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REVIEW ARTICLE

Comparison Between Major Types of Arthritis Based on Diagnostic Ultrasonography

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Abstract:

Background:

Ultrasound has been widely used in clinical settings for the assessment of different types of Arthritis as well as in their management. This Review study assessed the diagnostic value of Ultrasonography in comparison with major types of Arthritis namely Osteoarthritis (OA), Rheumatoid Arthritis (RA), Gouty Arthritis (GA), Pseudogout (Calcium Pyrophosphate Deposition Disease - CPPD), Psoriatic Arthritis (PA), Infectious Arthritis (IA) and Spondyloarthritis (SA).

Methodology:

Computerized literature search of PubMed was conducted from 1990 to present, for publications in English on diagnostic ultrasonography and major types of arthritis. A total of 206 publications were identified. Experimental and clinical studies that focused on the ultrasound features of the major types of Arthritis were accepted. A total of 52 out of the 206 publications, met our search criteria. Among these, 12 studies focused on OA, 7 on RA, 7 on GA, 5 on CPPD, 10 on PA, 4 on IA, and 7 on SA. From all the studies, some distinctive US features are reviewed for each of the major arthritis. Some of the features were unique and some overlapped.

Conclusion:

Ultrasound may demonstrate the ability to differentiate between the major types of Arthritis on a basic level when combined with history and physical examination. This can prove to be beneficial in the early diagnosis of the major types of arthritis, but with few limitations. This review literature shows that Ultrasound can be very helpful in bed side analysis of the major types of arthritis as well as in differentiating between them, because this modality besides being non-invasive is also very cheap.

Keywords: Ultrasound, Arthritis, Osteoarthritis, Rheumatoid arthritis, Gout, Pseudogout, Psoriatic arthritis, Infectious arthritis, Spondylo arhritis.

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1. BACKGROUND

1.1. Introduction

In the recent clinical setting, Ultrasound (US) technology offers many advantages like multiplanar image acquisition, the ability to image real-time dynamic structures, lack of ionizing radiation, and utility in interventional procedures [1]. US is also cost-effective, non-invasive and can be used without Contrast Enhancement (CE) to visualize various tissues involved in all the major forms of arthritis [2].

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The word arthritis is derived from the Greek arthron meaning “joint” and the Latin *itis* meaning “inflammation”. Arthritis, a form of the joint disorder, involves inflammation of one or more joints. Over 100 different forms of arthritis exist [3]. Osteoarthritis (OA) or degenerative joint disease is the most common type followed by Rheumatoid Arthritis (RA), Gouty Arthritis (GA), Pseudogout or Calcium Pyrophosphate Deposition Disease (CPPD), Psoriatic Arthritis (PA), Infectious Arthritis (IA), Spondyloarthritis (SA) and other related autoimmune diseases. Arthritis can also be secondary to many other medical conditions. Undifferentiated arthritis can exist as well, which does not fit into any well-known clinical disease categories [4].

The chief complaint of most arthritic patients is joint pain. This is due to multiple factors including inflammation that occurs around the joint, damage to the joint from disease, daily

wear and tear of joint, muscle strains caused by forceful movements against stiff painful joints and fatigue [5].

Our review study focuses on the diagnostic ultrasound based comparison between the 7 major types of Arthritis namely, OA, RA, GA, CPPD, PA, IA and SA. Diagnostic US when combined with a precise history and physical examination can help us understand the disease pathogenesis. The diagnosis becomes comparatively easy as well [6].

1.2. Objective

This review study assessed the diagnostic value of ultrasonography in comparison between major types of Arthritis namely OA, RA, GA, CPPD, PA, IA and SA. Specific emphasis is placed on the strengths and weaknesses of using ultrasonography [7]. Authentic basic science and useful inter-study comparison are focused upon. Future research perspectives are also discussed.

1.3. Materials and Methods

A computerized literature search of PubMed was conducted from 1990 to present, for publications on Diagnostic ultrasonography and major types of arthritis in English. This review is based on seven different PubMed searches conducted in 2017-2018 using Boolean intersections for the following seven sets of keywords:

(1) Ultrasound features of Osteoarthritis

(2) Ultrasound in Rheumatoid Arthritis

(3) Gout and Ultrasound

(4) Calcium Pyrophosphate Deposition Disease and Ultrasound

(5) Psoriatic Arthritis and Ultrasound

(6) Ultrasonography in Infectious Arthritis

(7) Ultrasonography in Spondyloarthritis

Experimental and clinical studies that focused on the ultrasound features of the major types of arthritis were accepted. Studies that used ultrasound in combination with other modalities were accepted but their conclusions were interpreted in the context of their methodological strengths and limitations. Case studies and articles dealing with less than 10 cases were excluded. A total of 206 publications were identified in the initial search. Out of the 206 publications identified, 52 met our search criteria. The rest were excluded because either those were not retrieved or did not meet the criteria. Of these 52 publications, 12 studies focused on OA, 7 on RA, 7 on GA, 5 on CPPD, 10 on PA, 4 on IA and 7 on SA.

