Advantage of Magnetic Resonance Imaging Over X Ray In Detection of Avascular Necrosis of Femoral Head

DR. PRAVEEN KUMAR GUPTA[1](RESIDENT),
DR. MEGHA MITTAL[2](ASSOCIATE PROFESSOR),
DR. AKSHARA GUPTA[3](PROFESSOR AND HEAD),
DR. SWETA SWAIKA[4](ASSISTANT PROFESSOR)

[1,2,3,4]DEPARTMENT OF RADIO-DIAGNOSIS, GRMC AND JAH GWALIOR, 474001, MADHYA PRADESH, INDIA

Email: sweta.sw@yahoo.com

FIRST AUTHOR: DR. PRAVEEN KUMAR GUPTA
CORRESPONDING AUTHOR: DR. SWETA SWAIKA

ABSTRACT

Introduction: MRIisusedintheevaluationof AVN hipbecauseit is highly sensitive and specific for the diagnosis as it establishesthe diagnosis of AVN in symptomatic patients before radiographic changes become apparently visible. We have assessed that MRI is the preferred modality of investigation in early detectionof AVNhipin patients presenting with hip pain when compared with plain radiographs.

Materials and Methods: A prospective observational study was conducted in Department of Radiodiagnosis, G.R.M.C. Gwalior on 50 patientswho presented with hip pain in 1.5 years. After proper detailed history including assessment of risk factors and clinical evaluation, he or she was taken for MRI evaluation of the hip joint which were then evaluated and staging was done and was correlated with X ray.

Results: In our study of 50 cases of AVN, 83 femoral heads were involved out of total 100 femoral heads.The most common etiologywas idiopathicfollowed by alcohol consumption. The most common stage of AVN was found to be stage II(45.78%) (Ficat and Arlet classification) and Type B (45.7%) (Mitchell's classification) with most common quadrant involved was anterosuperior. MRI could detect early AVN in 35 femoral heads (42.16%), in which plain radiographs were normal.

Conclusion: This study concludes that MRI is the gold standard investigation for diagnosing and staging AVN hip which can detect early cases usually missed on X rays. So with early detection by MRI, we can decrease the patient morbidity by decreasing the need for surgical intervention.

Key words: Avascular necrosis, Hip, Magnetic resonance imaging.

1. INTRODUCTION

Hip joint is one of the weight-bearing joints of the body which is subjected to various stresses in day to day life. Avascular necrosis (AVN) of the femoral head is one of the common cause of hip pain in a young adult in India. Avascular necrosis (AVN) is defined as cellular death ofbone due to loss of blood supply which can be due to anyreason resulting in

diseaseprogression leading to pain withloss of function and eventual collapse. Some of the risk factors for development of AVN are idiopathic, alcohol, fracture & dislocation, corticosteroid, sickle cell anemia etc.The disease starts unilaterally andprogression to contralateral hip femoral head withbilateral involvement in up to 72% of thepatients.[1]Various non-invasive diagnostic imaging used in detectingavascular necrosis includes plain X-rays, magneticresonance imaging (MRI), computed tomography(CT), skeletal scintigraphy and SPECT.[2]MR is a non invasive modality which plays a very crucialrole in detection of early stages of AVN as it ismore sensitive than plain film radiography in the diagnosis ofAVN, allowing earlydecompression leading to joint preservation.The main role of MRI is diagnosis ofavascular necrosis in asymptomatic patientsbefore x-ray changes become apparent.[3]Bone marrow edema detectedon MRI is considered a marker of progression tocollapse of femoral head.[4] Inpatients who present with signs and symptomssuggestive of AVN and have normal radiographs,MRI is the investigation of choice.[5]We conducted this prospective study to analysethe role of MRI in evaluation of avascular necrosis offemoral head.

