

## Role of Ultrasonography and Power Doppler of Wrist and Hand Joints in Diagnosis of Early Symptomatic Cases of Rheumatoid Arthritis

Ahmed Okasha<sup>a</sup>, Hend Nabil Mahmoud<sup>a</sup>, Waleed Nashaat Abdellah<sup>a\*</sup>

<sup>a</sup>Department of Diagnostic Radiology, Faculty of Medicine, South Valley University, Qena, Egypt.

### ABSTRACT

**Background:** Rheumatoid arthritis disease is a chronic inflammatory disease, characterized by development of synovitis, which damages cartilage, bone, ligaments and tendons. High resolution ultrasound has become an established imaging technique for the diagnosis and follow-up of patients with rheumatoid arthritis

**Objective:** The study was conducted on early symptomatic cases of Rheumatoid Arthritis that referred to Radiology out clinic in Qena General Hospital, to evaluate the role of gray scale ultrasound and power Doppler in the diagnosis.

**Patients and methods:** The total number was 30 patients, 25 females and 5 males suffering from rheumatoid arthritis. Patients examined by GE LOGIQ P5 ultrasound machine using a near focused linear array transducer with color Doppler and by Plain X ray radiographs.

**Results:** Results showed the following: Synovial thickening was detected in 22 patients (73%), active synovitis was detected by Doppler US in 13 patients (43%),

Effusion was detected in 15 patients (50 %), and Bone erosions were detected in 5 patients (17%) and X-ray finding was detected in 4 patients (13 %).

**Conclusion:** HRUS with PD is an efficient technique to assessment of (RA) patient and evaluation of vascularity, differentiate between inactive and active synovial hypertrophy and has the potential role in diagnosis, assessment and follow up of the patients with RA therapy.

**Keywords:** Rheumatoid arthritis, High resolution ultrasonography, power Doppler.

### Introduction:

Rheumatoid arthritis prevalence of approximately 1% of population. This disorder occurs three times in female than male and has a peak onset of age between 40 to 60 years old. Although the disease affects many joints of the body, hand and foot joints are the most common affected joints (Khurana and Berney, 2005).

Radiography imaging of the wrist and the hand joints has been classically used for diagnostic purposes of patients with rheumatoid arthritis. According to the international recommendations of the American College of Rheumatology and the European League Against Rheumatism (Anastasios et al., 2008).

Musculoskeletal ultrasonography and power Doppler imaging technique has a very significant role in the diagnosis of rheumatoid arthritis in a diseased patient. It could be used for the evaluation

and follow up of the multiple items of the intra-articular inflammatory process. Occurred within the joint (Joseph and Habib, 2004).

Synovitis commonly affects hand small joints, the wrist, the metacarpophalangeal, and the proximal interphalangeal joints. We think that (HRUS) and Power Doppler can help for detection and monitoring of synovitis with "hands and wrist" protocol (Guillemin et al., 2005).

Rapid technological improvements resulted in more precise, qualified, and higher resolution machines and made the assessment of early signs of rheumatoid arthritis in a patient and the early bone changes possible (McInnes and Schett, 2011).

Early and urgent need of protective therapies for the patients with (RA) makes the early di-

agnosis and assessment of the disease more valuable (Ospelt and Gay, 2012).

The Early Detection and clear classifications of the inflammation and the bone damage are important in clinical decision making. There is more proofs that ultrasound could detects the early synovitis. Ultrasound has the ability of rapid assessment of joints. The use of power Doppler technique helps the early detection of the neo-vascularization within the synovial lining of joints and tendons that is not available with other imaging techniques (Pratt *et al.*, 2009).

Hyperemia and the angiogenesis is one of the earliest detectable pathologic changes at the beginning of the joint inflammation (Khurana and Berney, 2005). Both of these processes result in an increased intra-articular perfusion at the micro vascular level that can be visualized by Power Doppler ultrasonography (Sabeh *et al.*, 2010).

Intra articular hyperemia is an indicator of the active type inflammation, (PDUS) is a useful imaging method to detect and determine early arthritis and to assess and monitor the arthritic activity during the (RA) disease (Schett and Teitelbaum, 2009).

#### **Aim of the work**

The study was carried out to investigate patients recently diagnosed as rheumatoid arthritis from Rheumatology out clinic, Qena General Hospital over the period from August 2018 to August 2019, to evaluate the role of HRUS and PD in the assessment of wrist and hand joints of early symptomatic RA patients.

