

## ORIGINAL RESEARCH

### A study for characterization of MRI findings in patients with non-traumatic hip pain

<sup>1</sup>Dr. Poonam Ohri, <sup>2</sup>Dr. Jaspal Singh, <sup>3</sup>Dr. Gagandeep Sharma, <sup>4</sup>Dr. Manasi Kohli

<sup>1</sup>Associate Professor, <sup>3</sup>Junior Resident, Department of Radiodiagnosis and Imaging, Govt. Medical College, Amritsar, Punjab, India

<sup>2</sup>Professor, Department of Orthopedics, Govt. Medical College, Amritsar, Punjab, India

<sup>4</sup>Intern, SGRR Medical College, Dehradun, Uttarakhand, India

#### Correspondence:

Dr. Gagandeep Sharma

Junior Resident, Department of Radiodiagnosis and Imaging, Govt. Medical College, Amritsar, Punjab, India

Email: [acrystalray@gmail.com](mailto:acrystalray@gmail.com)

#### ABSTRACT

**Introduction:** A study for characterization of MRI findings in patients with non-traumatic hip pain.

**Aims and objectives:** To characterize the MRI findings of underlying pathologies in patients with non-traumatic hip pain and give radiological diagnosis which will help in the management of patients.

**Materials and methods:** 50 cases referred to the Department of Radiodiagnosis and Imaging, Government Medical College, Amritsar with hip pain were evaluated and statistically analyzed.

**Results:** Out of the 50 patients, pathology was seen in 45 patients (90%) and while 5 patients (10%) were found to be normal on MRI. The most common pathology detected was avascular necrosis seen in 23 patients (46%), followed by 12 patients of infective arthritis patients (24%), 3 patients of perthes disease (6%), 2 patients of bone tumor (metastasis) (4%), 2 patients of osteitis condensans illi (4%), 2 patients of stress fracture (4%) and 1 patient of tendinitis 1 (2%).

**Conclusions:** MRI was helpful in diagnosing various abnormalities. Various bone signal abnormalities as well as excellent soft tissue contrast aided in making timely diagnosis and management. The role of MRI in detection of various abnormalities was also statistically significant (as compared to plain radiographs which was additionally done) and had more sensitivity and specificity.

**Keywords:** Magnetic resonance imaging, avascular necrosis, infective arthritis, perthes disease, stress fracture, osteitis condensans illi.

#### INTRODUCTION

The pelvis is a very complex structure which is composed of an osseous ring formed by the innominate bones and sacrum with numerous muscles attached for support and ambulation. The sacroiliac joint does not allow much movement and the weight is transmitted by articulating surfaces. The hip joint is a ball and socket joint which gains stability by the anterolateral orientation of the acetabulum and the anterior position of the femoral head with regard to the femoral shaft.

The joint capsule tauts during extension and relaxes during flexion. The iliofemoral ligament, pubofemoral and ischiofemoral ligaments constitute the capsular ligaments. The ligamentum

teres (ligament of the head of femur) is intracapsular in location. The fovea of the femoral head is attached to the apex of cotyloid notch by it. Injury occurring to the ligamentum teres can affect the foveal artery thereby causing osteonecrosis of the femoral head.<sup>1</sup>

Anterior hip pain can be caused by hip flexor strains, tears, and avulsion fractures. Common causes include femoroacetabular impingement, avascular necrosis of the femoral head, osteoarthritis of femoroacetabular joint. Greater trochanteric pain syndrome is one of the most common causes of lateral hip pain. The diagnosis of the cause of the posterior hip pain might be difficult due to the varied differential diagnosis that includes musculoskeletal causes and referred pain from intrapelvic and gynecologic problems.

Posterior hip pain can be a presenting complaint in lumbar spinal issues, sacroiliac joint dysfunction or arthritis, hamstring injuries. Malignancy is an uncommon cause of non-traumatic hip pathology. Most common primary bone cancer is osteosarcoma and second most common cause is Ewing sarcoma. Both of these diseases have a peak in adolescence and can involve the hip region.

MR imaging plays a very important role in the diagnosis of hip disorders because it provides a complete evaluation of articular structures, extra-articular soft tissues, and the osseous structures that can be involved by hip disease. In a patient with the chronic hip pain, a normal appearing radiograph with a nonspecific history and clinical findings can be a diagnostic dilemma. Coronal and axial MR images provide a good picture of the normal hip anatomy with detailed description of the femoral head and neck and the intertrochanteric region in coronal images and articular space, hip musculature, and supporting ligaments on Axial MR imaging.<sup>2</sup>

## **MATERIALS AND METHODS**

### **STUDY SITE**

Government Medical College, Amritsar.

### **STUDY POPULATION**

50 patients referred to the Department of Radiodiagnosis and Imaging, Government Medical College, Amritsar presenting with non-traumatic hip pain.

### **STUDY DESIGN**

Observational study

### **SAMPLE SIZE**

50

### **DURATION OF STUDY**

2years

Ethical clearance has been obtained from the Research and Dissertation Committee/ Ethical Committee of the institution for this study.

### **IMAGING TECHNIQUE**

MR Imaging was done with 1.5 Tesla Siemens Aera Magnetom machine. The patient was placed supine, head first and legs in full extension. Body coil was placed over the pelvis. Following sequences were obtained: spin-echo T1 weighted (coronal/axial/sagittal), PD FATSAT (coronal/axial/sagittal), T2 weighted (coronal/axial/sagittal), T2 FATSAT and inversion recovery (coronal). Intravenous gadolinium (0.1mmol/kg) paramagnetic contrast agent was used in case of suspicious lesions detected on MRI scan and T1 FATSAT axial, coronal and sagittal sections were obtained. The images were interpreted on 512 x 512-pixel

LED monitor.

