International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2018): 7.426

Role of Plain Radiography and MRI in the Evaluation of Avascular Necrosis of Head of Femur

Dr. Rekha[1], Dr. Kaur Amarjit[2], Dr. Garg Yogesh[3], Dr. Kaur Navkiran[4], Dr. Malik Priyanka[5]

[1]Junior resident, Department of Radiodiagnosis, Rajindra Hospital, G.M.C. Patiala

[2]Professor, Department of Radiodiagnosis, Rajindra hospital, G.M.C. Patiala

[3]Junior Resident, Department of Radiodiagnosis, Rajindra Hospital, G.M.C. Patiala

[4]Professor and Head, Department of Radiodiagnosis, Rajindra Hospital, G.M.C. Patiala

[5]Senior Resident, Department of Biochemistry, Rajindra Hospital, G.M.C. Patiala

Abstract: ***Background: Avascular necrosis (AVN) affects mostly young adults within their 3rd and 5th decade. Today, MRI is the imaging modality of choice for diagnosing AVN. It is more sensitive than plain film radiography. The principal role of MRI is in establishing the diagnosis of AVN in symptomatic patients before radiographic changes become apparent. Aims: The aims of this study were to assess the role of MRI in the evaluation and staging of AVN of head of femur, correlating the MRI findings in various stages of AVN with plain radiography. Material and Methods: This cross-sectional study was conducted on forty patients who had risk factors and were clinically suspected to have AVN of Femoral head were evaluated by both plain x-ray and MRI and staged according to modified Ficat and Arlet classification. Results: In precollapsed stages (I and II), plain x-ray detected less number of hips than MRI (38.1% in stage I and 54.5% in stage II) whereas MRI was able to detect 95.2% of hips in stage I and 100% in stage II. In collapsed stages (III and IV), both plain x-rays as well as MRI detected 100% of hips of clinically suspected cases.Sensitivity, specificity, PPV and NPV of x-ray came out to be 73.44%, 83.33%, 97.92% and 22.73% respectively in comparison to MRI with a significant p value of 0.04. Conclusion: It was concluded that in initial stages, plain x-rays are less sensitive in detecting AVN changes as compared to MRI. However, in later stages, both are equally sensitive.A combination of both conventional radiography &MRI of the hips, helps in correctly staging AVN.***

Keywords: AVN of the femoral head, plain x-ray, MRI, Ficat-Arlet staging

1. Introduction

Avascular necrosis results from reduction or complete loss of blood supply. The femoral head usually the anterolateral aspect immediately below the weight-bearing articular surface is most commonly involved, as it is the site of the greatest mechanical stress, directly affecting the lateral epiphyseal arteries.[1]. It mainly affects menin their late 30s and early 40s. It is initially unilateral with progression to bilateral involvement in up to 72% of patients [2]. In the early stages, patients may be asymptomatic. As the disease progresses, most patients experience joint pain which may lead to osteoarthritis in some cases. [3] Hence,a quick and early detection can prevent further progression of the disease.Radiological diagnosis should begin with plain x-rays of hip taken in both AP and Frog leg views. Radiography is insensitive for early stages however, features are often characteristic in the late stages. MRI is considered as the most sensitive and specific imaging modality for identification of ON[4]

The specific findings of AVNinclude crescent shaped area corresponding to a rim of sclerosis."Double-line" sign seen on T2WIis characteristic of AVN.[5] It is seen as an outer low signal intensity rim of sclerosis and a second inner zone of high signal intensity representing the reparative granulation tissue of the reactive interface.

The modified Ficat and Arlet classification (1985) uses a combination of plain radiographs, MRI, clinical features and bone scan to stage avascular necrosis of the femoral head[6,7]

