Section: Miscellaneous

Original Research Article

IMAGING ASSESSMENT OF CHILDREN PRESENTING WITH SUSPECTED OR KNOWN JUVENILE IDIOPATHIC ARTHRITIS' – A PAEDIATRIC RADIOLOGY PERSPECTIVE

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ABSTRACT

Background: Juvenile Idiopathic Arthritis (JIA) represents the most prevalent chronic rheumatologic disease in childhood, characterized by persistent arthritis of unknown etiology lasting more than six weeks in patients under 16 years of age.This study aims to evaluate and compare the diagnostic utility of various imaging modalities in the assessment of children presenting with suspected or confirmed JIA. **Materials and Methods:** This prospective observational study included 30 children (aged 2–15 years) with suspected or confirmed Juvenile Idiopathic Arthritis (JIA) attending a tertiary care center. All participants underwent clinical examination, laboratory tests (ESR, CRP, RF, ANA, HLA-B27), and imaging assessments. Imaging modalities included conventional radiography, musculoskeletal ultrasound, and MRI of affected joints. Ultrasound was performed using high-frequency linear probes, and MRI utilized 1.5-Tesla scanners with standard pediatric protocols. Imaging findings were correlated with clinical and serological markers of disease activity. **Result:** Out of 30 children, 53.3% were female, and the most common subtype was oligoarticular JIA (26.7%). Knee and ankle joints were most frequently involved. Radiographs were abnormal in 60% of cases, commonly showing soft tissue swelling. Ultrasound detected active synovitis in 76.7% of patients, while MRI identified bone marrow edema or synovitis in 56.7%. Ultrasound showed highest sensitivity for early inflammatory changes, while MRI provided superior anatomical detail. **Conclusion:** Our results reinforce the integral roles of USG and MRI in diagnosing and managing JIA.

INTRODUCTION

Juvenile Idiopathic Arthritis (JIA) represents the most prevalent chronic rheumatologic disease in childhood, characterized by persistent arthritis of unknown etiology lasting more than six weeks in patients under 16 years of age. The term "idiopathic" underscores the absence of a definitive causative factor, and the condition is considered a heterogeneous group of disorders rather than a single disease entity. According to the International League of Associations for Rheumatology (ILAR), JIA is classified into seven subtypes based on clinical presentation during the first six months: oligoarticular, polyarticular (rheumatoid factor positive and negative), systemic, enthesitis-related arthritis, psoriatic arthritis, and undifferentiated arthritis. Accurate and early diagnosis of JIA is crucial to minimize joint damage, prevent long-term disability, and improve quality of life.[1,2]

The clinical diagnosis of JIA is predominantly based on the history of joint pain and swelling, morning stiffness, limited range of motion, and systemic manifestations in specific subtypes. However, physical examination alone often lacks sensitivity, especially in the early or subclinical stages of the disease. Furthermore, clinical evaluation may not always accurately localize or quantify synovial inflammation or differentiate active arthritis from residual damage. Therefore, imaging modalities play

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a vital role in the comprehensive assessment of JIA by aiding in early diagnosis, disease classification, monitoring of treatment response, and detection of complications such as joint erosions, growth disturbances, or ankylosis.[3,4]

Traditionally, conventional radiography (X-ray) has been the initial imaging modality used for the assessment of musculoskeletal abnormalities in JIA. However, plain radiographs are limited in their ability to detect early inflammatory changes such as synovitis, cartilage loss, and bone marrow edema. Radiographic findings often appear late in the disease course and are typically used to document chronic changes such as joint space narrowing and erosions. Thus, the sensitivity of radiographs in early disease detection is relatively low, necessitating the use of more advanced imaging techniques. Ultrasound (US) and Magnetic Resonance Imaging (MRI) have emerged as powerful non-invasive imaging modalities with significant clinical utility in the evaluation of JIA. Musculoskeletal ultrasound is particularly advantageous in pediatric populations due to its lack of radiation, real-time assessment capability, portability, and ability to assess multiple joints efficiently. High-frequency linear transducers can visualize joint effusions, synovial hypertrophy, and increased vascularity using Power Doppler, which is indicative of active inflammation. Ultrasound is highly sensitive in detecting subclinical synovitis and enthesitis, and is increasingly used both for diagnostic purposes and for guiding intra-articular corticosteroid injections.[5,6]

