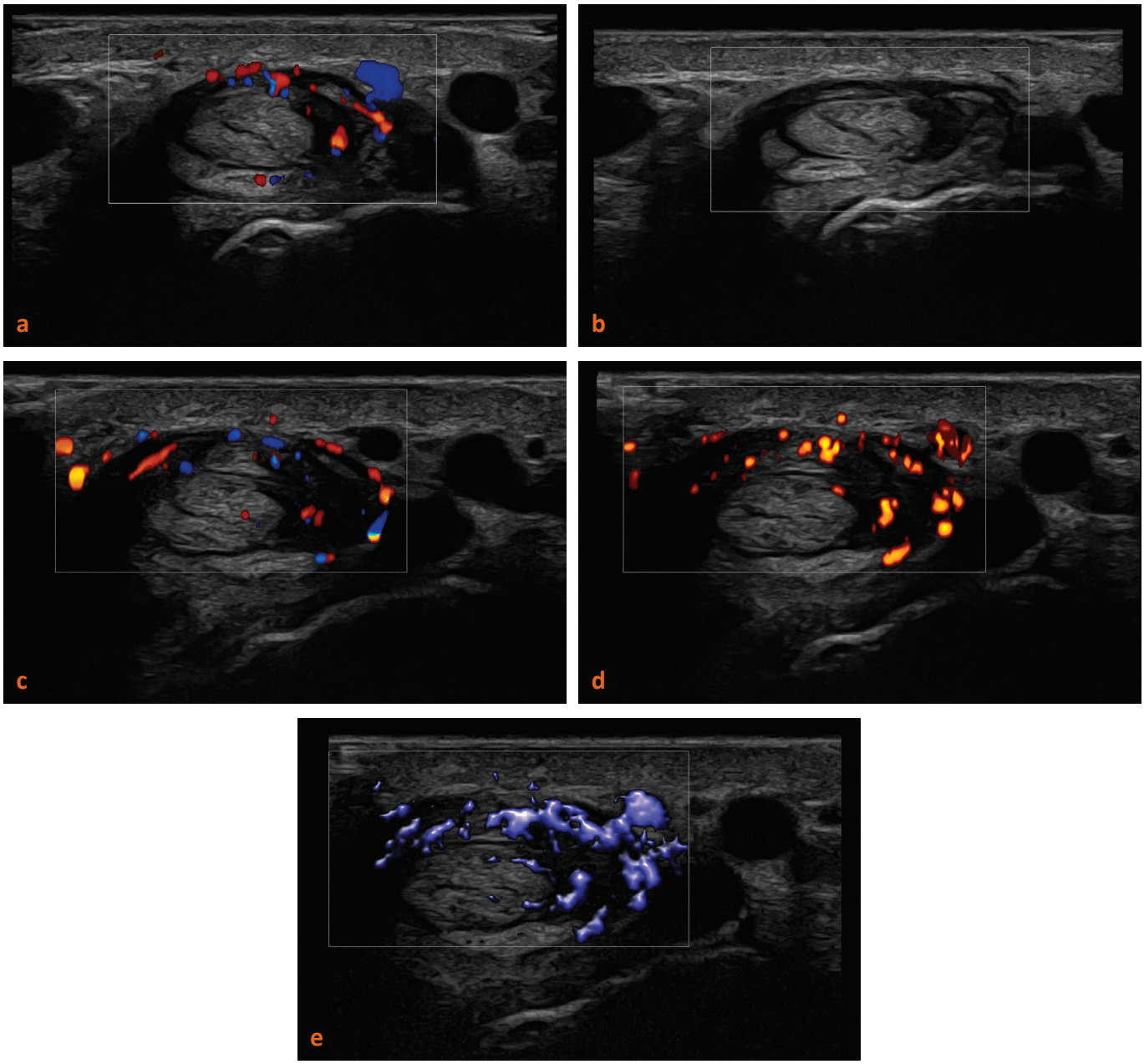

Figure 2: **a-b**: ***Scanning technique (Rule II). Don't apply pressure.*** **(a)***Transverse scan of extensor tendons with active tenosynovitis in a patient with Rheumatoid Arthritis (RA). Without applying pressure, the thickened synovium and vascularity are evident.* **(b)** *Pressure is applied. The synovium and increased vascularity are not visualized due to the pressure applied by the probe on the examined tissues ;* **c-e**: ***Scanning technique (Rule III). Use flow imaging techniques.*** **(c)** *Color Doppler Imaging depicts increased vascularity in the synovium of extensor tendons.* **(d)** *Power Doppler Imaging is more sensitive in depicting vascularity in the inflamed synovium.* **(e)** *Microvascular imaging is even more sensitive in the depiction of small vessels.*

