Original Article

The ROLE OF MRI IN EARLY AND ACCURATE DIAGNOSIS OF AVASCULAR NECROSIS OF HIP JOINT

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ABSTRACT

Avascular necrosis of the femoral head (AVN) often occurs between the third and fifth decade of life, and since it includes middle-aged patients , and this age group represents the productive group within the community, early diagnosis and better management is necessary, as delays in diagnosis lead to high rates of bone degeneration and loss of joint function, as it usually progresses to the collapse of the femoral head, which often leads to complete degeneration of the hip joint, and the need to replace it with an arthrodesis artificial, while the treatment is more successful in the early stages of avascular necrosis and Here comes the importance of showing the role of magnetic resonance imaging in early detection of avascular necrosis of the femoral head, and thus improving the chance of saving the affected joint. **Materials And Methodes-** This study was a cross-sectional descriptive study, and the research sample included 45 patients (69 hips) of patients who were referred to the orthopedic clinic or admitted to the Orthopedic Department of Tishreen University Hospital in Lattakia with a story of suspected avascular necrosis in the femoral head, who achieved Inclusion criteria in the research, during the period from March 1, 2021 until the end of April 30, 2022. **Results-** The study included 45 patients (69 hip joints), and it was evaluated by plain radiography and magnetic resonance imaging. The plain radiograph was able to detect avascular necrosis of the hip joint in 50 hips (72.5%) and did not in 19 hips (27.5%). The male/female ratio was 1.5:1. The mean age of infection was 36.8 ± 11.6 years. The history of corticosteroids intake was the most common risk factor associated with avascular necrosis (40%), followed by a history of previous trauma and sickle cell anemia (20%) for each. The double line sign was seen in (78%) and the band-like sign was seen in (34.7%). **Conclusion-** The evaluation of an osteonecrosis lesion based on plain radiographs leads to negative results in detecting early stage, as well as inaccurate results in determining the stage of avascular necrosis. Magnetic resonance imaging (MRI) is the most sensitive and qualitative medical imaging method for detection early stage of avascular necrosis of the femoral head and accurately determining the stage where early and accurate diagnosis leads to better treatment results.

KEYWORDS: Avascular necrosis/ MRI / Femoral head / hip joint / AVN / conventional radiography/ Osteonecrosis.

I. INTRODUCTION

The head of the femur is the most common site of avascular necrosis, and a destructive condition of bone tissue, and usually happens between the third and fifth decade of life.[1][2][3]

Although t the origin of this disease is not well known, it is mainly the necrosis of bone cells as a result of exposure for risk factors that affect the microcirculation of femoral head like as[1]:

1- Mechanical vascular rupture.
2- Obstruction of blood vessels.
3- Pressure outside the blood vessels.

These factors can be the result of trauma, corticosteroids, alcohol abuse, hematodyscrasia, and a variety of other factors.[4,5]

This disease is asymptomatic in its early stages. When symptoms appear, the patient complains of deep and

persistent pain in the thigh, groin, or knee for a period longer than six weeks [1][6][7][8] and the pain increases when moving and lifting weights.[7,8]

In case of avascular necrosis, the medical imaging description should not be limited to the general appearance of the affected area only, but several additional findings that affect the development and treatment of the disease must be mentioned.[9]
1- The site.
2- The percentage of affected area of the femoral head (based on the axial axes) and the percentage of the weight bearing surface affected by the injury (according to coronal axes).
3- The presence of osteoarthritis or degenerative changes following the injury.
4- The presence of an accompanying joint effusion or not.
5- Possible presence of an unstable osteochondral fragment.
6- Subchondral fractures.

Evaluation of the femoral head with conventional radiographs is an available and inexpensive method thus it is the next step every time the findings of the clinical examination and the pathological history indicate the suspicion of a avascular necrosis in the femoral head, Although this diagnostic method is not sensitive in the early stages of the disease and need additional medical imaging methods like MRI, but the findings of plain radiography in the more advanced stages are often diagnostic and may exclude the need for MRI.

