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Original Research Article

Role of Magnetic Resonance Imaging in Clinically or Radiographically Suspected Patients of Avascular Necrosis of Femoral Head

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Abstract

Background- Present study was conducted to diagnose AVN (avascular necrosis) in patients presenting with complaint of pain hip joint pain and to study role of MRI in patients who are clinically or radiographically suspected cases of avascular necrosis of femoral head.
Methodology- This cross-sectional study was conducted on patients referred to the Radio-Diagnosis department with suspicion of AVN. X-ray and MRI hip was done and modified Ficat and Arlet classification was used for staging.
Results- About 50 patients had AVN, of which 32 had AVN unilaterally and 32 bilaterally. Out of 29 patients who were at stage 0 in X ray (normal plain radiograph), 3 patients were found be at stage I, 25 patients were found to be at stage II and 1 patient was diagnosed with stage III AVN on MRI. Out of 37 patients with stage 3 AVN on X ray, MRI was also able to confirm stage III in all the 37 patients with additional 3 patients and 1 patient, who were at stage 2 and stage 1 in X ray respectively. Similarly, out of 9 patients diagnosed with stage 4, all were confirmed in stage IV in MRI.
Conclusions- As compared to X-ray, MRI has an advantage in terms of being non-invasive, radiation free and ability for detection of earliest changes of femoral head AVN. Majority of patients were diagnosed with early AVN changes where plain radiographs were normal and unable to show any significant changes.

Keywords: Avascular necrosis, MRI, X- ray, Ficat and Arlet

1. Introduction

Femoral head is supported by femoral neck, which is the most proximal section of the femur [1]. When blood supply to the proximal femur cuts off, a disease known as avascular necrosis (AVN) develops. Risk factors for AVN include corticosteroid usage, trauma, pancreatitis, alcoholism, sickle cell disease. Up to two-thirds of patients with femoro-acetabular impingement develop bilateral involvement [2]. The importance of early diagnosis and treatment cannot be overstated due to the fact, young adults are more likely to be diagnosed and treated. In the early stages of AVN, there are no symptoms and the disease advances quickly to the degeneration of the hip joint.

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A prompt and early diagnosis can lead to the development of more effective and less debilitating treatment options for patients [3]. The changes in AVN can be detected by various imaging modalities, including X-ray, CT (computed tomography), MRI and nuclear medicine hybrid techniques [4]. Conventional radiographs are unable to detect AVN in stages 0 and 1 [5]. However, the non-invasive modality of choice for detecting early avascular necrosis changes is MRI because of its superior tissue resolution and multiplanar imaging [6].

2. Methodology

This study was conducted as a cross sectional study on patients referred to the Department of Radio-Diagnosis, Gandhi Medical College & Hamidia hospital, with clinical or radiographical suspicion for avascular necrosis of femoral head, for MRI scan, during the study period of 20 months (from January 2020 to September 2021). All the patients referred for MRI hip joint investigation of all age groups and both sexes who gave consent were included. However, patients undergone

hip joint surgery, or those having metallic implants insertion and cardiac pacemakers were not included in study. Ethical clearance was obtained from the Research and Dissertation Committee/ Ethical Committee of the institution for this study. Informed consent was taken after explaining about the procedure.

Technique

MRI hip was performed on 1.5 Tesla MRI Hitachi machine using dedicated surface coil. Patients were asked to lie in a supine position and both hips were scanned simultaneously using hip protocol. Based on MRI findings, modified Ficat and Arlet classification is determined in all the cases for staging of AVN. The sequences obtained were

(a) T1W coronal- slice thickness (1-3mm)
(b) T1W axial- slice thickness (1-3mm)
(c) T2W coronal- slice thickness (1- 3mm)
(d) T2W axial- slice thickness (1- 3mm).
(e) STIR coronal- slice thickness (3- 5mm)
(f) PD sagittal- slice thickness (3- 5mm).

Data Analysis

All the data analysis was performed using IBM SPSS version 25. Frequency distribution and cross tabulation was performed to prepare the tables. Quantitative data was expressed as mean and standard deviation whereas categorical data was expressed as proportions. Chi- square test was used to compare the proportions. Prism software was used to prepare the graphs. P-value of less than 0.05 was considered statistically significant.

