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### Abbreviations

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<tr>
<td>ACPA</td>
<td>Anticitrullinated protein antibody</td>
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<td>ACR</td>
<td>American College of Rheumatology</td>
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<td>CPPD</td>
<td>Calcium pyrophosphate dihydrate deposition disease</td>
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<tr>
<td>CRP</td>
<td>C-reactive protein</td>
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<tr>
<td>CT</td>
<td>Computed tomography</td>
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<tr>
<td>DAS28</td>
<td>Disease Activity Score based on 28 joints</td>
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<td>DECT</td>
<td>Dual energy computed tomography</td>
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<td>EULAR</td>
<td>European League Against Rheumatism</td>
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<td>MHz</td>
<td>Megahertz</td>
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<td>MRI</td>
<td>Magnetic resonance imaging</td>
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<td>OA</td>
<td>Osteoarthritis</td>
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<tr>
<td>OMERACT</td>
<td>Outcome Measures in Rheumatology</td>
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<td>PMR</td>
<td>Polymyalgia rheumatica</td>
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<tr>
<td>PsA</td>
<td>Psoriatic arthritis</td>
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<td>RA</td>
<td>Rheumatoid arthritis</td>
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<td>RA-GLOSS</td>
<td>Rheumatoid Arthritis Global Synovitis Score</td>
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<td>RF</td>
<td>Rheumatoid Factor</td>
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<tr>
<td>T2T</td>
<td>Treat-to-target</td>
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<tr>
<td>US</td>
<td>Ultrasound</td>
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<td>USSONAR</td>
<td>Ultrasound Society of North American Rheumatologists</td>
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Introduction

Diagnostic imaging has become an important part of the management of musculoskeletal and other rheumatologic disorders. Over the past 3 decades, ultrasound (US, sonography) has been demonstrated to be a safe, cost-effective, and accurate method of imaging. The patient is not exposed to ionizing radiation and it is currently the only modality capable of imaging dynamically.

US was enthusiastically adopted in Europe but was slow to take hold in the United States. A prospective study published in 1999 showed the importance of an imaging approach for obtaining accurate findings. It compared musculoskeletal US, plain X-ray, magnetic resonance imaging (MRI), and 3-phase scintigraphy of the fingers in patients with arthritis to determine which imaging modality was best at detecting both bone erosions and synovitis in patients with normal and abnormal X-rays. The study found that US, MRI, and 3-phase bone scans were more sensitive than plain films for detecting synovitis. However, scintigraphy had a low specificity and, therefore, was thought to be inadequate as a screening test for patients with early inflammatory arthritis. The study also reported that US using a 7.5-megahertz (MHz) transducer was more sensitive than MRI in detecting synovitis but not at detecting bone erosions. However, in an earlier report in 1993 using a higher frequency 13-MHz transducer, Grassi et al. described visualization of both cartilage and bone erosions in patients with rheumatoid arthritis (RA). The difference in results between the two studies demonstrates the importance of using the correct equipment, especially the highest-frequency transducer possible.

In 2001, Backhaus et al. published the first European League Against Rheumatism (EULAR) guidelines for US in rheumatology. The paper reviewed some of the technical advances in US at that time which included improved visualization of soft tissues, fluid collections, cartilage and bone surfaces. The authors describe the pathologic conditions that can be seen with US in the shoulder, elbow, hand, wrist, hip, knee, ankle, heel, and foot as well as the proper positioning of the patient and the views that should be used for different joints. Recently, EULAR has published two excellent updates to the original guidelines. The first, is the EULAR ultrasound scanning app which can be accessed at https://www.eular.org/eular_ultrasound_scanning_app.cfm and the second is the EULAR imaging library which can be accessed at https://www.eular.org/eular_imaging_library_intro.cfm. The former document includes images of probe position during actual scans based on anatomic site, normal US anatomy and cine clips of the scan itself, and the latter document contains multiple images of abnormal scans with explanations.

OMERACT (Outcome Measures in Rheumatology) established a special interest group for US in 2004. In 2005, the group published its first report which included definitions of terms commonly used in US. Since that time the group has been known as the OMERACT Ultrasound Task Force and has published updates on its activities annually. In 2015, the group reported on using US as an outcome measure in rheumatic diseases. According to this paper, OMERACT continues to work on the development of a reliable, validated US scoring system for synovitis called Rheumatoid Arthritis Global Synovitis Score (RA-GLOSS) (global synovitis score) as well as a US scoring system for RA and the frequency at which US studies should be performed. The group is also interested in studies that can validate the use of US in determining bone
erosions in RA as well as a better US definition of bone erosion. This work is important in developing US standards for the diagnosis and monitoring of patients with rheumatic disorders.

More widespread adoption of US into rheumatologic practice in the United States has been limited by several factors. Perhaps the most significant of these has been the lack of fellowship training in the United States and a relatively steep learning curve. Additional factors have included a limited standardized lexicon of terms, inadequate guidelines for the appropriate use of US, inadequate protocols for performing US examinations in an active office environment, absence of validated scoring systems, inadequate knowledge of the standards for reporting results and lack of validated recommendations for repeat studies.

In addition to the problems listed above, rheumatologists in the United States have reported difficulty obtaining adequate training and experience in US. This problem has been addressed by EULAR, the American College of Rheumatology (ACR) and USSONAR (the Ultrasound Society of North American Rheumatologists). Since 1998, EULAR has offered beginner, intermediate, and advanced level US training courses in Europe. In 2008, they also published requirements for musculoskeletal training courses describing requirements for the content and conduct of these courses. For example, regardless of the level of training, EULAR indicated that there should be no more than six students per faculty member and that no less than 50% to 60% of the course time should be spent on actual scanning. Each course should include at least 20 hours of training over 3 days. The ACR introduced its first US course in 1999 and has continued to offer US training courses for rheumatologists.

The USSONAR is a relatively new organization founded in 2006, and since 2008 has offered an 8-month course for training rheumatologists in the United States which prepares participants for the ACR credentialing examination. In addition, the USSONAR has developed a training curriculum for rheumatology fellows.

Over the past decade there have been significant advancements in US technology, particularly with high-frequency linear array transducers needed to produce detailed images. The introduction of extended-field-of-view imaging provides more complete visualization of an anatomic area on a single image. The current equipment is also more user friendly and less costly than in the past. As a result, US has become more widely accepted as an alternative to MRI in many clinical contexts. Ultrasound does not use ionizing radiation and therefore is safer than computed tomography (CT) or radiography. The soft tissue resolution of US is superior to that of radiography; even bone erosions in patients with normal radiographs can be detected. With the introduction of 3D- or volume-imaging, US can now provide multi-planar imaging, enabling the user to determine the optimal image plane for visualizing an abnormality.

The use of power Doppler (see additional definitions under Glossary) imaging identifies areas of increased vascularity that are consistent with inflammatory changes such as synovitis, before they can be identified on physical examination. Wakefield et al. found that US detected more bone erosions in patients with RA than can be seen on X-ray. Power Doppler evaluation of erosions seen on grey scale sonography can determine if there is active synovitis in an erosion by demonstrating increased vascularity in the hypertrophied synovium (pannus) within the erosion.
US can perform real-time dynamic imaging to evaluate fluid collections in soft tissues and joints as well as muscles. Joint movement can also be visualized on dynamic US imaging. Ultrasound can distinguish between synovial fluid/joint effusion, which is compressible, and synovial hypertrophy, which is not, although both may appear hypoechoic on grey scale sonography.

Unlike MRI, US evaluation of joints and soft tissues can be performed without sedation or anesthesia, which is often required when imaging children or very anxious adults with MRI.

Diagnostic musculoskeletal US is cost effective. In 2008, a paper in the Journal of the American College of Radiology estimated that substituting US for MRI, when appropriate, in the Medicare population alone could result in savings of more than $6.9 billion between 2006 and 2020. However, the indiscriminate or inappropriate use of US to clinical scenarios in which it has not previously been validated may add to the total cost of care.

The clinical use of US for the evaluation of musculoskeletal disorders is still in relatively early stages of development. Indications for its use continue to grow as the equipment improves, the images become easier to interpret, and US training becomes more widely available and incorporated into more rheumatology fellowship programs. At this time, the literature consists mostly of small studies, often using only one manufacturer’s US equipment. Larger, multicenter studies are needed to standardize both image acquisition and interpretation and to clarify the precise clinical scenarios wherein US adds value to care.