Magnetic resonance imaging MRI is the most sensitive method with a sensitivity (71-100%) and specificity (94-100%).[10]

Given the high probability of bilateral injury, the imaging field should include both hip joints, at least in some sequences.

Characteristic signs of avascular necrosis that can be seen on an MRI of the hip joint include:
1- Band-Like Sign.
2- Double-Line Sign
3- Bright Band-Like Sign

Other findings that may be seen on an MRI include
1- Subchondral Fractures
2- Joint effusion

II. MATERIALS AND METHODS
Study design
Descriptive Study (Cross sectional)

Duration of study
13 months (1 March 2021 – 30 April 2022).

Inclusion criteria
1- All clinically suspected patients with hip pain from the orthopedic clinic and orthopedic department of Tishreen University Hospital
2- All positive cases of avascular necrosis of the femoral head confirmed by simple radiography.

Exclusion criteria
1 - Cases where the MRI was negative for AVN of the hip
2- Patients who have contraindications for magnetic resonance imaging (claustrophobia, cardiac pacemakers,..).

Materials
All patients underwent both plain radiography and magnetic resonance imaging (MRI) , after a detailed explanation of all these procedures to the patient.

Sample size
A total of 45 patients 69 (hips) were included in the final study.

Sampling method
The study included all the study subjects, who satisfied the inclusion and exclusion criteria, hence no sampling was done.

Procedure
First, all patients underwent plain x-ray imaging in two positions:
1- Antero-posterior (AP) position
2- Frog leg lateral view

Then all patients underwent magnetic resonance imaging of the hip joints using the standard protocol and without injections, according to the following:
- Standard Protocol: Coronal T1, Axial T2, Coronal T2 FS.

Data collection methods
Data were collected for the study, using a structure case report form. The data were gathered from the history, clinical examination, and the investigation reports of the study participants.

III. RESULTS

A total of 45 patients (69 hips) were included in this study, out of which 18 were females and 27 were males with statistically significant differences with p-value=0.01.

The most frequent age group was 21-30 years (33.3% of the cases), and followed by the age group 31-40 years(31.1% of the cases) with statistically significant differences with p-value<0.05.

18 patients (40% of patients) was with history of using corticosteroids, as a risk factor for AVN of the hip joint , followed by the presence of a history of previous pelvic

trauma and sickle cell anemia equally 9 patients for each risk factor, at a rate of 20% for each , and one case was Idiopathic.

MRI was performed for all patients and the following results were obtained after excluding cases that were negative for MRI: 24 hips had a band-like sign (34.7% of the total cases), 54 hips had a double-line sign(78% of the total cases) , 42 hips had bone marrow edema (61% of the total cases), 45 hips joint effusion(65% of the total cases).

The research sample was distributed according to the Mitchell classification: 13 of the total hips were within stage A with a percentage of 18.8%, 14 of the total hips were within grade B with a percentage of 20.3% , 15 Of the total hips were in grade C, with a percentage of 27.7% , and 27 of the total hips were within stage D with a percentage of 39.1%.

Plain x-ray was performed for all patients and the sample was distributed according to the classification of Ficat and Arlet and the following results were found : 19 hips had no radiographic changes on simple radiography, meaning that the picture was negative in 27.5% of the total cases, and they were classified as stage 1 according to the classification of of Ficat and Arlet , 11 hips had sclerotic and/or cystic changes(15.9% of the total cases) and they were classified as stage 2 according to the classification of Fickat and Arlet, 16 cases had a subchondral hip fracture (Crescent Sign)(23.2% of the total cases) and they were classified within stage 3 according to the classification of Ficat and Arlet , 23 cases had femoral head damage and collapse (33.3% of the total cases) were classified as stage 4 according to the classification of Ficat and Arlet.

Correlation between MRI Findings and the stage of AVN according to Mitchell classification was done:
The research samples were classified according to Mitchell into:

- Early stage includes grades A and B.
- Late stage includes grades C and D.

