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Original Article

Radiology Section

Evaluation of Hip Disorders Using Magnetic Resonance Imaging

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ABSTRACT

Introduction: The hip joint is a major weight-bearing joint in the human body. It is often difficult to assess painful hip disorders clinically. This necessitates the need for imaging to arrive at an accurate diagnosis. Magnetic Resonance Imaging (MRI) is an imaging modality with good soft tissue contrast and resolution for evaluating hip pathologies.

Aim: To identify and study the spectrum of imaging features in various hip disorders in adults and to establish a differential diagnosis using MRI.

Materials and Methods: A hospital based cross-sectional study was done from June 2017 to May 2018 in a tertiary care centre of Southern India, where 70 patients who presented with unilateral or bilateral hip pain were evaluated with MRI. Demographic data including the patients age and sex was collected. The clinical features with which the patients presented were recorded. Conventional radiographic imaging of bilateral hip bone in antero-posterior and lateral views were obtained. Specialized imaging using appropriate MRI sequences in various imaging planes were obtained. The collected data was analysed and the differential diagnoses described. Data analysis was done by descriptive statistics using Microsoft Excel and Epi Info. Results were presented as mean (maximum-minimum) and percentage.

Results: Out of 70 patients, majority of them were in the 20-29 years age group, with a male preponderance overall and also in the study subgroups. Unilateral hip involvement was more common than bilateral. The most common clinical presentation was hip pain. The commonest hip disorder encountered was Avascular Necrosis (AVN) of the femoral head (n=50), followed by Osteoarthritis (OA) (n=10), Tubercular (TB) arthritis (n=4), Transient Osteoporosis of Hip (TOH) (n=2), Metastasis (n=2), Synovial osteochondromatosis (n=1) and Perthe's disease (n=1). Each of the conditions showed specific age group in which it commonly occurred. Bone Marrow Oedema (BME), joint effusion, soft tissue signal intensity changes, synovial thickening and enhancement, articular surface changes and subchondral changes were the spectrum of imaging features which occurred in various hip disorders studied. Double line sign was pathognomic of AVN of femoral head. MRI was more sensitive than conventional radiography in the identification of presence of hip disorders like AVN in early stages and TOH.

Conclusion: MRI enables assessment of articular structures, soft tissues and osseous structures of the hip joint that can be affected by disease. It helps in better staging of various hip disorders like AVN, OA, Perthe's, etc. It can help diagnose early stages of AVN and TOH, where it can be missed on conventional radiograph and Computed Tomography (CT). Hence, its role in the evaluation of painful hip disorders in adults is invaluable.

Keywords: Articular structures, Avascular necrosis, Bone marrow oedema, Differential diagnosis, Osseous structures

INTRODUCTION

The hip is categorized as a synovial joint of ball and socket variety. It is an articulation between the acetabulum and femoral head. The anatomy of hip joint is complex due to its morphology and orientation, and it is important to localise the exact site of pathology to determine the accurate diagnosis of the primary disease and look for secondary involvement of the surrounding structures [1]. Hip pain may be due to pathology in osseous structures or soft tissue structures and patients usually present with pain, limp and restriction of joint movements. A plain radiograph and CT reveal inconclusive radiographic findings in hip disorders like AVN in early stages and TOH which present with BME. BME cannot be identified using plain radiographs and CT. Evaluation of cartilaginous structures, bone marrow, ligaments and soft tissues cannot be optimally done using plain radiograph and CT. MRI has an advantage over plain radiograph and CT in terms of its superior soft tissue contrast and ability to depict bone marrow changes. Hence, MRI would be an ideal imaging modality to evaluate hip disorders. Specific indications for the use of MRI include evaluation of bone marrow and soft tissue involvement in conditions like AVN of femoral head, TOH, Tubercular hip arthritis, etc.

Early diagnosis and treatment are important so as to reduce the morbidity caused by the disease and its progression. The pathway for hip imaging has evolved considerably with the advent of MRI, which is non-invasive and very sensitive in the early detection of BME and other hip joint pathologies. Close correlation of the clinical symptoms and MRI findings is hence necessary for accurate diagnosis [2]. The diagnostic role of MRI in the evaluation of femoral head AVN is evolving, as it is important for its early detection before radiographic changes become apparent [3]. This study aims to identify and describe the spectrum of imaging features in various hip disorders in adults and to establish a differential diagnosis using MRI. There have been studies by previous investigators on evaluation of hip pain caused by both articular and extra-articular aetiologies, which have different management protocols. A comprehensive evaluation of hip disorders in adults using MRI in this study emphasises on articular aetiologies of hip pain. This will influence therapeutic decisions significantly as early localisation and accurate diagnosis of hip disorders can contribute to reduction in joint morbidity by joint preservation management protocols.

