

# **ROLE OF MRI AND ULTRASOUND IN THE ASSESSMENT OF RHEUMATOID ARTHRITIS IN THE HAND AND WRIST JOINTS**

**Essay**

Submitted for partial fulfillment of  
Master Degree of Radiodiagnosis

**By:**

**Mohamed Elsayed Hussein**

M.B.B.Ch  
Faculty of Medicine  
Ain Shams University

**Supervised by:**

**Prof. Dr. Mohamed Zaky Elhedek**

Professor of Radiodiagnosis  
Ain Shams University

**Dr. Amir Louis Louka**

Lecturer of Radiodiagnosis  
Ain Shams University



Faculty of Medicine  
Ain Shams University  
2016

## **ABSTRACT**

MRI and sonography can be useful tools in evaluating patients with early rheumatoid arthritis. Both imaging techniques can detect preerosive synovitis. They can also identify early bone damage before it becomes apparent on radiography. Furthermore, MRI can be used to predict future bone damage.

Rheumatoid arthritis is characterized by proliferative, hypervascularized synovitis, resulting in bone erosion, cartilage damage, joint destruction, and long-term disability. Diagnosis is based on clinical, laboratory, and radiographic findings.

## **KEYWORDS**

Rheumatoid arthritis; ultrasound; MRI; hand; wrist.

# CONTENTS

	<i>List of Abbreviations</i>	III
	<i>List of Tables</i>	IV
	<i>List of Figures</i>	V
	<i>Introduction</i>	1
	<i>Aim of the Work</i>	4
<b>Chapter 1</b>	<i>Anatomy of the Hand and Wrist Joints</i>	5
	- Gross Anatomy	5
	- Sonographic Anatomy	22
	- MRI Anatomy	42
<b>Chapter 2</b>	<i>Basic Physics of Examination Modalities</i>	50
	- Ultrasound and Doppler Physics	50
	- MRI Physics	56
<b>Chapter 3</b>	<i>Pathology of Rheumatoid Arthritis</i>	66
	- Etiology and risk factors of RA	66
	- Pathophysiology of RA	70
	- Clinical Presentation and Management of Rheumatoid Arthritis	74
<b>Chapter 4</b>	<i>Technique of Examination</i>	79
	- Ultrasound technique	79
	- MRI technique	98
<b>Chapter 5</b>	<i>Manifestations of Rheumatoid Arthritis in the Hand and Wrist by US and MRI</i>	105
	<i>Summary</i>	161
	<i>References</i>	166
	<i>Arabic Summary</i>	188

## LIST OF ABBREVIATIONS

<b>AIUM</b>	American institute of ultrasound in medicine
<b>BME</b>	Bone marrow edema
<b>CCP</b>	Cyclic citrullinated peptide
<b>CEUS</b>	Contrast enhanced ultrasound
<b>CMCJ</b>	Carpometacarpal joint
<b>DCE-MRI</b>	Dynamic contrast enhanced magnetic resonance
<b>DIP</b>	Distal interphalangeal joint
<b>DMARDs</b>	Disease modifying anti-rheumatic drugs
<b>DRUJ</b>	Distal radioulnar joint
<b>ECU</b>	Extensor carpi ulnaris
<b>EULAR</b>	European league against rheumatism
<b>FCR</b>	Flexor carpi radialis
<b>FOV</b>	Field of view
<b>IL</b>	Interleukin
<b>MCP</b>	Metacarpophalangeal joint
<b>MHz</b>	Megahertz
<b>MRI</b>	Magnetic resonance imaging
<b>MTP</b>	Metatarsophalangeal joint
<b>OMERACT</b>	Outcome measures in rheumatoid arthritis clinical trials
<b>PDUS</b>	Power Doppler ultrasound
<b>PIP</b>	Proximal interphalangeal joint
<b>RA</b>	Rheumatoid arthritis
<b>RAMRIS</b>	Rheumatoid arthritis magnetic resonance imaging score
<b>RF</b>	Rheumatoid factor
<b>RUL</b>	Radioulnar ligament
<b>SH</b>	Synovial hypertrophy
<b>STIR</b>	Short-T1 Inversion Recovery
<b>TFCC</b>	Triangular fibrocartilage complex
<b>TNF</b>	Tumor necrosis factor
<b>TUI</b>	Targeted Ultrasound Initiative
<b>UCL</b>	Ulnocarpal ligament
<b>US</b>	Ultrasound