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What to scan

Usually joints with signs of disease are scanned first. In order to correctly classify the disease as mono- or poly- articular a systematic scanning is required. Various recommendations about scanning protocols have been published in the literature. For diagnostic purposes it is useful to be aware of the disease pattern. For example, in cases of suspected Rheumatoid Arthritis (RA), the radiocarpal, midcarpal, metacarpophalangeal (MCP) and proximal interphalangeal (PIP) joints are scanned; while in cases of suspected Osteoarthritis (OA), proximal interphalangeal (PIP) and distal interphalangeal (DIP) as well as the joints of the bases of the thumbs are scanned **(Fig.3a,3b)**.

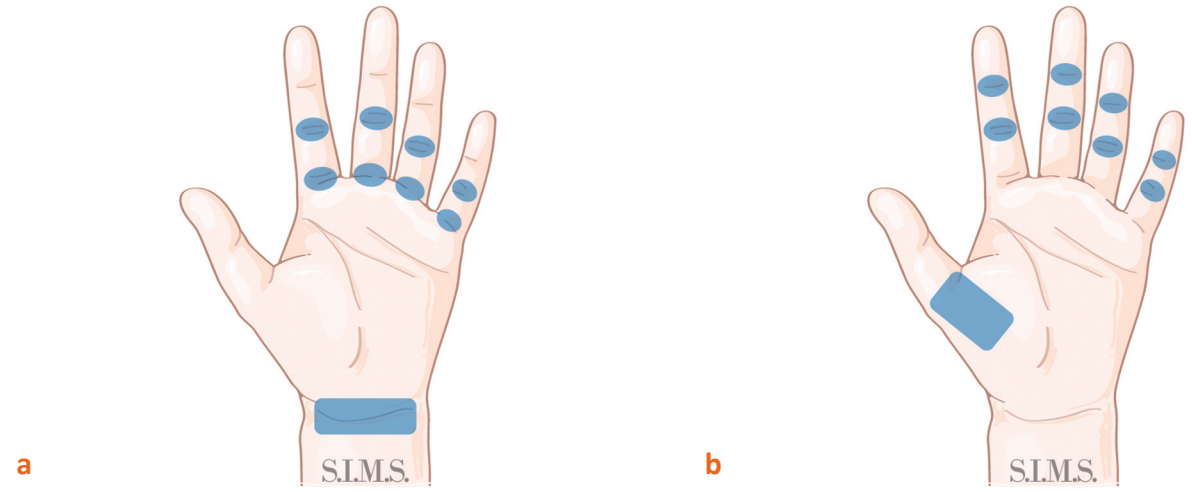

Figure 3: *Patterns of disease.* **(a)** *Joints most frequently affected in patients with Rheumatoid Arthritis (RA).* (b) *Joints most frequently affected in patients with Osteoarthritis (OA).*

US scanning for diagnosis and follow-up

The main indication of US scanning in the context of arthritis is to reach an early diagnosis. Early diagnosis is important for patients with RA and Spondyloarthritis (SpA) and US can detect synovitis and enthesitis that may not be detected by clinical examination. Monitoring the efficacy of new therapies and deciding whether a patient is in remission or relapse is another important indication for US examination. A grading system has been established in order to determine the degree of disease activity in synovitis and is explained in Table 1 **(Fig. 4a-4d)**.

