

**Magnetic Resonance Imaging spectrum of Avascular necrosis of the femoral head in the post-COVID era – A Single Institutional based study**

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**Conflicts of Interest:** Nil

**Abstract:**

**Background:** SARS-CoV-2 (COVID-19), primarily a respiratory viral illness with broad-spectrum clinical manifestations of multiple organ involvement, is still under analysis. Avascular necrosis of bone is an emerging musculoskeletal manifestation of post-COVID-19 infection. There is varied ongoing research for early outcome prediction using various imaging patterns

**Aims and objectives:** 1) To study the relationship between COVID-19 infection and avascular necrosis of the femoral head.

2) To analyze the role of magnetic resonance imaging in avascular necrosis of the femoral head in patients treated for COVID-19.

**Materials and methods:** This is a retrospective observational study reporting a series of 30 cases over a period of 24 months (1<sup>st</sup> January 2021 to 31<sup>st</sup> December

2022), in which patients presented with hip pain after being treated for COVID-19.

From January 1st, 2021, to December 31st, 2022, all patients with suspicion of avascular necrosis of the femoral head who presented with hip pain after being treated for COVID-19 were retrospectively evaluated to determine the relationship between COVID-19 infection and avascular necrosis. The various imaging patterns of avascular necrosis of the femoral head were analysed using a 1.5-T SEIMENS MRI machine in the department of Radiodiagnosis at the Alluri Sitarama Raju Academy of Medical Sciences.

**Results:** A total of 30 patients were available for the study, but only 19 patients were diagnosed with AVN of the femoral head post-COVID-19 infection with a mean age of 37 years (range 23–60). Out of the 30 patients, 27 were male and 3 were female. The study showed a clear correlation between the development of avascular necrosis of the femoral head and the history of COVID-19 disease in the patients with moderate-to-severe symptoms.

**Conclusion:** Magnetic Resonance Imaging is the excellent non-invasive investigation tool for avascular necrosis due to excellent soft tissue contrast resolution and multiplanar imaging. With the global increase in COVID-19 cases, AVN of the femoral head is a new musculoskeletal manifestation of post-COVID-19 infection. For prompt diagnosis and treatment, the medical community should be aware of this risk and notify the patients.

**Keywords:** COVID-19, SARS-CoV-2, avascular necrosis (AVN), femoral head

### **Introduction**

The novel coronavirus was named COVID-19, which stands for Corona Virus Disease 2019, and originated

from Wuhan, Hubei Province, China, beginning in December 2019.<sup>1</sup>

Although many questions about COVID-19 remain unanswered, numerous studies and reports have shown a profound prothrombotic state on both a micro- and macrovascular level in those with recent infections.

Cytokine storm or cytokine release syndrome may play a role in COVID-19 extra-pulmonary involvement, such as myocardial and hepatic damage, venous thrombosis, neurological complications, and acute renal injury.<sup>2</sup>

AVN is defined as cellular bone death following decreased blood supply or complete loss of blood supply due to various reasons. Systemic inflammation mediated by cytokines, which include CXCL10, IL-17, and TNF-alpha, results in a reduction of proliferation and differentiation of osteoblasts.<sup>3</sup> The hip joint being one of the body's major weight-bearing joints and subjected to various stresses during daily activities, AVN of the femoral head is more common than at other body sites. The necrotic process disintegrates the bone, causing its collapse, followed by secondary osteoarthritic changes in the hip.

Excess corticosteroid usage is one of AVN's most common medical causes.

### **Aims and objectives**

To study the relationship between COVID-19 infection and avascular necrosis of the femoral head.

To analyze the role of magnetic resonance imaging in avascular necrosis of the femoral head in patients treated for COVID-19.

### **Materials & Methods**

This retrospective observational study includes the data of all the patients with suspicion of avascular necrosis of the femoral head who underwent MRI hip joints in the Department of Radiodiagnosis, ASRAM Medical

College, over a period of 24 months, from January 1st, 2021, to December 31st, 2022.

#### Source of data

Patients referred from a tertiary care center's outpatient department with a history of hip pain following COVID-19 infection.

#### Selection criteria

#### Inclusion criteria

Patients who had developed hip pain post-COVID-19 treatment were included using the following criteria:

- Positive RT-PCR for SARS-CoV-2 with Nasopharyngeal or oropharyngeal swabs or COVID-19 positive on a rapid antigen test prior to receiving COVID-19 treatment
- received steroids during the treatment for COVID-19.
- No new-onset hip pain episodes existed prior to being infected with COVID-19.
- underwent MRI scan.
- Patients of all age groups and both sexes

#### Exclusion criteria

- Patients without COVID-19 PCR or RAPID antigen evaluation.
- Patients with COVID-19 positivity who were treated without steroids
- known AVN-diagnosed patients and are undergoing treatment.
- post-traumatic AVN hip.
- AVN in dysplastic hips
- Patients on chemotherapy
- Patients with chronic illnesses who are receiving steroid treatment

All patients were imaged using a 1.5 Tesla Siemens MagnetomAventoSyngo (MR D-13) 16-channel machine in the department of Radiodiagnosis at

ASRAM, Eluru, using the required protocol and sequences.