2. MAIN TEXT

2.1. Osteoarthritis and Usefulness of Diagnostic Ultrasonography

OA is a chronic, debilitating joint disease. Characterized by degenerative changes to the bones, cartilage, menisci, ligaments, and synovial tissue, OA most commonly affects people who are older or overweight or have any joint injury. Any joint can be affected by OA but the hips, knees, finger joints, thumb joints and lower spine are most commonly affected. Common signs and symptoms include pain, stiffness, loss of flexibility, tenderness, bone spurs or a grating sensation [8]. Diagnostic tests include imaging modalities such as X-ray, Magnetic resonance imaging (MRI), optical coherence tomography (OCT), and ultrasound (US) along with other tests such as blood studies and joint fluid analysis. Medications, physical therapies, surgeries and lifestyle modification are commonly used for management [9].

For OA diagnosis, plain X-Ray has been the standard imaging technique for many years. But, X-Ray has some limitations which include the indirect visualization of the Articular Cartilage (AC) and inability to image co-existent soft tissue pathology. On the other hand, US can reliably measure both. It principally delineates progressive changes, demonstrates synovial changes within joints and visualizes soft tissue pathology. Additionally, US can identify osteophytosis and bone erosions as well [10]. For the finest detailed imaging within the AC, Grey scale US using high frequency linear transducers are needed. Lower levels of power and gain facilitate normal imaging details of AC. Its echotexture is characteristically homogeneously anechoic or hypoechoic depending on the level of gain [11]. The main pathological features detected by US in OA are cartilage damage, joint inflammation and osteophyte formation. In the knee joint, US can depict even the minimal amount of joint effusion, which appears as anechoic but may be inhomogeneous resulting in posterior acoustic shadowing [12]. With US, the hyperechoic rim of an osteophyte will create acoustic shadowing leading to obscuration of the adjacent bone surface. It can also frequently demonstrate the presence of Baker's cysts and additionally bursitis [13]. Recently, contrast enhanced-US (CE-US) has been proposed as a novel technique aimed at quantifying synovial vascularisation. US is also helpful in guiding local procedures like joint aspiration, drug injections and biopsy which can be easily and safely performed. In addition, US allows disease process monitoring and treatment follow-up in OA [14].

2.2. Rheumatoid Arthritis and Usefulness of Diagnostic Ultrasonography

RA is an autoimmune disease commonly seen in women. This chronic, systemic inflammatory disorder principally attacks synovial joints which commonly includes the small joints of the hand, feet and cervical spine, but larger joints like the shoulder and knee can also be involved. Common signs and symptoms include tender, warm and swollen joints, morning stiffness lasting for hours, rheumatoid nodules which are firm tissues under the skin and few constitutional symptoms like fever, fatigue and weight loss. Diagnostic tests include imaging modalities such as X-rays, MRI and Ultrasound (US) along with other tests such as Rheumatoid factor blood tests and serology. Disease modifying treatment, surgery and lifestyle modification are commonly used for management [15].

In RA, MSUS applications focus on US feature identification, which would give us some predictive markers for the development of erosions. Such markers include high synovial vascularity, persistent synovitis, tenosynovitis and

erosive changes. In synovitis detection, US has been shown to be superior to clinical examination, which would suggest that US count of inflamed joints can discriminate oligoarthritis from poly-arthritis. In bone erosion detection also, US was proved to be superior that X-rays [16]. Tenosynovitis in RA is seen as a hypoechoic or anechoic thickened tissue with or without fluid within the tendon sheath and may exhibit doppler signal [17]. In the case of Bursitis because of the presence of sonolucent fluid with or without additional echogenic material inside of it, the maximum diameter of the bursa increases [18]. Presence of high grey scale score, power doppler signal and at least one erosion at the early stage of the disease have been associated with increased probability of RA [19]. So, for the evaluation of RA patients, ultrasonographic scores are also being feasibly integrated into daily practice. Current MSUS scoring systems effectively access RA synovitis activity and predict disease progression. Other application of US in RA includes treatment response monitoring and intra-articular procedures guidance [20].