2. MATERIAL AND METHODS

A prospective observational study was conducted, in which 50 patients of suspected cases of AVN of femoral head of all age groups and both sexes were evaluated by X ray and MRI hip in the Department of Radiodiagnosis, GajraRaja Medical College and J.A. Group of Hospitals, Gwalior, over a period of 1.5 years. Detailed history and associated risk factors were taken from all the patients. Patients who didn't give consent, had known contraindications (metallic prosthesis, prosthetic valves) or were claustrophobic were excluded from the study. After clinical evaluation, once a patient satisfied the inclusion and exclusion criteria for this study, he or she was taken for MRI of the hip joint which were then evaluated and modified Ficat and Arlet and Mitchell classifications were determined in all the cases for staging of AVN and correlated with x ray.

MRI hip was performed on 1.5 Tesla (Philips Ingenia 1.5 Tesla dStream) MRI machine with the help of dedicated surface coil. Patients were asked to lie in a supine position and both hips were scanned simultaneously using hip protocol. The sequences obtained were T1 weighted, T2 weighted, short-tau inversion recovery, proton-density fat saturation coronal with sagittal images, and T1-weighted and T2-weighted axial images.

3. RESULTS

Table 1: Frequency distribution of AVN cases according to etiology

Etiology	Frequency(n)	Percentage%
Idiopathic	18	36%
Alcohol	13	26%
Steroid	11	22%
Trauma	7	14%
Radiotherapy	1	2%
Total	50	100%

Table 2: Frequency distribution of various MRI features in AVN of affected hips

MRI features in AVN	Number of AVN affected hips (n=83)	Percentage %
Focal subchondral signal abnormality (geographic pattern)	70	84.3%
Bone Marrow Edema	68	81.92%
Joint Effusion	59	71.08%
Double linesign	56	67.4%
Femoral head / acetabularsubchondral cysts	22	26.5%
Femoral head fragmentation with collapse	40	48.2%
Altered Femoral head contour	43	51.8%
Osteophytes	11	13.25%

Table 3: FicatArlet staging of AVNHIP

Stage	No of femoral heads affected (n=83)	Percentage (%)
STAGE I	5	6.02 %
STAGE II	38	45.78%
STAGE III	29	34.93%
STAGE IV	11	13.25%

Table 4 : Staging of AVN on basis of Mitchell's classification system

Mitchells classification (class)	No femoral heads involved	Percentage (%)
A	4	4.8%
B	38	45.7%
C	26	31.3%
D	15	18.2%
TOTAL	83	100%

Table 5: Sensitivity of X-ray v/s MRI in identification of presence of hip disorder.

Total number of hips affected	Identified on X ray	% OF Detection on XRAY	Identified on MRI	%
83	48	57.83	83	100

