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ANKLE AND FOOT LESIONS IN RHEUMATOID ARTHRITIS – A COMPARATIVE STUDY OF TRIPLE PHASE ^{99m}Tc-MDP BONE SCINTIGRAPHY WITH SPECT/CT, MRI AND USG IMAGING

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Abstract

Introduction. Rheumatoid arthritis [RA] is a chronic inflammatory disease of unknown etiology. It marked by a symmetrical, peripheral polyarthritis with many extra articular manifestations. It is a form of chronic inflammatory arthritis which leads to joint damage and physical disability with extra articular manifestations. Evaluation of antibodies, anti-CCPs and rheumatoid factors are routinely used a marker of diagnostic and prognostic significance. The incidence of RA increases between 25 and 55 years of age. Recently imaging modalities like ultrasonography, MRI, bone scintigraphy and PET/CT have been used to provide information about joint inflammation and damage for clinical assessment of RA.

Aims: 1) To evaluate the frequency of ankle/foot joint involvement in RA patients, 2) To compare triple phase ^{99m}Tc-MDP bone scintigraphy with SPECT/CT, MRI & USG imaging.

Materials and method: Study include 50 patients of RA, underwent 99mTc- MDP scan for affected joints. 30 patients further underwent MRI followed by USG.

Result: In 50 patients who underwent triple phase bone scan, clearly demonstrated 786 joints involvement. Out of which 280 (~36%) were large joints and 506 (~64%) were small joints. In this 30 patients further underwent MRI. When compared, it suggested fair to moderate agreement between two imaging tools. In our study MRI scan clearly demonstrated the synovial changes as well as bone errosion and marrow edema. Planar and SPECT/CT images are also demonstrated increasing activity at correponding site. Also showed if disease involvement present in clinically silent joints. All three imaging modalities showed some extent of disease present before symptoms of RA become clinically evident.

Conclusion: Triple phase ^{99m}Tc- MDP bone scintigraphy is an excellent imaging modality for evaluation of all small and large joints in single study. It provides valuable information about the disease activity, number and location of joint involvement. 99m-Tc MDP triple phase bone scan and MRI showed fair to moderate agreement to elicit the disease burden in MTP joints. USG help to detect the syn.

Key words: Rheumatoid Arthritis of ankle joints, ^{99m}Tc - Triple phase bone scan, SPECT/CT, MRI ankle joint, USG ankle joint.

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Резюме

ПОВРЕЖДЕНИЯ ГОЛЕНОСТОПНОГО СУСТАВА И СТОПЫ ПРИ РЕВМАТОИДНОМ АРТРИТЕ – СРАВНИТЕЛЬНОЕ ИССЛЕДОВАНИЕ ТРЕХФАЗНОЙ СЦИНТИГРАФИИ КОСТЕЙ С ИСПОЛЬЗОВАНИЕМ ^{99m}Tc-MDP С ПОМОЩЬЮ SPECT/КТ, МРТ И УЗИ

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Актуальность. Ревматоидный артрит (РА) — хроническое воспалительное заболевание неизвестной этиологии. Оно характеризуется симметричным периферическим полиартритом с множеством внесуставных проявлений. Это форма хронического воспалительного артрита, приводящая к повреждению суставов и физической инвалидности с внесуставными проявлениями. Оценка антител, анти-ЦЦП и ревматоидных факторов обычно используется в качестве маркера диагностического и прогностического значения. Заболеваемость РА увеличивается в возрасте от 25 до 55 лет. В последнее время для получения информации о воспалении и повреждении суставов с целью клинической оценки РА используются такие методы визуализации, как ультрасонография, МРТ, костная сцинтиграфия и ПЭТ/КТ.

Цели: 1) Оценить частоту поражения голеностопного сустава/стопы у пациентов с РА. 2) Сравнить трехфазную костную сцинтиграфию с ^{99m}Tc-MDP с визуализацией SPECT/CT, МРТ и УЗИ.

Материалы и методы: В исследование включены 50 пациентов с РА, которым было проведено сканирование пораженных суставов с помощью ^{99m}Tc-MDP. 30 пациентов дополнительно прошли МРТ, а затем УЗИ.

Результаты: У 50 пациентов, прошедших трехфазное сканирование костей, было четко продемонстрировано поражение 786 суставов. Из них 280 (~36%) были крупными суставами, а 506 (~64%) — мелкими суставами. Эти 30 пациентов дополнительно прошли МРТ. Сравнение показало, что между двумя методами визуализации наблюдается хорошее или умеренное согласие. В нашем исследовании МРТ-сканирование четко продемонстрировало синовиальные изменения, а также эрозию кости и отек костного мозга. Плоские и SPECT/CT-изображения также продемонстрировали повышенную активность в соответствующих участках. Также было показано, присутствует ли поражение заболеванием в клинически бессимптомных суставах. Все три метода визуализации продемонстрировали некоторую степень заболевания до того, как симптомы РА стали клинически очевидными.

Заключение: Трехфазная ^{99m}Tc-MDP-сцинтиграфия костей является отличным методом визуализации для оценки всех мелких и крупных суставов в рамках одного исследования. Она предоставляет ценную информацию об активности заболевания, количестве и расположении пораженных суставов. Трёхфазная сцинтиграфия с ^{99m}Tc-MDP и МРТ показали умеренное соответствие в оценке выраженности поражения суставов плюснефаланговой области (МТР-соединения). УЗИ помогает выявлять синовиальные изменения.