2.3. Gouty Arthritis and Usefulness of Diagnostic Ultrasonography

GA characterized by deposition of needle-like monosodium uric acid crystals most commonly affects the big toe (metatarsophalangeal joint). It can also affect foot, ankles, knees, wrists, fingers and elbows. Men are more susceptible. Common sign and symptoms include joint pain, tenderness, redness and swelling. Diagnostic tests include imaging modalities, synovial fluid analysis and blood tests. Management is primarily by medical treatment and lifestyle modification [21].

In the field of Crystalline arthropathy, both gout and Calcium Pyrophosphate Deposition (CPPD) disease are significant diseases of concern [22].

Gout, being one of the most common inflammatory arthritis is characterized by cartilaginous deposits. These deposits are not readily demonstrated with X-Ray, MRI, CT or bone scintigraphy due to disadvantages like lack of specificity and inability to assess early soft tissue changes like effusions, early erosions, synovial hypertrophy and small tophi hypervascularity. In recent years, US is identified to be a promising imaging modality. In GA, US usually shows a hyperechoic, irregular band over the superficial margin of the articular cartilage of the metatarsal heads, metacarpal heads, femoral condyles and humeral head [23]. In most GA of MTP joint, hypoechoic to hyperechoic, inhomogeneous material surrounded by a small anechoic rim, representing tophaceous material is seen [24]. Tophi having a sonographic appearance of 'wet sugar clumps' is characterized by hyperechogenicity. Erosions in GA were identified as breaks in hyperechoic outline of the bony cortex. In the case of synovial hypertrophy, US shows a concentric thickening of the synovial membrane. In few cases, fluid collection can also be seen [25]. However one evident limitation of using US in GA is about the uncertainty of the duration of hyperuricemia, that must be present before crystalline precipitation occurs [26]. In spite of limitations, US is proving to be a sensitive and reliable tool for GA assessment and short-term monitoring [27].

2.4. Calcium Pyrophosphate Deposition Disease (CPPD) and Usefulness of Diagnostic Ultrasonography

CPPD or Pseudogout also known as chondrocalcinosis, is a rheumatologic disorder and is caused by the accumulation of calcium pyrophosphate dihydrate crystals in the connective tissue. It is more common in older adults and the knee joint is most commonly affected. It can be asymptomatic or may mimic gout symptoms. Diagnostic tests include imaging modalities and joint fluid analysis. Management is directed at relieving the symptoms of joint inflammation by medical treatment [28].

Pseudogout or CPPD characterized by the deposition of calcium pyrophosphate (CPP) crystals in and around joints, particularly, hyaline and fibrous cartilage, is diagnosed by detection of this crystals in the synovial fluid usually by Conventional Radiography. However, in the hands of a trained sonographer, US provides bedside, radiation-free and non-invasive assessment of patients with CPPD with a high degree of accuracy. Subclinical and radiographically invisible signs can also be disclosed [29]. In CPPD, important ultrasonographic features include a thin hyperechoic band that is parallel to the surface of the hyaline cartilage, the punctuated pattern of the fibrocartilage and soft tissue calcifications [30]. Hence, the US as an impressive imaging modality in crystalline arthropathy, can differentiate between GA and CPPD based on anatomical location and features [31].

2.5. Psoriatic Arthritis and Usefulness of Diagnostic Ultrasonography

PA, a type of inflammatory arthritis develops in 30% of patients suffering from psoriasis. It is a seronegative spondyloarthropathy and occurs more commonly in patients with tissue type HLA-B27. Pain, swelling and stiffness in one or more joints are commonly present. Diagnosis of PA is by family history, physical exam and lab tests. Management is directed at reducing and controlling inflammation by medical treatment [32].

PA, a chronic inflammatory arthritis, occurs in relation with psoriasis and is often associated with significant inflammation and joint damage. Traditionally, Plain radiographs were used to detect the extent of joint damage [33]. However, with the advent of newer imaging modalities such as ultrasound and MRI, the ability to detect joint damage is comparatively accurate and time efficient. With the increasing utilization of high frequency transducers (10 MHz or more), US provides excellent tissue resolution [34] and assesses synovial tissue, joint effusions and erosions as well. US in conjunction with Doppler can also show hyperaemia, which may be an indirect sign of inflammation. Furthermore, doppler is an important tool in analyzing tenosynovitis and more specific features of PA such as enthesitis [35]. Achilles' tendon enthesitis identified via US occurs in a comparatively higher frequency than on clinical examination in patients with psoriasis and PA. However, US findings are rendered nonspecific in PA, just like they may occur in patients with OA and RA [36]. Therefore, the correlation of US findings and histopathology is important. US might prove to be a useful tool in the assessment of dactylitis because flexor tendon

tenosynovitis and joint synovitis are the most characteristic features observed [37].