United Rheumatology encourages the use of US in the practice of rheumatology. Ultrasound can assist rheumatologists in establishing a diagnosis when the clinical diagnosis is unclear. It can also be used to monitor patient response to treatment and is an extremely effective tool when used to guide biopsies, injections, and/or aspirations; improving accuracy and decreasing the need for repeat procedures.

These guidelines are designed to assist the practicing rheumatologist in determining the appropriate use of US (see United Rheumatology Standards for Equipment and Quality). United Rheumatology will continually monitor the literature and update these guidelines when appropriate.

**Diagnostic Musculoskeletal Ultrasound**

When a new imaging modality is introduced to any medical practice there must be good evidence that it improves patient care. Over the last 2 years, there have been many reports indicating the superiority of US as compared to plain films for the diagnosis of synovitis, bone erosions and pathology of tendons, ligaments, cartilage and even peripheral nerves. However, additional research is needed to determine when and how often to use US when managing patients with rheumatic diseases, including monitoring and scoring of disease activity.

In 2012, the ACR issued their Report on Reasonable Use of Musculoskeletal Ultrasonography in Rheumatology Clinical Practice. The College did not use the term appropriateness as defined by the RAND/UCLA “ Appropriateness Methodology” (Page 1626), because the Task Force Panel was of the opinion that the published literature was incomplete. Instead, decisions were based on review of the literature and expert consensus. According to the ACR “reasonable” indications for diagnostic US
represent clinical circumstances when the “evidence and/or consensus of the Task Force Panel ... supported the use of ultrasound for the described scenario” (Page 1626).  

The ACR Task Force Panel found that US is reasonable in the following clinical scenarios, when the diagnosis is uncertain:

- Joint pain and swelling or mechanical complaints
- Arthralgia(s)
- Known inflammatory arthritis together with new or continuing symptoms (to evaluate for disease activity, bone or cartilage erosions)
- Hip pain or mechanical symptoms (to evaluate for fluid, intra- or periarticular lesions, or surrounding soft-tissue abnormalities)
- Periarticular pain (to evaluate for tendon and soft-tissue disease)
- Probable inflammatory entheal, sacroiliac, or spine pain (to evaluate for enthesopathy)
- Shoulder pain or mechanical symptoms (to evaluate for structural disease, but not to evaluate for adhesive capsulitis or preoperative evaluation)
- Regional mechanical complaints (to evaluate for inflammation, tendon and soft-tissue abnormalities)
- Regional neuropathic pain (to diagnose carpal tunnel syndrome, ulnar- or posterior tibial-nerve entrapment)
- To monitor disease activity or structural progression in patients with inflammatory arthritis
- Anatomic limitations to physical examination of a joint due to obesity or local abnormalities of the surrounding soft tissues
- Image guidance for periarticular or articular injections or aspirations
- Image guidance for a synovial biopsy
- Evaluation of the parotid or submandibular glands in patients being evaluated for Sjögren’s syndrome.

The Task Force indicated that US should not be used for the evaluation of the temporomandibular joint and the costochondral joints, unless otherwise indicated.

**Definition of Important Ultrasound Findings**

The OMERACT definitions\(^6\) for the most important US findings in rheumatologic diseases are provided in the Glossary.

**Rheumatoid Arthritis**

In the context of RA, US is used primarily to detect and assess joint inflammation and damage manifested by synovial hypertrophy, synovial fluid/effusion, and synovitis.\(^{15}\) Synovial fluid usually appears as an
Anechoic, compressible collection within the joint capsule at US. However, at times it may be hypoechoic. Synovial hypertrophy is typically hypoechoic, although it may appear as either anechoic or hyperechoic material within and/or adjacent to the joint capsule. Synovial hypertrophy is non-compressible. Both synovial fluid and synovial hypertrophy are initially evaluated on grey-scale US. Power Doppler is then used to further evaluate an area of synovial hypertrophy. Increased Doppler signal (increased vascularity) in an area of synovial hypertrophy indicates that there is active synovitis rather than simple hypertrophy.

In 2013, EULAR published 10 recommendations for imaging of the joints in patients with RA. The recommendations addressing the use of US include the following:

- Imaging with conventional X-ray, US, or MRI provides information that can improve the certainty of the diagnosis of RA when the clinical information is unclear
- US (and MRI) can demonstrate inflammation that is helpful in predicting which patients will progress from early, undifferentiated inflammatory arthritis to RA
- Joint inflammation is better detected with US (or MRI) than with X-ray or clinical examination
- Initial imaging of patients with clinically definite or possible RA should be done with X-rays of the hands and feet. If these films are negative then US (or MRI) may be useful to detect joint damage before it can be seen on plain films resulting in earlier, more intense treatment with the goal of preventing joint destruction
- Imaging can be used to predict response to treatment. Inflammation seen on US (or MRI) may be a better predictor of response than clinical evidence of disease activity
- US (and MRI) may be used to monitor disease activity, because they detect inflammation earlier than clinical examination
- Interval radiographs of the hands and feet may be helpful in evaluating joint damage but since US and MRI are both more sensitive than X-ray at detecting joint damage, they can be used to monitor disease activity
- US (and MRI) can detect inflammation, even in a subset of patients determined to be in clinical remission.

*Ultrasound for the Diagnosis of Rheumatoid Arthritis*

There is no definitive test for the diagnosis of RA. The diagnosis is based on clinical evaluation. Early in the course of the disease, symptoms may be subtle and X-rays (which are the current standard for imaging of RA) may be normal. Current diagnostic criteria depend on the identification of at least one joint with clinical evidence of synovitis with no other clinical explanation (see the United Rheumatology Clinical Practice Guideline for Rheumatoid Arthritis—Adult). Recent publications have demonstrated that the clinical evaluation for synovitis can miss significant inflammation when compared to power Doppler US, potentially delaying diagnosis and treatment.

In its most recent set of criteria for the diagnosis of RA, the ACR defines an “involved joint” as “any joint with swelling or tenderness on examination that is indicative of active synovitis” (Page 2576). The criteria
further state that US can be used to confirm the clinical diagnosis. However, power Doppler can diagnose synovitis in clinically normal joints. Using the ACR definition, some joints with active synovitis can be missed if US is not performed.

A case-controlled study of 40 patients with RA and 20 controls evaluated the sensitivity, specificity, and accuracy of US versus other imaging modalities for the evaluation of bone erosions and inflammation in finger joints. The study demonstrated that US has greater sensitivity and accuracy than either clinical examination or radiographs for the detection of bone erosions and synovitis in the fingers. In this study, erosive disease was found in 13 patients on X-ray and in 20 patients with both MRI and US. Another study involving 40 patients with RA found that power Doppler detected synovitis better than clinical examination (swollen and/or tender joints). In this study, one proximal interphalangeal or metacarpophalangeal joint was evaluated in each patient. Patients were equally divided into four groups: tender joint only; swollen joint only; tender and swollen joint only; and clinically unremarkable joint. Power Doppler demonstrated that the tender-joint-only group showed less vascularity than patients in either the swollen-joint-only or the tender and swollen joint groups. Power Doppler also found synovitis in joints that were clinically unremarkable (neither tender nor swollen), again demonstrating that clinically normal joints may have active synovitis.

Ten Cate et al. published a systematic review of the role of US in the diagnosis of early RA and remission and concluded that power Doppler US of metacarpophalangeal joints, the wrist, and metatarsophalangeal joints was helpful in establishing the diagnosis of RA by demonstrating clinically silent synovitis. The review also found that power Doppler scanning of the metacarpophalangeal joints of the dominant hand had value when assessing patients for remission. Some patients in clinical remission actually show signs of inflammation on US.

Baseline X-rays of the hands and feet should be obtained at the time of initial evaluation for suspected RA. However, since US has been demonstrated to be more accurate than radiographs in identifying erosions, it may be considered in addition to plain films, especially when the diagnosis is uncertain or radiographs are normal.

Ultrasound Follow-up and Monitoring in Rheumatoid Arthritis

The earlier the diagnosis of RA is established and treatment initiated, the better the outcome. When treating RA, the target is complete remission. Current therapy can achieve that target in many patients. Others may achieve low disease activity which is also an acceptable target in those not able to reach a complete remission.

Synovitis detected on US but not diagnosed on clinical evaluation can progress to X-ray-detectible joint destruction, even in patients who meet the ACR definition of remission. A study with a cohort of 90 patients with RA in clinical remission reported that over time, 63% had radiographic joint changes, 68% had US evidence of bone erosions, 89% had US detectable synovial hypertrophy, and 63% had power Doppler evidence of increased blood flow (hyperemia) consistent with synovitis not found on clinical examination. This study also demonstrated that US was more sensitive than either clinical examination.
or radiography for the diagnosis and management of patients with RA, and may be helpful for the identification of patients who, despite clinical remission, are at risk for the development of bone destruction and flares.