## LIST OF TABLES

<b>Table no.</b>	<b>Title</b>	<b>Page no.</b>
1.1	Normal sonographic appearance of different musculoskeletal structures	22
2.1	Image contrast as a function of TR and TE	64
2.2	Signal intensities of different tissues on T1- and T2-weighted images	65
4.1	Ultrasound examination of the Wrist	82
4.2	Ultrasound examination of the Hand	89
4.3	Routine wrist MRI protocol	98
4.4	3-T MRI Protocol for Evaluating the Wrist	99
5.1	Most commonly used ultrasound scoring systems at joint level.	109
5.2	Semi-quantitative scale for grading of proliferate synovitis	110
5.3	Agreement of EULAR-OMERACT PDUS composite scoring system	112
5.4	Pictorial reference of the ultrasound (US) scoring system for semi quantitative assessment of the cartilage damage at metacarpal head level	125
5.5	The OMERACT MRI joint space narrowing (JSN) scoring system	152
5.6	Comparison between US and MRI in RA	157

## LIST OF FIGURES

<b>Figure No.</b>	<b>Title</b>	<b>Page No.</b>
1.1	Bones and joints of the hand	7
1.2	The wrist and collateral ligaments	10
1.3	Anatomy of the volar plate at proximal interphalangeal joint	12
1.4	Extensor tendons and its sheaths	14
1.5	Joints and ligaments of the left hand	16
1.6	The pulley system of flexor tendons	17
1.7	Anatomy of the distal radioulnar joint and triangular fibrocartilage complex	19
1.8	Illustration of proximal carpal tunnel and corresponding ultrasound image	24
1.9	Illustration of distal carpal tunnel and corresponding ultrasound image	25
1.10	Axial scan of ulnar nerve between ulnar artery and pisiform	26
1.11	Extensor compartment short axis scan on the sides of Lister tubercle	27
1.12	Extensor compartment short axis scan on the ulnar side of the wrist	28
1.13	Illustration and corresponding ultrasound image showing Axial scan of distal radio-ulnar joint	29
1.14	Surface and radiographic anatomy of anatomical snuffbox, radial aspect of the wrist	30
1.15	Surface and radiographic anatomy of thumb carpometacarpal joint (Longitudinal scan)	31
1.16	Surface and radiographic anatomy of	32

	central palm (Transverse scan)	
1.17	Surface and radiographic anatomy of hypothenar eminence (Transverse scan)	33
1.18	Surface and radiographic anatomy of thenar eminence (Transverse scan)	34
1.19	Illustration of flexor digitorum tendons	36
1.20	Ultrasound scan of the hand palm (short axis).	37
1.21	Structures at the level of metacarpal heads - palmar aspect of the hand (long axis).	38
1.22	Structures at the level of proximal and distal interphalangeal joints (long axis).	39
1.23	Extensor tendons at metacarpophalangeal joints (long axis).	40
1.24	Extensor tendons at proximal and distal interphalangeal joints (long axis).	41
1.25	MRI wrist, axial section (1)	42
1.26	MRI wrist, axial section (2)	43
1.27	MRI wrist, axial section (3)	44
1.28	MRI hand, axial section (1)	45
1.29	MRI hand, axial section (2)	46
1.30	Coronal MRI images with cadaveric correlation	47- 48
1.31	MRI hand and fingers , sagittal section	49
2.1	Longitudinal magnetization	60
3.1	Pathogenesis of rheumatoid arthritis.	66
3.2	Illustration of a normal joint and rheumatoid arthritis joint.	71
3.3	Histological appearance of RA synovium	72
3.4	Pathogenesis of rheumatoid arthritis	73
3.5	Joints commonly involved in rheumatoid arthritis	75
3.6	Hand deformities in rheumatoid arthritis	76
4.1	Head first and prone patient positioning for a dedicated, multichannel wrist coil	101
4.2	Feet first and supine patient positioning for a dedicated multichannel wrist coil	102