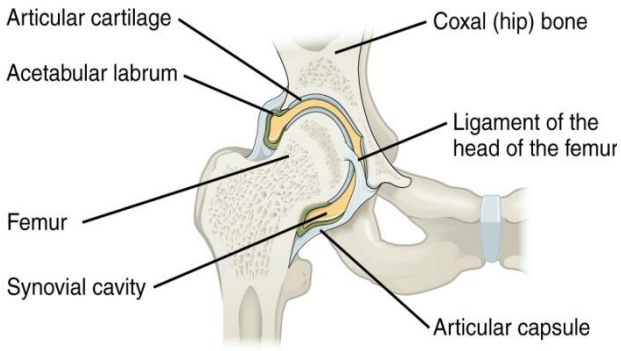

Figure 1: Frontal section through the right hip joint

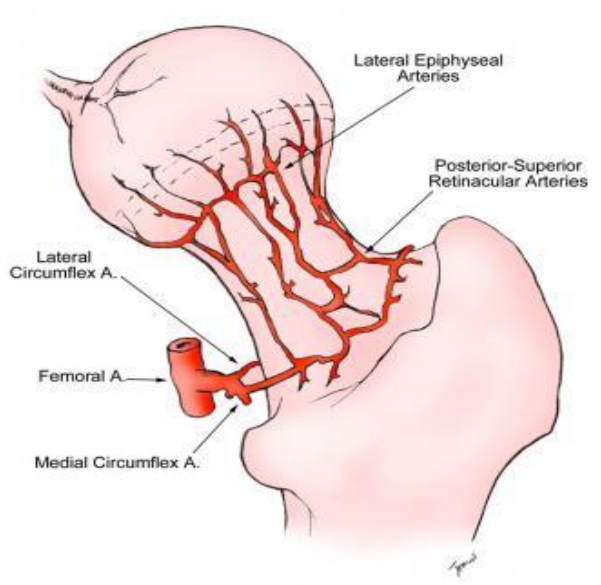

Figure 2: Illustration of the normal circulation of the femoral head, viewed from the posterior approach. A. = artery

2. Material and Methods

This cross-sectional study was conducted in The Department of Radiodiagnosis, Rajindra Hospital, G.M.C. Patiala for a period of two years. Following proper informed consent, forty patients who had risk factors and were clinically suspected to have AVN of Femoral head were evaluated by both plain x-ray and MRI and staged according to modifiedFicat and Arlet classification.

Inclusion Criteria

- Nontraumatic clinically suspected cases of AVN with unilateral or bilateral groin, buttock, thigh or knee pain, deformity or limitation of range of hip movement.
- Traumatic cases with dislocation of hip, fracture head/neck of femur or fracture of acetabulum.
- Patients giving consent for MR imaging.

Exclusion Criteria

- Patients with non AVN causes of hip, thigh or knee pain.
- Patients with ferromagnetic implants, claustrophobia etc.
- Patients with pre-existing hip pathology.
- Patients not giving consent.

Equipment

- X RAY by 300mA x-ray machine (Allenger company)
- MR techniques by 1.5-Tesla superconductive scanner (Siemens 1.5 Tesla Magnetom era MRI machine).

Technique

No specific patient preparation was required prior to the study. Suspected cases were examined initially by plain radiography in both AP and lateral 'frog leg' projections followed by MR Imaging by using various sequences such as spin echo PDFS, spin echo T2-weighted in transverse plane, spin echo T1-weighted , T1-weighted FS , T2-weighted 3D and T1 Inversion Recovery in coronal plane with the help of a dedicated body coil. With the patient in a supine position and both hips were examined simultaneously.

3. Study Analysis

A total of 40 patients were included in this study. After taking informed consent and fulfillment of all the inclusion and exclusion criteria, plain radiography followed by MR imaging of bilateral hips was done by various MR sequences. The modified staging system proposed by Ficat and Arlet was used to correlate the findings between MRI and radiography.

4. Results

A total of 40 patients who were clinically suspected for AVN of the femoral head were studied. Out of 40, 35 (87.5%) patients were detected to have AVN in either or both of the hip joints, while 5 (12.5%) patients turned out to be normal bilaterally.Maximum numbers of patients were observed in 31-40 years of age group. Males and females were 77.2% while 22.8% respectively. In 30 patients (85.7%) both the hip joints were involved while in rest of the 5 patients unilateral hip involvement was seen out of which in 4 patients (11.5%) left hip and in 1 patient (2.8%) right hip was involved. So total 65 hip joints of 35 patients were affected by AVN.AVN FH was seen in 14.2% of alcoholics, 28.6% of patients taking steroids, 11.4% of patients with history of trauma and only 5.8% of patients suffering from sickle cell disease. In rest of the patients (40%) no identifiable risk factor was found (idiopathic).Out of 35 patients of AVN FH, 5 patients were asymptomatic [4 on the right side (11.5%) and 1 on the left side (2.8%)] , 32 patients presented with chief complaint of hip pain [22 on right side (62.85%) and 10 on left side (28.6%)], 13 patients presented with hip pain radiating to knee with associated limp[2 (5.7%) on the right side and 11 (31.4%) on the left side], 20 patients presented with hip pain with associated limp [7 on the right side (20.0%) and 13 on the left side (37.2%)]. So in our study most of the patients with AVN presented with complaints like hip pain with or without associated limp. Radiation of hip pain to the knee also occurs in later stages.