#### **Patients and Methods**

This study was conducted on 30 patients recently diagnosed as Rheumatoid Arthritis patients, from Rheumatology out clinic, Qena General Hospital during the period from August 2018 and August 2019, the selection was according to the inclusion criteria

**Inclusion criteria:** Age: 30-60 years, sex: both, patients complaining of early symptoms of rheumatoid arthritis and patient consent

**Exclusion criteria:** Age below 30 and above 60years, history of hand or wrist surgery or trauma or other bone diseases and Patient di-

agnosed as rheumatoid arthritis before 2 years  
Patient disagreement

#### **Methodology:**

**1. Personal history:** including name, age, gender and occupation.

**2. History of the present condition:** including onset of the disease, the duration before presentation, coarse and history of trauma (type and mechanism).

**3. Past history:** including any upper extremity trauma or Surgery.

**Clinical examination:** including Examination of hand and wrist joint

**Laboratory tests:** Including Serum, (RF) Rheumatoid Factor, C reactive protein, Serum creatinine

#### **Imaging investigations:**

**Conventional Radiography image:** Plain X ray radiographs for both hands joints including wrists were taken

**Ultrasonography (US):** patients were examined by using (GE.LOGIQ P5) ultrasound machine using the near focused linear array transducer with a center frequency of 7.5-12 MHz It was equipped by color/power Doppler. The collected data will be subjected to descriptive and discriminate analysis.

#### **Statistical analysis:**

IBM SPSS-22 program (Inc., Chicago, IL, USA) has been used to perform statistical analysis. Data have been examined for normal distribution via the Shapiro Walk testing. Qualitative data have been presented as frequency and relative percentage. .

#### **Ethical Considerations:**

The current study has been approved by the Ethics Committee of Faculty of Medicine, South Valley University, and Qena, Egypt.

#### **Results**

Site of Paragraph recommended to be deleted by reviewers

Out of 30 PT, the patients of the total study, 22 PT (73%) using (HRUS) scanning showed the synovial thickening, while (8) patients (27%) had no synovial thickening, (14) patients were (grade1) thickening, (8) patients (grade-2) thickening and (0) patients of (grade-3) thickening. **Table (1)**

Out of (22) patients that showing synovial thickening, only (12) patients (55%) showed

hyper-vascularity by the power Doppler, while (10) patients (45%) did not show vascularity.

**Table (2)**

Using (US), Erosions depicted in (5) patients (23%) out of (22) patients, while (17) patients (77%) did not show erosions. Joint effusion in (13) patients (59%), while (9) patients (41%) showed no effusion. X-ray finding was depicted in (4) patients (18%) while (18) PT (82%) no X-ray finding. **Table (3)**.

By using US, Effusion was depicted in (16) patients (53%) of total study (30) patient and non-effusion in (14) patients (47%). From (16) patients those having effusion. There were (13) patient associated with Synovial thickening (81%) and (3) patient (19%) without synovial thickening, hyper-vascularity was noted in (10) patients (63%) by US while( 6) patients (37%) out of (16) did not show hyper-vascularity,(5) patients(31%) showed bone erosions while(11) patients(69%) had no bone erosions, (4) patients (25%) were associated with X-ray finding. While (12) patient 75% without X-ray finding. **Table (4)**

Hyper-vascularity was detected in (13) patients (43%) of the (30) while (17) patients did not show hyper-vascularity (57%). The vascularity of the (30) patients was distributed as follows: **Grade 0:** (17) patients (57 %), **Grade1** :( 9 ) patients (30 %), **Grade 2:** (4) patients (13%) and **Grade 3:** (0) patients(00%)

Out of (13) patients with hyper-vascularity by PDUS (12) patient (92%) showed Synovial thickening by HRUS and (1) patient (8%) was negative Hyper-vascularity was associated with bone erosions in (5) patients (38%) and (8) of patient (62%) without bone erosion. Effusion was detected in (10) patients (77%) out of (13) with hyper vascularity and no effusion in (3) patients (23%). (3) PT shows X-ray finding (23%) And (10) patient (77%) show no x-ray finding. **Diagram (1)**

Erosions could be depicted in (5) patients out of (30) patients (17%) and remaining (25) patients not have erosion (83%). All The above (5) patients that showing erosions were seen to be associated with Synovial thickening by HRUS (100%).and There was an association between the erosions which is detected by us and hyper-vascularity by PDUS in (5) patients (100%).

