ORIGINAL ARTICLE

CORRELATION BETWEEN FICAT-ARLET AND MITCHELL'S STAGING FOR AVASCULAR NECROSIS OF FEMUR HEAD

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ABSTRACT

Introduction: Avascular necrosis (AVN) of the femoral head is an increasingly common cause of musculoskeletal disability, and it poses a major diagnostic and therapeutic challenge. Surgical management involves joint preserving surgeries in early stages of disease and joint replacement procedures in advanced stage disease. Thus, pre-operative staging is of utmost importance in deciding the appropriate treatment option.

Objective: The objective of the study was to stage avascular necrosis involving head of femur according to Ficat-Arlet (using X-RAY and MRI features) and Mitchell staging (using MRI features) and to study the correlation amongst the above mentioned staging systems.

Methodology: X-RAY and MRI images of thirty patients having Avascular Necrosis of femur head (23-bilateral and 7-unilateral) were studied retrospectively and staged according to Ficat-Arlet and Mitchell staging.

Results: Most of the Ficat-Arlet stage I and stage II joints (early stage) had Class A signal on MRI and most of the Ficat-Arlet stage III and stage IV joints (advanced stage) had class B or class C signal on MRI. Most of the affected joints with class A signal in the necrotic core had early stage disease while those with class B or class C signal had advanced stage disease.

Conclusions: Our study suggests that Mitchell's MRI staging for Avascular necrosis involving head of femur may have prognostic significance and Mitchell's MRI staging may be used in surgical decision making (joint preservation versus joint replacement).

Keywords: Avascular Necrosis, AVN staging, Mitchell staging, Ficat-Arlet staging, femur head

INTRODUCTION

Avascular necrosis, also referred to as aseptic necrosis, osteonecrosis or ischemic necrosis is used to indicate cellular necrosis of bone and marrow elements.[1, 2] The term "avascular necrosis" is used to refer to these changes when they occur in the epiphyseal region or subchondral bone.[1] Osteonecrosis of the femoral head is a disabling clinical entity that usually leads to destruction of the hip joint.[3] A number of joint salvaging treatment options are available if early diagnosis can be achieved, replacement of the hip joint is the last resort for pain relief and function.[3] Although bone scintigraphy using single photon emission computed tomography (CT) may be nearly as accurate as MRI, MRI offers a more specific diagnosis in the patient who presents with hip pain of uncertain etiology.[4] The reactive interface between infarcted bone and viable bone could be identified on MRI as a low signal intensity band.[5] On conventional radiographs the reactive interface appeared as a lucent zone on the plain films.[5] The necrotic volume of hips with bone marrow oedema was significantly larger than those without bone marrow edema.[6] Joint preserving surgeries (such as core decompression) are performed in early (stage I/II) and joint replacement in advanced stages (stage III/ IV).[7] The results of core decompression may be poor in general and may have an unpredictable effect on disease progression.[8] A quantitative system for staging avascular necrosis may allow more accurate evaluation of progression or resolution and better comparision of different methods of management.[9] It is most important to diagnose the disease as early as possible, to establish the prognosis before collapse and to chose effective measures to prevent progression to painful arthritis.[10,11] The extent and location of the necrotic portion as well as the Ficat stage can be used as predictors for the result of core decompression in osteonecrosis of the femoral head.[12,13] Because it is easily understood and clinically relevant, the Ficat classification is currently one of the most widely used classification scheme.[14]

The objective of the study was to stage avascular necrosis involving head of femur according to Ficat-Arlet (using X-RAY and MRI features) and Mitchell

staging (using MRI features) and to study the correlation amongst the above mentioned staging systems. As preoperative staging for Avascular Necrosis of the femoral head is of utmost importance in deciding the management of the patients, studying the correlation between the commonly used classification systems may help the surgeon in deciding the surgical procedure as and when required.

METHODOLOGY

The retrospective study was carried out in New Civil Hospital, Surat, from July to November 2016, involving thirty subjects, first thirty cases of Avascular Necrosis of Femur Head with both X-RAY and MRI records were included in the study, there was no direct communication with the subjects and no interventions were carried out as per the guidelines of the ethical committee. X-RAY and MRI images of thirty patients having Avascular Necrosis of femur head (23-bilateral and 7-unilateral) were studied retrospectively and findings were noted down as present /absent in the following format. Plain films- usually anteroposterior (AP) and frog lateral views, are used in staging AVN.