Nguyen et al.\textsuperscript{30} published a systematic literature review that included 19 studies involving 1618 patients with RA, of whom 1369 were in remission. The analysis found that 44\% of patients in clinical remission had power Doppler evidence of synovitis. The presence of power Doppler signal (synovitis) in patients in clinical remission can predict which patients may relapse, develop flares, or experience progressive bone destruction. This problem was addressed in the EULAR recommendations for imaging in RA (see above).\textsuperscript{17}

Molenaar et al.\textsuperscript{31} followed 187 patients with RA who had been in clinical remission (according to both, ACR criteria\textsuperscript{32} and the Disease Activity Score based on 28 joints (DAS28) for 2 years with plain films. At the end of 2 years, only 52\% of these patients remained in remission. In 15\% of those who remained in remission, erosions developed in previously normal joints. The radiographic progression seen in patients in clinical remission may be related to the presence of synovitis, which is not seen on clinical evaluation but can be detected on power Doppler.

A recent study comparing clinical and imaging remission in patients with early RA, who were managed with a treat-to-target (T2T) approach, demonstrated that 43\% achieved a clinical remission as defined by DAS28 and C-reactive protein (CRP).\textsuperscript{33} However, within this group only 42\% had no power Doppler activity in the synovium when in clinical remission. This finding is consistent with the other studies cited above and suggests that a significant number of patients with RA who have achieved remission may not actually be in complete remission but rather in a subclinical remission. These patients may require a different treatment approach to achieve a complete remission.

Tenosynovitis is another manifestation of RA that can lead to discordance between clinical remission and symptoms.\textsuperscript{34} If fact, US evidence of tenosynovitis was recently found to predict a shorter duration of clinical remission among 427 patients with RA.\textsuperscript{34}

Another study described the histologic differences of the synovium in patients with RA who were in clinical remission but had no power Doppler evidence of synovitis compared to patients with RA who were in clinical remission with power Doppler evidence of synovitis.\textsuperscript{35} The latter group showed evidence of high macrophage infiltration of the synovium, which is usually seen in patients with active RA. However, unlike patients with active RA, these patients had reduced levels of lymphocyte and mast cell infiltration and demonstrated fibroblastic hyperplasia in the synovium. The authors postulated that the persistently increased level of macrophages in the synovium may be responsible for flares and continued bone destruction in this subset of patients.

Many papers have recognized the significantly increased risks for patients with RA in clinical remission but with US evidence of subclinical synovitis, particularly as identified by power Doppler signal.\textsuperscript{29, 30, 36, 37} Related risks include RA flares, development of radiographic erosions, and failure to maintain remission upon tapering of medications.
Two recent studies (TaSER and ARTIC) compared clinical remission by DAS28 versus imaging remission with US in a T2T strategy and reported that using US did not lead to significantly better outcomes than conventional disease-activity assessment (clinical remission). A trend towards improved clinical outcomes in the US-directed treatment group was identified in one of the studies. Both studies reported increased use of biologics and increased cost of treatment for the US groups when compared to the clinical disease-activity groups. Thus, neither the TaSER nor the ARTIC study supported the use of US remission as the end point for achieving the treatment target in the management of patients with early RA. Each study has been criticized for issues related to the methodology employed. The TaSER study, which demonstrated a trend toward better outcomes among those treated according to a US-T2T approach was likely under-powered. In the ARCTIC trial, at each study visit, every inflamed joint was treated with an US-guided steroid injection, an approach that diverges significantly from, and is not reflective of, RA treatment practices in the United States. The aggressive, longitudinal, intraarticular corticosteroid injection treatment was applied asymmetrically to the treatment arms of the trial as all joints with Doppler activity in the US T2T arm, in addition to those in each arm with overt, clinical evidence of synovitis, were injected. The impact of longitudinal US-guided steroid injection on the long-term course of RA, and the resulting impact on the ARCTIC trial results, remains unclear. Regardless, there are other studies cited above that document disease progression (development of bone erosions) in patients in clinical remission but with evidence of subclinical synovitis on US. Therefore, in RA patients who are in clinical remission, screening with US may be considered, because it provides additional data to assist in treatment decision making, including drug escalation or tapering.

**Limitations of Ultrasound in Rheumatoid Arthritis**

A validated US scoring system for RA and a standardized protocol for imaging is needed. There are several small reports of using a combination of power Doppler and grey-scale US to score RA disease activity, but none have been adequately validated in a large multicenter study using different US scanners. Currently, the OMERACT Ultrasound Task Force is working on validating a US scoring system for RA (RA-GLOSS), which will be based on a combination of grey-scale and power Doppler findings. Two systems may be developed, one for initial diagnosis and a second one for monitoring response to treatment. In addition to being accurate, the systems must be time efficient.

The most commonly utilized US scoring system is the approach described by Szkudlarek et al. This approach scores synovitis using power Doppler and grey-scale imaging for synovial fluid/hypertrophy according to separate scales. However, this system remains to be validated.

**Ultrasound in Rheumatoid Arthritis (Summary/Conclusions)**

US can be used to assist with establishing the diagnosis of RA. Although imaging protocols of the hands, wrists, and feet are still evolving, US can be a helpful tool to resolve uncertainty in patients with joint complaints but no evidence of synovitis on clinical examination. It may also be helpful in evaluating patients in clinical remission. United Rheumatology will continue to monitor the literature and update
these guidelines as appropriate. The United Rheumatology Clinical Practice Guideline for Rheumatoid Arthritis provides a more complete discussion of the diagnosis and management of adults with RA.

**Psoriatic Arthritis**

Psoriatic arthritis (PsA) affects up to 30% of patients with psoriasis. A wide spectrum of musculoskeletal changes can be seen in patients with PsA including arthritis of the distal interphalangeal joints of the hands and feet, sacroiliitis, seronegative symmetric polyarthritis (which is indistinguishable from RA), oligoarthritis, spondyloarthritis, enthesitis and dactylitis (see the United Rheumatology Clinical Practice Guideline for Psoriatic Arthritis).

**Ultrasound for the Diagnosis of Psoriatic Arthritis**

Ultrasound findings in the peripheral joints of patients with PsA are nonspecific and may be seen in other forms of inflammatory arthritis such as RA and gout. The current literature contains many reports of US findings in PsA, which help to distinguish it from RA. However, these are all small studies and the findings have yet to be demonstrated and validated on a large scale, at multiple institutions, using different US scanners. Nevertheless, US can be a useful adjunct to conventional radiography and clinical examination.

One study comparing US findings in patients with PsA and RA reported that PsA was associated with more bone erosions, bone destruction, and synovitis in the distal interphalangeal joints than RA. Hyperostosis was also shown to occur more frequently in PsA than RA, but tenosynovitis was detected more frequently in RA than PsA. Currently, conventional X-rays are used to assist in the diagnosis and monitoring of PsA. However, both US and MRI have been reported to be more sensitive than plain films or clinical evaluation for the detection of inflammatory joint changes (synovitis, tenosynovitis), enthesitis, new-bone formation, bone erosions, destructive bone lesions (osteolysis), and dactylitis.

The US findings in PsA include:

- Synovial fluid collections—usually anechoic compressible collections within the joint
- Synovial hypertrophy—commonly hypoechoic material in and/or around the joint, which is not compressible and rarely may be hypo- or hyper-echoic without power Doppler signal
- Synovitis—power Doppler signal in areas of synovial hypertrophy
- Tenosynovitis—hypoechoic or anechoic thickening of the tendon, which may be accompanied by anechoic fluid in the tendon sheath. The findings must be seen in two orthogonal planes. Power Doppler signal may or may not be present
- Tendinosis—disruption of the normal fibrillar echotexture of the tendon
- Enthesitis—hypoechogenic and/or thickened entheses with power Doppler signal
- Dactylitis—flexor tenosynovitis of a digit plus metacarpophalangeal and/or metatarso-phalangeal, proximal interphalangeal, and distal interphalangeal synovitis.
Delle Sedie et al.\textsuperscript{49} published a study of both knees in 83 patients with known PsA and reported that, on clinical examination, 62 of the 186 knees examined had evidence of active arthritis. Ultrasound with power Doppler found evidence of active synovitis in 70 knees, once again indicating that US detects subclinical active disease in clinically unremarkable joints. In addition, enthesitis was found in 39.7\% of the patients.