Out of (5) patients with bone erosions all showed joint effusion (100%) one patients with bone erosion showed X-ray finding (20%). And (4) PT without x ray finding. **Diagram (2)**

Out of (30) patients X-ray finding was found in (4) patients (13%) and no finding in 26 PT (87%) **Diagram (3)**.Out of (4) patients with x-ray finding by US (4) patient (100%).Showed synovial thickening Out of (4) patients with X-ray finding by ultrasound (3) patients (75%). showed hyper-vascularity by PDUS Out of (4) patients with X-ray finding by US (1) patients (25%) showed bone erosions Out of (4) PT. with X-ray finding by US (4) patients showed joint effusion (100%). **Diagram (4)**.

**Table (1): HRUS detected Synovial thickening.**

| Synovial thickening | No of patients out of 30 | %  |
|---------------------|--------------------------|----|
| Grade 1             | 14                       | 46 |
| Grade 2             | 8                        | 27 |
| Grade 3             | 0                        | 0  |

**Table (2) Correlation between synovial thickening and hyper vascularity**

| Synovitis | No of patients out of 22 | %  |
|-----------|--------------------------|----|
| (H.V)     | 12                       | 55 |
| No (H.V)  | 10                       | 45 |

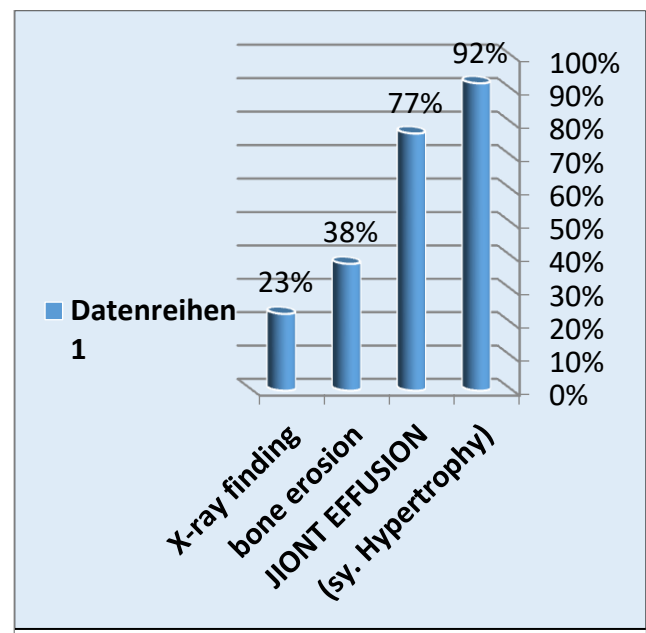
**Table (3): Correlation between synovial thickening and other findings**

| Patient with Synovial thickening | Out of 22 patient Having Synovial thickening | %  |
|----------------------------------|--|----|
| Bone erosions                    | 5  | 23 |
| No bone erosions                 | 17   | 77 |
| Effusion                         | 13   | 59 |
| No effusion                      | 9  | 41 |
| X-Ray finding                    | 4  | 18 |
| No x-ray finding                 | 18   | 82 |

|                       |    |    |
|-----------------------|----|----|
| No hyper-vascularity  | 6  | 37 |
| PT with bone erosion  | 5  | 31 |
| No bone erosion       | 11 | 69 |
| PT with X-ray finding | 4  | 25 |
| No X-ray finding      | 12 | 75 |

**Table (4): Correlation between joint effusion and the other Ultrasonography findings**

| Patient with Effusion       | Out of 16 PT have joint effusion | %  |
|-----------------------------|----------------------------------|----|
| PT with Synovial thickening | 13                               | 81 |
| No thickening               | 3                                | 19 |
| PT with hyper-vascularity   | 10                               | 63 |



