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INFECTED HIP: ADVANCED MRI AND X-RAY IMAGING WITH DIAGNOSTIC DIFFERENTIATION FROM MIMICS

Radio-Diagnosis

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ABSTRACT

Background: X-ray / Plain film is the first imaging modality for evaluating suspected hip infections, offering an accessible and rapid assessment of bony structures and joint abnormalities. However, its sensitivity is limited in early-stage infections. Magnetic Resonance Imaging (MRI) is the primary investigation of choice, providing superior soft-tissue contrast and early detection of inflammatory changes with extent of involvement. Differentiating infectious conditions such as septic arthritis, osteomyelitis, and abscess formation from non-infectious mimics like transient synovitis, inflammatory arthritis(rheumatoid arthritis), avascular necrosis, and neoplasms is crucial for appropriate management. This paper provides a comprehensive review of X-ray and MRI findings in hip infections and strategies to distinguish them from similar presenting pathologies and compares the diagnostic performance of X-ray and MRI in detecting hip infections, supported by illustrative case series. **Method:** In a retrospective review of 15 tertiary-care patients with suspected hip infection, all underwent standard AP and lateral (± frog-leg) radiographs alongside 1.5–3.0 T MRI (T1, T2, STIR, and gadolinium-enhanced sequences in axial, coronal, and sagittal planes), with final diagnoses confirmed by imaging, clinical correlation, and microbiological or surgical data. **Results:** MRI demonstrated superior sensitivity (100%) in identifying early signs of infection such as marrow oedema, joint effusion, and synovial enhancement, while X-ray findings were often normal or equivocal in early disease. MRI also helped distinguish infectious from non-infectious mimics such as avascular necrosis (AVN), which showed characteristic "double-line signs" and lacked diffuse oedema. X-rays were more helpful in advanced or chronic cases, showing features like joint space narrowing, osteopenia, and bony erosions. **Conclusion:** MRI significantly outperforms X-ray in diagnosing early-stage hip infections and delineating the extent of disease, especially when clinical findings are ambiguous. Early MRI should be considered in all high-suspicion cases where radiographs are inconclusive. X-rays remain useful for initial screening and long-term follow-up, but their diagnostic sensitivity in early infection is limited.

KEYWORDS

Infection, arthritis, tubercular arthritis, MRI, Plain film

INTRODUCTION

Hip joint infections, including septic arthritis and osteomyelitis, are medical emergencies that require prompt diagnosis to prevent irreversible joint damage and systemic complications. While plain radiographs are often the first imaging modality used due to their accessibility, they lack sensitivity in early infection. In contrast, MRI provides superior soft-tissue contrast and is highly sensitive for detecting early inflammatory changes such as marrow oedema, synovial enhancement, and joint effusions. However, accurate differentiation between true infection and non-infectious mimics—such as transient synovitis, inflammatory arthritis, avascular necrosis, or neoplasms—is critical, as these conditions can present with overlapping clinical and imaging features. This paper reviews the comparative diagnostic value of MRI and X-ray in hip infections and highlights key imaging features that help distinguish infections from mimics, aiming to guide timely and accurate clinical decision-making.

METHODS:

A retrospective review of 15 cases from a tertiary care centre was conducted. Patients underwent both X-ray and MRI as part of the evaluation for suspected hip infection. MRI Protocol

- **Sequences:** T1-weighted, T2-weighted, Short Tau Inversion Recovery (STIR), and contrast-enhanced imaging.
- **Field Strength:** 1.5T or 3.0T preferred for optimal resolution
- **Imaging Planes:** Axial, coronal, and sagittal views
- **Role of Contrast:** Gadolinium-based contrast enhances detection of abscesses and active inflammation

X-ray Protocol

- **Standard Views:** Anteroposterior (AP) and lateral views of the hip
- **Additional Views:** Frog-leg lateral for better femoral head visualization

Final diagnosis was based on imaging findings, clinical correlation, and microbiological or surgical data when available.