Ключевые слова: *Ревматоидный артрит голеностопного сустава, 99mTC - трехфазное сканирование кости, SPECT/КТ, МРТ голеностопного сустава, УЗИ голеностопного сустава.*

Для цитирования:

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Түйіндеме

РЕВМАТОИДТЫ АРТРИТ КЕЗІНДЕГІ ТОБЫҚ ЖӘНЕ ТАБАН БУЫНДАРЫНЫҢ ЗАҚЫМДАНУЫ – ^{99m}Tc-MDP ҚОЛДАНЫП ЖҮРГІЗІЛГЕН ҮШ ФАЗАЛЫ СҮЙЕК СЦИНТИГРАФИЯСЫН SPECT/КТ, МРТ ЖӘНЕ УДЗ ӘДІСТЕРІМЕН САЛЫСТЫРМАЛЫ ЗЕРТТЕУ

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Кіріспе. Ревматоидты артрит (РА) — этиологиясы белгісіз созылмалы қабыну ауруы. Ауру симметриялы шеткері көпбуынды артритпен және буыннан тыс көптеген көріністермен сипатталады. Бұл — буындарды зақымдап, физикалық мүгедектікке әкелетін, буыннан тыс көріністері бар созылмалы қабыну артритінің бір түрі. Антиденелерді, анти-ЦЦП және ревматоидты факторларды бағалау әдетте диагностикалық және болжамдық маңызы бар маркерлер ретінде қолданылады. РА ауруы көбінесе 25–55 жас аралығында жиі кездеседі. Соңғы жылдары клиникалық бағалау мақсатында қабыну мен буын зақымдануы туралы ақпарат алу үшін ультрадыбыстық зерттеу (УДЗ), магнитті-резонанстық томография (МРТ), сүйек сцинтиграфиясы және ПЭТ/КТ сияқты бейнелеу әдістері қолданылуда.

Мақсаттар: Ревматоидты артритпен (РА) ауыратын науқастардағы тобық және табан буындарының зақымдану жиілігін бағалау. ^{99m}Tc-MDP қолданылған үш фазалы сүйек сцинтиграфиясын SPECT/КТ, МРТ және УДЗ әдістерімен салыстыру.

Материалдар мен әдістер: Зерттеуге РА диагнозы қойылған 50 науқас қатыстырылды, оларға зақымданған буындарды ^{99m}Tc-MDP көмегімен сканерлеу жүргізілді. Оның ішінде 30 науқасқа қосымша МРТ және кейіннен УДЗ жасалды.

Нәтижелер: Үш фазалы сүйек сцинтиграфиясынан өткен 50 науқастың 786 буынында патологиялық өзгерістер анықталды. Оның ішінде 280 буын (~36%) ірі буындар, ал 506 буын (~64%) ұсақ буындар болды. Осы 30 науқасқа қосымша МРТ жасалды. Салыстыру нәтижесінде бейнелеу әдістері арасында жақсы немесе орташа деңгейдегі үйлесімділік бары анықталды. Зерттеу барысында МРТ синовиалды өзгерістерді, сүйек эрозиясын және сүйек кемігіндегі ісінуді нақты көрсетті. Планарлы және SPECT/КТ кескіндері де сәйкес аймақтардағы белсенділіктің артқанын көрсетті. Сонымен қатар, клиникалық белгілері жоқ буындарда да аурудың бар-жоғын анықтауға мүмкіндік берді. Үш бейнелеу әдісі де РА клиникалық түрде білінбей тұрып, аурудың белгілі бір дәрежеде басталып кеткенін көрсетті.

Қорытынды: ^{99m}Tc-MDP қолданылатын үш фазалы сүйек сцинтиграфиясы — ұсақ және ірі буындарды бір зерттеудің аясында бағалауға арналған үздік бейнелеу әдісі. Бұл әдіс аурудың белсенділігі, буындардың зақымдану саны мен орналасуы туралы құнды ақпарат береді. ^{99m}Tc-MDP сүйек сцинтиграфиясы мен МРТ метатарсофалангеалды (МТР) буындардағы зақымдану дәрежесін бағалауда орташа деңгейде сәйкестік көрсетті. Ультрадыбыстық зерттеу синовиалды өзгерістерді анықтауға көмектеседі.

Түйінді сөздер: Тобық және табан буындарының ревматоидты артрит, 99mtc-үш фазалы сүйекті сканерлеу, SPECT / КТ, Тобық және табан буындарының МРТ, Тобық және табан буындарының УДЗ

Дәйексөз үшін:

Сайни Вивек Кумар, Арья Амитабх, Агарвал Викас, Мохиндра Намита, Туласи Сунита Дипа; Ревматоидты артрит кезіндегі тобық және табан буындарының зақымдануы – ^{99m}Tc-MDP қолданып жүргізілген үш фазалы сүйек сцинтиграфиясын SPECT/КТ, МРТ және УДЗ әдістерімен салыстырмалы зерттеу // Ғылым және Денсаулық сақтау. 2025. Vol.27 (4), Б. 79-90. *doi 10.34689/SH.2025.27.4.011*

Introduction

Rheumatoid arthritis (RA) is a chronic, inflammatory autoimmune disease of unknown origin that primarily affects symmetric joints. It is most common between 25 and 55 years of age [1], though it can occur at any age. It leads to joint damage, disability, and various extra-articular manifestations. These include subcutaneous nodules, fatigue, pulmonary abnormalities, peripheral neuropathy, and hematologic issues such as anemia.

RA tends to affect small joints of the hands and feet first, often causing morning stiffness lasting over an hour, which improves with activity. In advanced stages, joints like the wrists, MCP, PIP may be most affected, while the DIP joints are typically spared (indicative of coexisting osteoarthritis if involved). Joint deformities such as swan neck, boutonnière, and Z-line deformities can develop, along with tendon issues like tenosynovitis and reduced grip strength.

Involvement of larger joints such as the knee, shoulder, and ankle is common in established disease, while atlantoaxial subluxation (C1-C2 spinal involvement) can cause compressive myelopathy, potentially leading to neurological dysfunction.

Extra-Articular Manifestations:

Subcutaneous nodules occur in 30-40% of patients. Pulmonary involvement, including pulmonary nodules, interstitial lung disease, and pleural effusions, is common. Cardiovascular issues such as coronary artery disease and heart failure are prevalent due to chronic inflammation, making cardiovascular health a priority. Anemia is common, along with other hematologic abnormalities like neutropenia and splenomegaly. Sjogren's syndrome (~10% of RA patients) can occur, causing dry eyes and mouth.The risk of developing lymphoma (especially diffuse large B-cell lymphoma) is 2-4 times higher than in the general population, especially in patients with high disease activity or Felty's syndrome (splenomegaly and neutropenia).

RA can also involve ocular issues like keratoconjunctivitis sicca (dry eyes) and episcleritis, oral manifestations such as xerostomia (dry mouth), and neurological manifestations like cervical myelopathy [1].