**Fig.1. illustrate Correlation between hyper vascularity and other US and clinical findings.**

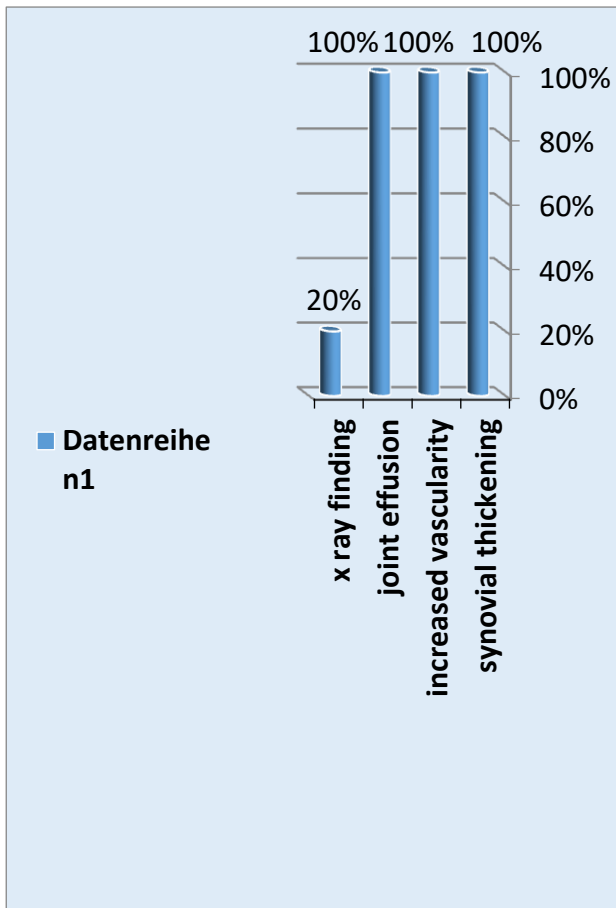


Fig.2 illustrate Correlation between Bone erosions and other US and clinical findings

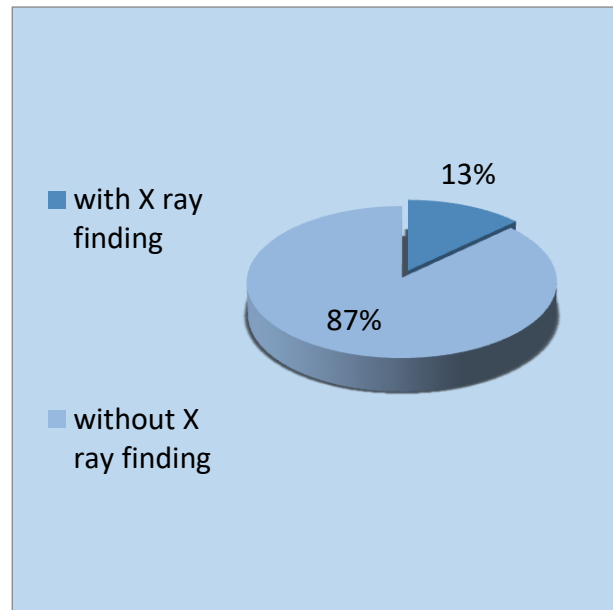


Fig.3. Percentage of PT with X-ray finding to those without.

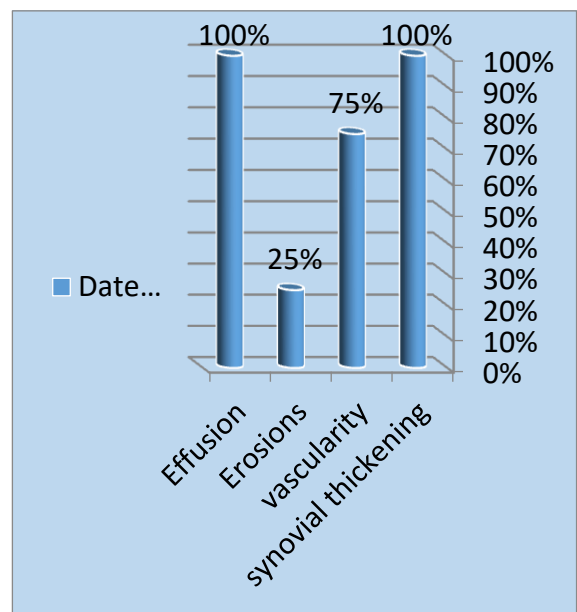


Fig.4. Correlation between X-ray finding and finding detected by US

Table (5): illustrating total ultrasonographic finding and x ray finding in 30 patients.