Table: *Scoring system for classification of synovitis in grayscale and color/power Doppler.*

Grade	Grayscale synovitis	Color/Power Doppler signal
0	Absence or mild synovial thickening	Absence of flow signal
I	Mild synovial thickening[a]	Single vessel signals
II	Moderate synovial thickening[a]	Confluent vessel signals, extent < 50% of synovium[b]
III	Severe synovial thickening[a]	Confluent vessel signals, extent > 50% of synovium[b]

[a]Mild synovial thickening: filling the angle between the periarticular bones, without bulging over the line linking tops; moderate synovial thickening: bulging over the line linking tops of the periarticular bones but without extension along the bone diaphysis; severe synovial thickening: bulging over the line linking tops of the periarticular bones and with extension to at least one of the bone diaphysis.

[b]Confluent vessel signals < 50%/> 50% of the area of the synovium.

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US scanning for needle guidance

- Injection with US guidance is important for the successful aspiration of small effusions and accurate synovial biopsy for diagnostic purposes. US guidance increases the rate of successful aspiration and biopsy compared to conventional aspiration.
- Injection with US guidance is important for treatment in joints that do not respond to systematic therapy as well as for performing tendon therapies. 50% of conventional joint injections are inaccurately placed.

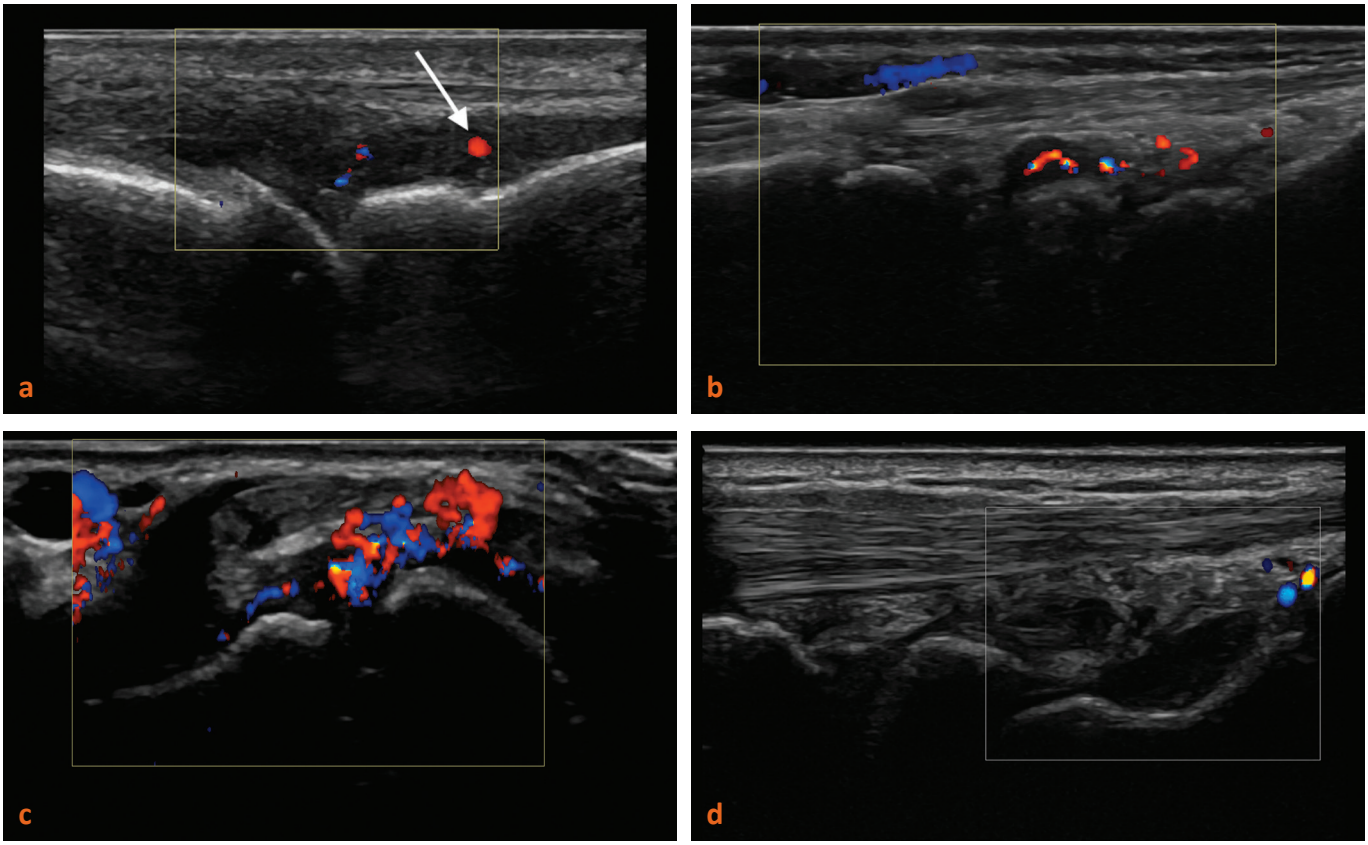