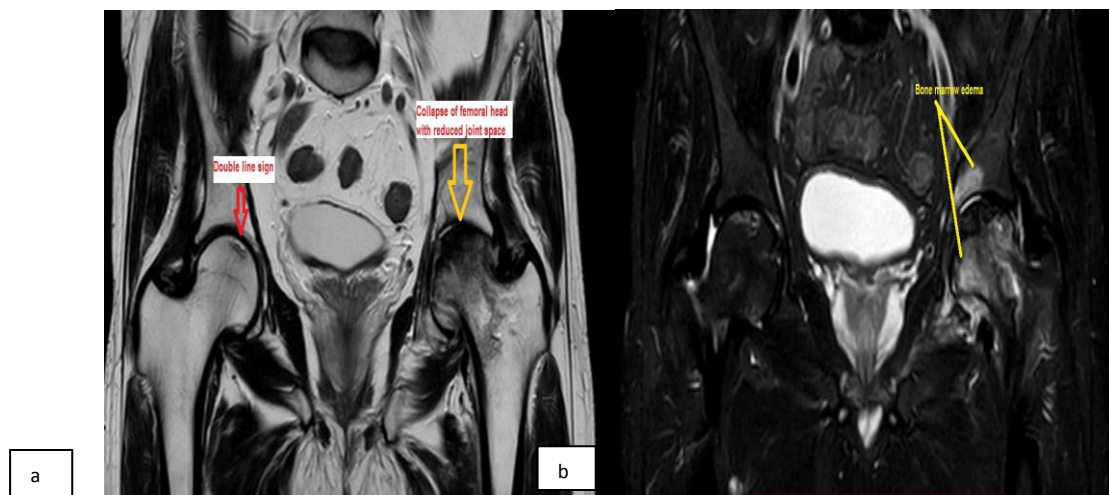**Figure 1- Case of bilateral hip AVN(Ficat and Arlet classification) with Stage II AVN in right femoral head showing double-line sign (seen on T2-weighted sequence and consists of inner bright line representing granulation tissue and surrounding dark zone representing sclerosis) and Stage III in left femoral head showing collapse of left femoral head on T2WI with bone marrow edema on STIR (a) T2 coronal. (b) STIR coronal.**
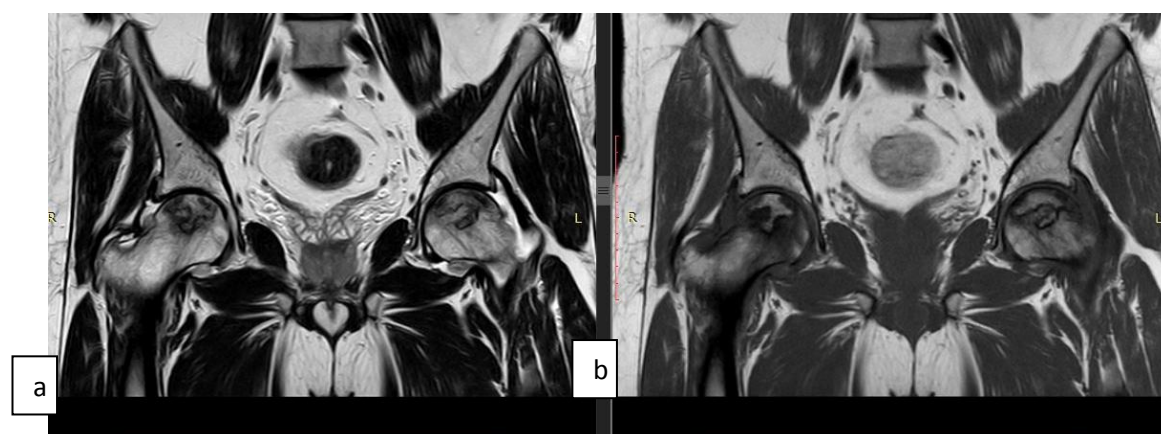

Fig. 2: Case of bilateral AVN hip showing grade B on both sides (hyperintense signal on both T1WI and T2WI) according to Mitchell grading. (a) T2 coronal. (b) T1 coronal.

Total of 50 patients,agedbetween 11-80 years,clinicallysuspectedtohaveAVN of hip underwent hip evaluation using MRI. Maximum numbers of patients were in the age group of 21-30 years (50%). There was a Male predominance with M:Fratio was approximately 4:1.The most common etiology in development of AVN of the hip [Table 1] was found to be idiopathic accounting for 36% of thecases followed by alcohol consumption (26%), steroid intake (22%), post traumatic (14%), while 1 patient had history of radiotherapy. The total number of head affected was 83, out of which bilateral hip involvement (66%) is more common in AVN of femoral head with left hip (51.8%) involvement was slightly more than the right hip(48.2%). The most common location of AVN is anterosuperior (46.98%) in head of femur followed by anteromedial area (26.5%). The most common MRI finding of AVN[Table 2] was focal subchondral signal abnormality (geographic pattern) (84.3%),followed by bone marrow edema (81.92 %)[Figure 1]. The other common MRI findings were double-line sign [Figure 1], subchondral cyst, subarticular collapse of femoral