4.3	Head first and prone patient positioning for a dual loop coil (TMJ coil) and knee coil	102
5.1	Longitudinal palmar scan of metacarpophalangeal joint: grayscale ultrasound	115
5.2	Longitudinal dorsal scan of metacarpophalangeal joint: grayscale and power Doppler ultrasound	115
5.3	Longitudinal dorsal scan of metacarpophalangeal joint: grayscale and power Doppler ultrasound.	116
5.4	Longitudinal dorsal scan of four metacarpophalangeal joints with different grade of synovitis.	116
5.5	Marginal erosion in an RA patient	119
5.6	An ultrasound normal aspect of extensor carpiulnaris in a transverse scan	122
5.7	Ultrasound longitudinal scan of extensor carpiulnaris with minimal tenosynovitis	123
5.8	ultrasound longitudinal scan of extensor ulnaris carpi with severe tenosynovitis	123
5.9	MRI of the wrist of a patient with clinically active early rheumatoid arthritis	138
5.10	MRIs and X-ray of the hand and wrist of patient with rheumatoid arthritis with ulnar deviation and luxation of the metacarpophalangeal joints	139
5.11	Dynamic contrast-enhanced MRI of wrist and 2nd–5th metacarpophalangeal joints of a patient with early rheumatoid arthritis	140
5.12	Enhancement curves from a series of DCE-MRI images of a patient with RA	142



---

## INTRODUCTION

---

Recent advances in imaging technology are dramatically changing the approach to patients with inflammatory arthritis. Conventional radiography is still the major imaging modality used to evaluate patients with rheumatoid arthritis (RA) in daily clinical practice, but an ever-growing number of rheumatologists are integrating the radiographic findings with those obtainable using ultrasound (US) and MRI (**Colebatch et al, 2013**).

In daily clinical practice, four main imaging techniques are used to explore bone and joint involvement in RA: conventional radiography, computed tomography (CT), US and MRI. Other techniques such as nuclear medicine imaging, peripheral quantitative computed tomography (pQCT), digital X-ray radiogrammetry and dual X-ray absorptiometry have limited indications and are less frequently used to image RA patients. Conventional radiography and CT offer information mainly on the bone damage, while US and MRI provide a detailed evaluation of soft tissues, as well (**Grassi et al, 2016**).

Early diagnosis and personalized treatment is the cornerstone of an effective strategy aimed at inducing clinical

remission and preventing irreversible anatomical damage. Imaging is crucial for fulfilling these tasks. Both US and MRI allow for a careful confirmation of the clinical suspicion of RA by revealing even minimal pathologic changes indicative of soft tissue inflammatory involvement and/or joint damage **(Schmidt et al, 2013)**.

Ultrasound has been demonstrated to be superior to clinical examination in detecting synovitis because of its capability to identify otherwise undetectable fine, soft tissue changes. The main advantages of US, with respect to other imaging techniques, include absence of radiation, good visualization of the joint cavity, low running costs, multiplanar imaging capability, quantifications of soft-tissue abnormalities and real-time imaging. Moreover, it is rapidly performed and readily accepted by patients and may be used to assist needle positioning within the selected target area and facilitate joint aspiration, biopsy and local injections. In RA patients, US can detect a core set of basic findings which indicate either the disease activity or its severity, these include: joint cavity, tendon sheath and bursal enlargement (due to an abnormal amount of synovial fluid and/or synovial hypertrophy), Doppler signal, cartilage damage, tendon tear and bone erosion. A variable combination of these basic findings may be

detected, giving reason for the wide range of pathological changes detectable even in a single RA patient. Each of these findings can be graded using different scoring systems and data obtained in different anatomic sites can be added together to gather information at patient level **(Grassi et al, 2012) and (Hammer et al, 2010)**.

MRI plays an important role in RA, providing diagnostic and prognostic information. MRI can visualize both the inflammation and the structural damage in RA patients. MRI findings include synovitis, tenosynovitis, bone edema/osteitis, enthesitis, bone erosion and cartilage damage. One of the major advantages of MRI compared to other techniques is the ability to assess bone edema/osteitis, which is visualized only by MRI **(Grassi et al, 2016)**.

This review will summarize the options, uses and optimization of these imaging modalities with a special focus on US which is currently the most promising tool to change the paradigms in both early diagnosis and therapy monitoring of RA.

---

## **AIM OF THE WORK**

---

The aim of this work is to discuss and compare the role of ultrasound and MRI of the hand and wrist joints in early diagnosis, follow-up and detection of response to treatment in rheumatoid arthritis.

## **( I ) GROSS ANATOMY**

The anatomic linkage between the distal forearm and the hand is composed of 15 bones: 8 carpal bones, the distal radius and ulnar, and the bases of the 5 metacarpals (**Phillips, 2013**).