3. Results

The study included a total of 82 femoral heads of cases with avascular necrosis with mean age of 33.70±11.43 years.

Table -1 Distribution according to baseline variables

Baseline variables		Frequency	Percentage
Age	≤20	6	7.32%
	21-40	57	69.52%
	41-60	16	19.52%
	>60	3	3.66%
Sex	Male	73	89.02%
	Female	9	10.98%
Locatio n/ Quadra nt	Ant Lateral	2	2.44%
	Ant Medial	7	8.54%
	Ant Superior	64	78.05%
	Comp	9	10.98%
Causes	Steroid consumption	5	6.10%
	Alcohol consumption	39	47.56%
	Traumatic injury to Hip	12	14.63%
	Blood Dyscrasias	14	17.07%
	Radiation exposure	1	1.22%
	Idiopathic	11	13.41%

Majority of the patients with suspected AVN belonged to age range of 21 to 40 years (69.52%). And about 89.02% cases were males. Most common location/ Quadrant for AVN was anterosuperior (78.05%) followed by Complete (10.98%). Alcohol consumption was the most common cause of AVN in 47.56% followed by Blood Dyscrasias (17.07%) and Traumatic injury to Hip (14.63%). Out of 82 femoral head affected, 11 (13.41%) were idiopathic.

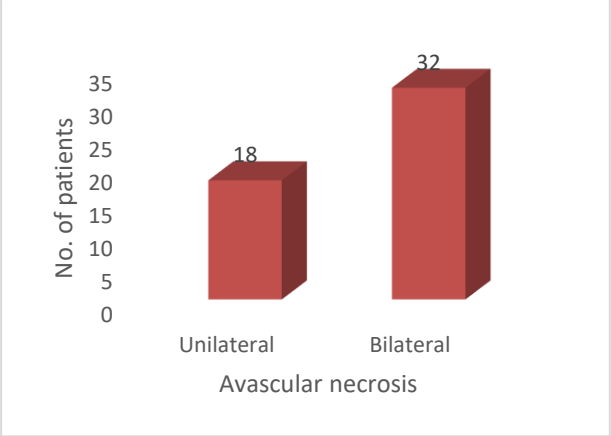


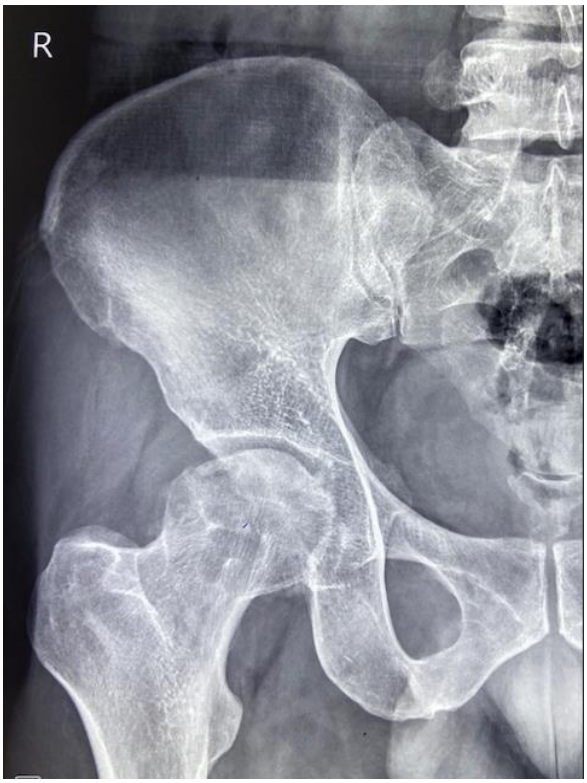
Figure 1- Distribution according to Presence of avascular necrosis

About 50 patients had AVN and of them, 18 (36%) had Unilateral AVN whereas 32 (64%) had Bilateral AVN. Thus, a total of 82 femoral heads were examined.

Most common abnormal X- ray findings in patients with AVN was Focal & segmental flattening of femoral head (56.10%) followed by Mixed osteopenia with Sclerosis (50%), Crescent sign (due to sub-chondral fracture) (31.71%) and Cortical collapse (14.63%). There were 2 (2.44%) patients who had Mild osteopenic changes. Majority were at stage 3 (45.12%) followed by 29 (35.37%) who were at stage 0, 7 (8.54%) patients were at stage 2. There were 9 (10.98%) patients who were at stage 4.