RESULTS:

Diagnostic Findings on X-ray vs MRI

A.) X-Ray: X-ray findings across various musculoskeletal pathologies vary based on the condition and its progression. In infective pathologies , early septic arthritis may show normal films, but progresses to joint space narrowing, periarticular osteopenia, and chronic reactive sclerosis. Osteomyelitis often presents with regional osteopenia, periosteal reaction, and focal bony lysis or cortical destruction. Tuberculous arthritis is characterized by gradual joint space narrowing, periarticular osteopenia, subchondral cysts or erosions, and atrophic arthropathy with irregular cortical outlines. Prosthetic infections may show periprosthetic osteolysis, component loosening, and periosteal reaction. Among non-infective pathologies , avascular necrosis (AVN) initially appears normal but later reveals subchondral fractures, sclerosis, a crescent sign, or rim sign. Osteoarthritis (OA) commonly presents with joint space narrowing, osteophyte formation, and subchondral sclerosis or cysts. Inflammatory arthritis such as rheumatoid or psoriatic arthritis may show periarticular osteopenia, joint space narrowing, and erosions (especially in RA). Fractures vary with time; acute fractures show a visible fracture line, stress fractures may present with periosteal reaction, and healing fractures exhibit callus formation. Bone tumors , whether primary or metastatic, can appear as lytic or sclerotic lesions, with possible periosteal reaction and cortical destruction in aggressive forms.

B.) MRI: MRI findings in infective musculoskeletal pathologies vary across different sequences. In septic arthritis , T1-weighted imaging shows low signal in the joint space and subchondral bone, while T2/STIR highlights a thin rim of subchondral edema and pericapsular

edema. Post-contrast, there is diffuse, intense synovial enhancement, and diffusion-weighted imaging (DWI) may reveal restricted diffusion. Osteomyelitis presents with a low signal central component on T1, surrounded by lower than normal signal, and high signal in the bone marrow on T2. Post-contrast imaging shows intense marrow and periosteal enhancement, while DWI often demonstrates restricted diffusion in infected bone. Tuberculous arthritis appears hyperintense on T1 due to blood degradation products, and T2 shows high signal in the synovium, possibly with rim-enhancing abscesses. On post-contrast images, thick synovial enhancement and possible abscesses are visible, with DWI revealing restricted diffusion in abscesses. For prosthetic infection , T1 shows low signal in infected tissues, with T2 revealing high signal in peri-prosthetic fluid and edema in adjacent bones. Post-contrast imaging shows peripheral enhancement of fluid collections, and DWI may demonstrate restricted diffusion in infected areas. These MRI findings provide detailed insights into the severity and extent of the infection in different musculoskeletal structures.

MRI findings in non-infective musculoskeletal pathologies across different sequences demonstrate distinct patterns. In inflammatory arthritis (including RA, reactive, and psoriatic types), T1 shows low to intermediate signal in the synovium, while T2/STIR exhibits high signal in the synovium with synovial thickening, joint effusion, and bone marrow edema. Post-contrast imaging shows diffuse, symmetric synovial enhancement, with no significant restriction on diffusion-weighted imaging (DWI). For avascular necrosis (AVN), T1 imaging reveals low signal in the necrotic area with bright signal in the surrounding reactive bone. The characteristic "rim sign" and "double-line sign" (inner bright granulation tissue, outer dark necrosis) are visible on T2. There is no synovial enhancement unless secondary inflammation occurs, and DWI shows no restricted diffusion in the early stages. Fractures (acute and stress) appear with low signal along the fracture line on T1, and T2/STIR shows high signal surrounding the fracture site. Mild enhancement is seen along fracture edges post-contrast, with no restriction on DWI unless complicated by bone injury. Neoplasms, whether metastases or primary tumors, exhibit variable T1 signals, often low in aggressive tumors, and heterogeneous high signal in necrotic or cystic areas on T2. Post-contrast imaging shows irregular, heterogeneous enhancement, reflecting the tumor's complexity and aggressiveness. These MRI findings help to differentiate between different non-infective pathologies and assess their extent and impact on surrounding tissues.

