

Doppler Ultrasonography in Rheumatology: Adding Color to the Picture



Over the past decade, the number of publications on musculoskeletal ultrasound has increased every year; many are written by rheumatologists. Much of this research originates in Europe, but rheumatologists in North America are taking notice and enroll increasingly in ultrasound courses. Skepticism remains on this side of the Atlantic regarding reproducibility and “operator dependability.” Interestingly, intraclass correlation coefficients and kappa values of inter-reader agreement are not lower for musculoskeletal ultrasound when compared with similar magnetic resonance imaging (MRI) studies¹⁻¹⁰.

B-mode (or “brightness modulated”) ultrasound shows soft tissues and bony cortices in different shades of gray, depending on the echogenic properties of the tissues. It offers greater detail for superficial structures such as joints compared with MRI. Joint capsule, synovial proliferation, subtle effusions, and small erosions can be identified (Figure 1). Once synovial lining cell proliferation is identified with grayscale ultrasound, the degree of inflammatory activity of this tissue becomes of interest.

Color Doppler and power Doppler ultrasound detect shifts in frequency of sound waves reflected from moving objects. In the human body, such objects are mostly erythrocytes. Doppler ultrasound can therefore be used to assess blood flow in normal or inflamed tissues (Figure 2). Color Doppler encodes direction and velocity of blood flow. Power Doppler detects the strength of blood flow, and is often thought to be more sensitive in detecting low-flow states, such as in inflamed tissues. Hyperemia seen on Doppler ultrasound correlates well with hypervascularity found histologically after synovectomy¹¹.

In rheumatology, Doppler ultrasound is used to detect hyperemia of inflamed synovial tissues¹², monitor treatment response as a decrease or disappearance of this hyperemia, detect abnormal enthesal blood flow at the interface of tendons and bone in spondyloarthropathies^{13,14}, help assess

large-vessel vasculitis such as temporal arteritis and Takayasu arteritis¹⁵, assess blood flow in primary and secondary Raynaud’s phenomenon¹⁶, and assist in finding the movement of the needle tip or the jet of the injection in ultrasound-guided aspirations, injections or synovial biopsies. Grayscale and Doppler ultrasound can measure carotid luminal stenosis or intima-media thickness and help assess the cardiovascular risk in chronic inflammatory states. An interesting question remains whether an improvement of luminal stenosis or intima-media thickness can be seen sonographically with effective treatment of inflammatory arthritis. In the differential diagnosis of swollen calf, grayscale and Doppler sonography can enable a rapid distinction between popliteal cysts and deep venous thromboses¹⁷.

However, standardization of the Doppler ultrasound examination is essential, since this technology is prone to artifacts and false-positives. If the Doppler gain is set too high, artificial color pixels appear. This can be overcome by slowly decreasing the gain until signals remain persistent at locations that are expected to have blood flow, such as proliferative synovial tissue or larger vessels. Pulse synchronicity of the color signal also confirms vascular flow versus artifact.

Motion of patient or ultrasound probe will lead to motion artifacts, so probe contact with the patient needs to remain steady. Ambient room temperature or body temperature, physical activity, or alcohol consumption prior to the examination all can influence blood flow, so these factors need to be considered.

In this issue of *The Journal*, Terslev and colleagues address the important question of how normal blood flow in articular and periarticular tissues can be distinguished from the abnormal, increased blood flow of inflammation. They examine tender or swollen joints and compare the degree of vascularity seen with Doppler with a cohort of healthy vol-