Table 2- Distribution according to X ray findings

X-ray		Frequency	Percentage
X-ray findings	Normal	29	35.37
	Mild osteopenic changes	2	2.44
	Mixed osteopenia with Sclerosis	41	50.00
	Cortical collapse	12	14.63
	Crescent sign (due to sub-chondral fracture)	26	31.71
	Focal & segmental flattening of femoral head	46	56.10
FICAT and ARLET staging	0	29	35.37
	1	0	0.00
	2	7	8.54
	3	37	45.12
	4	9	10.98



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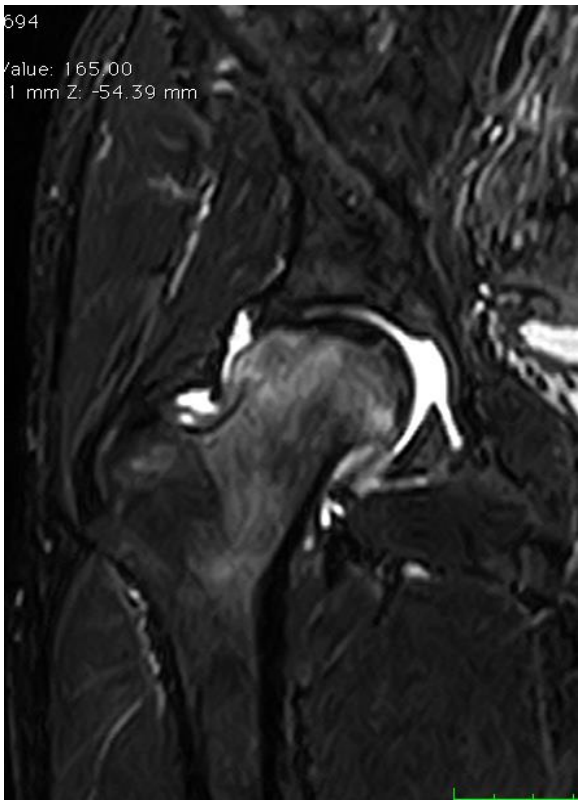

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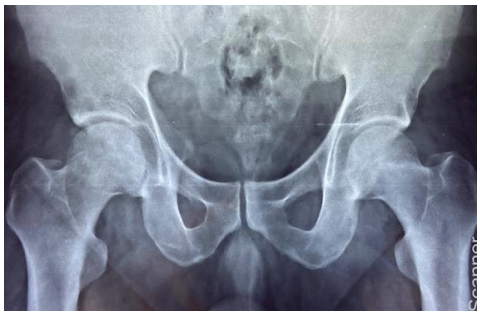
Figure 1: Grade 1 avascular necrosis (Ficat and Arlet) of the right femoral head (A) no significant abnormality on X-ray right hip antero-posterior view. (B) Hyperintense marrow edema with mild joint effusion on STIR (Short-tau inversion recovery) coronal MRI sequence.



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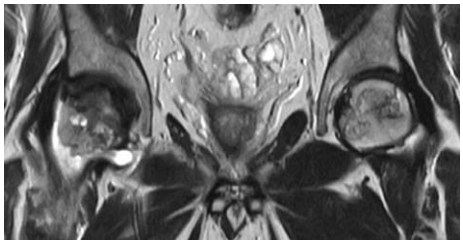

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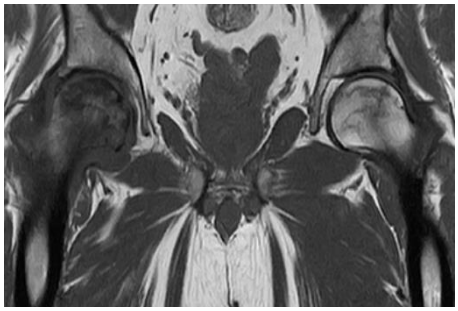

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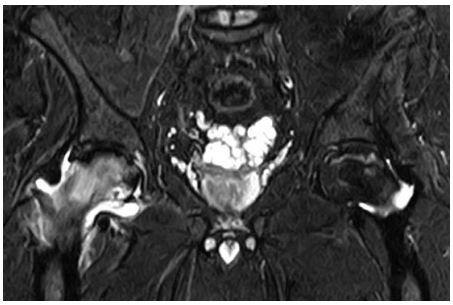