### STATISTICAL METHODS

MRI of the hip was done on a 1.5 Tesla Siemens Aera Magnetom machine. Images were obtained in the axial, coronal and sagittal planes. The characterization of the lesions affecting the hip was done with respect to marrow signal, joint space, femoral head symmetry, acetabular shape and symmetry, position of epiphysis, synovial lining and pre-articular soft tissue. The final data was analyzed descriptively and compiled in tabulated form. Results of the descriptive study are presented as mean and percentages for continuous and categorical variables respectively. Since plain radiographs were available with the patients, we compared them with our MR findings.

### RESULTS

The present study was conducted over a period of two years (July 2019 to June 2021) on 50 patients with history of non-traumatic hip pain who were referred to the Department of Radiodiagnosis, Government Medical College, Amritsar for MRI of hip joints.

The study results have been described below:

**Table 1: diagnosis based on MRI findings**

Diagnosis	Number of Patients (%)
AVN	23 (46%)
Infective	12 (24%)
Perthes	3 (6%)
Tumor	2 (4%)
Stress fracture	2 (4%)
Osteitis condensans illi	2 (4%)
Tendinitis	1 (2%)
Normal	5 (10%)

On MRI, 23(46%) patients of AVN, 12 (24%) patients of Infective arthritis, 3 (6%) cases of Perthes disease, 2 (4%) cases each of Tumor, Stress fracture, Osteitis condensans illi and 1 case (2%) of Tendinitis were diagnosed.

We additionally compared our MRI findings with the radiographs which were already available with the patients and showed the following findings:

**Table 2: diagnosis suggested on plain radiography**

Diagnosis	Number of patients
AVN	13 (26%)
Infective	7 (14%)
Perthes	3 (6%)
Tumor	2 (4%)
Stress fracture	2 (4%)
Osteitis condensans illi	2 (4%)
Tendinitis	0 (0%)
Normal	21 (42%)

These radiographs suggested the diagnosis of AVN in 13 (26%) cases, infective arthritis in 7 (14%) cases, perthes disease in 3 (6%) cases, tumors, stress fracture and osteitis condensans illi in 2 (4%) cases each, which were then additionally compared with our MR findings.

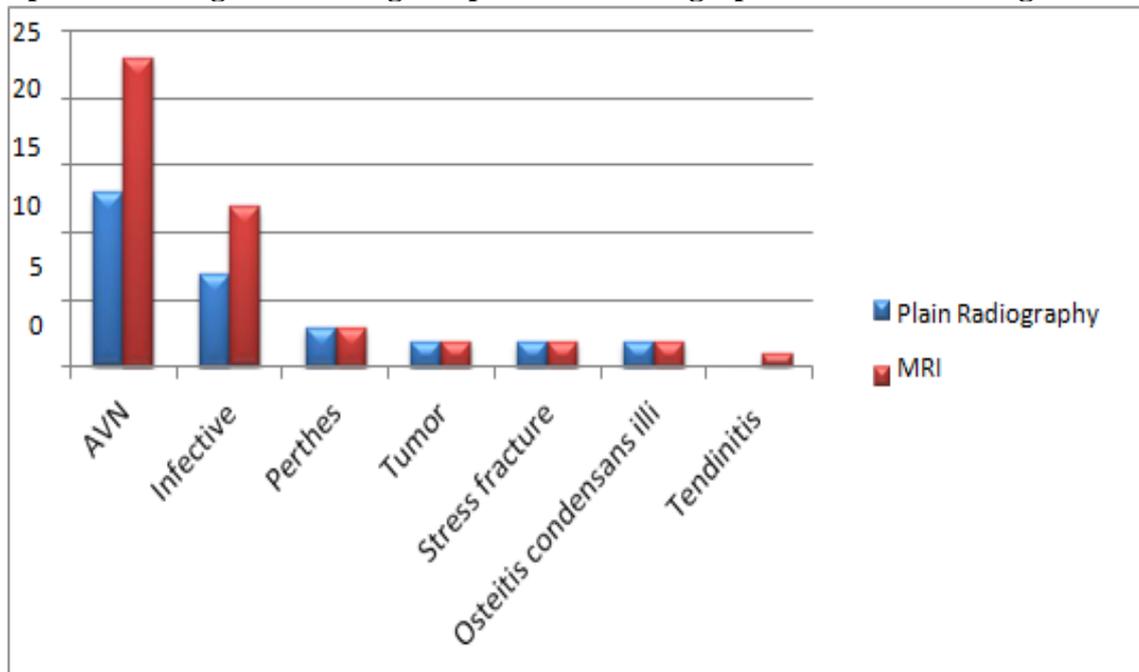
**Table 3: comparison of imaging findings between radiographs and MRI**

Findings	On Radiography	On MRI
AVN	13 (26%)	23 (46%)
Infective	7 (14%)	12 (24%)
Perthes	3 (6%)	3 (6%)
Tumor	2 (4%)	2 (4%)
Stress fracture	2 (4%)	2 (4%)
Osteitis condensans illi	2 (4%)	2 (4%)
Tendinitis	0 (0%)	1 (2%)
Normal	21 (42%)	5 (10%)

'p' value:0.01

Additional comparison was done between the Radiographs (already available with the patients) and MRI which showed that 10 (43.5%) cases of AVN, 5 (41.6%) cases of infective arthritis and one (100%) case of tendinitis were missed on plain radiography. However, all cases of perthes, stress fracture and osteitis condensans illi were diagnosed on radiographs. Though tumors were detected on radiograph MRI was necessary for proper characterization of lesion and its extension.