head, osteophytes and joint effusion. According to Ficat-Arletclassification[Table 3], Stage II [Figure 1] was the most common class of AVN present in 45.78 % of the total affected femoral heads followed by stage III seen in 34.93 % femoral heads.According to Mitchell classification[Table 4] based on MRI signal characteristics within the centre of the lesion, Type B [Figure 2] (signal analogous to that of blood) was the most common seen in 38 femoral heads (45.7%).Double line sign was seen on T2 WI in 67.4% of cases. It is most common sign seen in Stage II disease, occurring in 94.73 % of cases with Stage II disease and 69 % of cases affected with Stage III disease. "Double line sign" is a pathognomonic imaging indicator for AVN.Grade I joint effusion was the most common grade which was found in all the hips affected with AVN.Maximum number of cases with significant joint effusion (=/> grade 2) were noted in stage III AVN.All thehipswith StageIAVNshowedthepresenceof bone marrow edema.AmongstagesII, III and IV, the incidence of bone marrow edema was highest in stage IV followed by stage III disease. MRI had 100% sensitivity in the identification of presence of AVN hip whereas X-ray had 57.83 % sensitivity in the identification of presence of AVN hip.

4. DISCUSSION

Avascular necrosis (AVN) of the femoral head is one of the common cause of hip pain in a young adult in India. In this current study, benefit of MRI over Xray for evaluation of AVN of hip in patients presenting with hip pain was determined. Sensitivity of MRI in detection of AVN of hip was 100% which was much more than Xray. Thus, comparison was done in the present study.

Our results showed that maximum numbers of patients were in the age group of 21-40 years (80%), which correlated with study done by HarshaVardan et al[6](age group range 14-70 years) where 70.28% patients were between 20 to 40 years. This also correlated with the study done by Tushar K et al.[7]

The most common etiology in development of AVN of the hip [Table 1] was found to be idiopathic (36%) followed by alcohol consumption (26%), steroid intake (22%) and trauma (14%) as other causes.

The most common MRI finding of AVN of hip [Table 2] was focal subchondral signal abnormality (geographic pattern) (84.3%), followed by bone marrow edema (81.92%), joint effusion (71.08%), double-line sign (67.4%) , femoral head /acetabularsubchondral cysts (26.5%), femoral head fragmentation with collapse (48.2%), altered femoral head contour (51.8%) and osteophytes (13.25%).

Double line sign was found mostly in stage II AVN of hip which is seen on T2-weighted image and is a pathognomic sign of AVN of hip which consists of inner bright line representing granulation tissue with surrounding dark zone representing adjacent sclerotic bone.

Altered femoral head contour, subchondral cysts in femoral head and/or acetabulum with or without reduction of joint space, femoral head fragmentation with collapse and osteophytes seen on MRI were found in advanced stages of AVN of hip.

AVN cases were classified into various stages based on Ficat-Arlet classification system[Table 3]. In our study, stage I AVN (5 femoral heads, 6%) revealed diffuse bone marrow edema in femoral head. Stage II AVN accounting for 38 out of total 83 femoral heads affected (45.78 %) revealed focal geographical area of signal alteration in subchondral region of femoral head with double-line sign. Stage III AVN (29 femoral heads, 34.93 %) revealed disruption of the normal contour of the femoral head with eventual cortical collapse. Stage IV AVN (11 femoral heads, 13.25 %) revealed subarticular collapse of femoral head associated with advanced degenerative changes of hip. So, stage II AVN was the most

common stage found in our study.

AVN cases were also classified into various stages based on Mitchell's classification system according to MRI signal intensity within the center of the lesion.

• Stage A – Signals similar to fat
• Stage B – Signals similar to blood
• Stage C – Signals similar to fluid
• Stage D – Signals similar to fibrosis.

Mitchells Classification[Table 4]on the basis of signal intensity showed that Type B (45.7%) followed by type C signals (31.3%) were found to be the most common type of signal intensity lesions. Similar findings were seen in study conducted by SaurabhGoyal et al which concluded that, Class A signal in necrotic core are usually associated with early changes of AVN while those with Class B and C signal within had advanced Stages.[8]

Joint effusion was present in 71.08% femoral heads whose incidence was highest in stage III AVN (93.1%) followed by stage IVAVN (81.8%) and stage II AVN (60.52%) whereas joint effusion was absent in all the hips with stage I AVN. So, it was concluded that stage I AVN of hip had no association with joint effusion whereas stage III AVN of hip had maximum association with joint effusion.