2.6. Infectious Arthritis and Usefulness of Diagnostic Ultrasonography

IA is an infection in the joint caused by bacteria, virus or fungus that spread from another part of the body. Also known as septic arthritis, it is a very serious condition that can cause irreparable damage to joints. Common signs and symptoms include intense pain in the joint, redness, swelling, fever, chills and inability to move the infected joint. IA usually affects knee, ankle or toes. Diagnosis of IA is by family history, physical exam, synovial fluid analysis and blood tests. Management is usually by intravenous antibiotics, analgesics and joint aspiration [38].

Acute IA, most commonly caused by pyogenic pathogens is a common diagnosis usually encountered by radiologists, internists, and family physicians. Early diagnosis and prompt treatment are essential for restoring joint function. Although radiologic findings show bone erosions and increase in articular space, these conventional examinations are of little utility in early diagnosis [39]. CT, scintigraphy and MRI, being expensive are not widely used. US in IA defines anatomy, detect joint effusions and correlate sonographic features with the disease aetiology [40]. Even small collections of fluid could be detected with accuracy. In IA, both hypo and hyperechoic synovial fluid was seen, but the most characteristic findings were hyperechoicity and a thickened capsule [41]. Other imaging modality usage can be minimized because US can be used not only to demonstrate effusions early in the disease but the intra-articular compartment, joint capsule, bony surface and adjacent soft tissues [42] are exhibited as well. Hence, US should be used more commonly to diagnose IA, and if the presence of a fluid collection is ruled out, no arthrotomy or drainage should be performed in the patient [43].

2.7. Spondyloarthritis and Usefulness of Diagnostic Ultrasonography

SA (or spondyloarthropathy) belongs to a family of inflammatory rheumatic diseases that cause arthritis. The most common of all is ankylosing spondylitis, which affects the spine. Spondyloarthritis differs from other types of arthritis given the fact, it involves the “entheses”, which are sites where ligaments and tendons attach to bones. Common signs and symptoms include joint pain and stiffness due to inflammation, spine deformity and poor functioning of the shoulders and hips due to bone destruction. Diagnosis of SA is by family history, physical exam, imaging modalities and blood tests. Management is through medical treatment or physical therapy [44].

SA represents a broad group of diseases involving the axial skeleton and peripheral joints. Sonographers are intrigued because it requires the evaluation of both articular and extra-articular regions. Enthesitis involving both the axial and the peripheral joints, is an important sign of SA [45]. However, Clinical diagnosis of enthesitis being neither sensitive nor specific often relies on typical abnormalities noticed in imaging studies. US, due to its cost effectivity and easy availability, is emerging as the preferred technique for detection of enthesitis. US features of enthesitis include tendon hypoechogenicity and thickening, calcifications, bone erosions, and Doppler signal. Enthesitis was characterized mainly by increased thickness and hypoechogenicity of different soft tissue structures [46]. To quantify US abnormalities, several semi-quantitative scoring systems have been developed. Besides being used for early diagnosis and classification of SA, these methods are also used for monitoring treatment response. Additionally to enthesitis, US can also visualize most of the other relevant MS pathologies that are associated with SA. These include bone erosions, synovitis, bursitis and tenosynovitis. Given the incapability of the US beam to penetrate the bony cortex, Osteitis cannot be visualized and hence is a limitation. In SA, US is able to detect early inflammatory lesions [47]. US features noticed in SA patients generally do not differ much from those observed in RA or PA. The notable difference is related to the US appearance of enthesitis. New US techniques such as elastography, contrast ultrasonography and 4D ultrasonography are currently being evaluated for their use in enthesitis. In conclusion, US is an important tool for the evaluation of peripheral involvement of SA, especially in the diagnosis and follow-up of enthesitis [48].