X-RAY features in Avascular Necrosis involving head of femur include Osteoporosis, Sclerosis, Sub-chondral radiolucent line due to sub-chondral bone fracture - Crescent sign, Sub-chondral cystic changes, Loss of spherical weight bearing dome, Partial collapse of head & Secondary osteoarthritis.[15]

MR Imaging: Imaging protocols for evaluation of patients with AVN include T1- or PD-weighted images and contrast-enhanced T1- weighted fat-suppressed images, a T1-weighted axial localizer and coronal images are acquired with either a T1- and T2-weighted spin-echo sequence, an FS PD FSE sequence, or a STIR (FSE STIR) sequence, sagittal plane imaging may be helpful in defining early changes of cortical flattening associated with subchondral collapse, STIR sequences, which negate yellow marrow–fat signal, provide excellent contrast for the detection of marrow replacement, fluid, and necrotic tissue. [1]

General MR characteristics of AVN include the following:

- A hypointense peripheral band (primarily granulation tissue and to a lesser extent sclerosis) outlining a central region of bone marrow represents the reactive interface between necrotic and reparative zones, as seen on T1-weighted images. [1]
- There may be associated bone marrow edema of head and neck of the femur. [1]
- A joint effusion may be seen and is hypointense on T1- weighted images and hyperintense on FS PD FSE images. [1]
- A wedge-shaped subchondral infarct may also be seen. FS PD FSE images allow further characterization of AVN, but determination of the percentage of femoral head volume involved requires the use of at least two imaging planes. In the double-line sign there is a combination of a hypointense peripheral border (sclerosis) and a hyperintense inner border (granulation tissue) visualized on FS PD FSE images. AVN may exist in the absence of a double-line sign. Hyperintense effusion and marrow edema require characterization with FS PD FSE sequences.[1]

All the affected hip joints were staged according to 'FICAT-ARLET' system using X RAY and MRI features and clinical symptoms and according to Mitchell's staging using type of MRI signal in the necrotic core. Data was tabulated in a series of tables, graphs and charts. Correlation amongst the above staging systems was studied. Fischer's exact test was used to compute a P value and to see statistical significance.

Table 1: Ficat-Arlet system uses a combination on plain radiograph and MRI features[1, 16]

Stage	X-RAY	MRI
0	Normal	Normal
I	Normal or minor osteopenia	Edema
II	Mixed osteopenia and/or sclerosis and/or subchondral cysts, without any subchondral lucency (crescent sign)	Geographic defect
III	Crescent sign and eventual cortical collapse	Same as x-ray
IV	End stage with evidence of secondary degenerative change	Same as x-ray

Table 2: Mitchell MRI staging based on the signal characteristics of the necrotic core [1, 16]

Class	T1	T2	Definition
A	Bright	Intermediate	"fat" signal
B	Bright	Bright	"blood" signal
C	Intermediate	Bright	"fluid" or "edema" signal
D	Dark	Dark	"fibrosis" signal

Selection and description of participant: First thirty cases from the month of July – 2016 with both X-RAY and MRI records were included in the study.

RESULTS

A total of thirty patients were included in the study. Twenty three patients were males and seven were females. Twenty three patients had bilateral disease and seven patients had unilateral disease. Total numbers of positive hip joints were 53. All the affected hip joints were staged according to 'FICAT-ARLET' system using X-RAY and MRI features. All the patients were also staged according to Mitchell's staging using

type of MRI signal in the necrotic core. Seven patients had unilateral affection. Out of the rest 23 patients who had bilateral affection, 15 had unilateral complaints and the contralateral hip joint findings were incidental. Seven patients had underlying sickle cell disease, two patients were in renal failure, two patients were post traumatic, while a cause could not be found in the rest of the patients.

Table 3: Predisposing factors for AVN (n=30)

Predisposing Factors	No. (%)
Sickle Cell Disease	5 (16.67)
Trauma	2 (6.67)
Renal Failure	2 (6.67)
Unknown	21 (70.0)

Out of seven patients with unilateral disease, none had stage I disease, two had stage II and stage III disease each and three had stage IV disease. Five out of the patients who had unilateral disease, had advanced disease at presentation (Stage III and IV).

Fischer's exact test was used to compute a P value. The two-tailed P value was less than 0.0001 and the association of Stage I-II with Mitchell's Class A was found extremely statistically significant. Similarly, the association of Stage III-IV with Mitchell's class B/C was also found statistically significant. 29/36 (approximately 75 %) affected joints with early stage disease (stage I or stage II) had class A signal on MRI. 14/17 (approximately 82%) affected joints with advanced stage disease (Stage III or stage IV) had class B or class C signal on MRI. 12/16 (75 %) hips with Ficat-Arlet stage I are Mitchell class A. 17/23 (73.9 %) hips with Ficat-Arlet stage II are Mitchell class A. 5/7 (71.4 %) hips with Ficat-Arlet stage III are Mitchell class B. 4/7 (57.1 %) hips with Ficat-Arlet stage IV are Mitchell class C. Mitchell class D shows no correlation with Ficat-Arlet stages. Most class A joints (29/30) are either Ficat-Arlet stage I or II. Most class B or C joints are either Ficat-Arlet stage III or IV.

