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Role of magnetic resonance imaging findings in evaluation of painful hip joint

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Abstract
MRI Imaging of the painful hip joint is a valuable tool in the evaluation of hip disorders because it enables assessment of articular structures, extra-articular soft tissues, and the osseous structures that can be affected by hip disease. In the setting of chronic hip pain, a normal appearing radiograph, a nonspecific history and clinical findings can be a difficult diagnostic dilemma. Trauma, infection, arthritis, avascular necrosis, tumor, and hip dysplasia can all manifest with extremely subtle radiographic abnormalities.

Keywords: MRI, AVN, perthe's, tuberculosis

Introduction
Imaging of the hip was among the earliest reported applications of musculoskeletal magnetic resonance (MR) imaging. MR imaging is a valuable tool in the evaluation of hip disorders because it enables assessment of articular structures, extra-articular soft tissues, and the osseous structures that can be affected by hip disease. In the setting of chronic hip pain, a normal appearing radiograph, a nonspecific history and clinical findings can be a difficult diagnostic dilemma. Trauma, infection, arthritis, avascular necrosis, tumor, and hip dysplasia can all manifest with extremely subtle radiographic abnormalities [1].

The principal benefit of the true coronal and axial planes is that they provide symmetric, bilateral images, which can be important in the diagnosis and can greatly accelerate the time required to evaluate both hips. Normal hip anatomy can be routinely demonstrated on coronal and axial MR images. The femoral head and neck and the intertrochantric region are best appreciated on coronal MR images. Axial MR images provide good visualization of the articular space, hip musculature, and supporting ligaments.

The diagnostic ability of MR imaging in the evaluation of AVN is evolving. MR imaging is performed to detect AVN in its early stages, thus allowing early treatment and prevention of subsequent bone destruction. MR imaging has been shown to be the most sensitive modality for imaging AVN. Screening of asymptomatic, high-risk patients may enable early intervention. The principal role of MR imaging is in establishing the diagnosis of AVN in symptomatic patients before radiographic changes become apparently visible.

MR imaging is becoming increasingly useful in diagnosis and management of pediatric hip disorders. MR imaging offers several advantages that are especially important in the pediatric hip population. Because much of pediatric hip is cartilaginous, it is often not optimally imaged with other modalities such as plain radiography, ultrasound (US) (after 6 months of age), and computed tomography (CT). MR imaging is unique in its ability to depict cartilage and is, therefore, especially efficacious in the evaluation of the pediatric hip [2].

Currently, high-resolution direct MR imaging of the hip provides the best means for evaluating intra-articular pathology. However, radiography remains important for the diagnosis of subtle bony irregularities associated with femoro-acetabular impingement. Therefore, a comprehensive imaging strategy requires conventional radiographs and MRI to evaluate intra- and extra-articular sources of pain.

Aim and Objectives
Aim
To assess the role of MRI in early evaluation of painful hip joint.

Objectives
- To establish a differential diagnosis of various painful hip joint conditions on MRI.
- To assess the severity and extent of the lesion in various conditions of painful hip joint.

Material and Methods
Study Population
A prospective study was carried out on 50 patients over a period of 2 years from Dec 2014 to September 2016. Institute Ethics Committee Clearance was obtained before the start of the study.

Patient Selection Criteria
The study included patients from all age groups including both men and women presenting with acute or chronic unilateral or bilateral hip pain without recent history of trauma (less than one month). Patients with congenital hip conditions or tumour were not a part of this study. Also patients with history of claustrophobia or history of metallic implants insertion, cardiac pacemakers and metallic foreign body insitu were excluded from this study.

Method
MRI was performed using SIEMENS 1.5 Tesla Magnetom Avanto Machine. The size of bore was 60 cm and overall length of the system was 160 cm. A body coil was used. Detailed clinical history, physical and systemic examination findings were noted in addition to the laboratory investigations. All the patients were subjected to radiograph of Hip AP View.