'p' value was 0.01 (<0.05) which also revealed significant role of MRI in detection of various abnormalities as compared to plain radiographs.

**Graph 1: Bar diagram showing comparison of radiographic and MRI findings.****Table 4: Statistical analysis for plain radiographs**

Name	Sensitivity	Specificity	TP	FP	TN	FN	PPV	NPV
AVN	56.5	100	13	0	27	10	100	72.9
Infective Arthritis	58.3	100	7	0	38	5	100	88.4
Perthes	100	100	3	0	47	0	100	100
Metastasis	100	100	2	0	48	0	100	100
Osteitis condensans illi	100	100	2	0	48	0	100	100
Stress fracture	100	100	2	0	48	0	100	100
Tendinitis	0	100	0	0	49	1	-	98

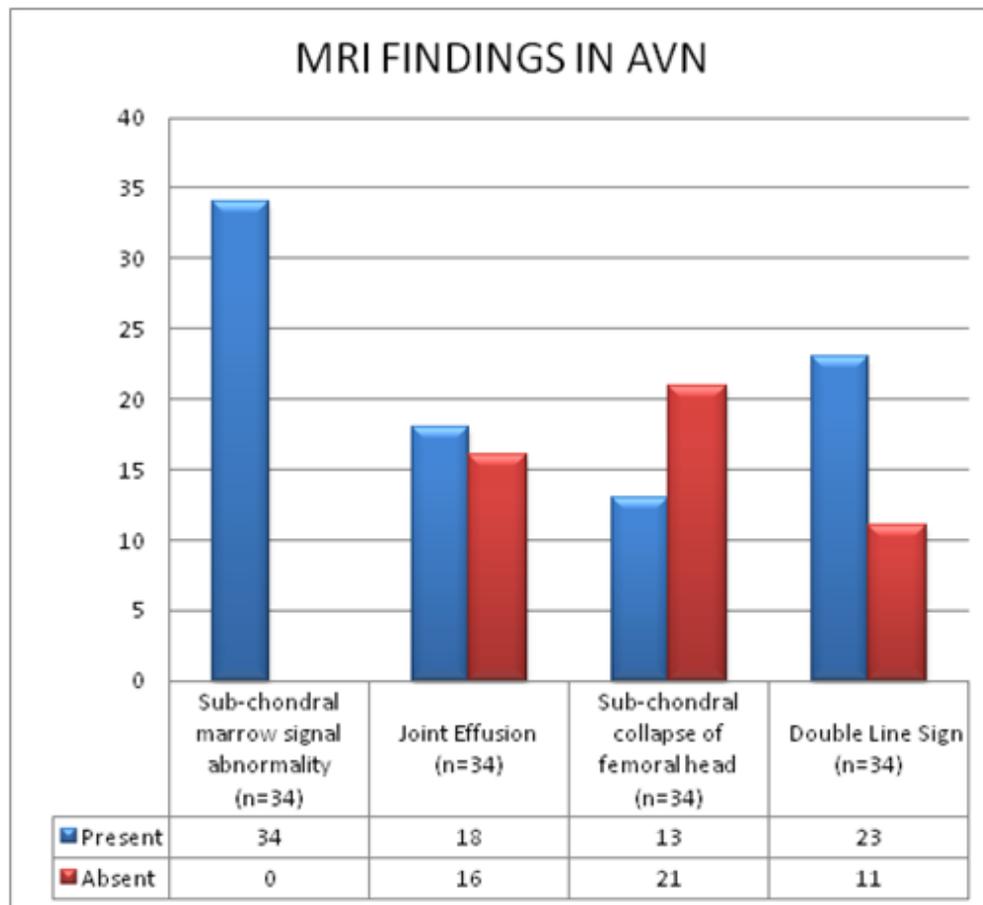
In our study, MRI had 100% sensitivity and 100 % specificity in diagnosing hip pathologies. It was additionally compared to already available radiographs of the patients which showed sensitivity of 56.5% and specificity of 100 % in case of AVN, sensitivity of 58.5 % and specificity of 100 % in case of infective arthritis, and 0% sensitivity and 100% specificity for tendinitis. All cases of perthes, tumors, stress fracture and osteitis condensans illi were detected on plain radiographs, however, MRI showed better anatomical detail, and extent of the disease.

**Table 5: MRI findings in AVN**

Findings on MRI	Present	Absent
Sub-chondral marrow signal abnormality	34(100%)	0
Joint Effusion	18(53%)	16(47%)
Sub-chondral collapse of femoral head	13(38%)	21(62%)
Double Line Sign	23(67.6%)	11(47.4%)

Out of 34 affected hips by AVN, MRI examination revealed a sub-chondral marrow signal abnormality in all 34 (100%), joint effusion in 18 (53%), sub-chondral collapse of femoral head in 13 (38%), double line sign in 23 (67.6%) and surrounding soft tissue inflammation in 4(19.1%) hips