Out of the five patients with sickle cell disease, four had bilateral disease and one had unilateral disease. Three patients with bilateral disease had stage I or stage II disease and most of the hip joints affected had class A signal on MRI. Other two patients had advanced stage of disease (Stage IV) and the affected hip joints had class B or class C signal on MRI. All the affected hip joints in sickle cell patients with Class A MRI signal had early stage of disease (Stage I or II) and most of the affected joints with class B or class C signal had advanced disease (Stage IV).

Table 4: Correlation between FICAT-ARLET and Mitchell MRI staging (N=56)

FICAT-ARLET Stage	No. (%)	Mitchell's MRI class	No. (%)
Stage I		Stage A	
A	12 (22.64)	I	12 (22.64)
B	0	II	17 (32.07)
C	1 (1.89)	III	1 (1.89)
D	3 (5.66)	IV	0
Sub – Total	16 (30.19)	Sub – Total	30 (56.60)
Stage II		Stage B	
A	17 (32.07)	I	1 (1.89)
B	2 (3.77)	II	1 (1.89)
C	1 (1.89)	III	5 (9.43)
D	0	IV	2 (3.77)
Sub – Total	20 (37.73)	Sub – Total	9 (16.98)
Stage III		Stage C	
A	1 (1.89)	I	1 (1.89)
B	5 (9.43)	II	1 (1.89)
C	3 (5.66)	III	3 (5.66)
D	1 (1.89)	IV	4 (7.55)
Sub – Total	10 (18.87)	Sub – Total	9 (16.98)
Stage IV		Stage D	
A	0	I	3 (5.66)
B	2 (3.77)	II	0
C	4 (7.55)	III	1(1.89)
D	1 (1.89)	IV	1 (1.89)
Sub – Total	7 (13.21)	Sub – Total	5 (9.43)

Table 5: Correlation between Ficat-Arlet and Mitchell MRI staging in Sickle Cell Disease patients (N=9)

FICAT-ARLET Stage	No. (%)	Mitchell's MRI class	No. (%)
Stage I		Stage A	
A	3 (33.33)	I	3 (33.33)
B	0	II	1 (11.11)
C	0	III	0
D	1 (11.11)	IV	0
Sub –Total	4 (44.44)	Sub – Total	4 (44.44)
Stage II		Stage B	
A	1 (11.11)	I	0
B	0	II	0
C	1 (11.11)	III	0
D	0	IV	1 (11.11)
Sub – Total	2 (22.22)	Sub - Total	1 (11.11)
Stage III		Stage C	
A	0	I	0
B	0	II	1 (11.11)
C	0	III	0
D	0	IV	2 (22.22)
Sub – Total	0	Sub – Total	3 (33.33)
Stage IV		Stage D	
A	0	I	1 (11.11)
B	1 (11.11)	II	0
C	2 (22.22)	III	0
D	0	IV	0
Sub – Total	3 (33.33)	Sub – Total	1 (11.11)

DISCUSSION

Class A signal in the necrotic core on MRI is associated with early stages of disease while class B or class C signal in the necrotic core is associated with advanced stage of disease.

Mitchell DG, Rao VM, Dalinka MK, Spritzer CE, ALAvI AB, Steinberg ME, Fallon MI, Kressel HY also produced similar results, in their study the central region within the rim was isointense with marrow fat on both T1W and T2W sequences in 20 (71%) of 28 lesions uncomplicated by fracture (stages I-II) but in only four (14%) of 28 stage III-IV lesions.[17]

Mitchell DG, Steinberg ME, Dalinka MK, Rao VM, Fallon M, Kressel HY also produced similar results, in their study the reactive interface between live and dead bone at the periphery of AVN lesions had a characteristic MRI appearance that facilitated diagnosis. Lesions that were isointense with fat on both the sequences had an earlier roentgenographic stage and less severe symptoms than did lesions that were less intense than fat.[18]

Possible explanation for the similar results is that MRI provides pathophysiologic information that is different from information obtained from conventional methods.

Our study suggests that Mitchell's MRI staging for Avascular necrosis involving head of femur may have prognostic significance and Mitchell's MRI staging may be used in surgical decision making (joint preservation versus joint replacement).

CONCLUSION

Most of the Ficat-Arlet stage I and stage II joints had Class A signal on MRI and most of the Ficat-Arlet stage III and stage IV joints had class B or class C signal on MRI.

Most of the affected joints with class A signal in the necrotic core had early stage disease while those with class B or class C signal had advanced stage disease.

Thus, class A signal in the necrotic core is mostly associated with early stage disease while those with class B or class C signal are associated with advanced stage disease.

Hence Ficat-Arlet and Mitchell's MRI classes may be used in deciding the treatment plan (joint preservation v/s joint replacement) in a patient.

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