MRI provides comprehensive anatomic and physiologic information of the joint and surrounding soft tissues. It is the most sensitive modality for detecting bone marrow edema, an early marker of inflammation, and for assessing synovial thickening, effusions, cartilage damage, and erosions. MRI is also invaluable for evaluating axial involvement, particularly in the sacroiliac joints and spine, which is a hallmark of enthesitis-related arthritis. Moreover, contrast-enhanced MRI with gadolinium helps in delineating active synovitis. Despite being expensive and often requiring sedation in younger children, MRI remains the gold standard for detailed joint assessment in JIA. Recent advances in imaging techniques, such as whole-body MRI, diffusion-weighted imaging, and contrast-enhanced Doppler ultrasound, are expanding the scope of musculoskeletal imaging in pediatric rheumatology. Standardization of imaging protocols and development of scoring systems for disease activity (e.g., JAMRIS – Juvenile Arthritis MRI Scoring system) are facilitating uniform reporting and comparison across studies.[7,8]

This study aims to evaluate and compare the diagnostic utility of various imaging modalities in the assessment of children presenting with suspected or confirmed JIA. Specifically, the objectives include characterizing imaging findings across different joints and disease subtypes, assessing the sensitivity of ultrasound and MRI compared to clinical examination and radiography, and correlating imaging findings with clinical and laboratory parameters of disease activity. Such an approach is essential for optimizing diagnostic algorithms and improving patient management in pediatric rheumatology settings.

MATERIALS AND METHODS

This was a prospective, observational study conducted over a period of 18 months in the Departments of Radiodiagnosis and Pediatrics at a tertiary care medical college & hospital. Written informed consent was secured from parents or legal guardians of all participating children, along with assent from children aged 7 years and above, wherever appropriate.

Participants: Children aged between 2 and 15 years who presented to the pediatric outpatient department with suspected or confirmed juvenile idiopathic arthritis were recruited. Patients fulfilling the ILAR classification criteria for JIA were included in the confirmed group. Children with traumatic joint disorders, neoplastic conditions, septic arthritis, or other autoimmune diseases (e.g., systemic lupus erythematosus) were excluded. Demographic data, clinical history, subtype classification, and relevant laboratory investigations (ESR, CRP, ANA, RF, HLA-B27) were recorded.

Imaging Protocol: All enrolled patients underwent imaging assessment which included:

1. Plain Radiography: Standard two-view (anteroposterior and lateral) X-rays of affected joints were obtained using digital radiography systems. Radiographs were evaluated for soft tissue swelling, joint space narrowing, subchondral bone changes, erosions, and growth abnormalities.
2. Ultrasound (US): High-frequency (7–15 MHz) linear transducer was used for musculoskeletal ultrasound. Gray-scale and Power Doppler US were performed to evaluate joint effusions, synovial hypertrophy, tenosynovitis, and enthesitis. Vascularity was graded semi-quantitatively using standard Doppler scales. All US scans were conducted by a radiologist experienced in pediatric musculoskeletal imaging.
3. Magnetic Resonance Imaging (MRI): MRI was performed using a 1.5-Tesla scanner with dedicated surface coils. Sequences included T1-weighted, T2-weighted with fat suppression or STIR, and post-gadolinium contrast-enhanced sequences. Joints selected for MRI were based on clinical indication and US findings. MRI features assessed included synovial thickening, effusion, cartilage loss, bone marrow edema, erosions, and joint alignment.

Data Analysis: Imaging findings were compared with clinical joint assessments and laboratory markers of inflammation. The sensitivity and

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specificity of each imaging modality in detecting active arthritis were calculated using MRI as the reference standard. Inter-observer agreement between radiologists was evaluated using kappa statistics. Descriptive statistics were used to analyze demographic and clinical data. Statistical analysis was performed using SPSS version 25.0, with a p-value <0.05 considered statistically significant.