Scanning Technique

Patient was positioned in supine position with head pointing towards the magnet.

A body coil was placed over the pelvis to provide a uniform signal to nose ratio. Standrad sequences prformed namely. Coronal T1W, Coronal STIR, Axial T1, Axial STIR, Sagital T1, Axial GRE.

Sex Distribution

Out of the 50 patients included in our study, 36 were males and 14 were females.

Age wise Distribution

Age of the patients ranged from 6 to 65 years with the highest incidence seen in the 21-40 age group (as seen in the table and graph below) comprising of 12 patients each in the 21-30 and 31-40 age groups.

Table 1: Age wise distribution

Age	Number of Patients	Percentage
0-10	4	8 %
11-20	5	10 %
21-30	12	24 %
31-40	12	24 %
41-50	8	16 %
51-60	6	12 %
61-70	3	6 %
Total	50	100 %

MRI Diagnosis

Commonest condition to be diagnosed on radiographs was avascular necrosis of the femoral head seen in 24 (48%) patients followed by osteoarthritis which was seen in 10 (20%) patients

Table 2: showing the distribution of conditions diagnosed on MRI

Serial No.	Pathology	No. of Patients	Percentage
1.	AVN	24	48 %
2.	Osteoarthritis	10	20 %
3.	Joint Effusion	8	16 %
4.	TB Arthritis	6	12 %
5.	Perthe's	2	4 %
	Total	50	100 %

Avascular Necrosis of Femoral Head

Out of 50 cases 24 (48%) cases were diagnosed as avascular necrosis of femoral head. In 24 cases of AVN, only 10 (42%) cases were detected on radiography whereas all 24 (100%) cases were detected on MRI. Out of 24 cases, 14 (58%) cases which were normal {stage I and stage II of FICAT Classification} on radiography were proved to have AVN on MRI. Thus MRI is more sensitive than plain radiography.

Out of the 10 (42%) cases which were detected both on radiography and MRI, 6 (25%) that were reported as stage II on radiography {FICATS} were staged as stage III on MRI {MITCHELL'S} and 4 (16%) cases which were reported as stage III on radiography {FICATS} were staged as stage III or more on MRI {MITCHELL'S}.

In 42% of the patients AVN was correctly diagnosed on radiography and all 100% were diagnosed on MRI

MRI findings of AVN

Commonest finding seen on MRI in cases with AVN was that of bone marrow edema which was seen in 25 cases followed by subchondral cysts seen in 16 patients. Joint space reduction was not commonly seen and was found in only one patient.

Table 3: Showing MRI findings of AVN

MRI Findings		Number of Patients	Percentage % (n=24)
Bone marrow edema	Femoral head	21	87 %
	Acetabulum	4	16 %
Double line sign		19	79 %
Subchondral cysts	Femoral head	15	62 %
	Acetabulum	1	4 %
Joint Effusion		15	62 %
Joint space reduction		1	4 %
Femoral head altered contour		9	37 %
Femoral head fragmentation with collapse		1	4 %

Osteoarthritis

Out of 50 cases ten (20%) showed osteoarthritis. All the ten cases were detected both on plain radiography as well as on MRI. But, out of ten cases three (30%) appeared to be stage I on radiograph and stage II or III on MRI. of the ten cases 3 (30%) showed stage II on radiography and stage III on MRI. Out of ten cases detected on radiography stage I (4 cases), stage II (4 cases) and stage III (2 cases). On MRI stage I (1 case), stage II (4 cases), stage III (3 cases) and stage IV (2 cases).

Table 4: Showing the MRI Findings of osteoarthritis

MRI Findings	Number of Patients	Percentage % (n=10)
Articular cartilage T2W high signal	5	50%
Indistinct trabeculae / signal loss in femoral head and neck on T1WI	9	90%
Indistinct zone between femoral head and acetabulum	3	30%
Subchondral signal loss	3	30%
Femoral head deformity	2	20%

MRI Findings of Osteorthritis

Commonest MRI abnormality seen in cases of osteoarthritis was signal loss in the femoral head and neck on T1W images which was found in 90% cases.