Table 1: Findings of AVN in the affected hip joints on Plain X-ray (n=65)

S. no	X-ray findings	Total no. of affected hip joints	Percentage	P value
1.	Osteopenia	44/65	67.7	0.09
2.	Lytic lesion	28/65	43.1	0.16
3.	Sclerotic lesion	32/65	49.2	0.02 (S)
4.	Crescent sign	33/65	50.7	0.002 (S)
5.	Collapse	29/65	44.6	0.02 (S)
6.	Joint space narrowing	20/65	30.7	0.14
7.	Osteophytes	15/65	23.0	0.05 (S)

In our study; osteopenia, lytic lesion, sclerotic lesion, crescent sign, collapse, joint space narrowing and osteophytes were the major plain x-ray findings of AVN. Among the total 65 hips affected by AVN, osteopenia was the most frequent x-ray finding 44/65 (67.7%). Lytic lesion was seen in 28/65 (43.1%) and sclerotic lesion was seen in

32/65 (49.2%) of affected hips. Crescent sign was seen in 33/65 (50.7%) and collapse was seen in 29/65 (44.6%) of affected hips. Joint space narrowing was seen in 20/65 (30.7%) and osteophytes were seen in 15/65 (23.0%) of affected hips.

Table 2: Findings of AVN in the affected hip joints on MRI (n=65)

S. no	MRI findings	Total no. of affected hip joints	Percentage	P value
1.	Double line sign	45/65	69.3	0.04 (S)
2.	Subchondral cysts	28/65	43.1	0.15
3.	Subchondral sclerosis	32/65	49.2	0.02 (S)
4.	Bone marrow edema	50/65	77	0.46
5.	Crescent sign	33/65	50.8	0.002 (S)
6.	Collapse	31/65	47.7	0.007 (S)
7.	Joint effusion	30/65	46.1	0.11
8.	Joint space narrowing	20/65	30.8	0.22
9.	Osteophytes	15/65	23.1	0.05 (S)

In our study; double line sign, subchondral cysts, subchondral sclerosis, bone marrow edema, crescent sign, collapse, joint effusion, joint space narrowing and osteophytes were the major MR findings of AVN. Among the total 65 hips affected by AVN, most common finding was the bone marrow edema seen in 50/65 (77%)of affected hips. Double line sign, subchondral cysts, subchondral sclerosis, crescent sign, collapse, joint effusion, joint space narrowing and osteophytes were found in 45/65 (69.3%), 28/65 (43.1%), 32/65 (49.2%), 33/65 (50.8%), 31/65 (47.7%), 30/65 (46.1%), 20/65 (30.8%), 15/65 (23.07%) of affected hips respectively.

Table 3: Distribution of hips of clinically affected patients on plain X-ray and MRI in various stages of AVN (n=65)

Stages of AVN	Total no. of hips of clinically affected patients	No. of hips detected by X-ray(%)	No. of hips detected by MRI(%)
I	21	8(38.1)	20 (95.2)
II	11	6 (54.5)	11(100)
III	13	13 (100)	13(100)
IV	20	20(100)	20 (100)
Total	65	47	64

Out of total 70 hips of 35 patients of AVN under study 5 hips (4 right hips and 1 left hip) were in stage 0 (preclinical and preradiographic stage). Only 65 hips were clinically affected by AVN.

In precollapsed stages (I and II), plain x-ray detected less number of hips than MRI (38.1% in stage I and 54.5% in stage II) whereas MRI was able to detect 95.2% of hips in stage I and 100% in stage II.

In collapsed stages (III and IV), both plain x-rays as well as MRI detected 100% of hips of clinically affected patients.