Figure 4: *Synovitis classification in grayscale and color/power Doppler.* **(a)** *MCP joint in a patient with RA. Mild synovial thickening with single vessel signals (Grade I).* **(b)** *Radiocarpal joint in a patient with RA. Moderate synovial thickening. Confluent vessel signals, extent < 50% of synovium (Grade II).* **(c)** *PIP joint in a patient with RA. Severe synovial thickening. Confluent vessel signals, extent >50% of synovium (Grade III).* **(d)** *Radiocarpal joint in a patient with RA after therapy (in remission). Mild synovial thickening without flow signal (Grade 0) [normal vessels seen on the right side of the Doppler box].*

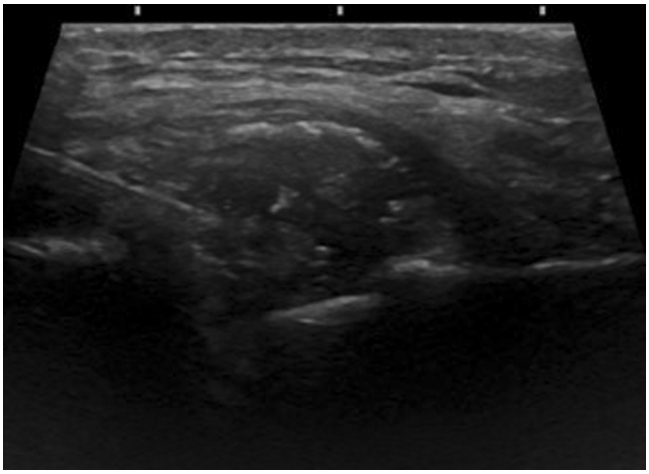

Figure 5: *US-guided injection in a patient with synovitis of a tarsal joint. The needle is visualized being placed correctly in the thickened synovium.*

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What are we looking for in RA

US findings in RA:

- *Effusion:* US is superior to clinical examination in the detection of effusion, even in large and relatively easily palpable joints. Detection of a fluid collection in joints, bursae, tendon sheaths and soft tissues is a useful sign of inflammation
- *Synovitis:* US can detect synovitis not detected by clinical examination. Detection of subclinical synovitis may lead to a re-evaluation of the clinical classification of arthritis as oligoarticular or polyarticular. Color Doppler can depict synovial hyperemia which is correlated to histological neo-angiogenesis (Figure 6a)
- *Erosions:* US can detect erosions earlier than X-Rays. US can detect seven times more erosions than X-Rays in early RA
- Tenosynovitis: Can be present in RA and SpA. US is gold standard for the examination of tendons **(Fig. 6b)**.