Joint Effusion

Out of 50 cases, 8 (16%) cases showed isolated joint effusion. Of these, three (37%) cases were detected on radiography alone and all eight cases (100%) were positive for joint effusion on MRI.

Findings on radiograph: widening tear drop distance.

Findings on MRI: T2W and STIR hyperintensity within the joint space which is graded as mild, moderate and severe.

Tuberculosis of hip joint

6 cases (12%) were diagnosed as Tuberculosis of hip, out of which five (83%) cases were correctly detected on radiography, where as all six (100%) cases were detected on MRI.

Out of five cases detected on radiograph stage I (1 case), stage II (1 case), stage III (2 cases), stage IV (0) and stage V (1 case).

Out of six cases detected on MRI shows stage I (1 case), stage II (1 case), stage III (1 case), stage IV (2) and stage V (1 case).

MRI Findings in TB hip joint

Commonest findings of TB hip seen on MRI were adjacent soft tissue hyperintensity and joint effusion each seen in 5 (83%) cases followed by bone marrow edema seen in 4(67%) cases.

Table 5: Showing MRI Findings of tubercular hip joint

Synovial hyperintensity on T2WI	2	33 %
Joint effusion	5	83 %
Bone marrow edema	4	67 %
Subarticular cysts	2	33 %
Joint space reduction	4	67 %
Joint destruction & bony ankylosis	1	17 %
Soft tissue hyperintensity on T2WI	5	83 %

Perthe's Disease

Two cases (4%) of Perthe's disease were seen in our study. Both of the cases were correctly detected on radiograph (100%) as well as MRI (100%).

MRI findings of Perthe's were T2 weighted epiphyseal hyperintensity and bone marrow edema.

Discussion

Our study aims at early detection of the disease before the appearance of signs on radiography or in patients having subtle findings on plain radiography by using MR imaging. It also aims at the accurate staging of the disease and assessment of involvement of pathology in cases which are already detected on plain radiography. This helps the clinician to treat the patient at an early stage and to improvise treatment according to the stage of involvement of the pathology thereby limiting further progression of the disease.

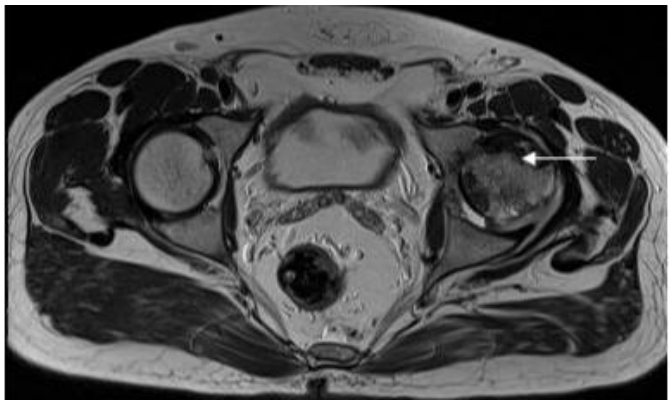

Fig 1: Axial T2W image showing well demarcated geographic lesions with typical peripheral low signal intensity rim (arrow) on the antero-superior aspect of the left femoral head (AVN grade II)