Pathophysiology of RA:

RA primarily affects the synovial tissue in joints, leading to synovial inflammation, pannus formation (a growth of inflamed tissue), and bone erosion. Fibroblast-like synoviocytes play a critical role in the destruction of cartilage and bone by secreting matrix-degrading enzymes. The infiltrating immune cells, primarily T-cells and B-cells, secrete proinflammatory cytokines such as TNF-α and IL-1, which cause joint inflammation and damage. Over time, this results in pannus formation that invades both cartilage and bone [2].

The disease is thought to be influenced by genetic factors, environmental triggers (e.g., smoking), and hormonal factors (with estrogen playing a role in disease pathogenesis). RA is more common in women (2-3:1 ratio) [2].

NEW 2010 ACR-EULAR
[American College of Rheumatology -European League Against Rheumatism]

Joint involvement	**Score**
1 - large joint [shoulder, elbow, hip, knee, ankle]	0
2- 10 large joints	1
1 -3 small joints [MCP, PIP, thumb, Ip, MTP, wrists]	2
4- 10 small	3
> 10 joints [at least 1 small joint]	5
Serology	
Negative RF and negative ACPA	0
Low- positive RF or low- positive anti-CCP antibodies [<3 times ULN]	2
High -positive RF or high positive anti-CCp antibodies [>3 times ULN]	3
Acute-phase reactants	
Normal CRP and normal ESR	0
Abnormal CRP or Abnormal ESR	1
Duration of symptoms	
<6 weeks	0
>6 weeks	1

A score of >6 fulfills requirements for definite RA.

Investigations:

Blood tests:

ESR and CRP are markers of inflammation and correlate with disease activity.

CBC often shows anemia of chronic disease, and thrombocytosis (elevated platelets) is common.

Rheumatoid factor (RF) is present in 60-80% of RA patients but is not specific to RA and can be found in other conditions [3].

Anti-CCP antibodies have high specificity for RA and can predict more erosive disease.

Imaging:

Radiography is the primary method for assessing joint damage, though it is more useful for monitoring disease progression than for early diagnosis.

MRI and ultrasonography are more sensitive for detecting early inflammation and soft tissue involvement (e.g., tendon sheath inflammation and synovitis). Ultrasonography of joints is gaining increased widespread acceptance in clinical practice; however, its use in RA is not yet the standard of care [4].

CT and PET scans are used in specialized cases for better assessment of damage and inflammation.

Treatment:

Early intervention with Disease-modifying antirheumatic drugs (DMARDs) is crucial to slow disease progression and prevent joint damage [5] [6].

Nonbiologic DMARDs (e.g., Methotrexate (MTX), Hydroxychloroquine, Sulfasalazine, Leflunomide) remain the cornerstone of treatment.

Biologic DMARDs (e.g., TNF inhibitors such as Adalimumab, Etanercept, Infliximab) target inflammatory cytokines and are effective in patients not responding to nonbiologic DMARDs.

Corticosteroids and NSAIDs are used for symptom relief but are not disease-modifying agents.

Surgical options may be considered in severe cases where joint deformities impair function or cause pain. This includes:

Synovectomy (removal of inflamed synovium).

Arthroplasty (joint replacement) or arthrodesis (joint fusion).

Vaccinations are recommended for patients on immunosuppressive therapies (e.g., pneumococcal, influenza, hepatitis, and HPV vaccines) to reduce the risk of infections.

Early DMARD therapy (within 6 months of symptom onset) is associated with better outcomes, including fewer joint erosions and a higher likelihood of remission.

Prognosis:

With timely diagnosis and effective treatment, most patients can achieve disease control and prevent further joint damage. However, untreated RA can lead to significant disability and reduced quality of life. The disease can be progressive and may require long-term management with a combination of medications, lifestyle modifications, and monitoring for comorbidities such as cardiovascular disease and osteoporosis.

Aims and Objective:

To evaluate frequency of ankle/foot joint involvement in RA patients.

To compare Triple phase ^{99m}Tc-MDP bone scintigraphy with SPECT/CT, MRI and USG imaging in picking up the Ankle/feet lesions in RA

Methods and Materials

Study Location & Population:

Conducted at:

Department of Nuclear Medicine in association with Radiodiagnosis and Clinical Immunology, SGPGIMS, Lucknow.

Participants:

50 patients diagnosed with Rheumatoid Arthritis (RA) based on the 2010 ACR-EULAR criteria, recruited from the Clinical Immunology OPD.

Consent:

Informed consent was obtained from all participants.

Main focus:

Assessment of left foot MTP (metatarsophalangeal) and PIP (proximal interphalangeal) joints, as they are commonly affected in RA.

Inclusion Criteria: Patients meeting 2010 ACR-EULAR criteria for RA.

Exclusion Criteria: Non-consenting or uncooperative patients.

Age <7 years

Patients with deformed feet

Pregnant or lactating women

Imaging Procedures:

1. Triple Phase Bone Scintigraphy (Bone Scan):

Radiotracer:

15–20 mCi of 99mTc-MDP prepared from a molybdenum-99/technetium-99m generator.

Procedure:

No fasting; patients remained hydrated.

Dynamic flow, blood pool, and delayed images (after 3 hours) were acquired.

Imaging done using Infinia Hawkeye 4 SPECT/CT, focused on feet (planter view) and whole body.

Interpretation:

Two blinded nuclear medicine physicians independently assessed joint involvement based on abnormal tracer uptake in MTP/IP joints.

2. MRI of the Left Foot:

Scanner: 3T Siemens MRI

Protocol: Included sequences like T2W, PD, T1 (pre- and post-contrast), and 3D SPACE.

Focus: Detection of synovitis, bone erosion, and bone marrow edema using the RAMRIS (OMERACT) scoring system.

Assessment:

Done independently by two blinded radiologists.

3. Ultrasonography (USG) of Left Foot:

Machine: ESAOTE with 18 MHz linear probe

Joints assessed: Only MTP joints (150 joints in total); PIP joints excluded due to variability.

Scoring:

Done using OMERACT-based grayscale and Power Doppler scoring.