**Graph 2: Bar chart showing MRI findings in a vascular necrosis and their frequency**



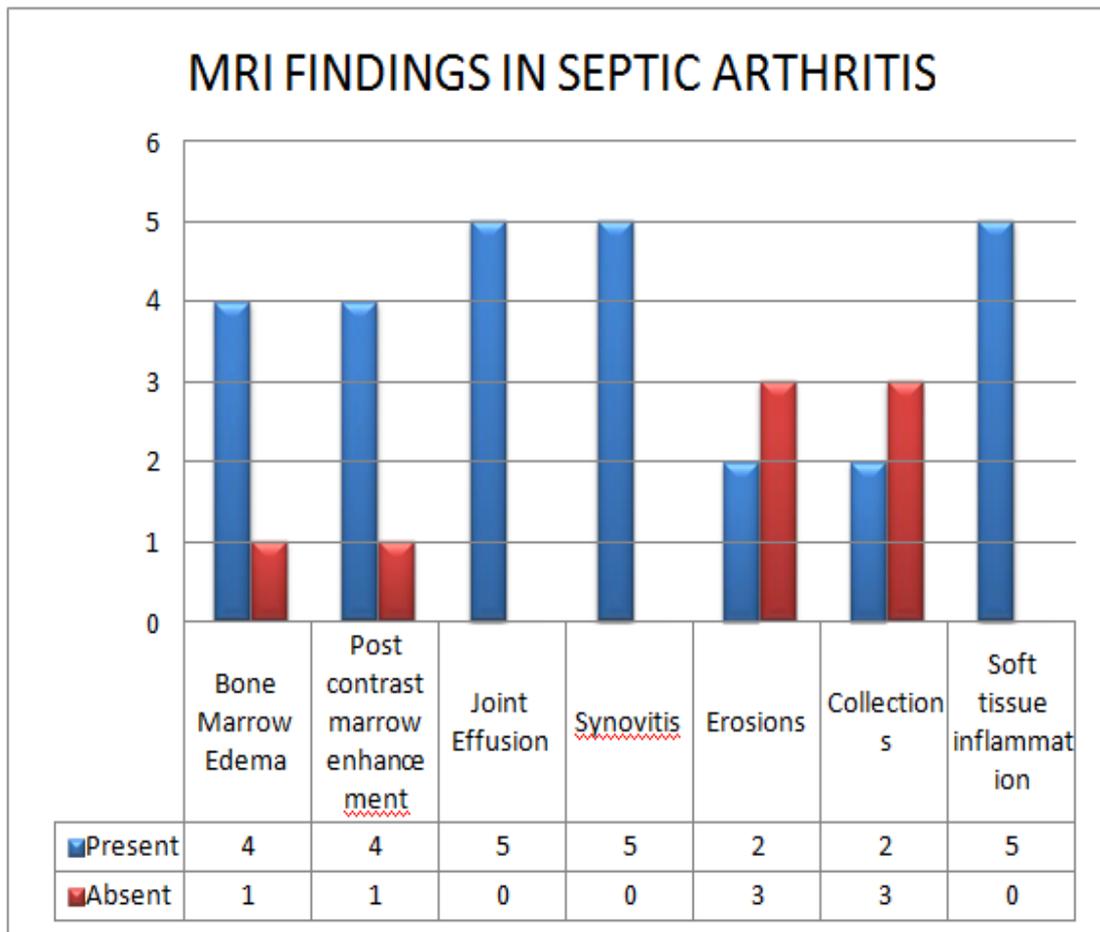
**Table 6: MRI findings in septic arthritis**

Findings on MRI	Present	Absent
Bone Marrow Edema	4(80%)	1(20%)
Post contrast marrow enhancement	4(80%)	1(20%)

Joint Effusion	5(100%)	0
Synovitis	5(100%)	0
Erosions	2(40%)	3(60%)
Collections	2(40%)	3(60%)
Soft tissue inflammation	5(100%)	0

Septic arthritis was diagnosed in 5 (41.6%) cases. Joint effusion, synovitis and soft tissue inflammation was seen in all (100%) the patients, erosions were found in 2 (60%) patients, collections were found in 2 (60%) patients. In addition, bone marrow edema and post contrast enhancement of bone marrow was observed in 4 (80%) patients.

**Graph 3: Bar diagram showing findings of septic arthritis**



**Table 7: MRI findings in tubercular arthritis**

MRI findings	Present	Absent
Bone Marrow Edema	6(85.7%)	1(14.3%)
Bone marrow enhancement	6(85.7%)	1(14.3%)
Synovitis	7(100%)	0
Joint Effusion	7(100%)	0
Erosions	6(85.7%)	1(14.3%)
Collections	5(71.4%)	2(28.6%)
Soft tissue inflammation	7(100%)	0
Femoral Head Collapse	2(28.6%)	5(71.4%)

Tubercular arthritis was diagnosed in 7 (14%) patients. Synovitis, joint effusion and soft

tissue inflammation was observed in all (100%) patients. Bone marrow edema and bone marrow enhancement was found in 6 (85.7%) patients, erosions were seen in 6 (85.7%), collections were seen in 5 (71.4%) patients, femoral head collapse was observed in 2 (28.6%) patients.

Clinical features, laboratory investigations and the MRI findings of bone erosions and thin walled collections pointed towards the diagnosis of tubercular arthritis (which was in accordance to the previous studies).<sup>3</sup> Further confirmation of the diagnosis was made on microbiological examination and response to therapy.

**Table 8: MRI findings in perthes disease**

Findings on MRI	Present	Absent
Bone Marrow Edema	3	0
Joint Effusion	3	0
Asymmetric epiphyseal size	3	0
Epiphyseal sclerosis	2	1

MRI findings of bone marrow edema, asymmetric epiphyseal size and joint effusion were seen in all 3 cases of Perthes disease. Epiphyseal sclerosis was seen in 2 (66.6%) out of 3 cases.