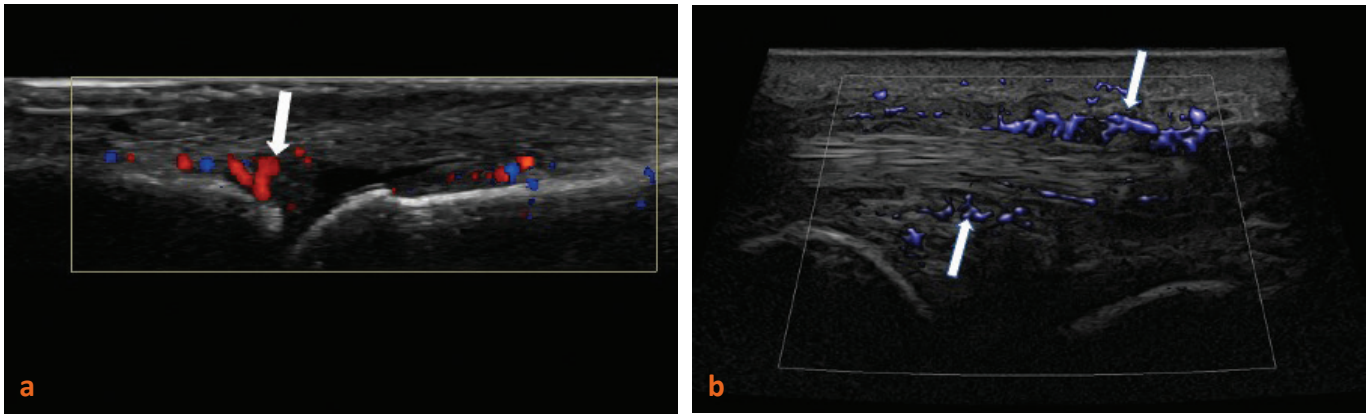

Figure 6: *US findings in RA.* **(a)** *MCP joint in a patient with RA. Joint effusion and active synovitis: positive Doppler signal (white arrow) without soft tissue swelling.* **(b)** *Longitudinal scan of the Extensor Carpi Ulnaris (ECU) tendon in a patient with RA. Signs of active tenosynovitis with thickened synovium and vascularity in the flow imaging technique (white arrows).*

What are we looking for in peripheral spondyloarthropathy (SpA)

The hallmark of peripheral SpA is enthesitis which is inflammation at the bone insertion of tendons, ligaments and joint capsule. The enthesis organ concept is used to explain pathologic imaging findings such as synovitis, bursitis and extracapsular changes adjacent to ligaments and tendon entheses **(Fig.7)**.

The main US findings in peripheral SpA are:

- *enthesitis;*
- *digital tenosynovitis;*
- *dactylitis* (with involvement of the tendon pulleys and joints capsules);
- synovitis.

Osteitis and bone marrow edema can only be detected with MRI.

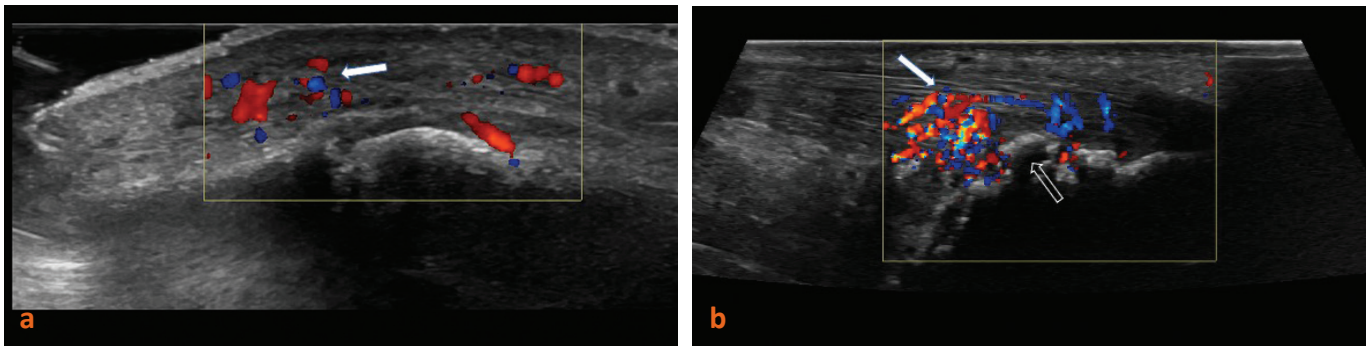

Figure 7: *US findings in peripheral SpA.* **(a)** *Longitudinal scan of the index finger: soft tissue swelling, positive Doppler signal – dactylitis (white arrow) in a patient with Psoriatic Arthritis.* **(b)** *Longitudinal scan of the Achilles tendon enthesis: enthesitis with positive Doppler signal (white arrow) osteoproliferation and bone erosions (void arrow) in a patient with SpA.*

What are we looking for in Crystal Arthropathies

Gout is a crystal arthropathy where monosodium urate crystals are present within joints and tendons and most frequently in the first metatarsophalangeal (MPT) joint. Characteristic US findings of gout include:

- *double contour sign* in the articular hyaline cartilage **(Fig.8)**;
- *tophus:* a circumscribed aggregation in chronic gout;
- *aggregates* (hyperechoic foci) in joint fluid, erosions and tendon sheaths;
- *erosions* that can be intra- or extraarticular.