Thus it is concluded that in initial stages, plain x-rays are less sensitive in detecting AVN changes as compared to MRI. However, in later stages, both are equally sensitive.

Figure A: Plain radiograph PBH frog leg projection showing osteopenia, crescent sign and collapse involving the left hip joint indicating stage III AVN FH . However, no signs are depicted in the right hip indicating stage 0.

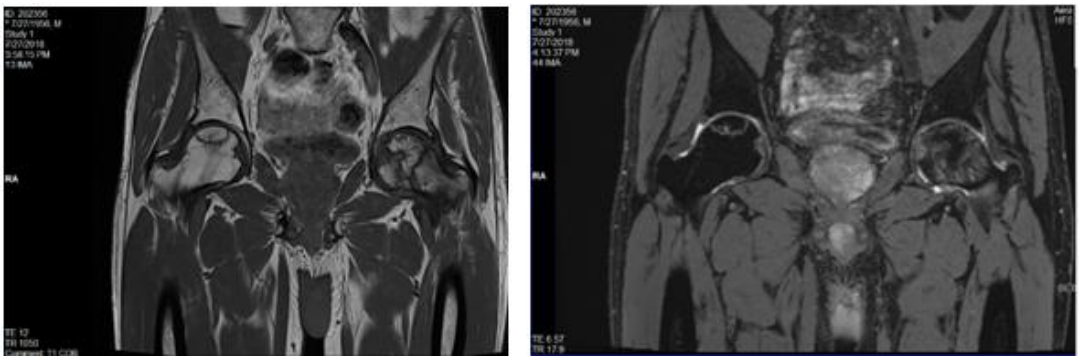

Figure B and C: T1-W and 3 D T2-Weighted coronal MR images showing double line sign, bone marrow edema, crescent sign and collapse involving the left hip joint and double line sign involving the right hip joint indicating stage III and stage II AVN FH respectively

5. Discussion

In our study, among 40 clinically suspected patients with various risk factors, AVN was seen in 35 patients (prevalence 87.5%).Age distribution of patients in our study ranged from 16-63 years. Overall mean age of patients in the study was 35.6 years ±12.88SD. Youngest patient in present study was 16 years old and oldest was 63 years old. Majority of patients were males 27 (77.2%) and only 8 (22.8%) were

females. Male to female ratio being 3.3:1. Similar results were obtained by Kaushik et al[2]in 2012, who found in their study that patients affected with AVN are generally younger adults age 35 years to 45 years, Males are affected up to three times more than females.

In our study, among 35 patients, 30 patients (85.7%) had bilateral hip joint involvement while in rest of the 5 patients unilateral hip joint involvement was seen out of which in 4(11.4%) patients left side and in 1 patient (2.85%) right side was involved. Similar results were seen by Khaladkar et al[8] in 2015, theyconducted a study in which a total of 45 patients who were suspected clinically and or on conventional radiography for AVN of the femoral head were referred for MRI hip. AVN was bilateral in 22 patients (61.1%) and unilateral in 14 patients (38.8%). Out of 58 hips, left hip was involved in 33 cases (56.8%) and right hip was involved in 25 (43.1%).

In our study, among 35 patients, Idiopathic 14 (40%) and steroid intake 10 (28.5%) were more commonly found as risk factors for AVN development than alcohol 5(14.2%), trauma 4(11.4%) and sickle cell disease 2 (5.7%). Similar results were obtained by Vaghamashi et al[9] in 2017, theyconducted a study where idiopathic was found to be most common risk factor in 50 % of cases. Of the associated risk factors, causes like steroids was observed in 18.7 %, alcohol in 12.5 % and trauma, sickle cell anemia and pancreatitis was found in 6.25 % each.

In our study, among 35 patients of AVN FH, 5 patients were asymptomatic while 32 patients presented with chief complaint of hip pain with or without associated limp. In our study, patients with hip pain were detected by MR in either stage I or II but x rays were non-diagnostic in some of these patients. Patients with radiation of pain and associated limp had MR as well as X-ray findings of stage III. Patients with pain and associated limp had MR as well as X-ray findings of stage IV.Similar results were seen by Garasiya et al[10] in 2017, they did a study in which a significant correlation was seen between severity of clinical symptoms, the stage and MRI signal intensity classification. The cases in the advanced post collapse stage were more painful than in pre collapse stage. Similarly pain was least severe in stage I and most severe in stage IV.