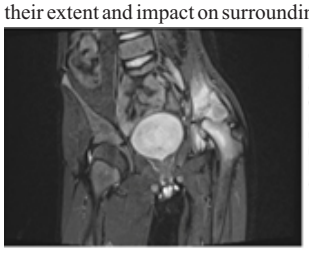

Fig 1: T2 /STIR Coronal: Geographical area of altered signal intensity is seen in involving left femoral head, neckand acetabulum appearing hyperintense on T2. Irregular cortical outline and cartilage erosion is seen in femoral head, neck and acetabulum with surrounding fluid collection. Above mentioned imaging findings are in favour of infective etiology likely tubercular — septic arthritis as described above

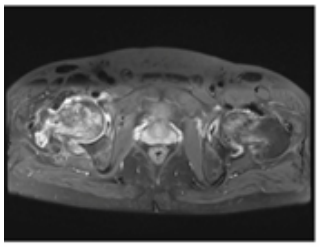

Fig 2: PD/FS Axial: On the right, there is geographic area in right femoral head with "double line sign" at the periphery and suspicious subchondral fracture in the anterosuperior aspect — suggestive of avascular necrosis stage IV.On the left, there is geographic area in left femoral head with "double line sign" at the periphery with no evidence of subchondral collapse — suggestive of avascular necrosis stage III.

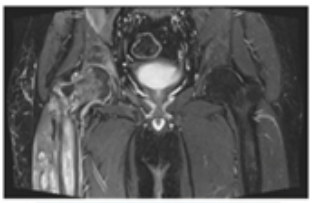

Fig 3: T2/STIR Coronal: Geographical area of altered signal intensity is seen in involving right femoral head, neck and visualized shaft of femur as well as right acetabulum appearing hyperintense on T2, PD & STIR images while hypointense on T1 images with fluid along the medullary fixation and surrounding mild fluid collection and edema in obturator internus and gluteus muscles. There is evidence of edema in right gluteus maximus muscle and superficial subcutaneous plane with fluid signal intensity tract — likely post operative infected / inflammatory.

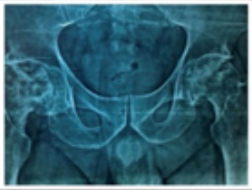

Fig 4: X - Ray Bilateral hip: Multiple areas of increased bone density, with flattening and collapse of femoral heads, reduced joint space and subchondral lucency.

Comparative Accuracy And Performance

Drawing from both our case analysis and literature data, MRI demonstrates markedly higher sensitivity and good specificity for hip infections compared to X-ray. In our small series, MRI achieved a 100% detection rate for confirmed infections (4/4), whereas X-ray detected definitive signs in only 1 of 4 (25%) at initial presentation. These numbers correlate with larger studies: MRI sensitivity for acute osteomyelitis or septic arthritis ranges from 82–100%, with specificity around 75–96%. X-ray sensitivity, by contrast, is variable and time-dependent –essentially 0% in the first few days, rising to perhaps ~50% after 2 weeks when osteolysis or periosteal reaction might be visible. Specificity of X-ray can be high (in our series, when an X-ray shows classic joint destruction in a febrile patient, it was truly infection) but radiographic changes of infection can overlap with other entities (e.g., Charcot arthropathy or tumour), so specificity is not perfect. According to paediatric guidelines, plain radiographs for osteoarticular infection have sensitivity <20% and specificity ~80–100% in early evaluation, which underscores their limited standalone value.