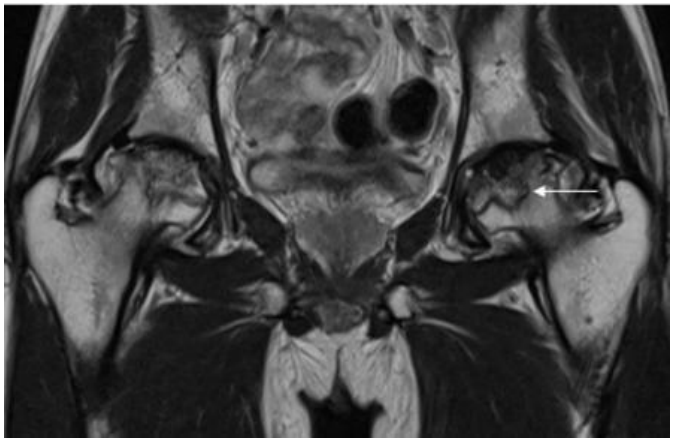

Fig 2: Coronal T2W image showing "double line sign" (arrow) as a high signal intensity inner border with a low intensity peripheral rim.

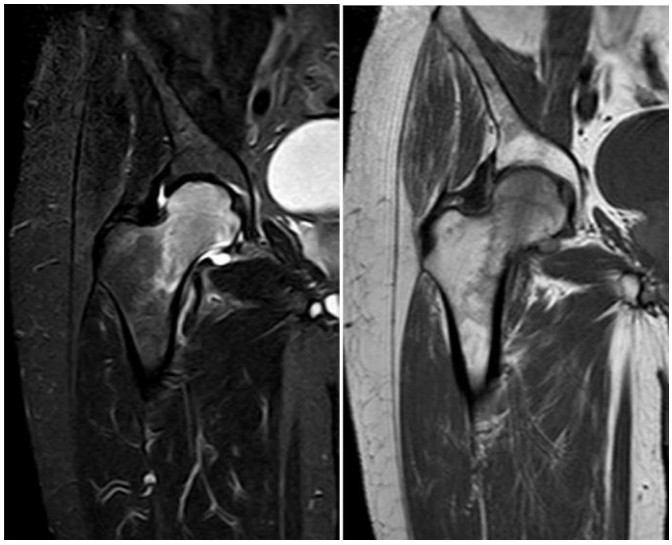

Fig 3a and 3b: Showing marrow edema which is high signal on STIR () suggestive of stage I AVN

Fig 4a and 4b: Showing heterogeneous signal on both coronal T1W () suggestive of stage II AVN

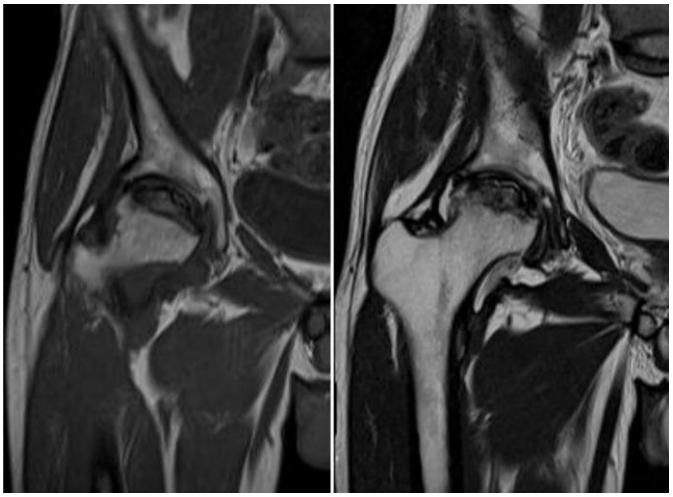

Fig 5a and 5b: Showing Crescent sign on both coronal T1W) images suggestive of stage III AVN