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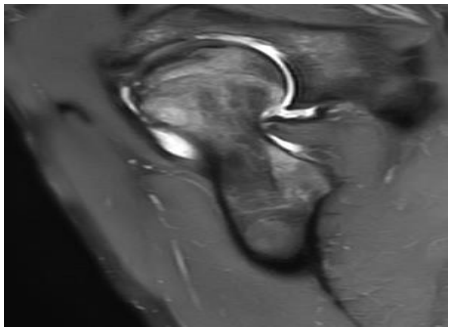

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Figure 2: Case of bilateral avascular necrosis. X-ray antero-posterior view of bilateral hip joint shows sub-chondral sclerosis without sub-chondral lucency or sub chondral cysts (Crescent sign)

Grade III AVN changes (Ficat and Arlet) showing irregular articular surface of right femoral head with altered marrow signals and adjacent short-tau inversion recovery (STIR) hyperintense marrow edema. Grade II AVN (Ficat and Arlet) showing focal subchondral area of signal alteration in anterosuperior quadrant of the left femoral head with double-line sign (seen on T2-weighted sequence and consists of inner hyperintense line representing granulation tissue with surrounding hypointense area representing sclerosis). (b) T1 coronal. (c) T2 coronal. (d) STIR coronal (e) Proton-density (fat sat) sagittal.

Table 3- Distribution according to MRI findings

MRI		Frequency	Percentage
MRI findings	Focal Subchondral Geographical Pattern	79	96.34
	Bone Marrow Edema	82	100.00
	Double Line Sign	30	36.59
	Subchondral Cysts	24	29.27
	Focal Flattening and Collapse of Femoral Head	50	60.98
	Degenerative Changes	9	10.98
	Joint Effusion	63	76.83
FICAT and ARLET staging	I	3	3.66
	II	29	35.37
	III	41	50.00
	IV	9	10.98

Table 4 - Comparing staging of FICAT and ARLET on X-Ray and MRI

X-Ray	MRI				Total
	I	II	III	IV	
0	3	25	1	0	29
2	0	4	3	0	7
3	0	0	37	0	37
4	0	0	0	9	9
Grand Total	3	29	41	9	82

All the patients with AVN had Bone Marrow Edema (100%), 96.34% patients had Focal Subchondral Geographical Pattern, 76.83% had Joint Effusion, 60.98% had Focal Flattening and Collapse of Femoral Head, 36.59% had Double Line Sign, 29.27% had Subchondral Cysts and 10.98% had Degenerative Changes. On observing the Staging of FICAT and ARLET on MRI, it was revealed that majority were at stage III (50%) followed by 29 (35.37%) patients who were at stage II, 10.98% were at stage IV and only 3 (3.66%) were at stage I.

On comparing the diagnostic efficiency of X-ray and MRI on finding the correct staging of FICAT and ARLET, it was found that out of 29 patients who were found to be at stage 0 in X ray (depicting normal plain radiograph), 3 patients were found be at stage I, 25 patients were found to be at stage II and 1 patient was diagnosed with stage III AVN on MRI. Out of 7 patients who were detected with stage 2 in X-ray, MRI found that, 4 patients were at grade II whereas 3 patients were showing grade III AVN changes. In addition to 4 patients, MRI was also able to detect grade II AVN changes in 25 patients, who were at stage 0 in X ray. Out of 37 patients with stage 3 AVN on X ray, MRI was also able to confirm stage III in all the 37 patients with additional 3 patients and 1 patient, who were at stage 2 and stage 1 in X ray respectively. Similarly, out of 9 patients diagnosed with stage 4, all were confirmed in stage IV in MRI. This highlight that MRI was able to diagnose stage 3 and 4 correctly.

4. Discussion

Increased alcoholic use in males and increased contraceptive use in females are well-known causal factors for AVN of the hip. It occurs at an early age, adding a lot of strain over health care system and decreasing the individual's financial and social productivity. Irreparable damage to the joint is caused by these factors, necessitating joint replacement in the future. Since corrective measures and removal of causative factors can restrict the progression and severity of disease, and also helped deferring joint replacement with improvement in the quality of life [7].