Interpretation:

Conducted by two trained immunologists independently.

Other Data Collection:

Clinical examination and hematological parameters were documented and correlated with imaging results.

Both small joints (MCP, PIP, thumb IP, MTP, wrist) and large joints (shoulder, elbow, hip, knee, ankle) were evaluated for involvement.

Result

Patient characteristics -

This study group included 50 patients (Mean age 42.9 years, Range 20-64 years. It was observed that 12 patients (24 %) were in the age group of 20-31 years followed by 12 patients (24 %) in the age group of 32-43 years16 patients (32 %) in the age group of 44-55 years and rest 10 patients (20 %) were in the age group of 57-68 years.

In our study out of 50 patients, 6 (12%) patient were male and 44 (88 %) were female.

Out of 50 patients only 4 (8%) patients had ESR less than 20 mm/hours. 28 (56%) patients had ESR between 20-40 mm/hours. 8 (16%) patients had ESR between 41 -60 mm/hour. 1 (2%) patients had ESR between 61-80 mm/hour and 9 (18%) patient had ESR either 81 -100 or more. This study showed maximum patients were in the 20-40 mm/hour group which considered raised as per the reference laboratory value. (< 20 mm/hour).

In our study 15 (30%) patients had anti-CCP antibody level between 0-30 units/ml. 11 (22%) patients had anti-CCP antibody level between 31-300 units/ml and 24 (48%) patients had anti-CCP antibody more than 300 units/ml.

In our study we observed 19 (38%) patient had C-reactive protein less than 0.6 mg/dl. Rest 31 (62%) had CRP level more than reference laboratory value. (< 0.6 mg/dl). It showed more ongoing inflammatory processes and disease activity.

In this study 35 (70 %) patients had rheumatoid factor more than 15 IU/ml that is considered more than reference laboratory value. (< 0-15 IU/ml).

Total disease activity index was less than 2.8 in 10 (20%) patients and it was more than 2.8 in the rest 40 (80%) patients. It showed active phase.

In our study 50 bone scan showed total number of joints involved were 786, 506 (~64%) were the small joints and 280 (~ 36%) were the large joints. Average number of total joints involvement was ~16 per patient.

- ❖ Large joints -Shoulder, Elbow, Hip, knee, Ankle joints.
- ❖ Small joints - MCP, PIP, Thumb, Proximal IP, MTP, wrists joints.

All fifty patients underwent bone scan examination, fifteen (30%) patients were clinically pain free, however scan reveals eleven (22 %) patients had abnormal tracer uptake in the left foot joints. On the other hand, thirty five (70%) patient who clinically had foot pain, thirty one patients showed abnormal tracer uptake in the left foot joints suggested for disease involvement but four patients didn't show any abnormal tracer uptake in the left foot joints.

Above mentioned table showed that clinically silent sites may have abnormal tracer uptake that suggestive of disease activity.

Thirty patients underwent MRI examination, ten (~33%) patients were clinically pain free, however five had left foot joints involvement. On the other hand, twenty patients who clinically had pain, eleven patients showed MRI feature suggested of disease activity in the joints but nine patients didn't show MRI feature suggested of disease activity.

Fifty patients included in our study, thirty further underwent of MRI examination as well. So total 300 joints (5 left MTP and 5 left PIP joints of 30 patients) were evaluated by both examinations.

Bone scan picked up disease activity in total 51 joints and MRI picked up disease activity in 49 joints of left foot. In these total involved joints 42 were MTP & 9 were PIP joints picked up by bone scan and 41 were MTP & 8 were PIP picked up by MRI scan.

Out of 300 joints (5 MTP and 5 PIP joints of 30 patients) that have been examined by both examination, results were concordant in the 258 joints (i.e either positive or either negative in both) and were discordant in 42 joints.

Individual joints assessment by Bone scan and MRI scan

1) First left MTP joints by bone scan and MRI

Thirty 1st MTP joints assisted by bone scan and MRI, ten same joints showed no involvement in the disease in both scans. 10 same joints showed disease involvement in the both scans. In the rest ten discordant 1st Left MTP joints bone scan was positive in all case and MRI was negative in all case. Statistically result showing a fair agreement in both test (kappa coefficient 0.40 with P value -.006).

BMTP1 * MMTP1 Cross tabulation

Count		MMTP1		Total
		N	Y	
BMTP1	N	10	0	10
	Y	10	10	20
Total		20	10	30

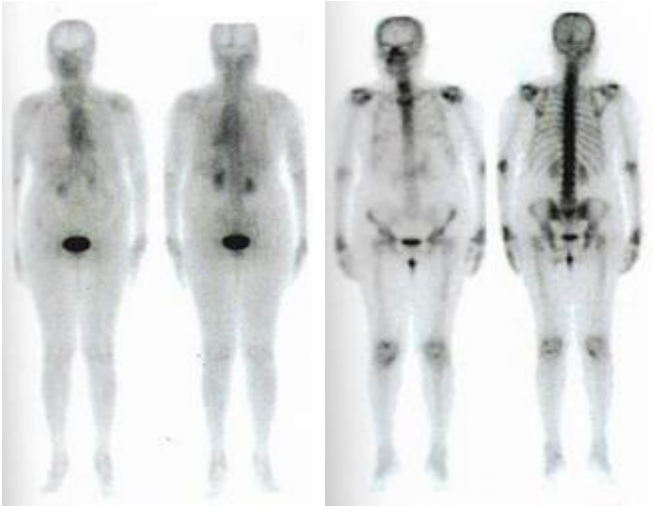
Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Measure of Agreement	Kappa	.400	.124	2.739	.006
N of Valid Cases		30			

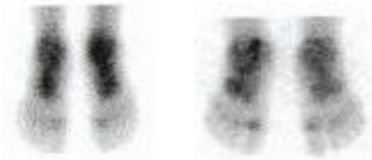
a. Not assuming the null hypothesis. *b. Using the asymptotic standard error assuming the null hypothesis.*

a) Blood pool imags both feet anterior and posterior view.

b) Blood pool images of upper limb anterior and posterior view.