| Patients<br>P No. | S.T<br>0=No S.T<br>1=Mild S.T<br>2=Moderate S.T<br>3=Severe S.T | J. Effusion<br>0=NO Effusion<br>1=With Effusion | Vascularity<br>0=NO<br>1=Mild<br>2=Moderate<br>3=Severe | B. Erosion<br>0=NO Bone Erosion<br>1=With Bone Erosion | X-ray<br>0=NO finding<br>1=With finding |
|-------------------|---|---|---|--|---|
| P1                | 2   | 1   | 1   | 0  | 1                                       |
| p2                | 2   | 1   | 2   | 1  | 0                                       |
| p3                | 1   | 0   | 0   | 0  | 0                                       |

|     |   |   |   |   |   |
|-----|---|---|---|---|---|
| p4  | 2 | 1 | 0 | 0 | 1 |
| p5  | 0 | 0 | 0 | 0 | 0 |
| p6  | 1 | 1 | 0 | 0 | 0 |
| p7  | 1 | 0 | 1 | 0 | 0 |
| p8  | 0 | 0 | 0 | 0 | 0 |
| p9  | 0 | 0 | 0 | 0 | 0 |
| p10 | 0 | 0 | 0 | 0 | 0 |
| p11 | 1 | 1 | 1 | 1 | 0 |
| p12 | 0 | 0 | 0 | 0 | 0 |
| p13 | 2 | 1 | 2 | 1 | 1 |
| p14 | 1 | 1 | 0 | 0 | 0 |
| p15 | 1 | 0 | 0 | 0 | 0 |
| p16 | 0 | 1 | 0 | 0 | 0 |
| p17 | 1 | 0 | 0 | 0 | 0 |
| p18 | 0 | 1 | 2 | 0 | 0 |
| p19 | 2 | 1 | 1 | 1 | 0 |
| p20 | 1 | 0 | 0 | 0 | 0 |
| p21 | 1 | 1 | 1 | 0 | 0 |
| p22 | 2 | 1 | 2 | 1 | 0 |
| p23 | 1 | 0 | 0 | 0 | 0 |
| p24 | 2 | 1 | 1 | 0 | 0 |
| p25 | 2 | 1 | 1 | 0 | 1 |
| p26 | 1 | 1 | 0 | 0 | 0 |
| p27 | 0 | 1 | 0 | 0 | 0 |
| p28 | 1 | 0 | 0 | 0 | 0 |
| p29 | 1 | 0 | 1 | 0 | 0 |
| p30 | 1 | 0 | 1 | 0 | 0 |

## Discussion

Radiography images of the hand and wrist joint is traditionally used for the clinical assessment of patients with rheumatoid arthritis (RA). According to the recommendations of the American college of Rheumatology and the European league against Rheumatism, radiography remains the standard method for the diagnosis and follow-up of patients with RA (**Takahashi et al., 1998**).

This study was performed to assess the role of Ultrasonography and power Doppler in detection of early inflammatory changes in rheumatoid arthritis patients, and to differentiate the active from non active synovitis. With the assessment of five diagnostic finding including synovial hypertrophy, intra articular joint effusion, any destructive lesions bone erosion and finally detection of the increase in vascularity

that may accompanied to the process of the inflammation.

The study was conducted on thirty patients recently diagnosed as Rheumatoid Arthritis, from Rheumatology out clinic Qena General Hospital during the period from August 2018 to August 2019.

The results of the present study showed that by using US, synovial thickening was detected in (22) patients (73%). Hyper-vascularity was detected by using Doppler ultrasonography in(13) patients (59%) .Effusion was detected in (13) patients (59%). Bone erosions were detected in (5) patients (23%) .X-ray finding was detected in (4) patients (13%).

Results reveal that synovial thickening have been detected in 22 patients (73%), this is coincides with result (**Botar-JID et al., 2010**), who

performed a study on (34) patients with rheumatoid arthritis to evaluate the role of gray scale and power Doppler ultrasonography in assessing early rheumatoid arthritis. He detected synovitis in (73%) of his patients.

Also that results are near the result of (**Scirè et al., 2009**) whose study was about the usefulness of a systematic musculoskeletal ultrasonography indices of grey scale (GS) and power Doppler (PD) in assessment of (106) patients with early RA. (75%) of the patients showed residual GS synovitis.

Results do not coincide with (**Mendonca et al., 2011**) who detected synovial thickening by GSUS in (66.6%) of the examined patients. This difference is because current study was conducted mainly upon patients with early RA. Results of the current study show that hyper-vascularity have been detected by using Power Doppler US in (13) patients (59%), this coincides with (**Scirè et al., 2009**). Whose studies the (106) patients with early RA showed positive PD signal in (59%) of the examined patients. Also the results are near the results of (**Weidekamm et al., 2003**), who detected hyper-vascularity in (54%) of the examined small joints on PDUS.