In our study; osteopenia, lytic lesion, sclerotic lesion, crescent sign, collapse, joint space narrowing and osteophytes were the major x-ray findings of AVN. Among the total 65 hips affected by AVN, osteopenia was the most frequent x-ray finding 44/65(67.6%).Lytic lesion was seen in 28/65(43.1%) and sclerotic lesion was seen in 32/65(49.2%). Crescent sign was seen in 33/65(50.7%) and collapse was seen in29/65(44.6%). Joint space narrowing was seen in 20/65(30.7%) and osteophytes were seen in 15/65(23.0%) of affected hips. Rangareddy et al[11] in 2016carried out a study in total 60 patients who presented with the complaint of hip pain and suspected clinically to be AVN.In this study, 20 cases (33.3%) had lytic lesion, 26 cases(43.3%) had sclerotic lesion, 9 cases(15%) had femoral head deformity &rest of the hips (33.3%) were normal on plain x-rays.

In our study; double line sign, subchondral cyst, subchondral sclerosis, bone marrow edema, crescent sign, collapse, joint effusion, joint space narrowing and osteophytes were the major MR findings of AVN. Most common finding being the bone marrow edema. Double line sign, subchondral cysts, subchondral sclerosis, crescent sign, collapse, joint effusion, joint space narrowing and osteophytes were found in 45/65 (69.3%), 28/65 (43.1%), 32/65 (49.2%), 33/65 (50.8%), 31/65 (47.7%), 30/65 (46.1%), 20/65 (30.8%), 15/65 (23.07%) of hips respectively. Vaghamashi et al[9] in 2017 studied 52 patients presenting with the complaint of painful hip. Most common MRI finding of AVN was focal subchondral signal abnormality which was present in 100 % of the involved hip joints. Hip joint effusion, bone marrow edema, collapse, double line sign, decreased joint space, osteophytes, thinning of articular cartilage and subchondral cysts were seen in 65.2%, 52.2%,56.5%,43.5%, 47.8%, 26.0%, 13.0%,8.7% of involved hip joints respectively.

In our study, among 70 hips of 35 patients of AVN, 5 hips (4 right hips and 1 left hip) were in stage 0 (pre-clinical and pre-radiographic stage). Only 65 hips were clinically affected by AVN. Upon evaluation by both plain x-ray and MRI, the findings were correlated. In precollapsed stages (I and II), plain x-ray detected less number of hips than MRI (38.1% in stage I and 54.5% in stage II) whereas MRI was able to detect 95.2% of hips in stage I and 100% in stage II. In collapsed stages (III and IV), both plain x-rays as well as MRI detected 100% of hips of clinically suspected patients. Thus it is concluded that in initial stages, plain x-rays are less sensitive in detecting AVN changes as compared to MRI. However, in later stages, both are equally sensitive.By plain x-ray we were able to detect only 47 hips showing one or the other finding of AVN as compared to 64 hips detected by MR imaging. 47 hips showed changes of AVN on x-ray as well as MRI. 5 hips were normal on both the modalities. Only one x-Ray with positive findings showed no abnormality on MR while 17 hips came out to be positive on MRI which had no abnormality on x-ray. Sensitivity, specificity, PPV and NPV of x-ray came out to be 73.44%, 83.33%, 97.92% and 22.73% respectively in comparison to MRI with a significant p value of 0.04.Karantanas[12] in 2011found in his study thatMRI was more sensitive than CT or scintigraphy for early detection of AVN inpatients with normal radiographs (stage I). They reported sensitivity of MRI for early diagnosis of AVN between 88% and 100%.They also found that plain radiographs can miss important information in stages II andIII, because they overestimate stage II, underestimate stage III lesions, and are inaccurate in estimating the collapse size, which is an important parameter in therapeutic decisions.

6. Conclusion

Based on the results of our study the following conclusions can be made: AVN of head of femur is most commonly seen in middle age group(31-40years). It is more common in males as compared to females. Bilateral hip joint involvement is more common than unilateral involvement. It has more prevalence in patients who are alcoholic, taking steroids, have a history of trauma or suffering from sickle cell disease. However, in majority of patients no identifiable risk factor is found. Patients with AVN FH usually present

with complaints like hip pain with or without associated limp. Radiation of hip pain to the knee also occurs in later stages. Severity of hip symptoms and gait generally correspond with that of the radiological lesions. The cases in the advanced post collapse stage are more painful than in precollapse stage.