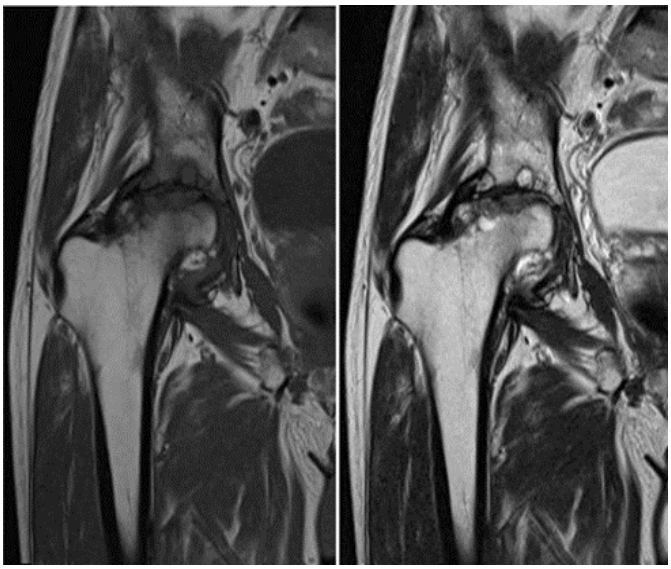

Fig 6a and 6b: Showing flattening of the femoral head on coronal images suggestive of stage IV AVN

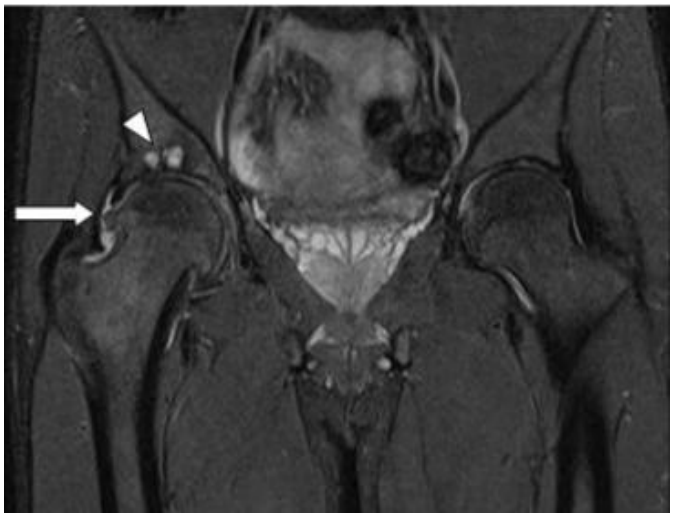

Fig 7: Osteoarthritic changes in right hip with thinning of articular cartilage with reduction of the right hip joint space. Marginal osteophytes with multiple subchondral cysts

Fig 8: Tuberculosis of right hip showing bone marrow edema in right acetabulum, right femoral head and neck with large erosion along articular surface of right acetabulum. Right hip joint space is narrowed and associated synovial effusion

Avascular necrosis of femoral head

In our study, AVN of femoral head was the commonest pathology identified as the cause for painful hip joint. In 24 (48%, n=50) cases of AVN diagnosed on MRI only 10 (20%, n=50) cases were identified on plain radiography.

Out of 10 (42%, n=24) cases diagnosed on plain radiography, 6 (25%, n=24) cases showed subchondral cysts and osteoporosis suggestive of stage I AVN {FICATS staging}. Rest of the 4 (16%, n=24) cases showed crescent sign, altered head morphology and osteoporosis suggestive of stage II AVN {FICATS staging}.

Of all the 24 cases detected on MRI, 21 (87%, n=24) cases showed bone marrow edema in femoral head, 4 cases (16%, n=24) cases showed bone marrow edema in acetabulum suggesting it to be a common associated feature that can be detected only on MRI as radiography has its limitation in diagnosing bone marrow edema.

MRI demonstrated double line sign i.e, on T2W sequences inner bright line representing granulation tissue and outer dark line suggestive of sclerotic bone in 19 (79%, n=24) cases.
Fourteen (58%, n=24) cases were diagnosed as normal or stage I (FICATS) on plain radiography and stage I or II on MRI.
Out of a total of 10 (42%, n=24) cases detected on plain radiography; 6 (25%, n=24) cases were staged as stage I (FICATS) which showed stage III (MITCHELL'S) with intermediate fluid signal on T1W images and bright signal on T2W images. Four (16%, n=24) cases which were staged as stage II (FICATS) turned out to be stage III or stage IV on MRI (MITCHELL'S) giving fibrous signal, dark on both T1W and T2W sequences, revealing that MRI is better than radiography in staging and assessing the extent of the pathological involvement in already proven cases of AVN on plain radiography.