Fournié et al.\textsuperscript{50} studied the US findings in 25 fingers with PsA and 25 fingers with RA to determine whether power Doppler imaging of the finger (a common place for bone erosions and destruction in both RA and PsA) could demonstrate differences between these two types of inflammatory arthritis. The scans were performed with a high-frequency transducer and included imaging of the dorsal, volar, and lateral aspects of the fingers. Ultrasound detected extrasynovial abnormalities (enthesis, enthesopathy of the deep flexor tendon insertion) in many of the PsA fingers but in none of the RA fingers. Based on these findings, the authors concluded that erosive synovitis and tenosynovitis occur equally in both PsA and RA. However, enthesopathy of the finger was only seen in patients with PsA and thus may distinguish the two conditions.

Enthesitis may be asymptomatic or present clinically with pain and tenderness with pressure of the enthesis. In a study of 40 patients with PsA, 40 with RA, and 80 control subjects, US was found to detect the presence of enthesitis more accurately than clinical examination.\textsuperscript{51} In this study, sonography was performed in both the transverse and longitudinal plains using a high-frequency transducer. The quadriceps enthesis was examined with the knee extended at rest, with contraction, and in 30° flexion. The authors considered enthesitis to be present if US showed at least one of the following:\textsuperscript{51}

- Heterogeneous decreased echogenicity and thickening of the enthesis
- A >2-mm irregularity of the patella
- Enthesophytes >5 mm in size
- Bone erosions

D’Agostino and Terslev\textsuperscript{52} have described enthesitis on grey scale US as the presence of any of the following lesions demonstrated within 2 mm of the bone surface:

- Hypoechochogenicity of the insertion of the tendon/ligament or capsule into the bone
- Increased thickness of the tendon/ligament or capsule at the point of insertion into the bone when compared to the body of the tendon/ligament or capsule with or without blurring of the margins of the tendon/ligament or capsule
- Calcifications or fibrous scars in the tendon/ligament or capsule insertion into bone (demonstrated in two orthogonal planes)
- Erosions (defect in the bony cortex) in two perpendicular planes
- Cortical irregularities with loss of the normal bone contour and no sign of an erosion or enthesophytes
- Doppler signal detected at the cortical insertion of an enthesis.

The clinical significance of these findings is unclear, especially in asymptomatic patients.
Dactylitis or so called ‘sausage digit’ occurs in up to 48% of patients with PsA and describes inflammation of the entire digit with diffuse swelling, pain, and tenderness.\textsuperscript{53} It is one of the CASPAR (C\textsc{lassification} criteria for P\textsc{soriatic} A\textsc{rthritis}) criteria for the diagnosis of PsA and is often associated with progressive disease. In a systematic review of the literature, Bakewell et al.\textsuperscript{54} reported that flexor-tendon tenosynovitis and joint synovitis were the most common MRI and US findings in dactylitis. This is considered to be an important imaging feature of PsA; however, according to Husic et al.,\textsuperscript{47} it is diagnosed more frequently on clinical examination than on US.

Additional studies are needed to determine whether PsA can be differentiated from other forms of inflammatory arthritis by the anatomic distribution of the involved joints using US.\textsuperscript{46, 55}

**Ultrasound Monitoring in Psoriatic Arthritis**

A recent study suggests utility of monitoring patients with PsA who appear to be responding well to treatment based on US. Of 54 PsA patients in clinical remission or with minimal disease activity at baseline, power Doppler evidence of synovitis predicted the need for advancing treatment because of an increased risk of disease flare over the next 6 months. Of those with synovitis at baseline detected by power Doppler, 65% (13/20) required escalation of treatment as opposed to just 5.9% (2/34) of those without synovitis.\textsuperscript{56}

**Ultrasound in Psoriatic Arthritis (Summary/Conclusions)**

The use of US for the diagnosis and assessment of response to treatment in patients with PsA is still evolving. Currently, there is little standardization of technique and reporting. Despite this shortcoming, United Rheumatology believes that sonographic evaluation of patients with known or suspected PsA may be helpful in establishing a diagnosis and following response to treatment. United Rheumatology will continue to monitor the literature and update the guideline as needed. The United Rheumatology Clinical Practice Guideline for Psoriatic Arthritis provides a more complete discussion of the diagnosis and management of patients with PsA.

**Osteoarthritis**

Osteoarthritis (OA) is the most common form of arthritis and the most common cause of disability, loss of productivity, and absenteeism from work.\textsuperscript{57} It is characterized by osteophyte formation, loss of cartilage and damage to ligaments, tendons, menisci, joint capsules, bursae, and synovial tissue. Under normal conditions, there is an equilibrium between cartilage destruction and cartilage synthesis in joints. When cartilage destruction exceeds synthesis, OA can develop.\textsuperscript{58}

Conventional X-rays have been the most common imaging modality used for evaluating joint changes in OA. X-rays can demonstrate joint-space narrowing, bone erosions, and osteophyte formation. However, unlike MRI and US, X-rays cannot evaluate joint cartilage, periarticular soft tissue, joint capsules, tendons, ligaments, bursae, menisci, and synovium. Narrowing of the joint space secondary to loss of cartilage is one of the earliest conventional X-ray findings in OA.
The diagnosis of OA is often delayed (see the United Rheumatology Clinical Practice Guideline for Osteoarthritis). Initially, patients may be asymptomatic, despite cartilage loss and joint-space narrowing, and do not seek medical care until they experience pain and/or stiffness or decreased function in one or more joints. Less commonly, in patients with symptoms, X-rays are normal and OA is not recognized. Ultrasound can be used as an adjunct to conventional X-rays and clinical examination, especially when there is a need to visualize soft tissue of the joints.8

Sonographically, normal articular cartilage appears as a homogeneous anechoic curved band, which has a sharp regular anterior margin. The posterior margin is more echoic and represents the interface between the articular cartilage and the bone.59 Early anatomic changes of OA in asymptomatic patients can be seen as areas of increased echogenicity within the anechoic band of articular cartilage, with loss of the sharp anterior margin. Destruction progresses to focal thinning of the articular cartilage, readily visible on US but not on conventional X-ray. Later in the disease process, there may be episodes of synovitis (areas of synovial hypertrophy or increased vascularity on color Doppler) and accumulation of joint fluid/effusion, all of which can be documented by US. Joint-capsule thickening and osteophytes can also be detected with US.59

The knee is the most commonly involved joint in OA. To visualize the maximum amount of weight-bearing cartilage, it is helpful to scan the knee flexed at the greatest pain-free position possible. As OA progresses, the anterior margin of the cartilage becomes blurry and irregular. Ultimately, the articular cartilage becomes narrowed or completely destroyed. Intermittent synovitis can be diagnosed and monitored by visualizing thickening of the synovium (usually measured in the suprapatellar bursa, normally measuring 2 mm to 3 mm) and evidence of increased vascularity on power Doppler. Thickening of the joint capsule can also be seen.59 US evaluation of the lateral and medial joint margins can demonstrate bone irregularities of both the distal femur and proximal tibia. In addition, joint effusions are often detected. Small effusions may be missed on clinical examination but can be seen with US. Most frequently, effusions are anechoic but loose bodies, may at times be seen. Proteinaceous material or crystals in a joint effusion result in a heterogeneous appearance on US. Fine debris in an effusion may be seen after intraarticular steroid injections. Baker’s cysts (popliteal cysts), which can greatly vary in size, may also be seen in patients with OA of the knee. At times, US can demonstrate communication of these cysts with the knee joint.60

A more difficult diagnostic problem is the evaluation of a painful hip with normal conventional X-rays. Effusions or joint fluid or synovitis may be detected by US in these patients. A distance of >7 mm between the hip joint capsule and the femur, or a difference of >1 mm distance between the joint capsule and the femur between the left and right hips indicates the presence of synovial fluid or synovial hypertrophy. Irregularity of the femoral head and neck and marginal osteophytes can also be seen on US of the hip. Anatomically, the articular cartilage of the hip cannot be visualized in its entirety by US.59

Sonography has been found to be helpful in the evaluation of other joints, including the wrist and hand; especially the first carpometacarpal joint, which is commonly one of the first joints to be affected by OA. This joint is usually scanned in anterior, lateral, and posterior longitudinal planes.
The role of US in the evaluation of OA is evolving. There are no standardized protocols at this time and no validated US-based scoring systems. United Rheumatology recognizes that, despite the limitations of the technique, US can be a valuable adjunct to clinical and radiographic evaluations early in the course of the disease and when the diagnosis is unclear. It should not be used routinely for every patient with OA and, at this time, does not replace conventional radiographs for the evaluation of patients with OA.

