



## ULTRASONOGRAPHY FOR RHEUMATIC DISEASES – A REVIEW

**HEMALATHA.R.J\*<sup>1</sup>, DR.VIJAYABASKAR.V<sup>2</sup>**

<sup>1</sup>*Assistant Professor, Department of Bioengineering - Biomedical, Vels University, Chennai, India -600117*

<sup>2</sup>*Professor, ETCE Department, Sathyabama University, Chennai, India-600119*

### ABSTRACT

Radiograph is considered as the gold standard method for imaging Rheumatoid arthritis. However features and information of imaging of synovium, soft tissues, and joint spaces are difficult to assess. More recently due to the improvement in the imaging technology musculoskeletal ultrasonography is increasingly being used in the clinical evaluation of arthritis diseases. This article aims at addressing the wide practice of musculoskeletal ultrasound in assessing the RA disease and highlights the strength of the imaging modality. Specific emphasis is placed on the methodology, design, and parameters used in the trials. A literature review was performed based on the title - role of ultrasound in assessing RA. Articles that detailed the applications of ultrasound experimentally and clinically were reviewed and the studies that compared ultrasound with MRI, X-ray imaging techniques were also included in the literature. This review article describes the role of musculoskeletal ultrasonography in patients with RA, focusing on identifying specific ultrasonographic features like vascular synovitis, tenosynovitis, bone erosions which can be an added value in evaluation of patients with arthritis

**Keywords:** Arthritis, musculoskeletal ultrasound, Rheumatology, synovitis, erosions, RA.



**HEMALATHA.R.J**

Assistant Professor, Department of Bioengineering - Biomedical,  
Vels University, Chennai, India -600117

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## INTRODUCTION

Medical imaging provides a non invasive means to probe the structural and morphological information of the body. Measures of physiological functions of organs and tissues are visualized by noninvasive imaging methods for assessing joint damages a conventional radiogram is considered as the gold standard as it is inexpensive and is widely available globally<sup>1</sup>. The visualization of cartilage, synovium and others of tissues are limited in radiographic imaging. High resolution imaging modality like magnetic resonance imaging (MRI) provides an actual evaluation of bone, cartilage, and soft tissue<sup>2</sup>. MRI is non-invasive, multiplanar and can provide soft tissue contrast. However, MRI consumes more time, expensive and not preferred for diagnosing arthritis<sup>3</sup>. High-frequency musculoskeletal ultrasound (MUS) is an imaging modality used to visualize musculoskeletal disorders in research and clinical practice<sup>4</sup>. MUS accurately depict superficial periarticular and intra-articular structures. MUS effectively identifies knee effusion and other joint disorders, and the sensitivity is higher than physical examination<sup>5-6</sup>. The further chapters give an outlook of uses, types and applications of ultrasound in detecting the arthritis.

## HISTORY OF ULTRASOUND

Since the early 1950s Ultrasound was used in medical practice. To visualize living tissues using high-frequency ultrasonic waves, the ultrasound technique has rapidly evolved and has been used in medicine because of its non-invasive nature and real-time<sup>7</sup>. Due to the development of linear array probes, improved transducer technology with near-field high-resolution and focusing capabilities musculoskeletal sonography has come along way over the past 25 years<sup>8</sup>. This has made musculoskeletal ultrasound (MSUS) as an imaging modality to visualize musculoskeletal disorders in research and clinical practice. The MSUS effectively depicts soft tissues, bony abnormalities, meniscus, and articular cartilage<sup>9</sup>. Modern treatment aims at early detection of arthritis. Accordingly, the need to establish different methods for early diagnosis of the disease has increased<sup>10</sup>. Recent advances like MSUS imaging technology have brought the sonographic equipment for imaging rheumatoid arthritis patients with inflamed joints. The most widely used ultrasound is grayscale and power Doppler ultrasound

## GRAYSCALE-HIGH FREQUENCY ULTRASONOGRAPHY

Musculoskeletal imaging in rheumatology is greatly improved due to Gray scale - High frequency ultrasonography (HFUS). Several clinical researchers have demonstrated that Gray-scale US performed with high-frequency linear array transducers is accurate in detecting joint effusions, synovitis and other bony abnormalities when compared with MRI and arthroscopic detection. The sensitivity of HFUS is higher

than clinical evaluation of assessing joint inflammation. It offers improved monitoring of soft tissue and bony abnormalities<sup>11</sup>.

## POWER DOPPLER ULTRASONOGRAPHY (PDUS)

The high resolution of modern ultrasound machines like PDUS detects the synovial fluid in healthy joints. The principle in which the Doppler ultrasound works is that sound waves increases when the frequency reflected from the object is moving towards the transducer and decreases when they are moving away from the transducer. Recent reports by Hau et al and Newman et al suggest that Doppler signal amplitude is measured during evaluation of disease activity in RA joints by power Doppler ultrasonography<sup>12</sup>. The soft tissue hyperemia in RA joints is easily visualized as it is very sensitive to blood flow. The ease of availability and low cost makes it readily available for the assessment of synovial inflammation.