#### MRI image pattern analysis

The following Ficat and Arlet classification system for MRI images was used for staging AVN of the femoral head.

- Stage 0: MRI: Normal
- Stage I: MRI shows bone marrow edema.
- Stage II: MRI: Geographic defect of altered signal intensity and "double line sign"
- Stage III: MRI: Crescent sign and eventual cortical collapse
- Stage IV: MRI: End-stage with evidence of secondary osteoarthritis changes

Crescent sign is due to the subcortical necrotic zone of trans radiancy which is seen on X Rays and not on MRI.

#### Results

A total of 30 patients were available for the study, out of which only 19 patients were diagnosed with AVN. The mean age of patients was 38 years (range 20-60). Out of 30 patients, 27 were males and 3 were females showing a male predominance. The total number of femoral heads affected was 33 out of which 5 cases were unilateral and 14 were bilateral

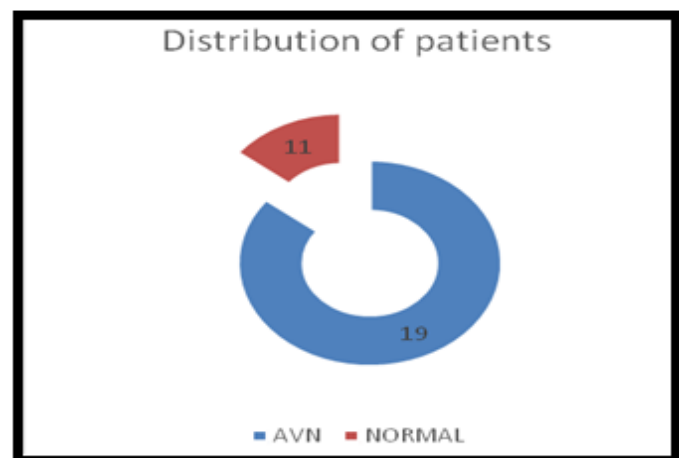


Figure 1: Distribution of patients according to the diseased (AVN) and normal study.

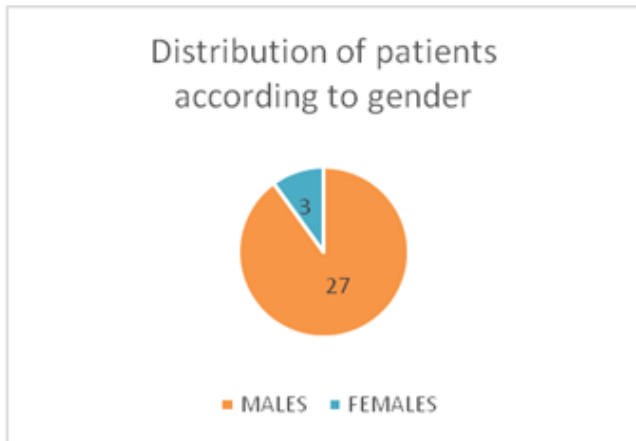


Figure 2: Gender distribution

**Distribution according to lesion location in the femoral head.**

Table 1: showing the distribution according to the location in the femoral head.

Location/ quadrant	Number of femoral heads	Percentage (%)
Anteromedial	8	24.2%
anterolateral	5	15.1%
Anterosuperior	18	54.5%
complete	2	6%

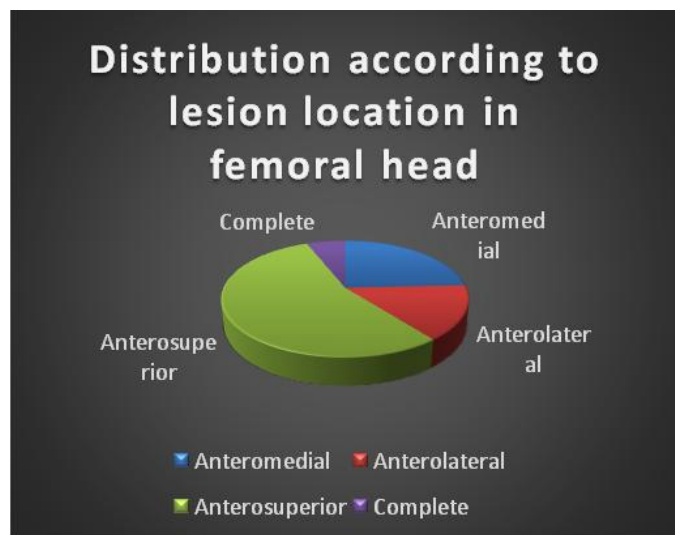


Figure 3: distribution according to the location in the femoral head.