The research samples was distributed according to Mitchell classification into:
- Early stage: included 27 cases of total hips (39%).
- Late stage: included 42 cases of total hips (61%).

And We noted in our results the following
1- The presence of a Band-LIKE Sign with a percentage of (88.8%) in the early stages and (0.0%) in the late stages, with statistically significant differences P-value < 0.05 for the early stages.
2- The presence of the Double-Line Sign by (51.8%) in the early stages and by (95%) in the later stages, without any statistically significant differences, P-value > 0.05.
3- The presence of bone marrow edema at a rate of (14.8%) in the early stages and (95%) in the later stages, with statistically significant differences P-value < 0.05 for the late stages.
4- The presence of joint effusion (18.5%) in the early stages and (95%) in the later stages, with statistically significant differences P-value < 0.05 for the late stages.

Correlation between X-RAY stage according to the classification of Ficat and Arle and MRI stage according to Mitchell classification was done and we found through the Chi-square test that:
1- In the early stages: there are statistically significant differences with p-value=0.0001 as 19 hip cases were normal on a plain radiograph and were classified within Stage 1, but according to the MRI they were affected and at an early stage and were classified as stage A with a percentage of 68.4% and stage B at 31.6% , And 11 hip cases were pathological by plain radiograph and were classified in Stage II, but according to the MRI they were in stage D, C, and B.
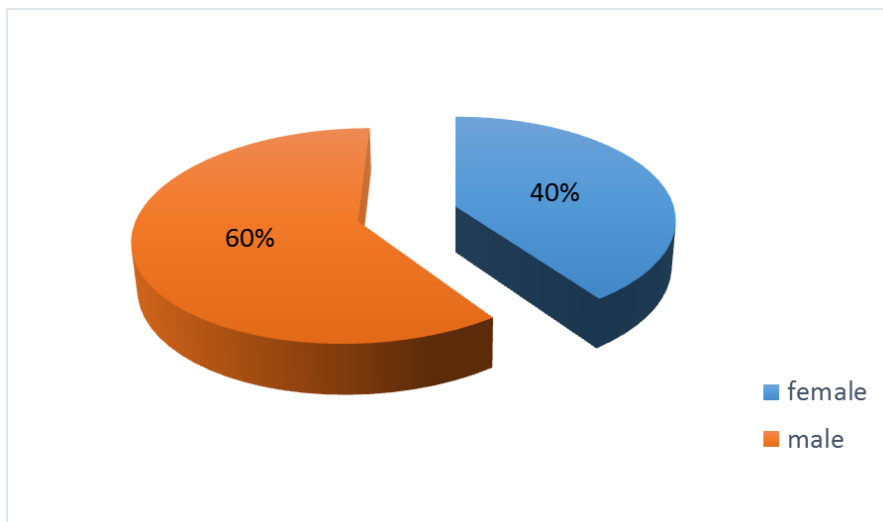2- In the late stages: there are no statistically significant differences with p-value > 0.05.

Figure (1): Graphical representation for the Distribution of the research sample by gender.
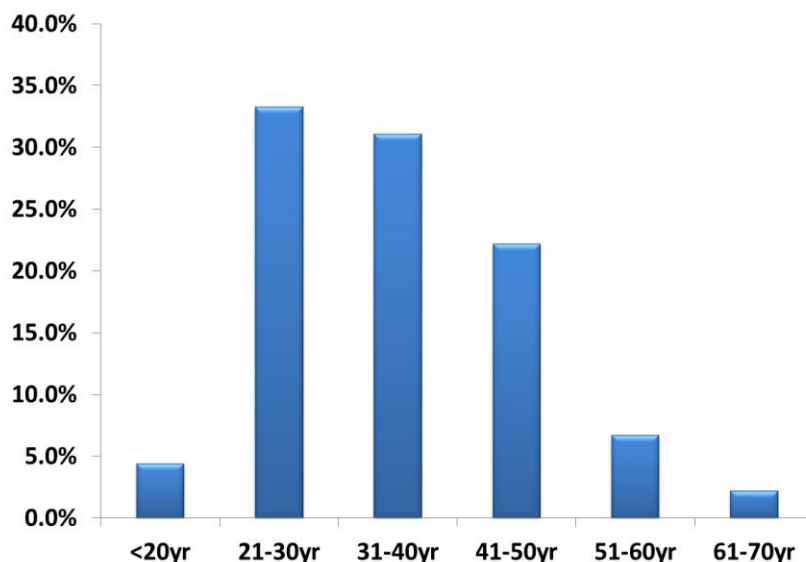
Figure (2): Distribution of the research sample by age groups.