Osteoarthritis
In this study, 10 (20%, n=50) cases of osteoarthritis were diagnosed. All of the 10 cases were correctly detected on plain radiography and on MRI.
On plain radiography, four (40%, n=10) cases showed stage I (Kellgren and Lawrence staging) in the form of possible narrowing of the joint space and osteophytes. Four (40%, n=10) cases were diagnosed as stage II with definite narrowing of the joint space inferiorly, minimal sclerosis and osteophytes. Two (20%, n=10) cases showed stage III with marked narrowing of the joint space, definite osteophytes, cyst formation, deformation of femoral head and acetabulum.
On MRI, one (10%, n=10) case showed stage I (Higgs and Aiesen staging) that is inhomogeneous high signal on T2W images within the cartilage. Four (40%, n=10) cases showed stage II that is inhomogenity of articular cartilage seen as high signal on T2Wsequences and indistinct trabeculae or signal intensity loss in femoral head and neck on T1W sequences. Three (30%, n=10) cases were diagnosed as stage III having criteria of stage I and II as mentioned above and indistinct zone between femoral head and acetabulum associated with subchondral signal loss due to bone sclerosis.
In our study Articular cartilage abnormalities were seen in 5 (50%) cases, joint effusion in 8 (80%) cases and osteophytes at various sites around the joint were noted in 6(60%) cases. Similar findings were noted in the study conducted by Horii et al [83] in 2000 who found articular cartilage abnormalities such as stripping and high signals in the antero-superior portions of the hip joint in about 90% cases, joint effusion in 29 cases and osteophye formation in 80 % cases.

Joint Effusion
On MRI, joint effusion was seen as high signal intensity within the joint space on T2W and STIR sequences suggestive of fluid collection within the joint capsule.
Also MRI demonstrated an added advantage of better and correct evaluation of the amount of fluid within the joint and grading to the effusion as minimal, moderate and severe joint effusion. Four (50%, n=8) cases had minimal joint effusion, 3 (38%, n=8) moderate and 1 (12%, n=8) case had severe joint effusion. Five (62.5%, n=8) cases diagnosed as normal on plain radiography showed joint effusion on MRI.
Reviewing the above findings, MRI proved to be more sensitive in detection of joint effusion particularly in cases where plain radiography showed normal or subtle changes

Tuberculosis of Hip joint
In the six cases (100%, n=6) diagnosed on MRI, 1 (17%, n=6) case showed only synovial T2W hyperintensity and joint effusion in the form of high signal intensity within the joint space in T2W and STIR sequences. This was diagnosed as normal on plain radiography.
On MRI, 1 (17%, n=6) case showed synovial hyper intensity, joint effusion and bone marrow edema as high signal intensity within the marrow on STIR sequence. Another single (17%, n=6) case showed sub articular T2 hyper intense cysts and joint space reduction. Joint deformity along with bone marrow edema, joint space reduction and para articular soft tissue hyper intense signal on T2W sequence was seen in two (33%, n=6) cases.
Thus, MRI helped in better delineation of synovial involvement and detection of joint effusion in early stages of TB hip where plain radiography has limitation in diagnosis. MRI also proved beneficial in detection of bone marrow edema in early stages of the disease. In the radiologically diagnosed cases, MRI helped in better evaluation of the extent of the articular cartilage destruction and also para articular soft tissue involvement.