In all of the above mentioned 7 major types of arthritis, Ultrasound can be used in the diagnostic evaluation as well as in the management of some. US is most commonly used in RA followed by OA, GA and CPPD. PA, IA and SA are not routinely diagnosed by US. But, US can be used in all the major arthritis and would show some distinctive features in each of them. Hence, here lies the main focus of our review study to draw a comparison between the major types of arthritis based on Diagnostic US [49]. (Table **1**)., titled ‘Comparison between major types of Arthritis based on Ultrasound mediated demonstration of Features’ summarizes the Results.

3. FUTURE PERSPECTIVES

With advancing days, New US techniques are increasingly being used in clinical practice, which includes contrast enhanced US, 4D US, elastography etc. US transducers with higher frequency is increasingly coming into practice. Future studies will possibly address the diagnostic and prognostic value of high frequency US with the Doppler technique in all the major types of Arthritis. In clinical practice and research, full evidence of the efficacy of US on the diagnosis, outcome and management of all the Arthritis types would allow the wide application of this technique [50]. Further advancement in the diagnostic evaluation of the major types of arthritis would be to minutely differentiate US features in all the types of arthritis and to avoid the overlapping of few features seen till date. This can be predicted to be possible in the near future with the use of high frequency US. So more and more clinical and research studies should be carried out in order to gain maximum usefulness of US in the diagnostic evaluation of all major types of Arthritis.

Table 1. Comparison between major types of arthritis based on ultrasound mediated demonstration of features.

Names of Arthritis	Osteoarthritis	Rheumatoid Arthritis	Gouty Arthritis	Crystal Pyrophosphate Deposition Disease (Pseudogout)	Psoriatic Arthritis	Infectious Arthritis	Spondylo-Arthritis
Abbreviation	OA	RA	GA	CPPD	PA	IA	SA
Ultrasound mediated demonstration of Features	Synovial changes within joints, Soft tissue pathologies, Osteophytosis, Bony erosions, Bakers cyst's and Bursitis.	High synovial vascularity, Persistent synovitis, Tenosynovitis and Erosive changes.	Tophi, Erosions, Synovial hypertrophy and Fluid collections.	Thin band parallel to hyaline cartilage. Punctated fibrocartilage and soft tissue calcification.	Synovial tissue, joint effusions, erosions and hyperaemia.	Joint effusions.	Tendon thickening, calcifications and bony erosions.
Echotexture	Articular Cartilage (AC): Homogeneously anechoic/ hypoechoic. Joint fluid: Anechoic.	Tenosynovitis: Hypoechoic/ anechoic thickened tissue.	Tophi and Erosions: Hyperechoic.	Hyperechoic band.	Tenosynovitis: Hypoechoic/ anechoic thickened tissue. Enthesitis: Hypoechoic Tendon.	Synovial fluid: Hyperechoic. Thickened capsule.	Enthesitis: Hypoechoic Tendon.

CONCLUSION

In recent years, Musculoskeletal US (MSUS) have rapidly become one of the most important imaging modality for the Rheumatologists. Two common indications for MSUS are to assist in the clinical diagnosis of major types of arthritis and to note the degree of synovitis. All over the World, Doctors are inquisitive about the efficacy of US in imaging and in investigating the structural changes noticed in all of the major Arthritis [51].

It can be seen from this review study, that US can be used for imaging and delineating characteristic features in each of the 7 major types of Arthritis. Some of the US features overlapped and some were idiosyncratic to each [52]. Hence, in addition to a good history and physical examination, US can prove to be a cheap, bedside, accurate imaging modality in evaluating and monitoring the disease process in each type of arthritis, if performed by a trained sonographer.

Although, MRI has been considered Worldwide as the main Modality for MS pathology evaluation, High resolution US with colour Doppler, probably is the imaging method of choice for superficial MS lesions assessment. US having the advantages of easy availability, cheaper modality, real time imaging, performing interventional procedures and improved characterization of tissue and fluid, is widely used nowadays.

LIST OF ABBREVIATIONS

OA = Osteoarthritis

RA = Rheumatoid Arthritis

GA = Gouty Arthritis

CPPD = Calcium Pyrophosphate Deposition Disease

PA = Psoriatic Arthritis

IA = Infectious Arthritis

SA = Spondylo Arthritis

US = Ultrasound

AC = Articular Cartilage

CE = Contrast Enhanced

MRI = Magnetic Resonance Imaging

OCT = Optical Coherence Tomography

CE-US = Contrast Enhanced Ultrasound

MSUS = Musculoskeletal Ultrasound

MTP = Metatarsophalangeal Joint

CPP = Calcium Pyrophosphate

HLA-B27 = Human Leukocyte Antigen – B27

CONSENT FOR PUBLICATION

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CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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