Table (1): Distribution of the research sample according to the risk factor associated with AVN.

Risk Factor	Number of patients	percentage
using corticosteroids	18	40%
history of previous pelvic trauma	9	20%
sickle cell anemia	9	20%
previous inflammatory condition	5	11.1%
Chronic alcohol history	3	6.7%
idiopathic	1	2.2%
Total	45 patients	100%

Tables (2): MRI findings.

MRI Findings	Number of hips	percentage
Band-Like Sign	24	34.7%
Double-Line Sign	54	78 %
Bone Marrow Edema	42	61%
Joint Effusion	45	65 %

Table (3): distribution of the research sample according to Mitchell's classification.

Classification of AVN stages according to Mitchell	Number of hips	percentage
Stage A	13	18.8%
Stage B	14	20.3%
Stage C	15	21.7%
Stage D	27	39.1%
Total	69 hips	100%

Table (4): The distribution of the research sample according to the classification of Ficat and Arlet.

Classification of AVN stages according to Ficat and Arlet classification	Number of hips	percentage
Stage I (negative plain x-ray)	19	27.5%
Stage II (sclerotic and/or cystic changes)	11	15.9%
Stage III (subchondral fracture Crescent Sign)	16	23.2%
Stage IV (collapse of the femoral head)	23	33.3%
Total	69 hips	100%

Table (5): Correlation between MRI findings and AVN stages according to Mitchell's classification.

Mitchell Classification		BAND-Like Sign	Double-Line Sign	Bone Marrow Edema	Joint Effusion
early stages N=27	Stage A(n=13)	13	-	-	-
	Stage B(n=14)	11	14	4	5
late stages N=42	Stage C (n=15)	-	14	13	14
	Stage D (n=27)	-	26	25	26
P-value		P-value<0.05 statistically significant differences	P-value>0.05 No statistically significant differences	P-value<0.05 statistically significant differences	P-value<0.05 statistically significant differences

Table (6): Correlation between the classification AVN stages according to the findings of plain x-ray and the classification of AVN stages according to the MRI findings (Mitchell's).

Classification of AVN stages according to Ficat and Arlet classification	Classification of AVN stages according to Mitchell's				Total
	A	**B**	**C**	**D**	
Stage I	13(68.4%)	6(31.6%)	0(0%)	0(0%)	19
Stage II	0(0%)	6(54.5%)	4(36.4%)	1(9.1%)	11
Stage III	0(0%)	2(12.5%)	11(68.8%)	3(18.8%)	16
Stage IV	0(0%)	0(0%)	0(0%)	23(100%)	23

IV. DISCUSSION

Our study sample included 45 patients 69 (hips), 60% of the cases were Males (27 patients) and 40% (18 patients) were females, so the prevalence of Femoral head AVN is higher in males than in females with a Sex Ratio (M:F) = 1.5:1 with statistically significant differences p-value=0.01. This can be explained by the fact that in males, there is more muscles and physical activity compared to females, as well as the rate of smoking and alcoholism in males is greater than in females, and as it is proven that alcohol and smoking affect blood supply to the femur head because of its harmful effect on the vascular endothelium, which causes endothelial dysfunction and thus the occurrence of impaired autoregulation, and disturbance of blood flow through the blood vessels. In addition, smoking is one of the important risk factors for atherosclerosis and the formation of blood plaques, which is a major pathogenetic mechanism in AVN.