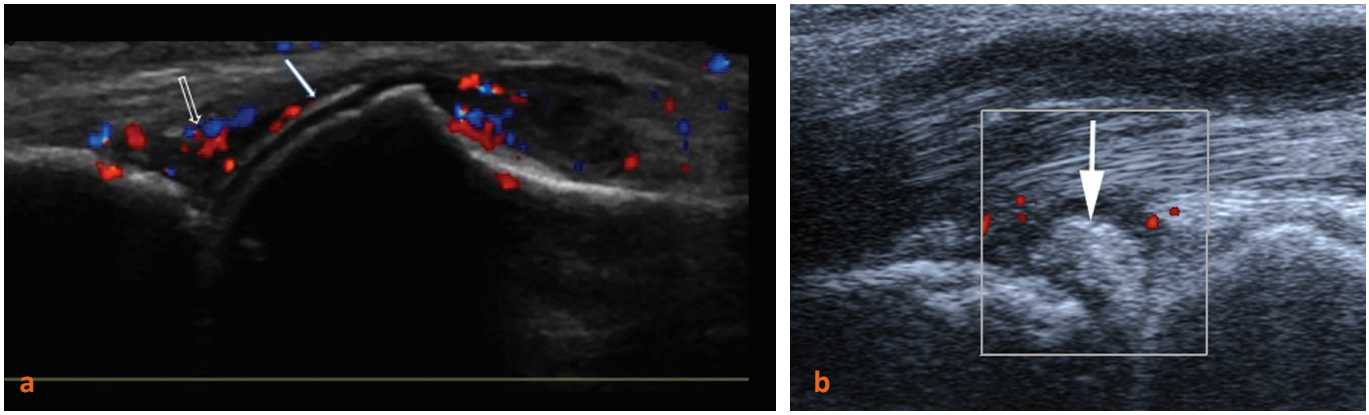

Figure 8: *US findings in crystal arthropathies.* **(a)** *Double contour sign (white arrow) in the MTP joint and active synovitis (void arrow) in a patient with gout.* **(b)** *Crystal depositions in the triangular fibrocartilage complex of the wrist (white arrow) in a patient with CPPD.*

Calcium pyrophosphate dihydrate deposition (CPPD) crystal deposits can be detected in many asymptomatic joints such as the elbow, hip, and metacarpophalangeal joints.

In CPPD findings are:

- *intraarticular crystal aggregates;*
- *joint effusion;*
- *synovitis;*
- *hyperechoic spots* within the hyaline cartilage of the knee;
- *crystal depositions* in the knee meniscus and the triangular fibrocartilage complex of the wrist.

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What are we looking for in Osteoarthritis (OA)

Cartilage damage, osteophytes and narrowing of the joint space can be detected to some extent with US especially in the small joints. Due to the limited accessibility of US in substantial portions of the cartilaginous surface of the joints the modality of choice at an early stage of the disease is MRI.

US in OA especially in small joints is important for differentiating it from RA, for depicting intra- and extra-articular soft tissue changes such as joint effusion, tendon and ligament abnormalities and bursitis.

The most clinically significant pathology detected by US is synovitis, associated with both symptoms and structural progression in OA **(Fig.9a,9b)**.