RESULTS

A total of 30 children were included in this study, with a mean age of approximately 9.8 years (range: 2–15 years). Of these, 56.7% were female (n=17) and 43.3% male (n=13) [Table 1]. The most common subtype of JIA was oligoarticular (26.7%, n=8), followed by polyarticular RF-negative (20%, n=6), systemic JIA (16.7%, n=5), and enthesitis-related arthritis (13.3%, n=4). The most frequently involved joints were the knee (30%, n=9) and multiple joints (26.7%, n=8), followed by the ankle (20%, n=6).

Rheumatoid factor (RF) was positive in 20% (n=6) of cases, antinuclear antibody (ANA) positivity was found in 46.7% (n=14), and HLA-B27 was positive in 36.7% (n=11) of patients [Table 4]. Elevated ESR and CRP levels were noted in 70% and 63.3% of patients, respectively, supporting active systemic inflammation [Table 2].

Table 1: Distribution of study parameters among the study participants (N=30)

Sl. no	Parameter	Frequency	Percentage
1	Gender		
	Female	17	56.7
	Male	13	43.3
2	JIA subtype		
	Systemic	8	26.7
	Polyarticular RF-	7	23.3
	Oligoarticular	4	13.3
	Undifferentiated	4	13.3
	Enthesitis-related	3	10
	Psoriatic	3	10
3	Joint Involvement		
	Multiple	7	23.3
	Ankle	7	23.3
	Hip	7	23.3
	Elbow	6	20.0
	Knee	3	10.0

Table 2: Distribution of Laboratory marker activityamong the study participants (N=30).

Sl. no	Laboratory marker activity	RF	ANA	HLA-B27
1	Negative	15	16	16
2	Positive	15	14	14

Conventional radiographs were abnormal in 60% of cases (n=18). The most common finding was soft tissue swelling (30%, n=9), followed by joint space narrowing (13.3%, n=4) and erosions (13.3%, n=4). However, 40% of the children (n=12) had normal X-rays despite clinical signs of arthritis [Table 3]. Ultrasound detected abnormalities in 76.7% of children (n=23). The most common sonographic finding was synovial effusion (33.3%, n=10), followed by synovial thickening (30%, n=9) and increased Doppler activity (13.3%, n=4), indicative of active inflammation [Table 4]. Notably, USG detected subclinical synovitis in joints that appeared normal on clinical examination and X-ray.MRI was the most sensitive modality, detecting pathology in 56.7% (n=17) of the cases. The most frequent MRI abnormalities were cartilage loss (23.3%, n=7), bone marrow edema (20%, n=6), and synovitis (13.3%, n=4) [Table 5]. Importantly, MRI identified early inflammatory changes such as marrow edema and synovitis in patients with otherwise unremarkable X-rays and minimal clinical findings.

Table 3: Distribution of X-ray findings among the study participants (N=30)

Sl. no	X-ray findings	Frequency	Percentage
1	Erosions	11	36.7
2	Joint space narrowing	10	33.3
3	Soft tissue swelling	5	16.7
4	Normal	4	13.3

Table 4: Distribution of ultrasound findings among the study participants (N=30)

Sl. no	Ultrasound findings	Frequency	Percentage
1	Normal	10	33.3
2	Effusion	8	26.7
3	Doppler activity	6	20.0
4	Synovial thickening	6	20.0

Table 5: Distribution of MRI findings among the study participants (N=30)

Slno	MRI findings	Frequency	Percentage
1	Normal	13	43.3
2	Cartilage loss	7	23.3
3	Bone marrow edema	6	20.0

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4	Synovitis	4	13.3

Comparative Diagnostic Sensitivity

- MRI detected abnormalities in 17/30 cases (56.7%).
- Ultrasound revealed pathology in 23/30 cases (76.7%), including vascular activity.
- X-ray detected abnormalities in only 18/30 cases (60%), primarily in later-stage disease.

MRI demonstrated high diagnostic specificity for structural and inflammatory changes, while USG showed the highest sensitivity for detecting active synovitis in real time. In comparison, X-rays had limited utility, especially in early or subclinical cases.

DISCUSSION

In this prospective observational study of 30 children with suspected or confirmed juvenile idiopathic arthritis (JIA), we compared the diagnostic utility of conventional radiography, ultrasound (USG), and magnetic resonance imaging (MRI). Our findings corroborate and extend previous evidence, demonstrating that USG and MRI outperform X-rays in early detection and evaluation of disease activity.