**Table 9: MRI findings in stress fracture**

Findings on MRI	Present (%)	Absent
Bone Marrow Edema	2(4%)	0
Medullary sclerotic line	2(4%)	0

Out of 50, 2 (4%) cases were diagnosed with stress fractures, one involving the pubic bone and one involving the medial femoral neck. MRI findings of bone marrow edema and sclerotic line were seen in both cases.

**Table 10: MRI findings in bone tumors**

MRI findings	Present	Absent
Focal marrow replacement	2(4%)	0
Post contrast enhancement	2(4%)	0
Adjacent Bone Marrow Edema	2(4%)	0
Joint Effusion	1(2%)	1
Soft tissue infiltration	1(2%)	1

MRI findings of focal marrow replacing lesion, post contrast enhancement and adjacent bone marrow edema were seen in both the cases (4%). Joint effusion and adjacent soft tissue infiltration was seen in one case (2%).

## DISCUSSION

In the present study, a total of 50 patients were included, in which the age ranged from 2 to 60 years of age, with mean age of 29.94 years. The number of patients was maximum in the age group of 31-40 years of age i.e., 16 out of 50 patients. The male to female ratio in our study group was 1.6:1. Similar male to female ratio was found by Ragab Y et al (2008)<sup>4</sup> and Vagamashi A et al (2017)<sup>5</sup> which were 1.6:1 and 2:1 respectively.

## AVASCULAR NECROSIS

In the study conducted by us, AVN was the most common pathology detected (46%) which is in accordance with the study conducted by Kalekar T and Shriramwar P (2018)<sup>6</sup> in which it was 48%. The age group most commonly affected was 31-40 years (56%) with the male predominance (69%). Similar age and sex distribution were noted in Vagamashi A et al<sup>5</sup> and

by Kamal D et al<sup>7</sup> respectively.

In our study, subchondral signal abnormality was present in all the affected hips which is in concordance with the study conducted by Ragab Y et al<sup>4</sup> and Drar et al.<sup>8</sup>

Double line sign was noted in 67.6% of the affected hips which is in concordance with the study conducted by Kalekar T and Shriramwar P where double line sign was seen in 79% of the patients.<sup>6</sup>

Femoral collapse was noted in 38.2% of the affected hips which is in concordance with the study conducted by Kalekar T and Shriramwar P where femoral head collapse was seen in 41% of the patients.<sup>6</sup>

Joint effusion was noted in 52.9% of the affected hips which is similar to the study conducted by Kalekar T and Shriramwar P where joint effusion was seen in 62% of the patients.<sup>6</sup> Bone marrow edema was seen in 61.7% of the affected hips which is in contrast to the study conducted by Kalekar T and Shriramwar P where bone marrow edema was seen in all the cases.<sup>6</sup> However, similar results were obtained by Huang GS et al.<sup>9</sup>

### **INFECTIVE ARTHRITIS**

In our study, infective arthritis was the second most common pathology detected. Infective arthritis constituted 24% of the total cases with the age ranging from 2 to 52 years and with the male predominance (66.6%). Similar sex distribution was seen in the study conducted by Karchevsky M et al where 68.4% of the patients were males.<sup>10</sup>

### **TUBERCULAR ARTHRITIS**

In our study, 14% of the patients were diagnosed with tubercular arthritis which formed 58.3% of the total cases of infective arthritis. The age ranged from 3 to 52 years with the male predominance (86%) which is in accordance with the study conducted by Ragab Y et al where tubercular arthritis was seen in 11.8% cases.<sup>4</sup> Synovitis was seen (100%) in all the cases which is in accordance with the study conducted by Hsu CY et al.<sup>11</sup>

Erosions of the articular surface were seen in 86% of the cases which is in accordance with the study conducted by Hsu CY et al<sup>11</sup> and Hong SH et al<sup>3</sup> where erosions were seen in 87% and 83% of the cases respectively.

Joint effusion was seen in 100% of the cases which is in accordance with the study conducted by Hsu CY et al.<sup>11</sup> Soft tissue inflammation was seen in 100% of cases and soft tissue abscess was seen in 71.4% of the cases which is in accordance with the study conducted by Prakash M et al where soft tissue inflammation was seen in all cases and soft tissue abscess was seen in 75% cases.<sup>12</sup>

### **SEPTIC ARTHRITIS**

In our study, 10% cases were diagnosed with septic arthritis which comprised 41% of the infective arthritis cases.

In our study, all the affected hips showed joint effusion which is similar to the study conducted by Kwack KS et al.<sup>13</sup> In our study, synovitis was seen in all the cases which is in concordance with the study done by Bierry G et al.<sup>14</sup>

In our study, bone marrow edema was seen in 80% cases. Lee SK et al found bone marrow edema in 8 out of 9 cases.<sup>15</sup> Soft tissue inflammation was seen in all cases. However, Kwack KS et al found soft tissue inflammation in 6 out of 9 cases.<sup>13</sup> Bone erosions were seen in 40% cases which is similar to the study conducted by Hong SH et al who found erosions in 46% cases.<sup>3</sup>

### **PERTHES DISEASE**

In our study, we found three (6%) patients of perthes disease.

All the patients were males with mean age of 7 years. Kalekar T and Shriramwar P found perthes in 4% of the patients.<sup>6</sup>

Epiphyseal sclerosis was observed in all the patients. Collapse of epiphysis, bone marrow edema and joint effusion were present in 2 out of 3 cases. Fragmentation of epiphysis, medial metaphyseal irregularity and increased joint space were seen in 1 out of 3 patients.