United Rheumatology will continue to monitor the literature and update the guideline as appropriate. The United Rheumatology Clinical Practice Guideline for Osteoarthritis of the Knee provides a more complete discussion of the diagnosis and management of patients with OA of the knee.

**Gout**

Gout is an inflammatory arthritis with recurrent episodes of synovitis, joint swelling, and pain. It is most common in joints of the lower extremities, especially the first metatarsophalangeal joint. An estimated 4% of the United States population is affected by gout (see the United Rheumatology Clinical Practice Guideline for Gout).

Although flares may occur in patients with normal uric acid levels, gout is typically associated with elevated levels of serum uric acid (>6.8 mg/dL), which can be due to the overproduction of uric acid or decreased excretion by the kidneys. When the serum concentration of uric acid exceeds 6.8 mg/dL, solid crystals of monosodium urate may be deposited in synovial fluid or in the soft tissues resulting in tophi. Not all patients with hyperuricemia or elevated uric acid levels develop gout and, conversely, not all patients with gout have hyperuricemia.61

Currently, the definitive diagnosis of gout is established by demonstrating monosodium urate crystals (intra- or extracellular) in synovial fluid or soft tissue tophi. However, aspiration of an involved joint or soft-tissue mass is not always necessary because the diagnosis may be established based on clinical presentation alone. In certain clinical circumstances—an attack of pain, swelling, and tenderness of a lower-extremity joint that reaches maximum intensity within 6 to 12 hours is highly suggestive of crystal-inflammatory arthritis and, if the first metacarpophalangeal joint is involved, particularly of gouty arthritis.62, 63

The 2015 Gout Classification Criteria (endorsed by both EULAR and the ACR)64 require a score of ≥8 to establish a diagnosis of gout (see United Rheumatology Clinical Guidelines for Gout). The demonstration of urate deposits in joints or bursae that have been symptomatic by either US or dual energy CT (DECT) is equal to 4 points. The criteria also assign 4 points if there is evidence of at least one gout-like erosion in either the hands or feet on conventional radiography (see the United Rheumatology Clinical Practice Guideline for Gout). Neither US (nor DECT) and conventional X-rays of the hands and/or feet are required to establish the diagnosis by these classification criteria, but they should strongly be considered when evaluating a patient with a clinical suspicion of gout.
Ultrasound for the Diagnosis of Gout

Musculoskeletal US in gout is not limited to the detection of intraarticular urate deposits. It also can demonstrate intraarticular and periarticular abnormalities including effusions, synovitis, bone erosions, tendonitis, bursitis, and changes in hyaline cartilage. In addition, soft tissue changes such as tophi can be seen. The most common US findings in patients with gout include:

- The “double contour sign” of the hyaline cartilage – focal or diffuse hyperechoic anterior margin of the hyaline cartilage, which may be slightly irregular. This sign is highly suggestive of gout, with a 43.7% sensitivity and 99% specificity for gout. It is best seen in the knees and metatarsal and metacarpal joints. This sign can be seen in asymptomatic hyperuricemic patients.

- Crystal deposition in synovial fluid, seen as hyperechoic spots measuring <1 mm floating in the synovial fluid, which may cause posterior acoustic shadowing or have a so-called “snowstorm” appearance when compression of the joint is released. This imaging sign is highly specific for gout. This is referred to as a “starry sky” on US. If pressure is gently applied to the joint the hyperechoic foci will move creating the appearance of a “snowstorm”.

- Tophus, seen as a hyper- or hypoechoic soft-tissue mass, which may result in posterior acoustic shadowing and is located in the soft tissue around a joint.

- Synovial hypertrophy, seen commonly as hypoechoic material in and/or around the joint, which is not compressible and rarely hypo- or hyperechoic without power Doppler signal. This is a nonspecific finding that can be seen in any inflammatory arthritis.

- Bone erosions, seen as breaks in the bony cortex, which can be very destructive.

Effusions may be present in any inflammatory arthritis and are not specific for gout. They can be completely anechoic; as seen in RA, PsA, and the earliest stages of gout; however, with time, urate deposits in the joint fluid can be seen as hyperechoic foci.

A recent study compared the sensitivity and specificity of US to the gold standard, arthrocentesis, in 824 patients with possible gout. In patients with at least one swollen joint or a palpable subcutaneous nodule, the presence of either a double contour sign, a snowstorm appearance in the joint fluid, or a tophus on US accurately identified gout with a specificity of 84.3%, a sensitivity of 76.9%, a positive predictive value of 83.3%, and a negative predictive value of 78.2%.

Synovial hypertrophy is nonspecific for gout and, if power Doppler signal is detected, then synovitis is present. Synovitis is usually detectable before erosions are seen. As in RA, small erosions are detected with US before they can be seen on conventional X-ray. The erosions in gout are usually deeper and more destructive than those in RA.

United Rheumatology encourages the use of US to assist in establishing a diagnosis of gout. In 2010, Thiele and Schlesinger published a study of five patients with documented gout and evidence of monosodium urate crystals in the joints who were treated with urate lowering therapy. They found that once a serum uric acid level was 6mg/dL or less for at least 7 months, US was able to demonstrate clearing of urate.
deposits in both synovial fluid and articular cartilage. The authors caution that a larger study is needed in order to determine whether or not US may be used to determine response to urate lowering therapy. In addition, demonstration of the double contour sign may allow the provider to avoid arthrocentesis in acutely painful joints. However, if arthrocentesis is not done, it is important to be confident that the painful joint is not infected.

**Calcium Pyrophosphate Dihydrate Deposition Disease**

Calcium pyrophosphate dihydrate deposition disease (CPPD) affects approximately 3% of the United States population between the ages of 60 to 70 years old. Calcium pyrophosphate crystals are deposited in joint cartilage and, when released into synovial fluid, cause a very painful attack of pseudogout. Such an attack is generally accompanied by swelling, redness, warmth, and joint disability. Attacks may also be brought on by trauma or surgery. However, most people with evidence of calcium pyrophosphate crystals in joint cartilage will never develop symptoms.

The causes of CPPD are not known; however, it is believed that it involves a combination of factors, including both genetics and aging. Other factors that may lead to the disease include hemochromatosis, hypercalcemia, hypothyroidism, hyperparathyroidism, or hypomagnesemia. The most common joint involved is the knee, which is affected in 50% of acute attacks; the wrist is the second most commonly involved joint. Shoulders, ankles, elbows, hands, and feet may also be involved. Acute attacks of pseudogout can last from a few days to a several weeks.

Calcium pyrophosphate crystals can also be seen in the joints of patients with OA, gout, or a septic joint. The gold standard for diagnosis in a patient with a warm, painful, swollen joint, and no other explanation is arthrocentesis demonstrating calcium pyrophosphate crystals from a synovial fluid aspirate. X-rays may show chondrocalcinosis (calcium deposits in the joint cartilage), which is not specific for CPPD.

A complete discussion of the diagnosis and management of CPPD is beyond the scope of this guideline. However, US has been found to be useful in establishing a diagnosis of this disorder. Filippucci et al. published a study of the US findings in 30 patients with gout and 70 patients with CPPD. All of the patients were clinically evaluated by an experienced rheumatologist prior to having a US of both knees. Among the 100 patients (with 200 knee US studies), the most common sonographic finding was an effusion, seen in 35% of the gout knees and 37% of the CPPD knees. Seventeen percent of the gout knees and 15% of the CPPD knees showed synovial hypertrophy with or without power Doppler signal. Meniscal calcification was found in 77% of the CPPD knees and in none of the gout knees. The double contour sign (described in the section on gout) was present in 41.6% of the gout knees and in only 0.7% of the CPPD knees. The co-existence of CPPD and gout in certain patients, a so-called “mixed crystalline” presentation may affect the clinometric performance of US in distinguishing the conditions.

Another study published in 2006 compared the US findings in patients with CPPD and gout (both proven by arthrocentesis and microscopic evaluation of synovial fluid). In gout, monosodium urate crystals were deposited on the surface of the articular cartilage (double contour sign); in CPPD, the crystal deposition
was within the articular cartilage. In addition, calcium pyrophosphate crystals were seen in tendons and fibrocartilage.