MATERIALS AND METHODS

Patient Selection

A prospective hospital based cross-sectional study was conducted in a tertiary care centre of Southern India from June 2017 to May 2018 (12 months). The study group consisted of 70 patients presenting to the Departments of Radiodiagnosis, Orthopaedics, Rheumatology and Medicine. A total of 140 hip joints were evaluated.

Patients aged ≥18 years of both genders, clinically presenting with unilateral or bilateral, acute (<3 months) or chronic (>3 months) hip pain were included in the study. Patients aged <18 years, those with traumatic hip pathology like recent fractures and dislocations (<1 month duration) and those with general contraindications to MRI like ferromagnetic implants and claustrophobia were excluded.

Informed and written consent was obtained from all the 70 participants. Approval from the Institutional ethics review committee was obtained (IEC number: BMC/PGs/289/2016-17).

The procedures followed were in accordance with the ethical standards of the Institutional committee on human experimentation and with the Helsinki Declaration of 1975 that was revised in 2000.

Procedure and Imaging Characteristics

MRI was performed using 1.5 Tesla Siemens MagnetomAvanto B15 machine (Siemens Medical Systems, Erlangen, Germany). Imaging was performed using a body coil placed over the pelvis with the patient in supine position and both hips were examined simultaneously. The following sequences were obtained: Coronal spin-echo T1-weighted (T1W) (TR range/TE range, 450-650/16-20), Proton Density (PD) with Fat Saturation (FS) (1500-2200/20-40), T2-weighted (T2W) (1500-2200/ 80-90), and Short Tau Inversion Recovery (STIR) (2500-3000/35-40; Inversion Time, 100-150). Subsequent PDFS and T2W images were obtained in the sagittal and axial planes using the same parameters as those in the coronal plane. Axial Gradient Echo (GRE) Image was taken when required.

Renal Function Test (RFT) was performed for patients with clinically suspected infective hip pathology. Patients whose RFT was normal, underwent contrast study. After fasting for 6-8 hours, 0.1 mmol/kg intravenous Magnevist (Gadopentetate Dimeglumine) solution was injected and Post Gadolinium (Gd) T1FS images were obtained in axial, coronal and sagittal planes.

Various MRI imaging characteristics of different hip pathologies like BME, joint effusion, soft tissue signal intensity changes, synovial thickening and enhancement, articular surface changes and subchondral changes were identified and described. With these imaging characteristics, appropriate differential diagnoses of various hip disorders viz., idiopathic, degenerative, infective, developmental pathologies like AVN, OA, TB arthritis, Perthe's, etc., was established. Though there is no standardised classification of hip disorders available in literature, the present study considers a generalised classification based on aetiology.

Patients with AVN of the femur head were further classified into various stages based on Ficat-Arlet classification system [4] which has been discussed in [Table/Fig-1].

Stage 0	Pre-clinical	Normal plain radiograph Normal MRI
Stage I	Pre-radiographic	Normal X-ray. Abnormal MRI-oedema Bone scan: Increased uptake
Stage II	Pre-collapse (reparative stage before flattening occurs)	Diffuse sclerosis of femoral head on X-ray. Geographic defect in femoral head on MRI- 'Double line sign'.
Stage III	Collapse	Subchondral fracture-'crescent sign' on X-ray. Eventual cortical collapse on MRI.
Stage IV	Osteoarthritis	Femoral head collapse with secondary degenerative changes. Acetabular involvement.

[Table/Fig-1]: Ficat and Arlet classification of Avascular Necrosis of femoral head [4].

STATISTICAL ANALYSIS

Purposive sampling technique was used based on patient selection criteria. The collected data was analysed using descriptive statistics. Microsoft Excel and Epi Info were used for data analysis. Statistical Package for the Social Sciences (SPSS) version 21 was used. Results of the descriptive study were presented as Mean (Min-Max) and Number (%) for continuous categorical variables respectively.