MRI is both a sensitive and specific imaging technique for the evaluation of LCP disease. MRI depicts the exact extent of femoral head involvement more precisely. MRI also does not expose the pediatric patient to the potentially harmful effects of ionizing radiation.

### **BONE TUMORS**

In our study, two (4%) out of 50 patients were found to have bone tumors. Both of which were metastasis secondary to the primary elsewhere. One patient was known case of lung cancer and other was a known case of breast cancer.

In the study conducted by Drar et al bone tumors were seen in 5% of the cases.<sup>8</sup>

### **STRESS FRACTURE**

In our study, two (4%) out of 50 patients were found to have stress fracture. Both of them were females with history of police training and complaint of right hip pain. One of them had fracture of neck of right femur while the other one had fracture of right pubic ramus.

Stress fractures are common in endurance athletes according to the study conducted by Williams T et al.<sup>16</sup>

Bone marrow edema with fracture line was seen in both the cases. Bone marrow edema with fracture line was seen in 54 % cases of patients of stress fracture femur according to the study conducted by Steele CE et al.<sup>17</sup>

### **OSTEITIS CONDENSANS ILLI**

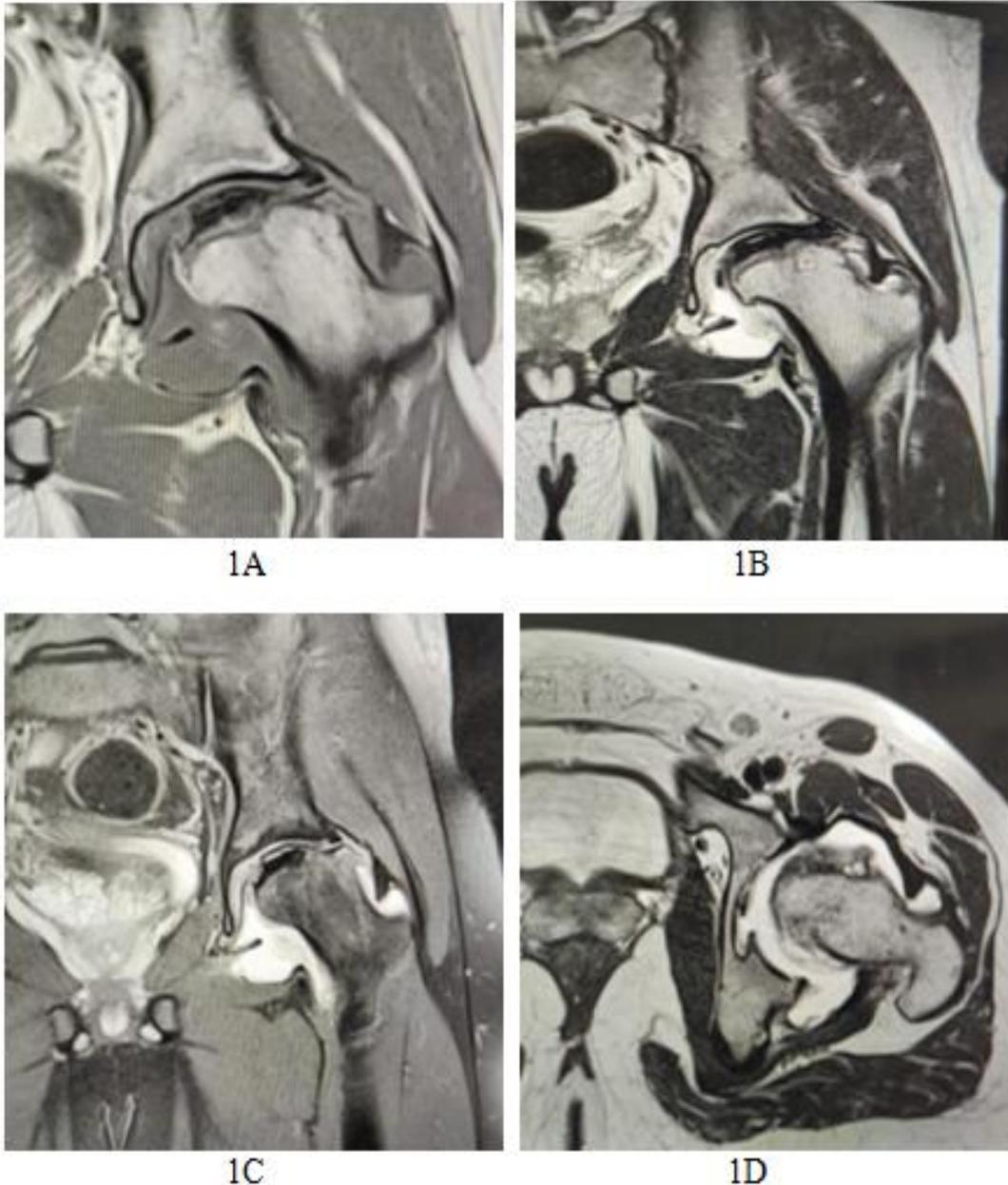
In our study, two (4%) out of 50 patients were found to have osteitis condensans illi. Both were females.