In a study published in 2014, Gutierrez et al. compared US and X-rays in the diagnosis of CPPD. This study included 74 patients with CPPD and 83 control subjects with a variety of other chronic arthritides. In addition to a clinical evaluation and synovial fluid analysis, all patients had X-rays and US of both knees. Hyperechoic spots consistent with crystal deposition within hyaline cartilage were found in at least one knee in 59.5% of the CPPD patients with US, but were detected by X-ray in only 45.9% of the patients. Detection of calcification in the menisci was seen with US in 90.5% of the CPPD patients; however, X-ray detected it in only 83.7%. The authors concluded that CPPD could be detected more reliably by US than by X-ray.

United Rheumatology supports and encourages the use of US for the diagnosis of CPPD, if available, because it appears to be more reliable than X-ray and may avoid arthrocentesis in acutely painful joints. However, if arthrocentesis is not done, it is important to be confident that the painful joint is not infected.

**Polymyalgia Rheumatica**

The diagnosis and management of polymyalgia rheumatica (PMR) is outside the scope of this document. However, a brief discussion of the role of US in establishing the diagnosis is appropriate.

About half of the patients with giant cell arteritis will develop PMR before, after or at the time of the diagnosis of giant cell arteritis. Like giant cell arteritis, PMR usually affects people 50 years of age or older and is more common in women. The diagnosis may be difficult to establish because the presenting symptoms such as pain and stiffness in the shoulders and hips are seen in many rheumatologic disorders.

In 2012, the ACR and EULAR published classification criteria for PMR. Like all other classification criteria in rheumatology, these are designed for use in clinical research studies and not for diagnosis. However, they are a helpful guide to the rheumatologist faced with a confusing clinical situation. Unfortunately, there is no one test that can establish the diagnosis of PMR. The published classification criteria can be used with or without US, but US use does increase the specificity and sensitivity.

According to EULAR and the ACR, there are two ways to use the classification system. The first system does not include US findings and requires a score of ≥4 to classify a patient as having PMR (see Table 1). When using this system all patients must be 50 years of age or older, complain of aching in both shoulders and have elevated acute phase reactants (erythrocyte sedimentation rate and CRP). No other joint pain can be present.
Table 1. EULAR/ACR classification system for PMR without US

<table>
<thead>
<tr>
<th>Clinical findings</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morning stiffness for more than 45 minutes</td>
<td>2</td>
</tr>
<tr>
<td>Normal RA serology (negative RF and negative ACPA)</td>
<td>2</td>
</tr>
<tr>
<td>Hip pain or limited range of motion</td>
<td>1</td>
</tr>
<tr>
<td>No other joint pain</td>
<td>1</td>
</tr>
</tbody>
</table>

A score of 4 or more classifies a patient as having PMR. The specificity of this scoring system is best when trying to tell the difference between PMR and other shoulder problems (79%) except when trying to differentiate between PMR and RA where the sensitivity is only 61%.

ACPA, anticitrullinated protein antibody; RF, rheumatoid factor.

The committee developing the classification criteria found that when US was added to the standard scoring system, the sensitivity of the criteria improved from 79% to 86% when differentiating PMR from other shoulder disorders except RA where the sensitivity of the criteria improved from 61% to 65%. When using the system with US findings, scores of 1 can be obtained for demonstrating either (see Table 2):

- One shoulder with either subdeltoid bursitis and/or biceps tenosynovitis and/or glenohumeral synovitis AND one hip with at least synovitis and/or trochanteric bursitis OR
- Both shoulders with subdeltoid bursitis and/or biceps tenosynovitis or glenohumeral synovitis.

The US system has the same requirements for entry as the non-US system for patient age, elevated acute phase reactants and bilateral shoulder aching. This system requires a minimal score of 5 to be classified as having PMR (see Table 2).
Table 2. EULAR/ACR classification system for PMR with US

<table>
<thead>
<tr>
<th>Clinical findings</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morning stiffness for more than 45 minutes</td>
<td>2</td>
</tr>
<tr>
<td>Normal RA serology (negative RF and negative ACPA)</td>
<td>2</td>
</tr>
<tr>
<td>Hip pain or limited range of motion</td>
<td>1</td>
</tr>
<tr>
<td>No other joint pain</td>
<td>1</td>
</tr>
<tr>
<td><strong>Ultrasound findings</strong></td>
<td></td>
</tr>
<tr>
<td>One shoulder with either subdeltoid bursitis, and/or biceps tenosynovitis and/or</td>
<td>1</td>
</tr>
<tr>
<td>glenohumeral synovitis AND one hip with synovitis or trochanteric bursitis</td>
<td></td>
</tr>
<tr>
<td><strong>Both</strong> shoulders with subdeltoid bursitis and biceps tenosynovitis or glenohu</td>
<td>1</td>
</tr>
<tr>
<td>mumeral synovitis</td>
<td></td>
</tr>
</tbody>
</table>

A score of 5 or more classifies a patient with PMR when US is included in the classification criteria scoring system.

ACPA, anticitrullinated protein antibody; RF, rheumatoid factor.

At US, tenosynovitis is seen as hypoechoic or anechoic material in the tendon sheath that is compressible and has no flow on power Doppler examination. The findings must be seen in two perpendicular views.

Synovitis (non-compressible hypoechoic soft tissue with increased power Doppler signal) in a joint may be seen in the glenohumeral- or hip-joint(s). These findings also must be confirmed on two orthogonal views.

Hypoechoic compressible fluid collections consistent with joint effusions may also be seen, especially in the shoulder or hip, and must also be confirmed on two perpendicular views.

Bursitis, especially at the subacromial-subdeltoid or trochanteric bursa in the hips may also be demonstrated. On US, bursitis appears as an anechoic or hypoechoic collection distending the bursa. There may be synovial hypertrophy and/or thickening of the bursal wall. The changes must be seen on two orthogonal views.

Patients suspected of having giant cell arteritis as well as PMR should be evaluated as described in the section on giant cell arteritis (see Appendix A).

Additional Applications of Diagnostic Ultrasound in Rheumatology

This guideline focuses on the use of US in the evaluation of some of the most common causes of rheumatologic disorders. There are many other indications for US that are beyond the scope of this
Some additional indications for diagnostic US that may be of interest to rheumatologists are listed in Table 3. The list is incomplete as appropriate indications for diagnostic and interventional US are changing. It is important to note that, although musculoskeletal US is the most common indication for which rheumatologists either perform or refer patients, there are other indications for US (some of which require specific training outside the usual musculoskeletal imaging courses, training and certification) which may be appropriate for rheumatologists to perform at the point of care. In Table 3, indications with an asterisk require more training and experience than that required to pass the current ACR certification examination.

**Table 3. Additional indications for diagnostic ultrasound**

<table>
<thead>
<tr>
<th>Anatomic location</th>
<th>Indications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoulder</td>
<td>• Rotator cuff tears (partial and full thickness)<em>&lt;br&gt;• Post-operative rotator cuff failure</em>&lt;br&gt;• Bursitis&lt;br&gt;• Calcific tendonitis</td>
</tr>
<tr>
<td></td>
<td>• Pectoralis/deltoid tear*&lt;br&gt;• Tendinopathy, dislocation, rupture of long head of biceps*&lt;br&gt;• Septic arthritis&lt;br&gt;• Sternoclavicular joint disease*</td>
</tr>
<tr>
<td>Elbow and wrist</td>
<td>• Lateral epicondylitis&lt;br&gt;• Medial epicondylitis&lt;br&gt;• Septic arthritis&lt;br&gt;• Olecranon bursitis</td>
</tr>
<tr>
<td></td>
<td>• Radial nerve compression*&lt;br&gt;• Median nerve entrapment*&lt;br&gt;• Ulnar nerve neuropathy*&lt;br&gt;• Ulnar nerve subluxation*</td>
</tr>
<tr>
<td>Hip</td>
<td>• Effusion&lt;br&gt;• Extraarticular snapping hip&lt;br&gt;• Sports hernia*</td>
</tr>
<tr>
<td></td>
<td>• Muscle injuries (high grade)&lt;br&gt;• Evaluation of lateral femoral cutaneous and femoral nerves*</td>
</tr>
<tr>
<td>Knee</td>
<td>• Patellar tendinopathy or tear&lt;br&gt;• Quadriceps tendinosis or tear&lt;br&gt;• Medial collateral ligament&lt;br&gt;• Iliotibial band friction</td>
</tr>
<tr>
<td></td>
<td>• Baker’s cyst&lt;br&gt;• Periarticular ganglion&lt;br&gt;• Periarticular bursitis&lt;br&gt;• Osgood Schlatter’s disease*</td>
</tr>
<tr>
<td>Ankle</td>
<td>• Tendinopathy&lt;br&gt;• Tendon tears&lt;br&gt;• Calcific tendinitis&lt;br&gt;• Retrocalcaneal bursitis&lt;br&gt;• Peroneal tendon dislocation*&lt;br&gt;• Anterior talofibular ligament injury*</td>
</tr>
<tr>
<td></td>
<td>• Calcaneofibular ligament injury*&lt;br&gt;• Effusion&lt;br&gt;• Plantar fasciitis&lt;br&gt;• Ganglion cyst&lt;br&gt;• Achilles’ tendinopathy or tear</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>• Giant cell arteritis* (See Appendix A)&lt;br&gt;• Sjögren’s syndrome * (See Appendix B)</td>
</tr>
</tbody>
</table>