RESULTS

Out of 70 patients in the study group, 52 (74.39%) were males and 18 (25.7%) were females, showing a significant male predominance with a Male: Female (M:F) ratio of 2.8:1. The mean age at presentation was 39.7 (20-69) years, with a majority in the age group of 20-29 years (34.3%). Unilateral hip involvement was found in 39 patients (55.71%) and bilateral was found in 31 patients (44.29%).

The most common pathology encountered in the study was AVN of femoral head in 71.43% (n=50) [Table/Fig-2].

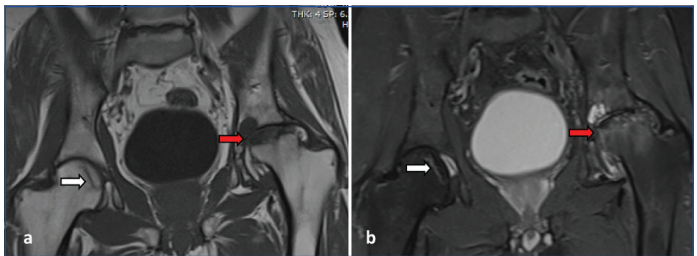
Hip disorders	No. of patients	Percentage
Avascular necrosis	50	71.43%
Osteoarthritis	10	14.28%
TB arthritis	4	5.71%
Transient osteoporosis of hip	2	2.86%
Metastasis	2	2.86%
Synovial osteochondromatosis	1	1.43%
Perthes disease	1	1.43%
Total	n=70	100%

[Table/Fig-2]: Case frequency distribution of hip disorders based on final diagnosis.

Among the 50 patients with AVN, 25 had unilateral hip involvement and 25 had bilateral involvement. The mean age at presentation was 36.3 years and upto 66% of patients presented in the 3rd and 4th decades, with a M:F ratio of 3.5. The commonest aetiology for AVN was idiopathic accounting for 31% of the cases, followed by alcohol consumption, steroid intake and sickle cell anaemia. The frequency distribution of various MRI features in AVN affected hips are presented in [Table/Fig-3]. BME and minimal joint effusion were commonly found MRI features in AVN affected hips. Double line sign [Table/Fig-4,5] was found in stage II AVN. In advanced stages, altered contour with fragmentation and collapse of femoral head was noted, with subchondral cysts in femoral head and/or acetabulum in the last stage [Table/Fig-4].

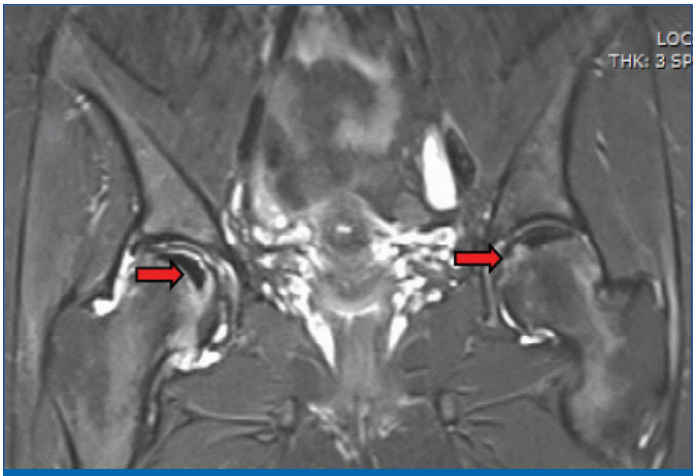
MRI features in AVN	Number of AVN affected hips (n=75)	Percentage %
Bone marrow oedema	41	54.67
Joint effusion	43	57.33
Double line sign	30	40
Altered femoral head contour	20	26.67
Subchondral cysts in femoral head and/or acetabulum with or without reduction of joint space	26	34.67
Femoral head fragmentation with collapse	25	33.33

[Table/Fig-3]: Frequency distribution of various MRI features in AVN affected hips.