## USES OF ULTRASOUND

The significant advantage of ultrasound is to immediately scan the abnormal area after clinical examination when compared to MRI, CT. Ultrasound has the advantage of clinical correlation of the joints at the time of scanning and is performed by rheumatology clinicians in the outpatient setting.

The Ultrasound finds many uses in the diagnosis and management of MSK disorders.

1. Ultrasound is more sensitive and less expensive than MRI.
  2. The level of damage to anatomical structure and inflammation in early arthritis can be easily assessed
  3. The machine is portable, comfortable which reduces the burden for patient and doctors.
  4. Ultrasound provides more precise and early diagnosis of arthritis with immediate results.
  5. Helps in placing needle in the joint more accurately
- The radiologist gets improved knowledge of the regional and functional anatomy, understands the pathological process and improved clinical examination skills.

## RHEUMATIC CLINICAL PATHOLOGIES

### ARTHRITIS

The term arthritis means joint inflammation and it describes many diseases and conditions that affect the body's joints. Any joint disorder that falls within the rheumatic diseases are categorized by inflammation and loss of function of connecting structures of the body<sup>13</sup>. Figure 1 shows the classification of arthritis. Worldwide, 0.5–1.0% of adults in the total population is affected by RA. According to WHO in India is 0.5% in urban areas and 0.55% of the rural population.

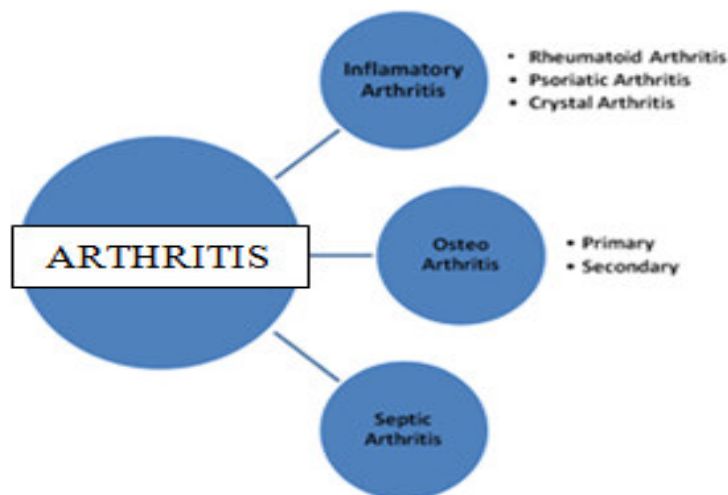


Figure 1  
Classification of Arthritis

### RHEUMATOID ARTHRITIS

An autoimmune disease that causes irreversible damage to joints and other physiological structures. RA is a systemic disease characterized by joint inflammation, synovitis, resulting in cartilage damage, bone erosion, joint destruction, and long-term disability<sup>14</sup>.

### SYNOVITIS

Synovitis is a condition in which the synovial membrane becomes irritated and inflamed as a result the fluid production is increased, resulting in tenderness, warmth, and swelling in and around the joint. The earliest pathologic change seen in rheumatoid arthritis is synovitis and is more common in women than in men. Gray-scale US primarily detects synovial hypertrophy in early RA<sup>15</sup>. In established RA increased vascularity along with active inflammation is confirmed PDUS with the presence of increased power Doppler signal. Even low levels of disease activity is assessed by US.

### OSTEOARTHRITIS

Second most frequent type of arthritis. Osteoarthritis occurs when hyaline cartilage weight bearing joints breaks down and wears away<sup>16</sup>. In erosive osteoarthritis of finger joints Gray-scale ultrasound is a valid imaging technique for detecting erosions and soft tissue changes. The pain in hand osteoarthritis is shown to be associated with Power Dopplersignals<sup>17</sup>.

### PSORIATIC ARTHRITIS

It is an, inflammatory arthritis which is chronic, involves structures, like tendons or bursae with periosteal neoformations. It is associated with psoriatic lesions of the skin and/or nails, and belongs to seronegative spondyloarthropathies<sup>18</sup>. Recent studies have shown that psoriatic arthritis can cause severe joint lesions. The structural alterations in the initial stages of the disease are revealed by Ultrasonography and it identifies more osteophytes and erosions in small joints.