Modality	Sensitivity for Early Infection	Sensitivity for Late Infection	Specificity for Infection (vs. Mimics)
X-ray	Very Low (<20% in first 1–2 weeks)– often normal early	Moderate (~70% by chronic phase) – can detect established bone erosions and joint destruction	High when advanced changes present (e.g., bony destruction is usually infection) but Low for early or subtle changes (non-specific findings)
MRI	Very High (~90–100%) – detects effusion, oedema, synovitis within days of onset	Very High – shows chronic changes plus active inflammation (if present)	Moderate to High – usually can distinguish infection from degenerative or inflammatory conditions by pattern of oedema and enhancement; however, false positives possible with severe inflammation or recent fracture (specificity ~80–90%)

In our study, MRI had no false negatives, whereas X-ray had multiple false negatives and one false positive concern. One should note that MRI's specificity can be slightly lower in practice because other causes of inflammation (e.g., inflammatoryarthritis or transient synovitis) can also cause bone marrow oedema and joint fluid. Forexample, an MRI in a case of acute transient synovitis (a self-limited inflammatory conditionin children) might show joint effusion and even mild marrow oedema, mimicking septicarthritis – yet there is no infection. In such cases, additional clinical correlation or aspirationmay be required. However, advanced MRI techniques such as diffusion-weighted imaging (DWI) can sometimes help: true abscesses in infection often show restricted diffusion,differentiating them from oedematous fluid of non-infectious causes.

DISCUSSION

Clinical Implications of MRI vs X-ray in Hip Infections

The findings from our case series reinforce the paradigm that while X-rays are a prudent first step in evaluating hip pain, MRI is indispensable for early and accurate diagnosis of hip infections. Early diagnosis is critical: a delay in identifying septic arthritis of the hip can lead to irreversible cartilage loss within days and can substantially worsen patient outcomes(including higher rates of surgical intervention and complications)1,2,3. Given that plain radiographs may be normal or equivocal in the early infection period, a high index of suspicion should prompt advanced imaging7. In practice, if a patient has acute hip symptoms and elevated inflammatory labs but an unremarkable X-ray, clinicians should strongly consider MRI as the next step1,7. Indeed, guidelines suggest that the imaging workup for suspected septic arthritis or osteomyelitis should include MRI, and reliance on ultrasound alone is insufficient MRI, by depicting both intra-articular (joint) changes and adjacent osseous changes, offers a one-stop evaluation[1].

Comparison of specificity for X-ray vs. MRI in diagnosing infective and non-infective hip pathologies:

X-ray and MRI have differing levels of specificity and sensitivity in diagnosing infective and non-infective hip pathologies. X-ray is generally less sensitive in the early detection of many conditions, such as septic arthritis, osteomyelitis, and tuberculous arthritis, where it may miss subtle or early changes like joint effusion, synovial thickening, or marrow edema. However, it is highly specific for advanced osteoarthritis, showing classic features like joint space narrowing, osteophytes, and sclerosis. For fractures, X-ray is highly specific for acute fractures but may miss stress fractures. MRI, on the

other hand, has high sensitivity and specificity for early detection of infective pathologies, such as identifying marrow edema, soft tissue involvement, and synovial thickening in conditions like septic arthritis and osteomyelitis. It is also excellent for detecting early avascular necrosis (AVN) and inflammatory arthritis, showcasing early marrow changes, synovial thickening, and erosions before they appear on X-ray. For tumors, MRI offers superior detail, detecting tumor extent, soft tissue involvement, and necrosis, which X-ray cannot fully assess. MRI is highly sensitive for fractures, especially stress fractures and subtle bone marrow edema, which may go undetected on X-ray. Overall, while X-ray is more specific for late-stage findings, MRI provides superior early detection and detailed imaging, particularly for soft tissue and marrow involvement.

CONCLUSIONS

A multimodal imaging approach is essential for evaluating hip infections, with MRI providing detailed visualization of intra-articular and periarticular structures and X-ray serving as an accessible first-line tool. A systematic approach to imaging interpretation, integrating both modalities, is crucial for distinguishing infections from their mimics, ensuring timely and appropriate treatment. MRI is more specific than X-ray for early detection of infective conditions (septic arthritis, osteomyelitis, TB arthritis).

MRI is superior for non-infective conditions like AVN, stress fractures, and transient osteoporosis, which may appear normal on X-ray in early stages.

X-ray remains specific for osteoarthritis and acute fractures but lacks sensitivity for early-stage pathology.

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