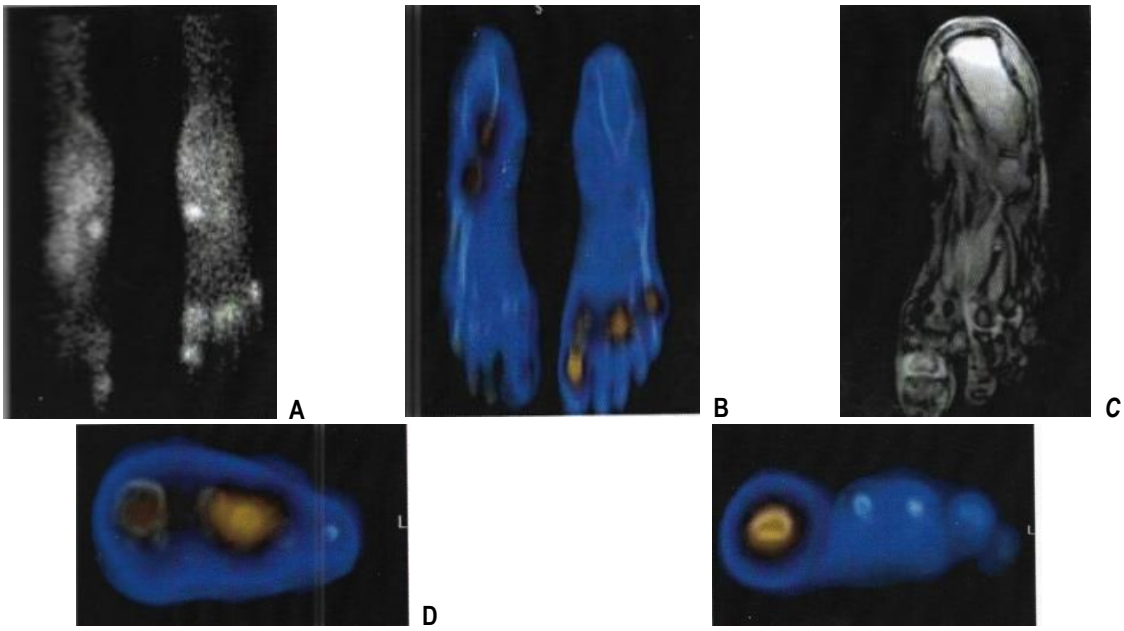


c) Blood pool images whole body anterior and posterior view **d) Delayed imageswhole body anterior and posterior view**



e) Delayed Images anterior and posterior view

***f*: SPECT/CT images of left foot**



Case 1: A 26 year old lady presented with pain in both feet joints. Image (A) delayed planar view of foot showing abnormal tracer uptake inleft 1st IP and Left 2nd IP, 3rd and 5th MTP joint region. Image (B), (D) and (E) SPECT/CT of corresponding site suggestive of abnormal tracer uptake in left 1st IP and 2nd, 3rd and 5th MTP joints. Images (C) MRI showing abnormal contrast enhancement at left 1st IP and 2nd and 3rd MTP joints.

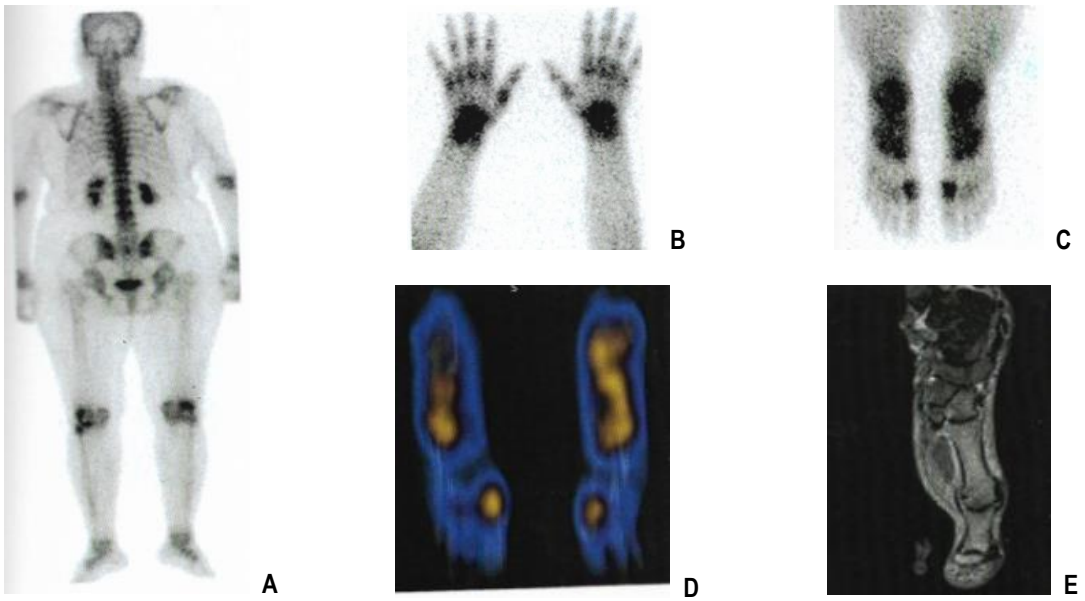


Figure: Image (A) whole body delayed image posterior view. Image (B) spot view of bilateral hand joints posterior view showing multiple small joints abnormal tracer uptake. Image (C) Delayed spot view of bilateral feet in the plantar position with abnormal tracer uptake in the 1st MTP joints. Image (D) SPECT/CT image of corresponding site showing increased tracer uptake in bilateral 1st MTP joints. Image (E) corresponding MRI images of left foot showing bony erosion at 1st tarsal bone.

2) 2nd left MTP joints assessment by bone scan and MRI scan

Thirty 2nd MTP joints assessed by both scans, twenty-one same joints showed no disease involvement. Four same joints showed disease involvement. In the rest 5 discordant 2nd Left MTP joints, bone scan was positive in 1 case and MRI was positive in four case. Statistically result showing a moderate agreement in both test (kappa coefficient 0.516 with P value -.003).