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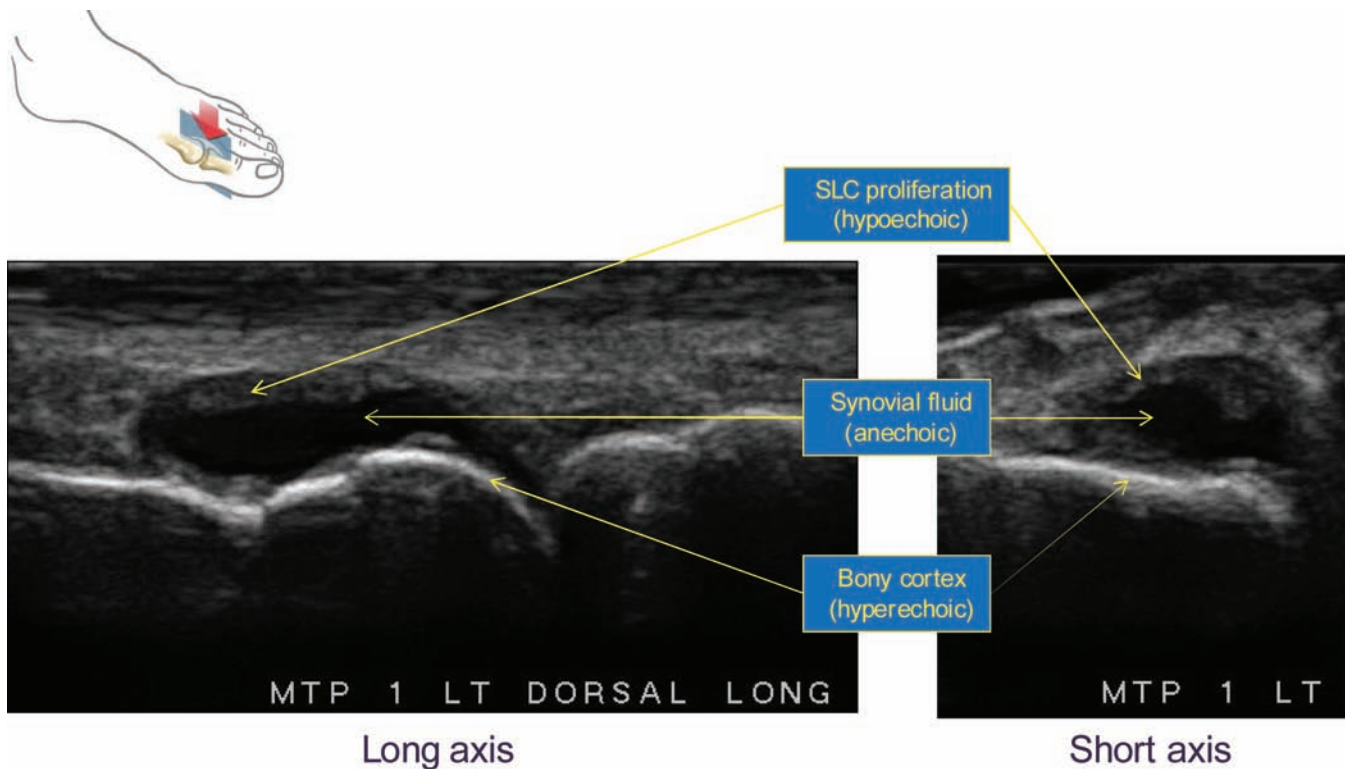


Figure 1. Grayscale ultrasound examination of dorsal aspect of first metatarsophalangeal joint. Chronic inflammatory arthritis. Concentric proliferation of synovial lining cell (SLC) tissue.