The results do not coincide with the work of (**Szkudlarek et al., 2006**), who observed that hyper-vascularity by the aid of power Doppler ultrasonography (PDUS) in (28.7%) of the examined small joints. These variations in hyper-vascularity could be attributed to US machine used in examination, which is more advanced equipment and highly sensitive to PD signal than the US used in that study. In addition, in this study, effusion was detected in 13 out of 30 patients (59%). These results do not coincide with the work of (**Botar-JID et al., 2010**) who detected effusion in 5 of (34) patients (14.7%). This difference may be due to the difference in data reported or because this study was conducted mainly upon the patients with early Rheumatoid Arthritis. Concerning bony erosions, the current results reveal that bone erosions were detected in five patients out of thirty (23%) and we found the hyper-vascularity was more common in those having erosion (67%) vs. (29.1%).

This result agrees with (**Pratt et al., 2009**) who concluded, that serial Power Doppler ultrasonography assessed synovitis was greater in patients who developed erosions than in those who did not. This did not coincide with the work of (**Botar-JID et al., 2010**) who detected erosions in (30) out of (34) patients (8.8%) of the examined patients.

The study of (**Scheel et al., 2006**) who studied 16 patients with RA, the number of erosions and the presence of synovitis were determined for each joint and graded as either normal (0) or abnormal (1). They demonstrated that US had detected erosions in (9%) of patients they explained the small number of erosions detected by US, by possibly the significantly low resolution of US device and the need to use an acoustic standoff pad, raising the possibility that some erosions might have been missed.

On the other hand results of this study agree with those of (**Wakefield et al., 2000**) who studied 100 RA patients and reported that US is a reliable technique for detection of erosions especially in the early RA patients, this also agrees with the results reported by (**Qvistgaard et al., 2001**), however (**Backhaus et al., 2001**) had reported that difficulties result from small erosions especially of the PIPs. Such erosions are difficult to differentiate from the normal irregularities of the small finger joints. They stated that US did not show to be a sensitive method for depicting bone lesions in contrast to (**Scheel et al., 2006**) who had found more frequent and distinct affection of PIP compared with MCP joints by US than by CR and MRI.

Finally, in this study, with X-ray findings were detected in 4 patients (13%), and these results are matching with (**Naredo et al., 2015**) who reported that ultrasonography exhibited high specificities in detecting bone erosions in MCP joints in RA, even in radiographically non-eroded joints, and that radiography had markedly lower sensitivity for bone erosions than US.

#### Case No. (1)

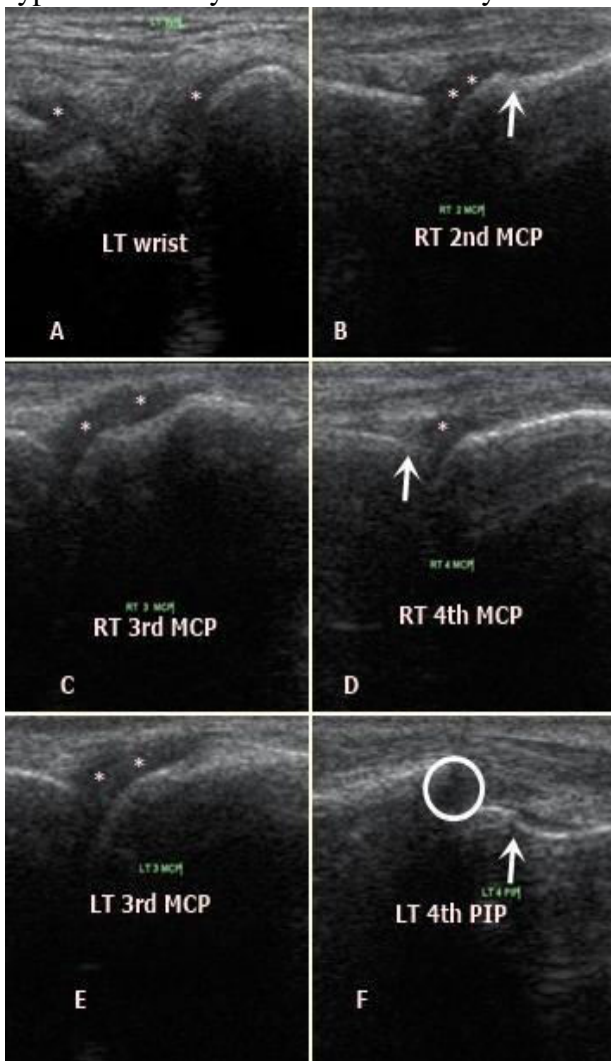
##### Present history:

Female patient 38 years old diagnosed as rheumatoid arthritis patient since 5 months. Complains of left wrist joint pain with

swelling of both wrists & hands associated with the left elbow joint pain.