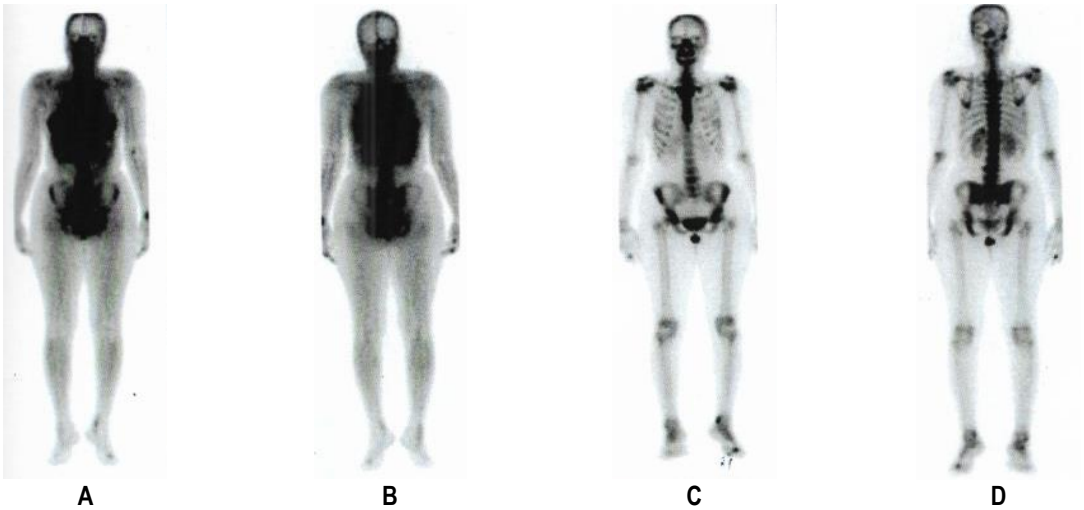
BMTP2 * MMTP2 Cross tabulation

Count		MMTP2		Total
		N	Y	
BMTP2	N	21	4	25
	Y	1	4	5
Total		22	8	30

Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Measure of Agreement	Kappa	.516	.183	2.954	.003
N of Valid Cases		30			

a. Not assuming the null hypothesis. *b. Using the asymptotic standard error assuming the null hypothesis.*



Case 2: 21 year old female presented with multiple joints pain. Image (A) whole body pool image anterior view Image (B) whole body pool images Posterior view. Image (C) delayed image anterior view. Image (D) delayed image posterior view.

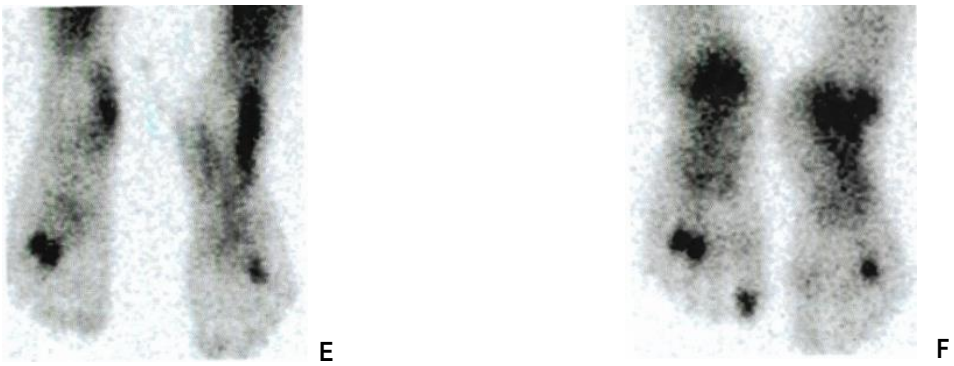


Figure: Image (E) & (F) increased tracer uptake in multiple foot joints.

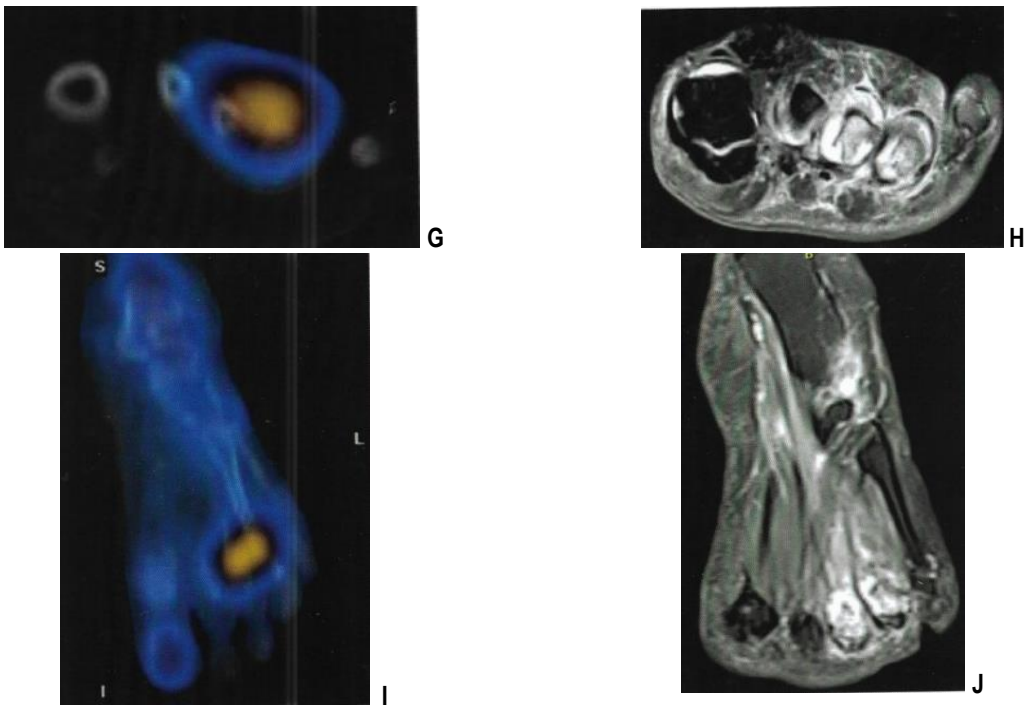


Figure: In the above mentioned case Image (G), (I) SPECT/CT showing abnormal tracer uptake in the Left 3rd and 4th MTP joints. Corresponding images (H), (J) of MRI also showing the contrast enhancement of the 3rd and 4th Left MTP joints.