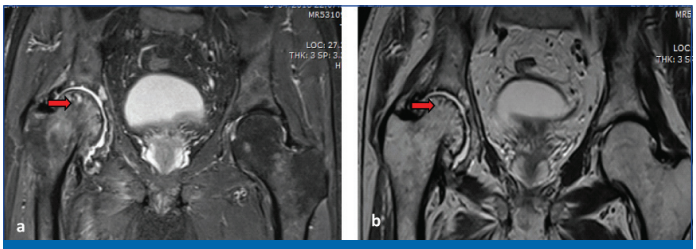
[Table/Fig-4]: Coronal T1W (a) and STIR (b) MR images of a 50-year-old male patient with bilateral hip joint pain showing 'Double line sign' (white arrow) with Ficat-Arlet stage II AVN on right side and deformed contour with collapse of left femoral head and secondary degenerative changes of hip (red arrow) suggesting stage IV AVN on left side.

Degenerative Joint Disease/Osteoarthritis (OA) was found in 10 (14.28%) patients, five patients had unilateral hip involvement and 5 had bilateral hip involvement. The mean age at presentation was



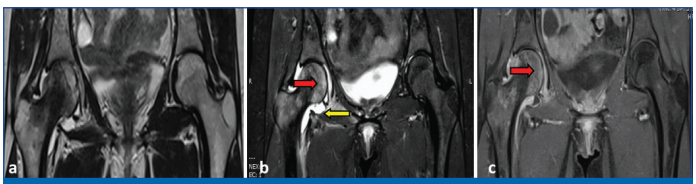
[Table/Fig-5]: Coronal STIR image of bilateral hip joints with Ficat-Arlet stage III AVN on both sides with double line sign (red arrows), BME and joint effusion.

55.5 years and all patients presented in the 5th to 7th decades. A 60% (n=6) were males. Commonest MRI abnormality seen in patients of OA was BME in the femoral head and neck on T1W images which was found in 86.67% of OA affected hips [Table/Fig-6].



[Table/Fig-6]: Coronal STIR (a) and T2W (b) images of bilateral hip joints showing uniform reduction of right hip joint space with subchondral erosions and cysts (red arrows) suggesting Osteoarthritis.

Tubercular Arthritis (TB) was found in 4 (5.71%) patients with unilateral hip involvement. Three patients presented in the 3rd decade and the other in 4th decade. Common findings associated with TB arthritis were joint effusion, BME and soft tissue hyperintensity on T2WI which were found in all these patients [Table/Fig-7].



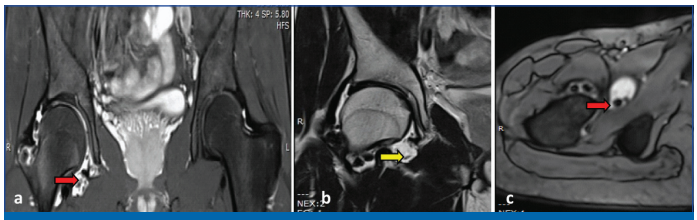
[Table/Fig-7]: Coronal T2W (a), STIR (b) and Post Gd-T1FS (c) MR images of a 22-year-old male who presented with fever and right hip joint pain with restricted joint movements shows mild effusion (yellow arrow) in right hip joint space, marrow oedema (red arrows) and soft tissue signal changes-suggestive of Tubercular arthritis.

Both patients with Transient Osteoporosis of Hip (TOH) in the study had unilateral hip involvement. One was a 50-year-old male with hip pain since three months, and the other a 25-year-old female in her 3rd trimester of pregnancy. Diffuse BME in the femoral head and neck with sparing of the subchondral bone was seen. The oedema in both these patients resolved completely on follow-up scans.

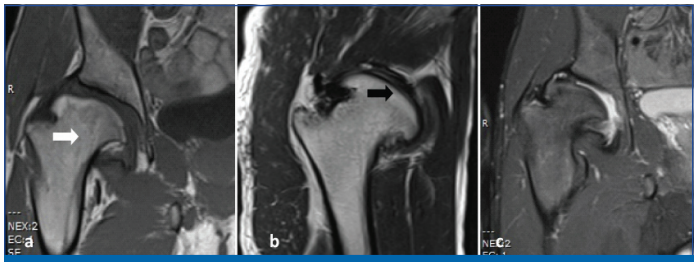
Two patients had metastases in the hip. The first one was a 62-year-old male with a prostate carcinoma who presented with bilateral osteoblastic hip metastasis. The other was a 60-year-old female with breast carcinoma who presented with a unilateral mixed lytic-sclerotic lesion in left hip. MRI showed STIR hyperintense, Post-Gd enhancing lesions in the femoral head.