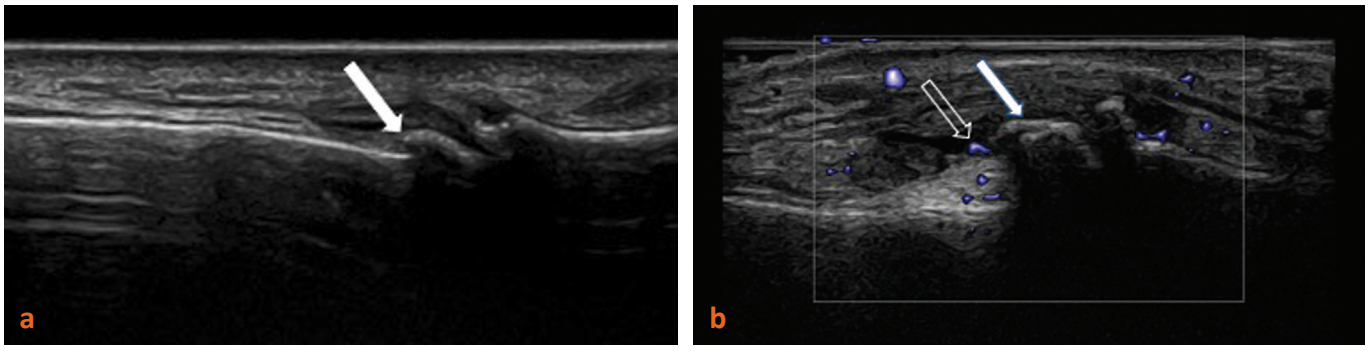

Figure 9: *US findings in OA.* **(a)** *PIP joint in a patient with OA. Osteophytes are present (white arrow).* **(b)** *PIP joint in a patient with OA and symptoms. Osteophytes (white arrow) and synovitis with increased vascularity (void arrow).*

Limitations

Due to the inability of the US beam to penetrate the bone cortex, bone marrow edema and osteitis cannot be assessed with US. Bone marrow edema is an important finding in the early stages of rheumatologic diseases and especially Spondyloarthropathies. Bone erosions in the spine, sacroiliac joints and some parts of the peripheral joints cannot be depicted with US. The accuracy of the US examination depends on the type of the US system used and the examiner's level of training. Other limitations of US are reproducibility and quantification of pathology such as synovitis.

References

1. Plagou A et *al.* Recommendations of the ESSR Arthritis Subcommittee on Ultrasonography in Inflammatory Joint Disease. *Semin Musculoskelet Radiol* 2016

2. Wakefield RJ et *al.* The role of ultrasonography and magnetic resonance imaging in early rheumatoid arthritis. *Clin Exp Rheumatol* 2003; 21 (Suppl. 31): S42-S49.

3. Ohrndorf S, Backhaus M. Advances in sonographic scoring of rheumatoid arthritis. *Ann Rheum Dis* 2013;72(2, Suppl 2): ii69–ii75

4. Szkudlarek M, Court-Payen M, Jacobsen S, Klarlund M, Thomsen HS, Østergaard M. Interobserver agreement in ultrasonography of the finger and toe joints in rheumatoid arthritis. *Arthritis Rheum* 2003;48(4):955–962

5. Szkudlarek M, Klarlund M, Narvestad E, et *al.* Ultrasonography of the metacarpophalangeal and proximal interphalangeal joints in rheumatoid arthritis: a comparison with magnetic resonance imaging, conventional radiography and clinical examination. *Arthritis Res Ther* 2006;8(2):R52

6. Sibbitt WL Jr, Band PA, Chavez-Chiang NR, Delea SL, Norton HE, Bankhurst AD. A randomized controlled trial of the cost-effective- ness of ultrasound-guided intraarticular injection of inflammatory arthritis. *J Rheumatol* 2011;38(2):252–263

7. Keen HI, Wakefield RJ, Grainger AJ, Hensor EMA, Emery P, Conaghan PG. Can ultrasonography improve on radiographic assess- ment in osteoarthritis of the hands? A comparison between radiographic and ultrasonographic detected pathology. *Ann Rheum Dis* 2008;67(8):1116–1120

8. Chowalloor PV, Keen HI. A systematic review of ultrasonography in gout and asymptomatic hyperuricaemia. *Ann Rheum Dis* 2013; 72(5):638–645

9. Gutierrez M, Schmidt WA, Thiele RG, et *al*. OMERACT Ultra- sound Gout Task Force group. International consensus for ultrasound lesions in gout: results of Delphi process and web- reliability exercise. *Rheumatology* (Oxford) 2015;54(10): 1797–1805

10. Feydy A, Lavie-Brion MC, Gossec L, et *al.* Comparative study of MRI and power Doppler ultrasonography of the heel in patients with spondyloarthritis with and without heel pain and in controls. *Ann Rheum Dis* 2012;71(4):498–503