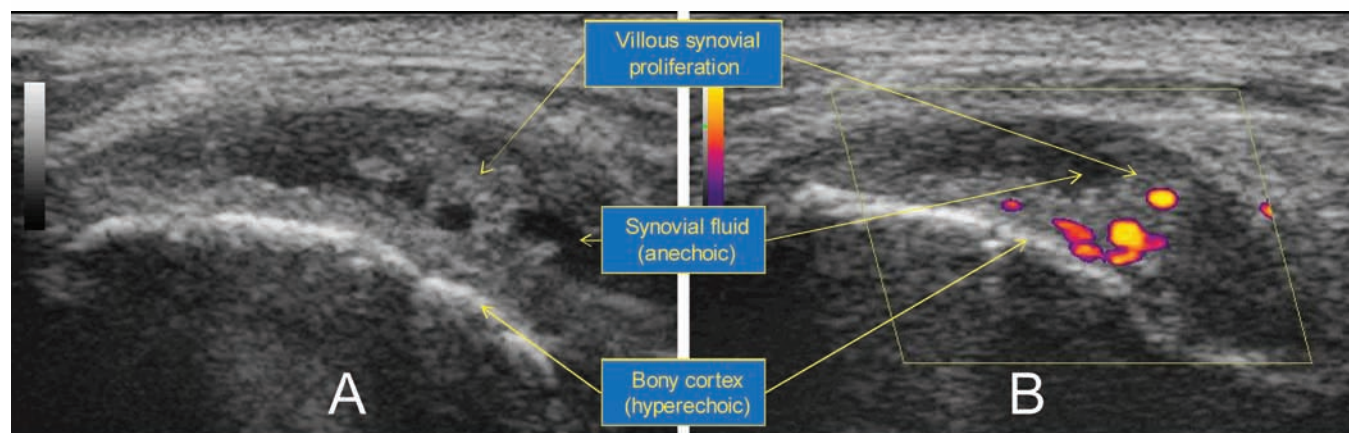
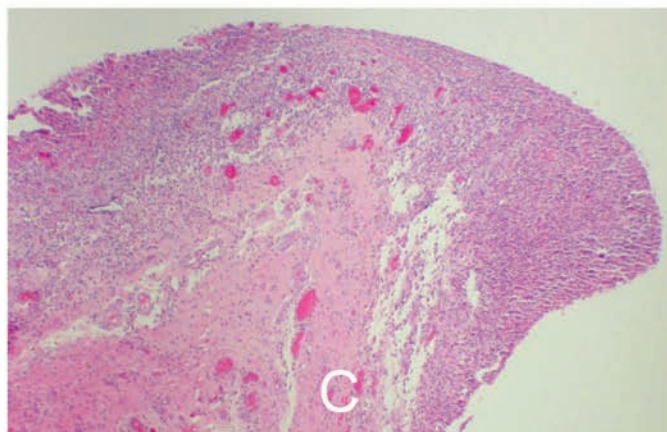


Figure 2. A. Grayscale sonogram of lateral recess of elbow joint. Inflammatory arthritis. Proliferative, villous synovial tissue is seen surrounded by anechoic synovial fluid. B. Same tissue; power Doppler is added. Color signals are seen within the villous tissue and proliferative synovial lining tissue. C. Same tissue after synovectomy. Histological examination shows hypervascularity.



unteers from a previous study. In addition to using color Doppler, they determine flow patterns and the resistive index — techniques that are not yet routinely used in rheumatology. The authors use the elegant method of determining a region of interest within a joint, and determine the fraction of color pixels, representing the degree of vascularization, in an automated fashion. This would appear to work well in homogenous tissue proliferation and less well if the region of interest is difficult to define. This may be the case if multiple strands of villous tissue are surrounded by synovial fluid. Synovial fluid within the region of interest would then be falsely added to the avascular fraction. Ideally, grayscale ultrasound would allow identification of proliferative synovial tissue within a joint and permit distinction from capsular structures. Once the examiner recognizes the *gestalt* of such tissue, a Doppler signal would only be sought within this tissue, which has already been identified as abnormal.

In this study, flow in healthy joints is compared with flow in synovial tissue of rheumatoid arthritis. Since the synovial lining is only one or a few cell layers strong in healthy joints, findings of flow in this group likely represent subintimal flow. In contrast, the region of interest that the authors determine in rheumatoid joints would largely represent intima proliferation, so they may actually compare 2 different types of tissue. They suggest cutoff values that distinguish physiologic from abnormal flow. It should be expected that flow characteristics in a given joint are similar across different high-performance ultrasound platforms. However, few rheumatology divisions or practices in North America have unrestricted access to ultrasound equipment similar to the one that the authors use. Instead, lower-performance machines or portable units are frequently used. It remains to be seen if the values found by Terslev, *et al* would be applicable for all ultrasound machines, or if individual cutoff levels have to be determined in every institution.

The assessment of flow patterns and resistive indices has not been studied much in rheumatology. If future studies confirm usefulness in rheumatologic indications, this may add further strength to the Doppler ultrasound examination.

With this work on the distinction between normal and abnormal flow in wrists and metacarpophalangeal joints, Terslev and colleagues set another milestone toward standardization of the ultrasound examination in rheumatology.

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