The study included a patient with Primary Synovial Osteochondromatosis of hip, who was a 20-year-old male who presented with unilateral hip pain. MRI findings included multiple well defined hypointense foci lying freely within the hip joint cavity showing blooming on GRE. Minimal joint effusion was seen. Synovial enhancement was noted in post contrast study. There were no secondary osteoarthritic changes in the affected joint [Table/Fig-8].

A 21-year-old male who presented with limp in stage-IV of Perthe's disease of the right hip was also included in the study. MRI showed widened and flattened epiphysis of femoral head-coxa plana, mild widening of femoral neck-coxa magna, minimal joint effusion and mild atrophy of gluteal and hip muscles. No osseous signal intensity changes/secondary OA changes were seen [Table/Fig-9].



[Table/Fig-8]: Coronal PDFS (a), T2W (b) and axial GRE (c) images of right hip joint shows synovial osteochondromatosis in a 20-year-old male patient. There is moderate effusion (yellow arrow) in right hip joint space with multiple loose bodies (red arrows), which show blooming on GRE image.



[Table/Fig-9]: Coronal T1W (a), T2W (b) and STIR (c) images of right hip joint in a 21-year-old male patient who presented with stiffness and restriction of movement shows healed stage IV Perthe's disease with coxa magna (white arrow) and coxa plana (black arrow).

DISCUSSION

Evaluation of hip disorders in adults using MRI helps to narrow down the differential diagnosis and thereby arrive at a more accurate final diagnosis. The importance of MRI lies in it being a non-invasive imaging modality which is very sensitive in the evaluation of extent of pathological involvement of various hip disorders even in early stages of the disease.

Hip disorders may be unilateral or bilateral. Hence both hips must be simultaneously assessed for pathologies. Conditions like AVN, OA and metastasis can have bilateral hip involvement. Overall, hip disorders in the present study presented with unilateral joint involvement. In the study, there were 55.7% (n=39) patients with unilateral hip involvement and 44.3% (n=31) with bilateral hip involvement. This corroborates with the study conducted by Tripathi P et al., in which 52% had unilateral hip involvement and 48% had bilateral involvement [5]. Also, in the study by Venkateshwar RK et al., 58% patients had unilateral hip involvement and 42% had bilateral involvement [6].

The present study showed a male predominance with a M:F ratio of 2.8:1. The studies by Tripathi P et al., and Venkateshwar RK et al., also showed a male predominance, with M:F ratios of 2:1 and 3:1 respectively [5,6]. Even within the AVN, OA and TB arthritis study groups, a male predominance was noted.

MRI has become the most sensitive, specific and widely used diagnostic imaging modality for evaluation of AVN of femoral head. It was the commonest hip disorder identified and diagnosed in the present study (71.43%). It corroborates with the studies conducted by other investigators viz., Tripathi P et al., (50%), Venkateshwar RK et al., (30.59%) [6], Kalekar T et al., (48%) [5-7]. In most reports, MRI was able to diagnose very early lesions with a greater than 90% specificity and sensitivity based on histology or eventual progression [8]. The diagnosis of AVN in stage II and III using MRI was also made in a good proportion of patients, thereby contributing to early initiation of treatment. Most AVN cases were idiopathic. Most

patients with significant joint effusion presented in stage III. Previous studies by Mitchel D et al., and Huang GS et al., also showed that peak occurrence of joint effusion occurred in stage III AVN [9,10].

BME is defined as an ill-defined area of low signal intensity on T1W images with corresponding high signal intensity on T2W and STIR images [Table/Fig-5]. A well-demarcated arcuate zone of high signal intensity on T2W images surrounding the necrotic area of the femoral head was considered granulation tissue [10]. BME cannot be detected on X-Ray, that being its limitation. In the study conducted by Huang GS et al., they found that 48% of patients of AVN had BME [10]. The present study had 54.67% cases with BME. Occurrence of BME has ranged from 30% to 55% as reported by other investigators previously. Several studies have shown that the strongest association of BME with AVN of the femoral head occurs in stage III disease [9,10]. BME was found only in the femoral head and neck in all cases.