Perthes Disease
In our study 2 (4%, n=50) cases were diagnosed as Perthes disease. Both the cases could be diagnosed on radiography as well as on MRI (100%, n=2)
The plain radiographic findings included cessation of femoral epiphyseal growth in the form of small epiphysis seen in one case and complete resorption of femoral epiphyses in healed/residual stage which was also seen in just one of the two cases.
On MRI, one of the cases, showed epiphyseal abnormality in the form of T1 hypo intensity, T2W hyper intensity and bone marrow edema in the form of STIR hyper intensity and metaphyseal T2W hyper intensities which was seen as cessation of femoral epiphyses growth on plain radiography

Summary
This was a hospital based study which was conducted to evaluate the various MRI findings in patients presenting with acute or chronic hip pain. Fifty patients with unilateral or bilateral hip pain, of all age groups and both sexes were studied over a period of 2 years.
MRI imaging of bilateral hip joints was performed and following noteworthy observations were made as follows:

- Majority of the patients were males in the age group of 21-30 and 31-40 years with equal number of patients in both age groups.
- The commonest cause of hip pain was found to be Avascular necrosis seen in 24 patients (48%) followed by osteoarthritis seen in 10 patients (20%).
- Of all the cases of Avascular necrosis, only 10 cases were accurately diagnosed on plain radiography, whereas all the cases were correctly diagnosed on MRI. Also MRI was found to be more sensitive in detection of AVN in early stages where plain radiography showed normal or very subtle findings. Hence, MRI helped in early and accurate diagnosis of the condition.
- Osteoarthritis was found in 10 patients presenting with hip pain. All of the 10 cases were diagnosed both on plain radiography as well as MRI. However, MRI showed a

better delineation of cartilage destruction and helped in accurate staging of the condition.

- Out of all the 50 patients, isolated joint effusion was seen in 8 patients (16%). MRI helped in diagnosing even minimal effusion that was often missed on plain radiographs.
- The 6 cases (12%) that were diagnosed as Tuberculous hip, MRI helped in
- quantification of the amount of marrow edema, better delineation of articular cartilage and assessment of the surrounding soft tissues in addition to plain radiography findings such as joint space reduction, osteopenia etc. Also MRI was helpful in diagnosis of early stages of the disease when the only detectable finding was articular cartilage hyperintensity.
- Perthe's disease was diagnosed in 2 patients. MRI demonstrated a proven added advantage in detection of early stages of the disease in the form of T2W hyperintensity in the involved epiphysis even before the actual displacement of the epiphysis occurred.

Conclusion

Plain film radiography is used in the initial evaluation of any cause of hip pain, including suspected avascular necrosis, arthritis, infection, dysplasia and tumour. Plain film may not detect early pathologies like avascular necrosis, also it cannot accurately characterize the articular cartilage pathology and soft tissue involvement.

In the setting of chronic hip pain, a normal appearing radiograph, a non specific history and clinical findings can be a difficult diagnostic dilemma. MR imaging is a valuable tool in the evaluation of hip disorders because it enables assessment of articular structures, extra-articular soft tissues, and osseous structures that can be affected by the hip disease. MRI is an imaging technique that does not require exposure to radiation. MRI of the hips should be performed early in patients with persistent pain and negative radiographic findings.

MR imaging is becoming increasingly useful in the diagnosis and management of pediatric hip disorders. It offers several advantages that are especially important in the pediatric population. Because much of the pediatric hip is cartilaginous, it is often not optimally imaged with plain radiography.

MR imaging is performed to detect avascular necrosis in its early stages, thus allowing early treatment and intervention to prevent or delay subsequent bone destruction. It has been shown to be the most sensitive modality for imaging avascular necrosis.

Joint effusion and synovial proliferation can be better detected by MRI than by conventional radiography. In proven cases on plain radiography such as Perthe's and infectious diseases of hip, MRI helps in better staging of the disease, assessing the extent of pathological involvement and soft tissue extension. Additionally, MRI is extremely sensitive to alteration in the bone marrow that may represent pathology occult to plain radiography of the hips.

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