The hip joint effusion is graded from 0 to 3 on the basis of the coronal STIR and coronal T2W images and joint effusion is considered significant if it is ≥ grade 2. It was seen that patients with AVN of hip had mostly grade 1 joint effusion(31%) and maximum number of cases with significant joint effusion (≥ grade 2) occurred in Ficat-Arlet stage III AVN of hip.

Bone marrow edema(BME) was found in 82 % of the hips in AVN patients. It was studied that all thehipswith StageIAVNshowedthepresenceof BME.AmongstagesII, III and IV, the incidence of BME was highest in stage IV followed by stage III disease. So our study concluded that BME is not only found in stage I AVN but its incidence also seen in advanced cases of AVN.

Plain radiographs could not detect AVN in all the 5 hips of stage I and 30 out of 38 hips of stage II which were then detected on MRI, so our study concluded that MRI can easily diagnose early stages (I, II) of AVN of hip which can be missed on plain radiographs. Hence MRI is more sensitive(100% sensitivity) in the identification of presence of AVN of hip when compared to X ray [Table 5].

5. CONCLUSION

MRI is an excellent modality in diagnosis, staging and in deciding the extent, severity&complicationsandpredictingprognosisofAVNofthefemoralhead.Itis far superior to radiography in all terms (except the cost and when prosthesis causes contradiction for MRIhip).

Most cases were idiopathic. Joint effusion showed maximum occurrence in FicatArlet stage III. "Double line sign" is a pathognomonic imaging indicator for AVN.

Early stage of AVN hip may be missed on plain radiography. MRI can identify the presence of AVN with 100 % sensitivity. Hence, MRI is a better investigation tool and should be included in the evaluation protocol of patients with clinically suspected AVN hip even if plain radiographs reveal no significant abnormality.

MR imaging should be the procedure of choice for screeningthosepatientsatgreatriskforthedevelopmentofAVN.Beingmultiplanar, MRIshowstheextentofinvolvementofweightbearingareandtotalinvolvementof head of femur more accurately than X-ray, which is very useful in predicting the prognosis of

AVN. MR is the imaging modality which is capable of diagnosing AVN early, thus it can be considered as a hip joint saving imagingmodality.

Thus, MRI is the modality of choice for early and accurate diagnosis of AVN hip and further treatment to prevent the morbidity of the patient by preventing the need for surgical intervention.

6. REFRENCES

[1] Moya-Angeler J, Gianakos AL, Villa JC, Ni A, Lane JM. Current concepts on osteonecrosis of the femoral head. World J Orthop. 2015;6(8):590-601. Published 2015 Sep 18.

[2] Stoica Z, Dumitrescu D, Popescu M, Gheonea I, Gabor M, Bogdan N. Imaging of avascular necrosis of femoral head: familiar methods and newer trends. Curr Health Sci J. 2009;35(1):23-8.

[3] Baig SA, Baig MN. Osteonecrosis of the Femoral Head: Etiology, Investigations, and Management. Cureus. 2018;10(8): e3171. Published 2018 Aug 21.

[4] Markisz JA, Knowles RJ, Altchek DW, Schneider R, Whalen JP, Cahill PT. Segmental patterns of avascular necrosis of the femoral heads: early detection with MR imaging. Radiology 1987; 162:717- 720.

[5] Iida S, Harada Y, Shimizu K, et al. Correlation between bone marrow edema and collapse of the femoral head in steroid-induced osteonecrosis. AJR 2000;174:735–743

[6] Vardhan H, Tripathy SK, Sen RK, Aggarwal S, Goyal T. Epidemiological Profile of Femoral Head Osteonecrosis in the North IndianPopulation. Indian J Orthop. 2018;52(2):140-146.

[7] Tushar K, Pooja S. Role of magnetic resonance imaging findings in evaluationof painful hip joint. International Journal of Medical and Health Research. July 2017; 3(7): 105-111

[8] Saurabhgoyal,Purvidesai , Devyaniambadekar , Simranjeetsingh correlation between ficat-arlet and mitchell's Staging for avascular necrosis of femur head NJMR, volume 6, issue 4, oct – dec 2016 page 301.