TABLE I  
List of OMERACT definitions for US identified pathologies

S.No	References	Year	Pathologies	Imaging technique	Ultrasound features	Detection sensitivity
1	WittoekR, Jens	2011	Synovitis	PowerDoppler/ Bmode Ultrasound	Abnormalhy poechoic intra articular tissue	86.5%
2	Dohn etal.	2006	Erosion	High frequency US	Intraarticular discontinuity of the bone surface	42%
3	Boutry N	2010	Bursuitis	Doppler Ultrasound	heterogeneous(hypo- and hyperechoic) collections	65%
4	DelleSedieet al	2011	Psoriatic arthritis	Musculoskeletal ultrasound	Increased vascularity	74.7%
5	Hayashi etal.	2011	Osteo Arthritis	Musculoskeletal ultrasound	With or minimal Doppler signal	High than CR
6	Grassi etal	2006	Crystal	Musculoskeletal	'doublecontour'	

			arthritis	ultrasound	sign Snowstorm	50%
7	Park etal	2008	Epicondylitis	Musculoskeletal ultrasound	Focal hypoechoic regions	80%
8	Hashefi	2009	Carpaltunnel syndrome	Musculoskeletal ultrasound	'notchsign' and power Doppler signals seen within the swollen nerve	82%
9	Arida etal.	2010	Vasculitis-giant cellarthritis (GCA)	Color Doppler Ultrasound	Unilateral periluminal hypo echo genic halo	68%
10	Wakefieldet al.	2004	Paediatric rheumatology	PowerDoppler Ultrasound	Sub clinical inflammatory change in the joints	80%

## CRYSTAL ARTHRITIS

The joint inflammation characterized by the presence of pyrophosphate dehydrate (CPPD) crystals in the joint cavity is crystal arthritis. Gout is the result of needle-like uric acid crystal deposits in the joints usually in the big toe. The detection is made easy by high frequency ultrasound<sup>19</sup>. US generate typical patterns based on the distribution of crystal deposition within a region. US can detect even minimal crystal deposits due to its high reflectivity.

## SEPTIC ARTHRITIS

It is caused by an intra-articular infection associated with pain and decrease in the range of motion. It is a destructive arthropathy. If unattended this leads to chronic deformity or mechanical arthritis<sup>20</sup>. Color Doppler shows increased peri-synovial vascularity, joint effusion and presence of echogenic debris.

## FIBROMYALGIA

A chronic disorder which causes pain all over the tissues that support and move the bones and joints. Fibromyalgia is characterized by tender points, sleep disturbances, and fatigue<sup>21</sup>. Tender points occur in muscles of the neck, hips, back, shoulders that hurt when pressure is applied.

## JUVENILE IDIOPATHIC ARTHRITIS (JIA)

It is the most common rheumatic disease in children that develop before the age of 16years. The synovium and periarticular tissue are inflamed at the onset of the disease which is the characteristic of JIA. It further leads to structural damage that is responsible for most disabilities in JIA<sup>22</sup>. US is highly sensitivity for detecting synovitis, cartilage and bone abnormalities.

## BURSITIS

A small fluid-filled sacs that helps in friction reduction between bones and other moving structures in joints is bursae<sup>23</sup>. Bursitis is a condition where the

bursae is inflamed and causes tenderness and pain. The movement of nearby joints is limited due to this condition.

## OBSERVATIONS

The different ultrasound findings of various abnormalities are listed out based on the references collected. Table1 shows The various clinically meaningful changes are provided with definitions by OMERACT. The Outcome Measures in Rheumatology Clinical Trials (OMERACT) is an international organization initiated in 1992 for improving the measurement outcome in rheumatology<sup>24</sup>. It standardizes and collects validated outcome measures and this helps to interpret the results from research outcomes to every day clinical evaluations.

## CONCLUSION

The ultrasound for musculoskeletal disease was clearly more sensitive for evaluating joint swelling in clinical trials than physical examination. It is a sensitive, non-invasive, reliable and readily available method complementary to standard clinical assessment. The diagnostic accuracy is greatly increased when ultrasound is added to routine rheumatological investigation. However the decision to use ultrasound for diagnosing musculoskeletal pathologies depends on the physicians' level of experience and accessibility to the modality in the hospital.

## FUTURE ADVANCES

Contrast enhanced ultrasound, fusion imaging, elastography, 3D and 4D ultrasounds are the techniques which are used in research level for the disease diagnosis. These techniques help to enhance the images of structures poorly visualized by current ultrasound systems. These techniques provide volumetric ultrasound to increase the sensitivity of power Doppler signal which may improve interobserver reliability in multicentre RA studies.

## CONFLICT OF INTEREST

Conflict of interest declared none.

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## Reviewers of this article

### **Dr.G.Harikrishnan, Ph.D**

Senior Assistant Professor, Department of  
ECE, Mandanapalle institute of  
Technology and Science, Kadiri Road,  
Angallu Village, Chittoor District,  
Madanapalle, Andhra Pradesh 517325



**Prof. Y. Prapurna Chandra Rao**

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