### **BONES**

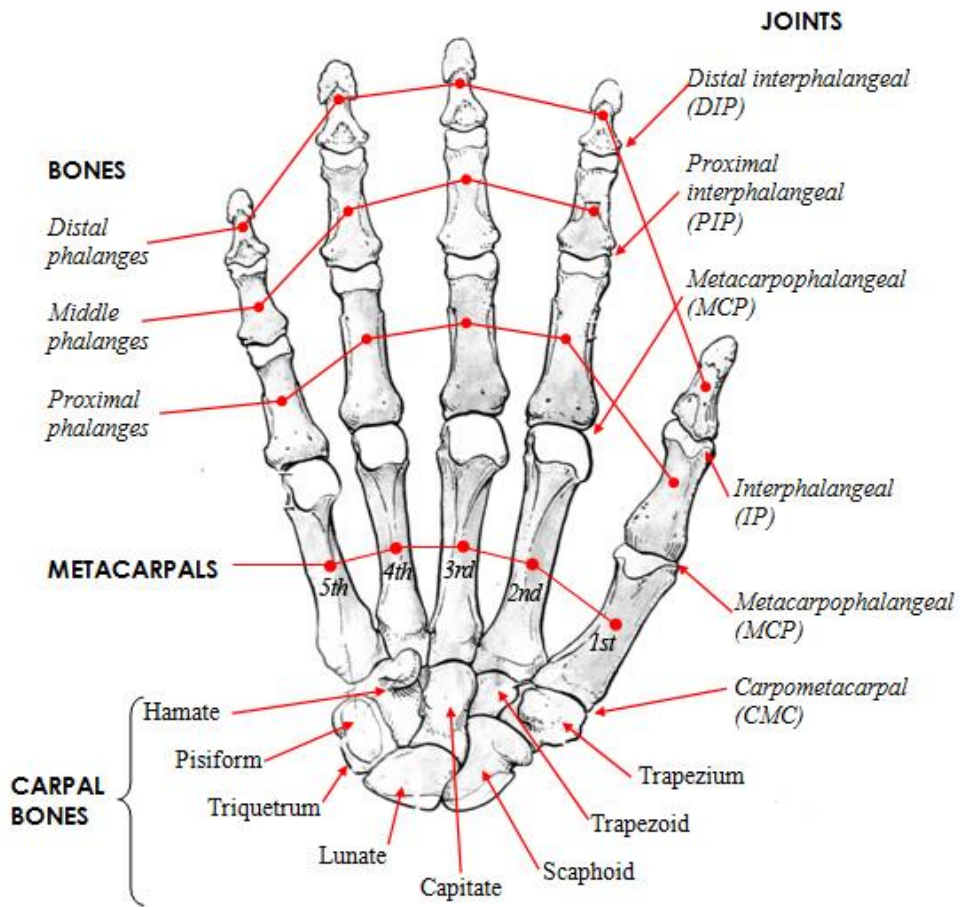
The carpal bones are divided into two rows: proximal and distal. The proximal carpal row is composed of the scaphoid, lunate, triquetrum, and pisiform. The distal carpal row is comprised of the trapezium, trapezoid, capitate, and hamate (**Boggess, 2014**).

All carpal bones participate in wrist function except for the pisiform, which is a sesamoid bone through which the flexor carpi ulnaris tendon passes. The scaphoid serves as link between each row; Therefore, it is vulnerable to fractures. The distal row of carpal bones is strongly attached to the base of the second and third metacarpals, forming a fixed unit. All other structures (mobile units) move in relation to this stable

unit. The flexor retinaculum, which attaches to the pisiform and hook of hamate ulnarly and to the scaphoid and trapezium radially, forms the roof of the carpal tunnel (**Wilhelmi, 2013**).

The hand contains 5 metacarpal bones. Each metacarpal is characterized as having a base, a shaft, a neck, and a head. The first metacarpal bone (thumb) is the shortest and most mobile. It articulates proximally with the trapezium. The other 4 metacarpals articulate with the trapezoid, capitate, and hamate at the base. Each metacarpal head articulates distally with the proximal phalanges of each digit (**Wilhelmi, 2013**).

There are 14 phalanges, three in each finger and two in the thumb. Each has a head, shaft and proximal base. The shaft tapers distally, its dorsal surface transversely convex. The palmar surface is transversely flat but gently concave anteriorly in its long axis (**Standring, 2015**).



**Figure 1.1:** Bones and joints of the hand.

Source: [www.davidlnelson.md](http://www.davidlnelson.md)

## JOINTS

The anatomy of wrist, thumb and hand is complex because of the presence of many different functional joints: the distal radioulnar joint, the wrist joint (containing the radiocarpal and the intercarpal joints, the carpometacarpal