*Denotes conditions that require that both the individual performing and/or interpreting the examination have additional training in US specific to the condition to be evaluated.
**Interventional Musculoskeletal Ultrasound**

Rheumatologists routinely perform joint aspirations and injections in the office setting. In addition to intraarticular injections of steroids or hyaluronic acid (or other agents), aspirations of an effusion are commonly performed for diagnostic purposes or to relieve symptoms. Many rheumatologists use palpation to identify a joint for injection and/or aspiration. Not all of these procedures are successful, and when the target is missed, repeat procedures may be needed. After a therapeutic injection, the patient may not have the expected improvement in symptoms or may even have an occasional adverse event secondary to an extraarticular injection, such as local soft-tissue damage. When procedures are performed with only palpation guidance, there is a risk of injuring a blood vessel, tendon, or nerve when passing a needle or other device into the soft tissue or joint. This can be avoided if US guidance is used.

Real-time US image guidance for joint aspirations, injections, and aspiration of soft-tissue collection and joint biopsies is gaining more acceptance by the rheumatology community. This approach has the advantage of providing visualization of the needle in real time as it is passes from the skin to the target joint or soft tissue. As a result, US guided procedures are less time-consuming, more accurate and safer than those done with palpation, and can usually be performed at the point of care. A US pre-scan can determine prior to needle entry whether free fluid for aspiration is available within a joint, thereby preventing the discomfort associated with futile ‘dry’ taps when no fluid is present. When very little fluid is present, US guidance allows rapid and accurate evacuation of the fluid, while limiting the trauma associated with “searching” for it. By visualizing the path of the needle and the target, the operator is able to avoid puncturing blood vessels, which could result in a post-procedure hematoma, especially in patients on anticoagulants or with a bleeding diathesis. In addition, direct injection into tendons, which can be associated with tendon rupture, can be avoided with an image-guided procedure.

Finnoff et al.\(^79\) published a systemic review comparing the value of US guidance versus palpitation alone for diagnostic or therapeutic injections, aspirations and tenotomies, releases, and hydrodissection. The authors concluded that US-guided interventions involving painful or inflamed joints were more accurate (95% for US-guided vs 81% for palpation), less painful, and more effective than palpation guided procedures.

In a study of 109 patients, different joints were injected using only palpation to guide the needle.\(^80\) The study found that half of the needles and injections were not inserted into the joint. Another study compared the accuracy of needle placement into the small joints (proximal interphalangeal joints and metacarpophalangeal joints) in patients with synovitis in at least one joint.\(^81\) Seventeen patients had a needle placed by an experienced rheumatologist using palpation. Fifty-three small joints (in 30 patients) of the hand were accessed using US image guidance. The position of the needle tip was evaluated by sonography and distention of the joint capsule after injection. In the group accessed by palpation, the needle tip was in the joint in 59% of cases, but no fluid could be aspirated. In joints accessed with real-time US guidance, the needle tip was inserted into the joint in 96% of the patients. In the US-guided group, joint lavage was performed to obtain samples of synovial fluid.
A report by Balint et al.\textsuperscript{62} compared the accuracy of US-guided needle placement in 32 patients with suspected effusions or a soft-tissue collection to palpation-guided needle placement in 30 patients who had RA (N=17), OA (N=6), or seronegative arthritis (N=6). The joints accessed in both groups included shoulders, elbows, knees, ankles, carpometacarpal joints, metacarpophalangeal, and proximal interphalangeal joints. Two of the RA patients in the group aspirated using palpation had two joints accessed. In the group accessed with US guidance, the success rate was 97%; in the group accessed by palpation, the success rate was only 32%. In the palpation-guided group, joints in the wrist were accessed successfully in 25% of cases. The US-guided group included soft-tissue collections, which were successfully aspirated 100% of the time. Difficulty with accessing joints was encountered not only in the small joints of the hand and wrist but also in larger joints such as the knee (40% success by palpation vs 95% success with US) and shoulder (25% success with palpation vs 100% success with US guidance).\textsuperscript{82} All of these studies were small, but all showed that US-guided joint aspiration was more successful than palpation-guided aspiration.\textsuperscript{80-82}

In 2012, Sibbitt et al.\textsuperscript{83} published a randomized controlled study comparing US-guided aspiration and steroid injections to those performed by palpation. They found that US guidance resulted in 48% less pain, a 183% increase in the volume of fluid aspirated, and overall improved outcomes 2 weeks after the procedure when compared to procedures performed without US guidance. It is important to note that, in this study, aspirations performed with US-guidance were done with controlled mechanical aspirating syringes. When aspirations and/or injections are performed with direct US visualization of the target, the accurate placement of the needle and injection of therapeutic agents can be confirmed.

\textbf{Indications}

The most common indications for US-guided needle placement into a joint include:\textsuperscript{84, 85}

- Injection of diagnostic or therapeutic agents such as steroids or hyaluronic acid into the joint
- Removal of joint fluid prior to the injection of a diagnostic or therapeutic agent
- Aspiration of joint fluid for analysis
- Aspiration of joint fluid for symptom relief
- Aspiration of joint to exclude infection
- Failed non-image-guided injection or aspiration
- Inability to localize the target by palpation due to body habitus; deep location such as the hip; or anatomic variants; which could be congenital or secondary to surgical intervention or trauma.
The most common indications for US-guided interventions of tendon, ligament, bursal, and muscle disorders include:\(^\text{84, 85}\)

- Tendinopathy and partial-thickness tears, including but not limited to rotator-cuff tendinopathy
- Calcific tendinitis of the rotator cuff
- Enthesopathy
- Tenosynovitis
- Tendon snapping
- Tendon subluxation or dislocation
- Trigger-point injections
- Trigger finger
- Lateral epicondylitis
- Contusions of muscles
- Trochanteric bursitis
- Olecranon bursitis
- Tenotomy.

The most common indications for US image-guided drainage procedures include:\(^\text{85}\)

- Undiagnosed soft-tissue collection such as a cyst, abscess, or liquefied hematoma
- Suspicion of abscess, to obtain fluid for culture
- Treatment of an abscess with aspiration and placement of drain
- Aspiration of a ganglion or synovial cyst.

**Contraindications**

The most common general contraindications for arthrocentesis include:\(^\text{84, 85}\)

- Active infection over the puncture site
- Tumor or mass overlying the site
- Rash over the sampling site
- Inaccessible site (inadequate acoustic window or visualization of the target).

United Rheumatology strongly encourages the use of US guidance for all interventions unless contraindicated, when available.
## Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
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<tbody>
<tr>
<td>Erosion</td>
<td>An intraarticular discontinuity of the bone surface that is visible in two perpendicular planes.</td>
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<tr>
<td>Joint effusion or synovial fluid</td>
<td>Abnormal hypoechoic or anechoic (relative to subdermal fat, but sometimes may be isoechoic or hyperechoic) intraarticular material that is displaceable and compressible, but does not exhibit Doppler signal.</td>
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<tr>
<td>Synovial hypertrophy</td>
<td>Abnormal hypoechoic (relative to subdermal fat, but sometimes may be isoechoic or hyperechoic) intraarticular tissue that is not displaceable and poorly compressible and may exhibit Doppler signal.</td>
</tr>
<tr>
<td>Tenosynovitis</td>
<td>Hypoechoic or anechoic thickened tissue with or without fluid within the tendon sheath that is seen in two perpendicular planes and may exhibit Doppler signal.</td>
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<tr>
<td>Enthesopathy</td>
<td>Abnormally hypoechoic (loss of normal fibrillar architecture) and/or thickened tendon or ligament at its bony attachment (may occasionally contain hyperechoic foci consistent with calcification) seen in two perpendicular planes that may exhibit Doppler signal and/or bony changes; including enthesophytes, erosions, or irregularity.</td>
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## Additional Definitions

<table>
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<th>Term</th>
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<td>Color flow Doppler</td>
<td>Technique which “estimates the average velocity of flow within a vessel by color coding the information. The direction of blood flow is assigned the color red or blue, indicating flow toward or away from the ultrasound transducer”. The color is superimposed on a grey scale image. Color flow is often combined with pulsed Doppler or spectral Doppler which “allows a sampling volume or “gate” to be positioned in a vessel visualized on the grey-scale image and displays a graph of the full range of blood velocities within the gate versus time. The amplitude of the signal is approximately proportional to the number of red blood cells and is indicated, not in color but simply as a shade of grey”.</td>
</tr>
<tr>
<td>Power Doppler</td>
<td>This technique “depicts the amplitude, or power of Doppler signal rather than the frequency shift”, which permits the detection of a larger range of Doppler signal and allows for the visualization of vessels with very low flow velocities but it cannot be used to determine direction of flow.</td>
</tr>
</tbody>
</table>
References


68. Thiele RG, Schlesinger N. Ultrasonography shows disappearance of monosodium urate crystal deposition on hyaline cartilage after sustained normouricemia is achieved. *Rheumatol Int* 2010;30(4):495-503.