3) **3rd MTP joint assessment by Bone scan and MRI**

Thirty 3rd MTP joints assessed by both scan, nineteen same joints showed no disease involvement. Six same joints showed disease involvement in the both scans. In the rest five discordant 3rd Left MTP joints bone scan was positive in 1 case and MRI was positive in four case. Statistically result showing a moderate agreement in both test (kappa coefficient 0.59 with P value -.001).

BMTP3 * MMTP3 Crosstabulation

Count		MMTP3		Total
		N	Y	
BMTP3	N	19	4	23
	Y	1	6	7
Total		20	10	30

Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Measure of Agreement	Kappa	.595	.159	3.358	.001
N of Valid Cases		30			

a Not assuming the null hypothesis. b. Using the asymptotic standard error assuming the null hypothesis.

4) **4th MTP joints assessment by bone scan and MRI**

Thirty 4th MTP joints assessed by both scans, nineteen same joints showed no disease involvement. 04 same joints showing disease involvement. In the rest seven discordant 4th Left MTP joints bone scan was positive in two case & MRI was positive in 5 case. Statistically result showing a fair agreement in both test (kappa coefficient 0.38 with P value -.028).

BMTP4 * MMTP4 Cross tabulation

Count		MMTP4		Total
		N	Y	
BMTP4	N	19	5	24
	Y	2	4	6
Total		21	9	30

Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Measure of Agreement	Kappa	.386	.186	2.191	.028
N of Valid Cases		30			

a. Not assuming the null hypothesis. b. Using the asymptotic standard error assuming the null hypothesis.

5) **5th MTP joints assessment by bone scan and MRI**

Thirty 5th MTP joints assessed by both scan, twenty four same joints showed no disease involvement. Two same joints showed disease involvement. In the rest four discordant 5th Left MTP joints bone scan was positive in two case & MRI was positive in two case. Statistically result showing a moderate agreement in both test (kappa coefficient 0.42 with P value -0.020).

BMTP5 * MMTP5 Cross tabulation

Count		MMTP5		Total
		N	Y	
BMTP5	N	24	2	26
	Y	2	2	4
Total		26	4	30

a. Not assuming the null hypothesis. b. Using the asymptotic standard error assuming the null hypothesis.

Individual proximal interphalangeal joint assessment by bone scan and MRI

1) 1st PIP joints assessment by bone scan and MRI.

Thirty 1st left IP joints assisted by both scan, nineteen same joints showed no disease involvement, three same joints showed disease involvement. In the rest 8 discordant 1st left IP joints bone scan was positive in six case and MRI was positive in two case. Statistically result showed a slight agreement in both test (kappa coefficient 0.27 with P value -.109).

BIP1 * MIP1 Cross tabulation

Count		MIP1		Total
		N	Y	
BIP1	N	19	2	21
	Y	6	3	9
Total		25	5	30

Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Measure of Agreement	Kappa	.273	.187	1.604	.109
N of Valid Cases		30			

a Not assuming the null hypothesis. b Using the asymptotic standard error assuming the null hypothesis.

2) **2nd left IP joint assessment by bone scan and MRI**

Thirty 2nd left IP joints assessed by both scans, twenty-nine same joints showed no disease involvement. Rest one discordant 2nd left IP joints was positive in MRI. No positive finding was noted in the bone scan. Statistically no agreement was noted in the both scans.

BIP2 * MIP2 Cross tabulation

Count		MIP2		Total
		N	Y	
BIP2	N	29	1	30
Total		29	1	30

Symmetric Measures

		Value	Asymp. Std. Error[b]	Approx. T[c]
Measure of Agreement	Kappa	.000[a]	.	.
N of Valid Cases		30		

a. No statistics are computed because BIP2 is a constant.
b. Not assuming the null hypothesis.
c. Using the asymptotic standard error assuming the null hypothesis.

3) **3rd left IP joint assessment by bone scan and MRI.**

Thirty 3rd left IP joints assessed by both scans, twenty-nine same joints showed disease involvement. Rest one discordant 3rd left IP joints was positive in MRI. No positive finding was noted in the bone scan. Statistically no agreement is noted in the both scans.

BIP3 * MIP3 Cross tabulation

Count		MIP3		Total
		N	Y	
BIP3	N	29	1	30
Total		29	1	30

Symmetric Measures

		Value	Asymp. Std. Error[b]	Approx. T[c]
Measure of Agreement	Kappa	.000[a]	.	.
N of Valid Cases		30		

a. No statistics are computed because BIP3 is a constant.
b. Not assuming the null hypothesis.
c. Using the asymptotic standard error assuming the null hypothesis.

4) **4th left IP joint assessment by bone scan and MRI**

Thirty 4th left IP joints assessed by both scan total 30 were negative on both scans.

BIP4 * MIP4 Cross tabulation

Count		MIP4	Total
		N	
BIP4	N	30	30
Total		30	30

Symmetric Measures

		Value
Measure of Agreement	Kappa	.[a]
N of Valid Cases		30

a. No statistics are computed because BIP4 and MIP4 are constants.

5) **5th left IP joint assessment by bone scan and MRI.**

Thirty 5th left IP joints assessed by both scan, twenty nine same joints showed no disease involvement. Rest one discordant 5th left IP joints was positive in MRI. No positive findings were noted in the bone scan. Statistically no agreement is noted in the both scans.

So finally, study conclude that for the evaluation of left MTP joints both scan showing fair to moderate agreement, but this agreement is not seen in the PIP joints, its largely likely due to less involvement of PIP joints in the rheumatoid arthritis.

Discordant 42 joints result.

MRI Scan	20 positives
Bone Scan	22 positives

Out of forty-two discordant joints twenty joints were positive on MRI and twenty two joints were positive on bone scan.

All patients after triple phase bone scan and MRI examination underwent Outcome measures in Rheumatology (OMERACT) Rheumatoid Arthritis (RA) ultrasound-based scoring of left MTP joints only was done. Total one hundred fifty joints were evaluated out of which one hundred joints were involved in RA according to USG scoring system.