On MRI, sclerosis was seen on iliac side of bilateral sacroiliac joint in both the cases. In our study, bone marrow edema was seen in 50% cases similar to the study conducted by Ma L et al which found bone marrow edema in 48.1% (13/27) of osteitis condensans illi patient.<sup>18</sup>

Above-described imaging features and diagnosis made on MRI revealed higher sensitivity and specificity of MR in evaluation of these pathologies with detailed anatomical involvement and pathology.

On additional comparison with plain radiographs, which were already available with the patient, MRI had more sensitivity and specificity than radiograph and was helpful in characterization of various causes of hip pain because of its excellent depiction of cross-sectional anatomy which was also proved to be statistically significant.

**FEW REPRESENTATIVE CASES FROM OUR STUDY  
FIGURE 1**



**Imaging findings in 34-year-old male:**

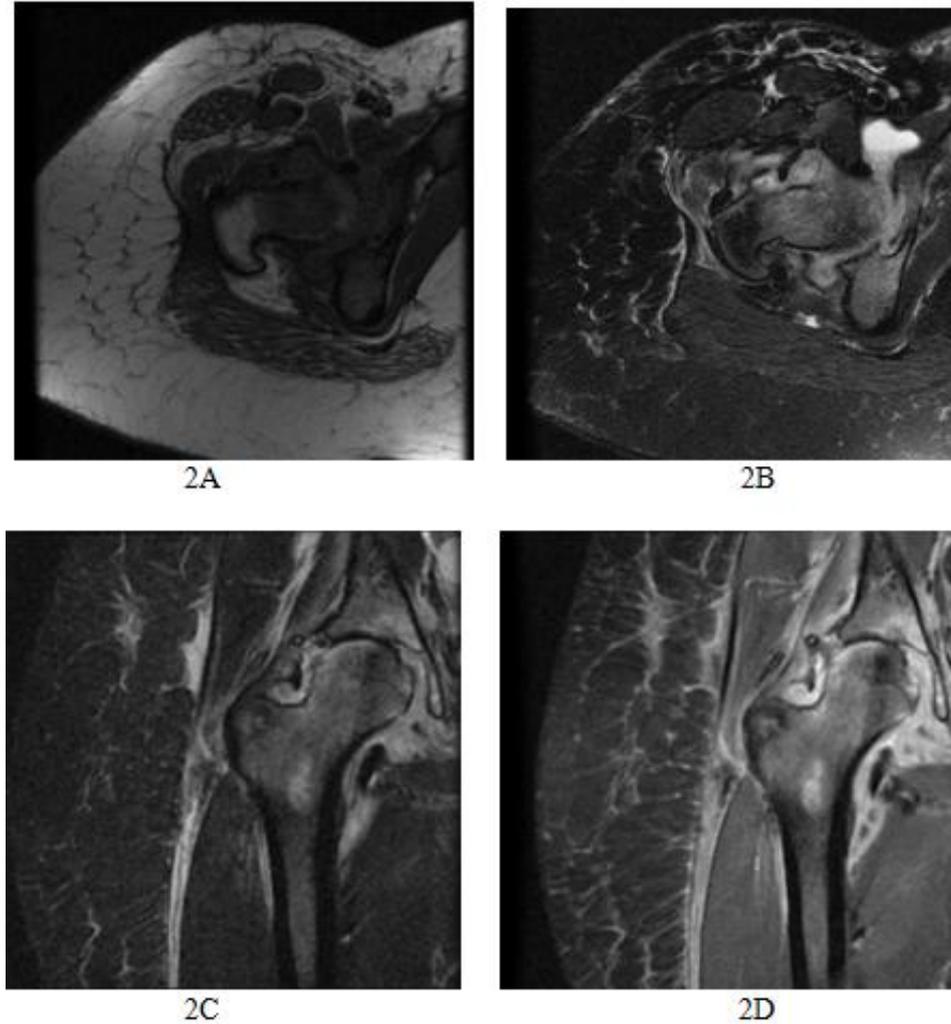
**1A: Coronal T1WI depicts abnormal subchondral signal with left femoral head collapse. Joint effusion is seen which is hypointense.**

**1B: Coronal T2WI shows similar changes of abnormal signal and collapse of head is seen with joint effusion which is hyperintense.**

**1C: Coronal PDFS depicts similar changes with hyperintense signal in adjacent marrow s/o edema.**

**1D: Axial T2WI shows joint effusion as well as femoral head irregularity.**

**Final diagnosis: Avascular Necrosis left hip**

**FIGURE 2**

**Imaging findings in a 24-year-old male:**

**2A:** Axial T1 show increased joint space with joint effusion as well as abnormal signal within the marrow of the right femoral head and acetabulum which is hypointense.

**2B:** Axial T2 STIR shows hyperintense signal fluid collection with hyperintense signal in the femoral neck as well adjacent soft tissue.

**2C:** Coronal STIR image shows similar changes with associated soft tissue inflammatory changes.

**2D:** Coronal post contrast fat saturation image showing enhancing collections.

**Final diagnosis: Tubercular Arthritis**

### **SUMMARY & CONCLUSION**

MRI accurately depicts the extent of the disease or soft tissue extension without the risks associated with radiation exposure. MRI combines high resolution anatomic delineation of the medullary space, cortex and periosteum with high soft tissue contrast for detection of edema and fluid.

We conducted a study to characterize the MRI findings in non- traumatic sources of pain in hip. The age ranged from 2 to 60 years of age, with mean age of 29.94 years. The clinical examination and the relevant microbiological and biochemical investigations were done wherever needed.

In our study, AVN was most common pathology detected. The age group most commonly affected was 31-40 years of age with the male predominance.