In our study, femoral head flattening (56.10%) was the most common abnormal X-ray finding in individuals with AVN, followed by mixed osteopenia with sclerosis (50%) and crescent sign (owing to subchondral fracture) (31.71%). Radiographs showed that FICAT and ARLET were both in various stages of development. There were 45.12 percent of stage 3 patients, followed by 29 (35.37 percent) stage 0 patients, and 7 (8.54) stage 2 patients. At stage 4, there were 9 patients (10.98 percent). Patients with mild osteopenic alterations were seen in 2 (2.44%) of the patients. Osteopenia, lytic lesion, sclerotic lesion, crescent sign, collapse, joint space narrowing, and osteophytes were the most common x-ray findings of AVN in Rekha et al study [8]. AVN Osteopenia was the most common x-ray finding in 44 of the 65 hips afflicted by AVN (67.6%). Lytic and sclerotic lesions were seen in 28/65 and 32/65 of the patients respectively. 33/65 (50.7%) showed the crescent sign, whereas 29/65 (29 percent) showed the collapse sign (44.6 %). Osteophytes were found in 15/65 (23.0 percent) of the hips that had joint space constriction.

MRI in our study population showed Bone Marrow edema seen in 100% of patients, 96% had Focal Subchondral Geographical Pattern, 76% had Joint Effusion, 60% of patients had Focal Flattening and Collapse of Femoral Head, 36% had Double Line Sign and 10% had Degenerative Changes. There were 50 percent of patients in stage III, followed by 29 (35.37 %) in stage II, 10.99 % in stage IV, and only three (3.66 percent) patients in stage I, according to MRI Staging of FICAT and ARLET. In their study, Choudhary et al [9] observed that grade I AVN found in 10 femoral heads (7.5%), and in 40 femoral heads (30.04%), AVN was

found in the subchondral region of the femoral head with the double line indication. Sclerosis and hyperintense inner borders seen in the double-line sign, which has a hypointense peripheral border (granulation tissue). Grade III AVN (52 femoral heads, 39.4 percent) demonstrated disturbance of the normal femoral head shape and eventual collapse of the cortical region. A subarticular collapse of the femoral head was found in 30 femoral heads (22.7 percent) suggesting grade IV AVN. The most common AVN grade seen in his research was Grade III. It was observed that MRI was very sensitive in the evaluation of early AVN, i.e., Grade I and Grade II (10 and 40 femoral heads, respectively), whereas plain radiographs failed to identify.

Comparing the diagnostic abilities of an anatomical imaging technique (X-ray or MRI) and a clinical (plain radiograph), it was found that out of 29 patients who were found to be at stage 0 in anatomical imaging technique (X-ray), three patients were found to be at stage I, 25 patients were found to be at stage II, and one patient was diagnosed with stage III AVN. 5 patients had stage 2 AVN on X-rays, and MRI indicated that 4 had grade II AVN alterations, and 3 had grade III AVN changes. As well as the four patients who had been diagnosed as having grade II AVN changes, MRI also found 25 patients who had been diagnosed as having stage 0 abnormalities.

An additional three patients and one patient whose AVN was at stage 2 or stage 1 on X-ray were able to be diagnosed with stage III AVN by MRI, bringing the total to 37 individuals. Additionally, of the nine patients who were diagnosed with stage 4, all were confirmed in stage IV by MRI. This shows that MRI was able to correctly identify stages 3 and 4.

However, in a study of Rekha et al [8], MRI was found more accurate in terms of specificity, positive predictive value (PPV), negative predictive value (NPV), sensitivity, and specificity. In 2011, Karantanas [10] discovered that MRI was more sensitive than CT or scintigraphy in detecting early signs of AVN in patients with normal radiographs (stage I). MRI's sensitivity for early diagnosis of AVN was found to be between 88% and 100%. Radiographs can overlook essential information in stages II and III because they overestimate stage II, underestimate stage III, and are erroneous in estimating the collapse magnitude, which is a key criterion for therapeutic considerations.

4. Conclusion

MRI has an advantage over other modalities like plain radiograph, in being non-invasive, radiation free and high sensitivity for detection of early changes of femoral head AVN. We diagnosed a large number of patients with early changes of AVN where plain radiographs were normal and showed no significant abnormality.

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Conflicts of interest- Authors declare that there are no conflicts of interest.

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