In addition, estrogen levels in females play a role as a protective factor against vascular thrombosis and thus reduce the incidence of AVN in females compared to males.

The ages of the patients in our study ranged from 18 to 64 years, and the most common age groups were: 21-30 years with a rate of 33.3%, followed by the age group 31-40 years with a rate of 31.1% of the cases with statistically significant differences p-value < 0.05. This can be explained by the fact that in this age groups there is a lot of muscular and physical activity, which make them more predisposing to traumatic AVN. Also, blood diseases like sickle cell anemia could cause a frequent occlusions of blood vessels, also hemophilia can cause frequent bleeding within the bone in in early stages of life .this tow diseases could Explain the early development of AVN in this age group.

Using Corticosteroids represented the most coincidental risk factor as it was found in 18 patients, followed equally by previous trauma history and sickle cell anemia in 9 patients for each risk factor and only 3 patients out of 45 patients were alcoholic. The high association of AVN with a history of using corticosteroids can be attributed to the mechanism by which corticosteroids affect: 1- the effect of corticosteroids on the bone balance 2- increase the susceptibility to thrombosis within the blood vessels, causing their blockage 3- increasing Vascular constriction in the epiphysis of the femoral head.

When correlation between MRI findings and the stage of AVN, we found the following:
- The presence of (Band-LIKE Sign) with a percentage of (88.8%) in the early stages and (0.0%) in the late stages, with statistically significant differences P-value < 0.05 for the early stages, This is due to the fact that it represents the earliest qualitative change characteristic of AVN.[11][12][13]
- The double-line sign was present at a percentage of (51.8%) in the early stages and by (95%) in the late stages, without any statistically significant differences, P-value > 0.05,
- The presence of bone marrow edema at a percentage of (14.8%) in the early stages and (95%) in the late stages, with statistically significant differences P-value < 0.05 for the later stages.

- This is due to the fact that the development of edema is reactive to the subchondral fracture, which appears in an advanced stage of the disease.[14][11]
- The presence of joint effusion (18.5%) in the early stages and (95%) in the late stages, with statistically significant differences P-value < 0.05 for the late stages.

This is because the development of joint effusion is secondary to AVN-associated synovitis in the advanced stages of the disease.[14]

Table 7: Comparison with international studies (Correlation between MRI findings and the stage of AVN).

Number of hips	joint effusion	bone marrow edema	The double-line sign	Band-LIKE Sign	Correlation between MRI findings and the stage of AVN	
69 hips	18.5%	14.8%	51.8%	88.8%	Early stage	Our study 2022
	95%	95%	95%	0%	Late stage	
81 hips	-	-	96%	-	Early stage	Mohammed Zeeshan Saleem et al[16]
	87.6%	96.43%	86.6%		Late stage	
61 hips	-	-	28%	-	Early stage	Samir Kathale et al[15]
	88.25%	63.25%	72%		Late stage	

Table 8: Comparison with international studies(Correlation between the classification AVN stages according to the findings of plain x-ray (Ficat and Arlet classification) and the classification of AVN stages according to the MRI findings (Mitchell's).

	Classification of AVN stages according to Ficat and Arlet classification	Classification of AVN stages according to Mitchell's				Total
		A	B	C	D	
Our study 2022	Stage I	13	6	0	0	19
	Stage II	0	6	4	1	11
Samir Kathale et al [15]	Stage I	11	6	0	0	17
	Stage II	0	4	3	2	9

V. CONCLUSION

Through our study, we noticed the great importance of MRI in diagnosing the AVN in the early stages of the disease in comparison with the simple radiograph, where the sensitivity of MRI reached (100%), while we did not notice statistically significant differences between the MRI and simple radiograph in late stages. Depending on the previous results, the MRI can be considered the primary examination in diagnosing the AVN, thus sparing the patient from the bad complications of the AVN, and provide appropriate and early treatment.

VI . REFERENCES

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