Most common findings include subchondral signal abnormality, followed by double line and femoral head collapse. Nonspecific findings including bone marrow edema and joint effusion were also seen.

In our study, Infective arthritis was the second most common pathology detected.

Amongst infective arthritis, tubercular arthritis was most common etiological agent. The age ranged from 3 to 52 years with the male predominance.

Findings in tubercular arthritis in decreasing order include synovitis, joint effusion, soft tissue inflammation, erosions of the articular surface and soft tissue abscess.

Septic arthritis constituted rest of the cases of infective arthritis. Findings in decreasing order include synovitis, joint effusion, soft tissue inflammation, bone marrow edema, erosions and soft tissue abscess.

Erosions and soft tissue abscess were more commonly associated with tubercular arthritis as compared to septic arthritis.

Perthes disease was the third most common pathology detected. All patients were males with mean age of 7 years.

They showed epiphyseal sclerosis, collapse of epiphysis, bone marrow edema, joint effusion, fragmentation of epiphysis, medial metaphyseal irregularity and increased joint space in decreasing order of frequency.

Stress fracture was seen in females with history of police training with one having fracture of neck of right femur and other having fracture of right pubic ramus.

Metastasis, osteitis condensans illi and tendinitis were some other pathologies noted.

Thus, MRI was helpful in diagnosing various abnormalities as mentioned above. Various bone signal abnormalities as well as excellent soft tissue contrast aided in making timely diagnosis and management. The role of MRI in detection of various abnormalities was also statistically significant (as compared to plain radiographs which was additionally done) and had more sensitivity and specificity.

## REFERENCES

1. Perumal V, Woodley SJ, Nicholson HD. Neurovascular structures of the ligament of the head of femur. *Journal of Anatomy*. 2019;234(6):778-86.
2. Gabriel H, Fitzgerald SW, Myers MT, Donaldson JS, Poznanski AK. MR imaging of hip disorders. *Radiographics*. 1994;14(4):763- 81.
3. Hong SH, Kim SM, Ahn JM, Chung HW, Shin MJ, Kang HS. Tuberculous versus pyogenic arthritis: MR imaging evaluation. *Radiology*.2001;218(3):848-53.
4. Ragab Y, Emad Y, Abou-Zeid A. Bone marrow edema syndromes of the hip: MRI features in different hip disorders. *Clinical rheumatology*.2008;27(4):475-82.
5. Vaghamashi A, Bhatt J, Doshi J, Patel V. MRI in evaluation of painful hip joint. *Journal of Dental and Medical Sciences*. 2017;16(5):85-96.
6. Kalekar T, Shriramwar P. MRI Evaluation of Non Traumatic Painful Hip Joint. *International Journal of Contemporary Medicine Surgery and Radiology*.2018;3(1):155-60.
7. Kamal D, Trăistaru R, Alexandru DO, Grecu DC, Mogoanta L. Epidemiologic Study of Avascular Necrosis of the Femoral Head. *Current health sciences journal*. 2013;39(3):2069-4032.
8. Drar HA, Mohammed BA, Ali ZA. The role of MRI in the evaluation of painful hip joint (MRI of hip joint). *International Journal of Medical Imaging*.2014;2(3):77-82.
9. Huang GS, Chan WP, Chang YC, Chang CY, Chen CY, Yu JS. MR imaging of bone marrow edema and joint effusion in patients with osteonecrosis of the femoral head: relationship to pain. *American Journal of Roentgenology*.2003;181(2):545-9.
10. Karchevsky M, Schweitzer ME, Morrison WB, Parellada JA. MRI findings of septic

- arthritis and associated osteomyelitis in adults. *American Journal of Roentgenology*.2004;182(1):119-22.
11. Hsu CY, Lu HC, Shih TT. Tuberculous infection of the wrist: MRI features. *American Journal of Roentgenology*.2004;183(3):623-8.
  12. Prakash M, Gupta P, Dhillon MS, Sen RK, Khandelwal N. Magnetic resonance imaging findings in tubercular arthritis of elbow. *Clinical imaging*.2016;40(1):114-8.
  13. Kwack KS, Cho JH, Lee JH, Cho JH, Oh KK, Kim SY. Septic arthritis versus transient synovitis of the hip: gadolinium-enhanced MRI finding of decreased perfusion at the femoral epiphysis. *American Journal of Roentgenology*.2007;189(2):437-45.
  14. Bierry G, Huang AJ, Chang CY, Torriani M, BredellaMA. MRI findings of treated bacterial septic arthritis. *Skeletal radiology*. 2012;41(12):1509-16.
  15. Lee SK, Suh KJ, Kim YW, Ryeom HK, Kim YS, Lee JM et al. Septic arthritis versus transient synovitis at MR imaging: preliminary assessment with signal intensity alterations in bone marrow. *Radiology*.1999;211(2):459-65.
  16. Williams T, Puckett M, Denison G, Shin A, Gorman J. Acetabular stress fractures in military endurance athletes and recruits: incidence and MRI and scintigraphic findings. *Skeletal radiology*. 2002;31(5):277-81.
  17. Steele CE, Cochran G, Renninger C, Deafenbaugh B, Kuhn KM. Femoral neck stress fractures: MRI risk factors for progression. *Journal of Bone and Joint surgery*.2018;100(17):1496-502.
  18. Ma L, Gao Z, Zhong Y, Meng Q. Osteitis condensans ilii may demonstrate bone marrow edema on sacroiliac joint magnetic resonance imaging. *International journal of rheumatic diseases*. 2018;21(1):299-30.