**Ultrasonography Findings:**

Moderate synovial thickening at the right second, third, fourth and the fifth MCP joints. Left wrist, the first, second, third, fourth and fifth MCP joints and left fourth PIP joint. Mild bone erosion and intra-articular effusion is noted, no hyper-vascularity could be detected by PD



**Fig.5.** US images show Synovial Thickening & bone erosion \* = Thickening .arrow = Bone erosion circle =Effusion

**Case N (2)**

**Present history:**

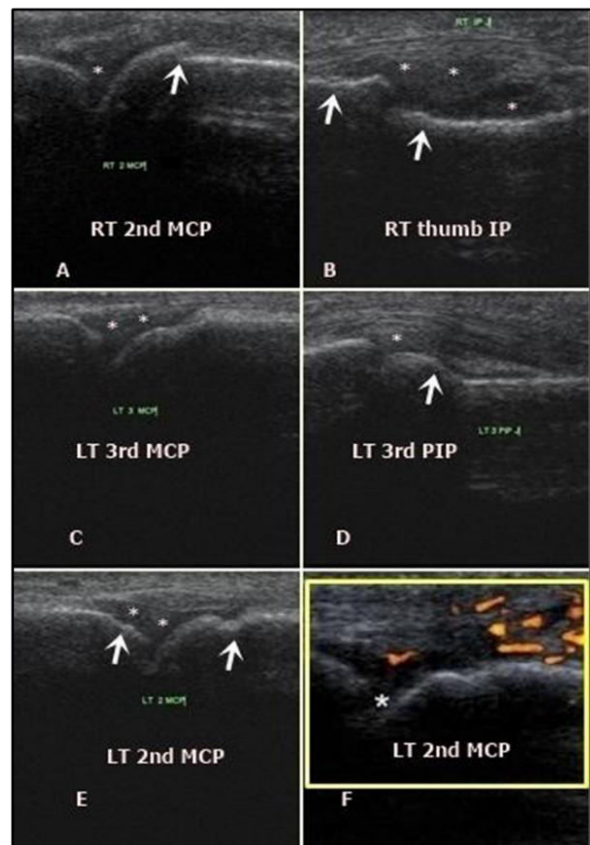
45 years old male patient have been diagnosed as Rheumatoid arthritis since 6 months. He was suffering from morning stiffness and bilateral painful swelling of wrist and fingers.

**Ultrasonography Findings:**

Mild to Moderate synovial thickening with minimal bone erosions of the thumb, Second metacarpophalangeal joints and interphalangeal Joint, Left second, third metacarpophalangeal joint and third proximal inter-phalangeal Joint PD showed increased vascularity.

**Conclusion**

HRUS And PD is a reliable technique for Assessment of both soft tissue, bone, and for evaluation of destructive joint changes occurs in early stage in rheumatoid arthritis, synovial hypertrophy and effusion. PD is an efficient and accurate diagnostic tool to differentiate between inactive and active Synovial hypertrophy. Ultrasonography has the potential role to become an essential tool for diagnosis, baseline assessment and follow up of the patient with RA therapy.



**Fig 6(A -E)** Ultrasonography images showing the intra-articular synovial thickening and Bone Erosion.(\*)=synovial thickening. Arrow =the bone erosion. (F) Power Doppler image show hyper vascularity