"Double line sign" [Table/Fig-4,5] is a pathognomonic imaging indicator for AVN. On MRI, 40% hips showed 'double line sign' i.e., on T2W sequences inner bright line representing granulation tissue and outer dark line suggestive of sclerotic bone [10]. This sign was predominantly seen in stage II disease. Femoral head collapse and degenerative changes occurred in advanced stages of AVN [Table/Fig-4].

Osteoarthritis (OA) is synonymous with Degenerative Joint disease. OA most commonly involves the weight-bearing articulations of the spine, hips, and knees [1]. Imaging diagnosis of OA is usually done using conventional radiographs. However, unlike radiography, MRI can directly depict articular cartilage thinning. Multiple studies are being done for the evaluation of OA using MRI over past several years. Li KC et al., studied the MRI grading system of OA [11]. On MRI, indistinct trabeculae/signal loss in femoral head and neck on T1WI was the most common finding. High signal intensity on T2WI in articular cartilage, bone sclerosis- subchondral signal loss, indistinct zone between femoral head and acetabulum and femoral head deformity were the other findings seen in OA.

TB of hip constitutes 15-20% of the musculoskeletal system Tuberculosis [12]. It is typically a monoarticular disorder. As hip is a large weight-bearing joint, it is more often involved in arthritis of tubercular aetiology. Tubercular arthritis of hip can occur as a result of haematogenous dissemination of pulmonary tuberculosis or direct invasion from an adjacent tubercular focus [13].

In the present study, joint effusion, BME and soft tissue T2W hyperintensity were found in all patients with TB hip arthritis. This was similar to the study by Kalekar T et al., [7]. Joint space reduction and subarticular cysts were noted in 75%. Synovial T2 hyperintensity and enhancement was seen in 50%. Joint destruction was present in 1 patient. No bony ankylosis was seen. Post-Gd MRI aids in early detection and assessment of TB hip in cases with strong clinical suspicion. Synovial T2W hyperintensity and enhancement, soft tissue oedema, joint effusion, BME in early stages and joint space reduction, subarticular cysts, joint destruction in advanced stages on MRI are consistent with TB hip.

TOH typically occurs in middle-aged men or women in third trimester of pregnancy. MRI in TOH shows diffuse BME involving the femoral head, neck, and sometimes intertrochanteric region with sparing of the subchondral bone. Absence of focal subchondral abnormalities differentiates it from AVN. Acetabulum may show mild inconsistent changes. It is usually associated with joint effusion. MRI is extremely sensitive and may demonstrate findings positive for transient osteoporosis before radiographic changes become visible [14].

A 70% of all malignant bone tumors constitute metastatic disease [15]. Preliminary evaluation of suspected bone metastasis is usually done by conventional radiography. MRI evaluates the extent of medullary and soft-tissue involvement, articular extension and involvement of neurovascular bundle [16].

Primary synovial osteochondromatosis is an idiopathic benign monoarticular disorder affecting joints like knee, elbow, hip and shoulder with a male preponderance. It is characterized by synovial proliferation with metaplastic transformation and formation of cartilage in the joint cavity [17]. This can present in various phases including active, transitional and inactive phase based on the ossification of the cartilaginous intra-articular loose bodies. Multiple intra-articular loose bodies in the hip joint cavity showing blooming on MRI are the distinguishing features of synovial osteochondromatosis. Joint effusion and synovial enhancement are commonly associated. Secondary osteoarthritis features must also be looked for.

Perthe's disease, although being a disorder of paediatric population, some patients can present later in adulthood in the healed stages like in our patient. In the present study, MRI of a 20-year-old male patient showed resorption of femoral head with widening and flattening of epiphysis. No BME or signal intensity changes were present. Minimal joint effusion was noted [Table/Fig-9]. These findings were suggestive of healed Perthe's as also noted in previous literature by Lamer S et al., [18].

LIMITATION

The proportion of hip OA is relatively more in comparison to AVN in general population. But OA occurs in elderly population and lesser proportion of OA patients present to the hospital to get MRI evaluation. MRI in terms of accessibility and cost often limits its use. Hence, the present study was subjected to this selection bias. Detailed correlative study of various hip disorders using conventional radiography and MRI requires further comprehensive studies with respect to each pathology. Further studies on each of these pathologies involving a larger study group are helpful. Correlation of the clinical symptoms and MRI findings is necessary for accurate diagnosis of hip disorders. This was a limitation in the present study.