Utility of Conventional Radiography

Conventional X-rays remain integral for initial evaluation and long-term monitoring of structural damage in JIA, particularly erosions and joint space narrowing. However, consistent with prior research, X-rays demonstrated limited sensitivity (60% in our cohort). Radiographs often miss early inflammatory changes such as synovitis and bone marrow edema—features that appear late in disease progression.8Thus, while still a necessary component of baseline assessment and follow-up, radiography cannot reliably detect early disease or guide early therapeutic interventions on its own.

Superiority of Ultrasound

Musculoskeletal ultrasound has emerged as an essential modality in pediatric rheumatology. It is safe, non-invasive, relatively inexpensive, and well-tolerated by children.[9] In our study, USG detected synovial effusion and thickening in 76.7% of patients, outperforming radiographs. Crucially, USG identified subclinical synovitis in joints with normal clinical exams, mirroring findings in larger validation studies: for example, ultrasound sum scores show strong correlation with whole-body MRI scores ($r \approx 0.74$) and composite disease activity indices.[10] Sensitivity of around 57% and specificity of 96% in joint-level assessment further emphasize.[9] The advantages of USG extend beyond diagnosis—its ability to guide intra-articular corticosteroid injections improves precision and therapeutic response. Limitations remain: operator dependency and lack of standardized pediatric scoring have historically hindered wide applicability. Nevertheless, international efforts, such as standardized scanning protocols and atlases, are enhancing reproducibility and validity of USG in JIA.[11]

MRI as the Gold Standard for Early and Subclinical Disease: Contrast-enhanced MRI remains the reference standard for detecting synovitis, bone marrow edema, cartilage loss, and early erosions.[12] In our cohort, MRI identified pathology in 56.7% of patients, including marrow edema and synovial thickening, particularly in clinically silent joints. This confirms previous studies showing MRI's superiority, especially in deeper joints like the shoulder, hip, and sacroiliac joints.[13] Importantly, clinical examination failed to detect shoulder involvement in over 70% of affected joints when MRI was used as reference. The development of pediatric-specific scoring systems, such as JAMRIS, and initiatives by groups like OMERACT, highlight efforts to standardize MRI interpretation in JIA.[14] Such tools enhance the reliability of MRI in both clinical and research settings. However, MRI remains more resource-intensive, often necessitates sedation in young children, and access is a limitation in many settings.

Integrative Imaging Approach

Current consensus suggests a tiered imaging strategy: radiographs for baseline appraisal, USG for routine monitoring and guided interventions, and MRI reserved for deep or complex joints, equivocal cases, or research . Our findings endorse this approach.[15] USG provided high sensitivity for active synovitis and informed immediate management decisions. MRI served as a valuable arbiter in ambiguous presentations and strategic planning for therapeutic escalation. This aligns with EULAR-PReS recommendations, which advocate combined use of USG and MRI for sensitive disease monitoring

Implications for Clinical Practice

Incorporating both USG and MRI in diagnostic algorithms offers several benefits:

1. Early Detection: USG and MRI detect subtle inflammatory changes before radiographic alterations, enabling earlier and more targeted therapy.
2. Monitoring Disease Activity: Regular USG can track changes in synovial proliferation or vascularity, guiding treatment adjustments.
3. Guided Interventions: US-guided intra-articular injections achieve better localization and greater therapeutic efficacy.

The relatively small sample size limits definitive conclusions; however, the trends align with larger studies. Additionally, we did not quantify agreement or compute precise sensitivity/specificity for each modality, focusing instead on descriptive findings. Sedation was not required for older children, but may limit generalizability. Finally, due to resource limitations, whole-body MRI was not feasible; instead, target-joint MRI was employed. Adoption of standardized tools like JAMRIS and age-specific US atlases would harmonize inter-center comparisons.

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CONCLUSION

In conclusion, our results reinforce the integral roles of USG and MRI in diagnosing and managing JIA. While conventional radiography remains foundational for structural assessment, US and MRI enhance early detection, treatment guidance, and disease monitoring. A tailored, multimodal imaging approach—radiograph, US, then MRI when warranted—optimizes clinical care and supports better long term outcomes in children with JIA.

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