## References

- **Anastasios M, Gleeson R, Jorge V, Moh-eb M, George E O Jr , John V (2008).** Radio carpal Dislocations Review of the Literature with Case Presentations and proposed Treatment Algorithm. *Orthopedics*, 31(4): 386 -392.
- **Backhaus M, Burmester G R, Gerber T,Grassi W, Machold K P, Swen W A, et al. (2001).** Guidelines for musculoskeletal Ultrasound in rheumatology. *Annals Rheumatic Disease*, 60(7): 641-649.
- **Botar-JID C, Bolboaca S, Fodor D, Bocsa C, Tamas MM, Micu M, et al. (2010).** Gray scale and Power Doppler ultrasonography in evaluation of early rheumatoid arthritis. *Medical Ultrasonography*, 12(4): 300-305.
- **Guillemin F, Saraux A, Guggenbuhl P, Roux CH, Fardellone P ,Bihan E Le , et al .(2005).** Prevalence of rheumatoid arthritis in France 2001. *Annals Rheumatic Diseases*, 64(10):1427-1430.
- **Joseph S Yu, Habib PA. (2004).**Normal MR imaging anatomy of the wrist and hands. *Magnetic Resonance Imaging Clinics of North America*, 12(2):207-219.
- **Khurana R, Berney S M. (2005).**Clinical aspects of rheumatoid arthritis. *Pathophysiology*, 12(3):153-165.
- **McInnes IB, Schett G. (2011).** The Pathogenesis of Rheumatoid Arthritis. *The New England Journal of Medicine*, 365(23): 2205-2219
- **Mendonca J A, YazbkM A, Laurindo I M M, Bertolo M B .(2011).**Wrist ultrasound analysis of patients with early rheumatoid arthritis. *the Brazilian journal of medical and biological research*, 44(1): 11-15
- **Naredo E, Montoro M, Janta L, 2015.** Rheumatoid arthritis disease. In: *Musculoskeletal Ultrasonography in Rheumatoid disease*, **ELMiedanyY**, 1<sup>st</sup>. Switzerland: Springer International Science.,PP: 65-69
- **Ospelt C, Gay S, 2012.** Epigenetic Epidemiology of Inflammation and Rheumatoid Arthritis in: *Epigenetic Epidemiology*, **Karin B and Michels** , Switzerland: Springer Science,PP: 292-394.
- **Pratt AG, Isaac JD, Matthey DL. (2009).** Current concept in the pathogenesis of early Rheumatoid Arthritis. *Best Practice and Research of clinical rheumatology*, 23(1):37-48
- **Qvistgaard E, Rogind H , Torp-Pedersen S,Terslev L,Danneskiold-Samsøe B , Bliddal H. (2001).** Quantitative ultrasonography in Rheumatic evaluation of inflammation by Doppler technique. *Annals Rheumatic Diseases*, 60(7): 690–693.
- **Sabeh F, Fox D, Weiss SJ.(2010).**Membrane type I matrix metalloproteinase dependent regulation of rheumatoid arthritis synovio-cyte function. *Journal of immunology*, 184 (11): 6396-6406.
- **Scheel AK , Hermann KG, Ohrndorf S, Werner C, Schirmer C, Detert J , et al. (2006).** Prospective 7 year follow up imaging study comparing radiography, ultrasonography, and magnetic resonance imaging in Rheumatoid Arthritis finger joints. *Annals of Rheumatic Diseases*, 65(5): 595-600.
- **Schett G, Teitelbaum SL.(2009).** Osteoclasts and arthritis. *Journal of bone and mineral research*, 24(7):1142-1146
- **Scirè CA, Montecucco C , Codullo V, Epis O, Todoerti M , Caporai R. (2009).** Ultrasonographic evaluation of joint involvement in early rheumatoid arthritis in clinical remission: PD signal predicts short-term relapse. *Rheumatology (Oxford)*, 48(9):1092-1097.
- **Szkudlarek M, Klarlund M, Narvestad E,Court-Payen M , Strandberg C, Jensen KE. (2006).**US of the metacarpophalangeal and proximal interphalangeal joints in Rheumatoid Arthritis: a comparison with magnetic resonance imaging, conventional radiography and clinical examination. *Arthritis research and therapy*, 8(2):R52.
- **Takahashi Y, Murai C, Shibata S,Munakata Y, Ishii T, Ishii K.(1998).** Human parvovirus B19 as a causative Agent for rheumatoid arthritis. *Proceedings of the National Academy of Science of the United States of America*, 95(14):227-232
- **Wakefield RJ, Gibbon WW, Conaghan PG, McGonagle D, Pease C, Green MJ,**

*et al.* (2000). The value of sonography in the detection of bone erosions in patients with Rheumatoid Arthritis: a comparison with conventional radiography. *Arthritis and Rheumatism*, 43(12): 2762-2770.

- **Weidekamm C, Koler M, Weber M, Kainberger F. (2003).** Diagnostic value of high -resolution B-mode and Doppler sonography for imaging of hand and finger joints in Rheumatoid arthritis, *Arthritis and Rheumatism*, 48(2):325-333