This scoring is based on synovitis according to the usual practice of different sonographers, using both grey-scale (GS) (synovial hypertrophy (SH) and effusion) and power Doppler (PD). Results Baseline reliability was highly variable but better for static than dynamic images that were directly acquired and immediately scored. Using static images, intrareader and inter-reader reliability for scoring PD were excellent for both binary and semiquantitative (SQ) grading but GS showed greater variability for both scoring systems. So false positive results may be high.

Clinical history and USG scan result of (n-30).

Clinical history	N-30	USG positive	USG negative
Pain in the left feet	20	18	02
No pain in the left feet	10	10	00

Thirty patients underwent USG examination, ten patients didn't had history of pain in the left foot however its result suggested that all patients had left foot joint involvement. On the other hand, twenty patient who clinically had pain, eighteen patients showing disease involvement but two patients didn't show any abnormality in the joints.

Discussion

As we know Rheumatoid arthritis is a chronic autoimmune disease that characterized by persistent inflammation of synovial membrane, increased capillary permeability with formation of new blood vessels, synovial changes, exudate collection in synovial stroma with infiltration of cellular elements cause synovial changes leading to progressive joints destruction and disability which causes pain, swelling of joints. In the clinical environment, final diagnosis of RA is made on the basis of typical clinical symptoms and signs, detailed physical examination, supporting biochemical findings and radiographic imaging. Recently, imaging modalities such as ultrasonography, MRI, bone scintigraphy and PET/CT in addition to plain radiography have been used to provide information about joint inflammation and damage in the clinical assessment of RA [7].

Several previous studies have underestimated the diagnostic efficacy of bone scintigraphy compared with other imaging modalities because the majority of these studies involved late phase bone scintigraphy without perfusion or blood pool phase. In recent years, many studies demonstrated that angiogenesis is an essential event in maintaining inflammatory and immune responses, as well as supporting pannus growth and development of RA New vessel formation and inflammation may increase the perfusion or blood pool phase. Therefore, comparable or even higher diagnostic efficacy to the other imaging modalities would be expected. [8] [9].

In our study abnormal increased tracer uptake was also based on blood pool and delayed images and for better image interpretation and localization we also performed SPECT/CT of bilateral feet joints. In fifty patients who underwent for triple phase bone scintigraphy, bone clearly demonstrated 786 joints involvement. Out of which 280 (~36%) were large joints and 506 (~64%) joints were small. This data showed head to toe evaluation of disease burden in RA can be clearly demonstrated with a single investigational tool.

Apart from this bone scintigraphy has many advantages over these other imaging modalities for evaluating multiple joint problems because of its high sensitivity, low cost, good availability, and the possibility of whole-body imaging [10].

In our study thirty patients underwent both MRI & triple phase bone scintigraphy. When compared both imaging modalities it suggested fair to moderate agreement between two imaging tools. Out of 300-foot joints evaluated by both scan, 258 (86 %) results were concordant either positive or negative. Only in 42 (14%) joints results showed discordant results.

As MRI concerned it recognized as the imaging technology of choice for visualization of the inflamed synovial membrane and bone edema. A part from this MRI has been shown to be a sensitive, non-invasive imaging modality for early detection and quantification of bone erosions. Erosions may be visible on MRI years before they are visible on radiographs. MRI can give us a better anatomical detail as bone marrow edema, bone erosion and synovitis of a specific joint or region. In MRI increased vascularity reflected by contrast enhancement.

In our study MRI scan clearly demonstrated the synovial changes as well as bone erosion and marrow edema. Planar and SPECT/CT images are also demonstrating the increased tracer activity at the corresponding site.

MRI picked up total forty-nine joints of left foot and bone scan picked up fifty joints of left foot. MRI reveals better anatomical detail as well as disease activity that reflected by contrast enhancement at the joint involved. However, in few joints effusion was noted without any contrast enhancement.

The major drawbacks of routine MRI usage are the time and expense of the procedure. It may be uncomfortable for some people because it can produce claustrophobia. MRI cost is significantly higher than the bone scan. From an economical point of view, the triple phase bone scan is still cheaper than performing multiple different scan.

Various studies showed high-frequency US and MRI are both effective in detecting bone erosion, tendinitis and tendon sheath edema in patients with early RA. MRI was demonstrated to be superior in the evaluation of bone marrow edema, while high-frequency US demonstrated an increased sensitivity for detecting early joint effusion and synovial proliferation in comparison with MRI. As further evidence becomes available, US and MRI will become increasingly important in the diagnosis and management of early RA. High-frequency US may be considered as a valuable modality for the detection of early RA, particularly when MRI is not accessible. The decision of which tool should be used in a given trial should rely on the clinical output requirement in order to minimize patient discomfort [11].

Us has been shown to be more sensitive than clinical examination in determining synovitis [12]. Studies showed that RA patients to be in remission had significant evidence of active inflammation on USG. This ongoing subclinical inflammation can lead to radiographic progression [13]. The accurate evaluation of disease status may improve RA management by providing a more timely and accurate diagnosis, improving treatment decisions and more accurately assessing remission. In our study 10 patients didn't had pain clinically however USG picked up disease in all joints. one hundred fifty joints evaluated by USG, one hundred (~66.66%) joints had synovial changes. Study suggest ultrasonography is non-inferior to other imaging modality to detect the joints detail expect bone edema.

Our study demonstrated that disease involvement may be present in clinically silent joints. All three imaging modalities showed that some extent of disease may present before symptoms of RA become evident. So disease, if detected in clinically silent joints these imaging modalities may help in better evaluation of disease extent.

Conclusion

❖ Triple phase ^{99m}Tc-MDP bone scintigraphy is an excellent imaging modality for evaluation of all small and large joints in single study. It provides valuable information about the disease activity, number and location of joints involvement.

❖ Bone edema, erosions, synovitis and contrast enhancement are MRI findings of joint involvement in RA. These MRI findings, if detected in clinically silent joints it help in better evaluation of disease extent.

❖ Both imaging modalities (^{99m}Tc-MDP triple phase bone scan and MRI) showed fair to moderate agreement to elicit the disease burden in the MTP joints.

❖ Ultrasonography is non-inferior imaging modality to detect the synovial changes in the early RA disease, although inter-observer variability may affect its efficiency.

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