Appendix A

Giant Cell Arteritis

A detailed description of giant cell arteritis as well as classification criteria, diagnostic criteria, treatment and monitoring of this disorder is beyond the scope of this guideline.

Giant cell arteritis is an auto-inflammatory and autoimmune disorder which results in inflammation in blood vessel walls. According to the 2012 Revised International Chapel Hill Consensus Conference Nomenclature of Vasculitides, giant cell arteritis is a large vessel vasculitis which most often involves the temporal and scalp arteries with sparing of the intracranial vessels. However, the disease can also involve the thoracic aorta, as well as the brachial, axillary and subclavian arteries. About half of the patients with giant cell arteritis also have polymyalgia rheumatica. It usually occurs in patients over age 50 and is more common in women.

The current gold standard for establishing the diagnosis of giant cell arteritis is a temporal artery biopsy with the following pathologic findings: According to a Health Technology Assessment from the National Health Service, National Institute for Health Research published in 2016, a temporal artery biopsy may be negative in a significant population of patients with the disorder. This prospective study, which included 381 patients, demonstrated better sensitivity of ultrasound (US) as compared to temporal artery biopsy, but poorer specificity. In contrast, Delle Sedie et al reported US has similar sensitivity and specificity to temporal artery biopsy.

For US examination of patients with either possible or known giant cell arteritis, a linear array, high-frequency probe of more than 10 megahertz (MHz) (preferably 15 MHz) with color Doppler is required. The entire length of the temporal artery can usually be evaluated with US. This is important since vessels may have so-called skip areas of involvement. Giant cell arteritis may involve the facial, external carotid ophthalmic, brachial and axillary arteries as well as the thoracic aorta and US imaging of patients suspected or known to have this rheumatologic disorder should include these vessels as well. All vessels imaged should be evaluated in two orthogonal planes.

The US findings of giant cell arteritis include the following:

- Hypoechoic ring in the wall of the vessel consistent with edema and swelling in acute giant cell arteritis (also referred to as the halo sign). A meta-analysis of the sensitivity and specificity of the halo sign was published in 2010. The authors of this study report sensitivity and specificity of a unilateral halo sign at 68% and 91%, respectively, and 43% and 100% for bilateral halo signs when “the 1990 ACR criteria are used as the reference standard” (page 46)
- Non-compressible vessel acutely
- Both the halo sign and non-compressibility rapidly disappear in most patients after 2-3 weeks of treatment with steroids
• Short segment vascular stenosis on color flow Doppler evaluation. Aliasing and persistent blood flow in diastole are seen when a stenosis is present. The maximum systolic velocity is also increased at least two-fold in a stenosis. Stenotic areas may be seen intermittently along the course of the vessel (so-called skip areas)
• Vascular occlusions with absent blood flow.

If US is to be used to assist in establishing or confirming the diagnosis of giant cell arteritis it should be performed prior to the introduction of steroids (or as soon as possible after the introduction of steroids) to optimize the visualization of the sonographic findings which may quickly resolve with steroids.
References


Appendix B

*Sjögren’s Syndrome*

A discussion of the diagnosis, epidemiology, classification criteria, and management of Sjögren’s syndrome is outside the scope of this guideline.

Sjögren’s syndrome is an autoimmune disease characterized by oral sicca (xerostomia) and dry eyes (xerophthalmia or keratoconjunctivitis sicca). Patients may also develop parotid gland enlargement and complain of difficulty talking and swallowing. Ocular sicca may manifest as complaints of foreign body sensation along with itchy eyes and sensitivity to light. The disease may be primary or associated with other rheumatic disorders (secondary Sjögren’s syndrome).\(^1\) It primarily occurs in women between the ages of 40 to 60.\(^2\) In the past, the gold standard for establishing the diagnosis of Sjögren’s syndrome has been biopsy of a minor salivary gland.\(^1\) However, more recently, criteria have been proposed to diagnose patients with a suspicion of this disorder.\(^3\) It is estimated that these criteria have a sensitivity of 96% and specificity of 95% (a complete discussion of these criteria is beyond the scope of this guideline and the reader is referred to the original article cited above).

The clinical diagnosis of Sjögren’s may be challenging. In the past decade, the role of ultrasound (US) in the diagnosis of Sjögren’s syndrome has been explored because it is non-invasive, inexpensive and can be performed at the point of care. Although salivary gland US has become widely used, it is still not clear if it can replace minor salivary gland biopsy at this time.\(^4\) Presently, there are insufficient standards to describe the US findings in the parotid and submaxillary glands.\(^5\)

A systematic review of US in Sjögren’s syndrome was published in the May, 2016 issue of *Rheumatology*.\(^6\) The review found that only 31 papers out of 167 met criteria to be included in the review. The population of patients studied varied from a low of 15 to a high of 150. The studies varied in their description of the US findings in B mode US and most did not use color Doppler. The authors believe that US is useful in detecting salivary gland abnormalities in this disorder (especially in the primary form of the disease) but they also suggest that more work is needed to standardize and validate the role of US in the diagnosis of Sjögren’s syndrome and develop a scoring system for parenchymal changes that can be widely used before US becomes routine for the evaluation of this disease.

If US evaluation of the salivary glands is performed, it should include bilateral parotid glands and submandibular glands. Any salivary gland studied should always be imaged in two orthogonal planes with a linear array transducer of at least 10 megahertz.\(^4\) Measurements should be taken in both transverse and longitudinal planes. Parenchymal echogenicity should also be evaluated.\(^4,\,7\) Although there is not yet a standardized reporting system for parenchymal echogenicity and homogeneity, a single system should be used by a practitioner. In the scoring system used by Carotti et al.,\(^8\) Grade 0 glands are normal; Grade 1 glands have regular margins, small hypoechoic areas, normal or increased volume without echogenic bands; Grade 2 glands have regular margins, multiple scattered hypoechoic areas measuring less than 2 mm which are not uniformly distributed throughout the gland, as well as normal or increased volume of the gland and no echogenic bands; Grade 3 glands have irregular margins with multiple confluent areas...
of hypoechogenicity, usually measuring 2–6 mm. Multiple cysts and echogenic bands may also be detected. The volume of the gland may be decreased and the posterior margin is not detectable; and Grade 4 glands have an irregular contour with large hypoechogenic areas measuring more than 6 mm. Cysts, calcifications and echogenic bands can also be seen. The volume of the gland is decreased and the posterior margin is not detectable. Each gland is given a score equal to the parenchymal grade. If both parotid glands or both submandibular glands have a score of 1 or more it was considered by these authors to be abnormal.

Evaluation of blood flow should also be undertaken in these patients using Doppler waveforms of the transverse facial artery both before and after stimulation with lemon juice or equivalent. A resistive index (peak systolic velocity – end diastolic velocity/peak systolic velocity) should be calculated as well. Other groups have evaluated color Doppler flow and Doppler waveforms of arteries in the parotid and submandibular glands before and after lemon stimulation. A normal salivary gland will demonstrate increased blood flow during lemon stimulation. Blood flow does not change significantly with lemon stimulation in either the parotid or submandibular glands of patients with Sjögren’s syndrome.

References


## Document Updates

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<tr>
<th>Document Version</th>
<th>Description of Changes</th>
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<tbody>
<tr>
<td>1.1.2016</td>
<td>Creation of first version</td>
<td>28 Nov 2016</td>
</tr>
<tr>
<td>1.1.2017</td>
<td>2017 Update</td>
<td></td>
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