CONCLUSION

Hip disorders are a common cause of diagnostic dilemma for clinicians. MRI can be regarded as the gold standard for identification, diagnosis and staging of AVN of femoral head as it can detect early changes of AVN even when the plain radiographic findings are normal or inconclusive. It helps in better staging of various hip disorders like AVN, OA, Perthe's, etc. Therapeutic measures are more successful in the management of AVN and other hip disorders, the earlier they are initiated. It can also limit and avoid permanent deformities. Due to good resolution, improved differentiation of tissue contrast and capacity for multiplanar imaging, MRI is the diagnostic modality of choice for assessment of hip disorders. Hence, it must be included in the evaluation protocol of all hip disorders.

REFERENCES

[1] Yochum TR, Rowe LJ, Kettner NW, Barry MS, Osterhouse MD, Longenecker RJ, et al. In: Yochum TR, Rowe LJ. Yochum and Rowe's Essentials of skeletal radiology. 3rd ed. Philadelphia, Pa: Lippincot Williams & Wilkins; 2005.

[2] Karantanas AH. Acute bone marrow edema of the hip: Role of MR imaging. Eur Radiol. 2007;17:2225-36.

[3] Karantanas AH, Drakonaki EE. The role of MR Imaging in avascular necrosis of the femoral head. Semin Musculoskelet Radiol. 2011;15(3):281-300.

[4] Berquist TH. MRI of the Musculoskeletal System, 6th ed. Philadelphia: Lippincott Williams & Wilkins; 2013: 238-58.

[5] Tripathi P, Singh S, Khantal N. Hip pathology findings on magnetic resonance imaging: A study from tertiary care institute. Int J Sci Study. 2016;4(3):35-38.

[6] Venkateshwar RK, Anu Kapoor K. MR Evaluation of non-traumatic hip pain. J Med Sci Clin Res. 2017;5(3):19090-101. DOI: https://dx.doi.org/10.18535/jmscr/v5i3.126

[7] Kalekar T, Shriramwar P. Role of magnetic resonance imaging findings in evaluation of painful hip joint. Int J Med Health Res. 2017;3(7):105-11.

[8] Parsons S, Steele N. Osteonecrosis of the femoral head: Part 1- Aetiology, pathogenesis, investigation, classification. Curr Orthop. 2007;21(6):457-63.

[9] Mitchell D, Rao V, Dalinka M, Spritzer C, Gefter W, Axel L, et al. MRI of joint fluid in the normal and ischemic hip. Am J Roentgenol. 1986;146(6):1215-18.

[10] Huang GS, Chan W, Chang Y, Chang C, Chen C, Yu J. MR imaging of bone marrow edema and joint effusion in patients with osteonecrosis of the femoral head: relationship to pain. Am J Roentgenol. 2003;181(2):545-49.

[11] Li KC, Higgs J, Aisen AM, Buckwalter KA, Martel W, McCune WJ. MRI in osteoarthritis of the hip: Gradations of severity. Magn Reson Imaging. 1988;6(3):229-36.

[12] Saraf S, Tuli S. Tuberculosis of hip. A current concept review. Indian J Orthop. 2015;49(1):01-09.
[13] Harisinghani M, McLoud T, Shepard J, Ko J, Shroff M, Mueller P. Tuberculosis from head to toe. RadioGraphics. 2000;20(2):449-70.
[14] Hayes C, Conway W, Daniel W. MR imaging of bone marrow edema pattern: Transient osteoporosis, transient bone marrow edema syndrome, or osteonecrosis. RadioGraphics. 1993;13(5):1001-11.
[15] Vanel D. MRI of bone metastases: The choice of the sequence. Cancer Imaging. 2004;4(1):30-35.
[16] O'Sullivan G. Imaging of bone metastasis: An update. World J Radiol. 2015;7(8):202.
[17] Kramer J, Recht M, Deely D, Schweitzer M, Pathria M, Gentili A, et al. MR appearance of idiopathic synovial osteochondromatosis. J Comput Assist Tomogr. 1993;17(5):772-76.
[18] Lamer S, Dorgeret S, Khairouni A, Mazda K, Brillet P, Bacheville E, et al. Femoral head vascularisation in Legg-Calvé-Perthe's disease: Comparison of dynamic gadolinium-enhanced subtraction MRI with bone scintigraphy. Pediatr Radiol. 2002;32(8):580-85.

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