Osteopenia, lytic lesion, sclerotic lesion, crescent sign, collapse, joint space narrowing and osteophytes are the major plain x-ray findings of AVN. Double line sign, subchondral cysts, subchondral sclerosis, bone marrow edema, crescent sign, collapse, joint effusion, joint space narrowing and osteophytes are the major MR findings of AVN.

In precollapsed stages (I and II), plain x-ray detects less number of hips than MRI whereas MRI is able to detect a number of abnormal lesions that are not detected by x-ray in this subgroup. The clinical implication of early detection of osteonecrosis by MRI are extremely important as several therapeutic modalities in case of AVN of femoral head (core decompression, fibular grafting, osteotomy) are available that may prevent the progress of this disease and delay the need for hip replacement surgery in younger patient population affected by this disease.

However, in collapsed stages (III and IV), both plain x-ray as well as MRI detect 100% of affected hips. MRI does not offer any diagnostic advantage over x-ray in such advanced cases of AVN except for detection of bilateral disease when unilateral involvement is suspected on x-ray.

MRI is also effective in assessing marrow edema, synovial effusion, acetabular involvement, physeal tear none of which is possible with radiography.

A combination of conventional radiography &MRI of the hips, helps in correctly staging AVN. MRI is the modality of choice for the confirmation of the disease.MRI should be done in all cases of hip joint pain with minimal movement restriction, as early diagnosis of AVN leads to preservation of hip joint.

References

[1] Murphey MD, Foreman KL, Klassen-Fischer MK, Fox MG, Chung EM, Kransdorf MJ. From the radiologic pathology archives imaging of osteonecrosis: radiologic-pathologic correlation. Radiographics. 2014Jul14;34(4):1003-28.
[2] Kaushik AP, Das A, Cui Q. Osteonecrosis of the femoral head: an update in year 2012. World journal of orthopedics. 2012May18;3(5):49-57.
[3] Gulhane B, UoE Radiology et al. Hip joint. Available at https://radiopaedia.org/articles/hip-joint-.1
[4] Aiello MR. Imaging in Avascular Necrosis of the Femoral Head. Available at http://emedicine.medscape.com/article/386808-overview
[5] Houdek MT, Wyles CC, Martin JR, Sierra RJ. Stem cell treatment for avascular necrosis of the femoral head: current perspectives. Stem cells and cloning: advances and applications. 2014;7:65-70.
[6] Dr. dehnokhalaji M. Osteonecrosis of the Femoral Head. Femoral head AVN based on Campbellsorthopaedic surgery. Health & Medicine. 2016 May13.
[7] R Bronson, A. Prof Frank Gaillard et al. Ficat and Arlet classification of avascular necrosis of femoral head. Available at https:// radiopaedia. org/ articles/ficat-and-arlet-classification-of-avascular-necrosis-of-femoral-head
[8] Khaladkar MS, Randhawa S, Singh G, Aditi G, Rajesh K, Rajeshwar S. Rapid magnetic resonance imaging protocol for detecting femoral head avascular necrosis: A case series-it's utility in the general population in developing countries. Medical Journal of Dr. DY Patil University. 2015Mar1;8(2):189-95.
[9] Vaghamashi AK, Bhatt J, Doshi J, Patel V. MRI in Evaluation of Painful Hip Joint. IOSR Journal of Dental and Medical Sciences. 2017May;16(5):85-96.
[10] Garasiya V, Bhimani D, Raychaudhuri C. Radiological evaluation of avascular necrosis at various sites. International Archives of Integrated Medicine. 2017Apr;4(4): 23-6.
[11] Rangareddy S, KS Prashanth Kumar. Femoral Head Avascular Necrosis: Correlation of Clinical Findings, Radiographic Staging and Magnetic Resonance Imaging. Sch. J. App. Med. Sci. 2016Nov; 4(11C):4064-69.
[12] Karantanas AH, Drakonaki EE. The role of MR imaging in avascular necrosis of the femoral head. Seminars in musculoskeletal radiology 2011Jul;15(3):281-300.