Table 2: showing MRI patterns distribution in femoral heads.

	Number of femoral heads	Percentage (%)
Bone marrow edema	13	39.3%
Focal subchondral signal abnormality (Geographic pattern)	25	75.7%
Double line sign	16	48.4%
Subarticular collapse of femoral head/ contour loss	8	24.2%
Decreased joint space	2	6%
Joint effusion	14	42.4%

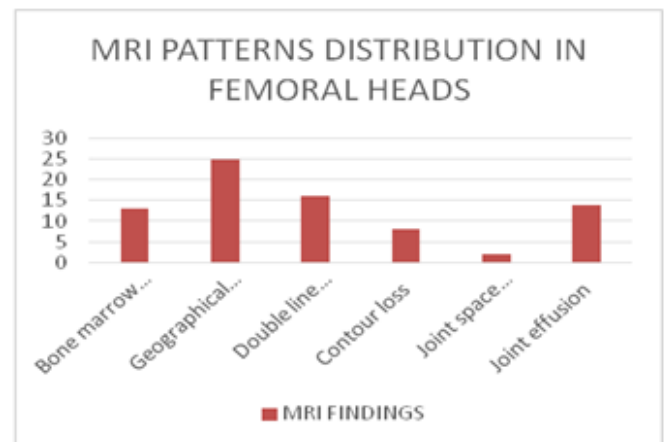


Figure 4: MRI patterns distribution in the femoral heads.

**Distribution of avascular necrosis cases according to FICAT & ARLET Staging.**

Table 3: showing distribution of avascular necrosis cases according to FICAT & ARLET Staging.

Grade	Number of femoral heads	Percentage (%)
Grade I	3	9%
Grade II	17	51.5%
Grade III	11	33.3%
Grade IV	2	6%

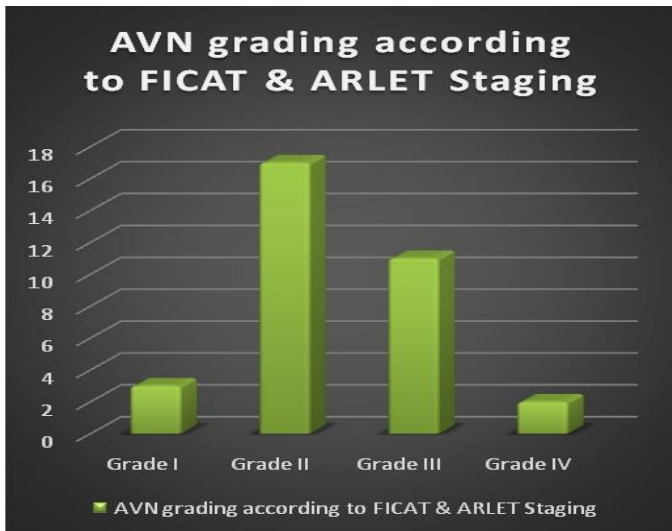


Figure 5: Distribution of avascular necrosis cases according to FICAT & ARLET Staging.

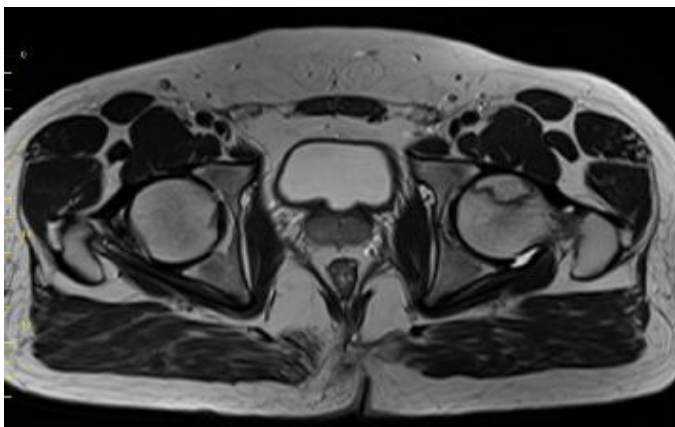


Figure 6: T2W axial imaging showing serpiginous hypointense line with adjacent hyperintense line (Double line sign) in left femoral head – stage II AVN

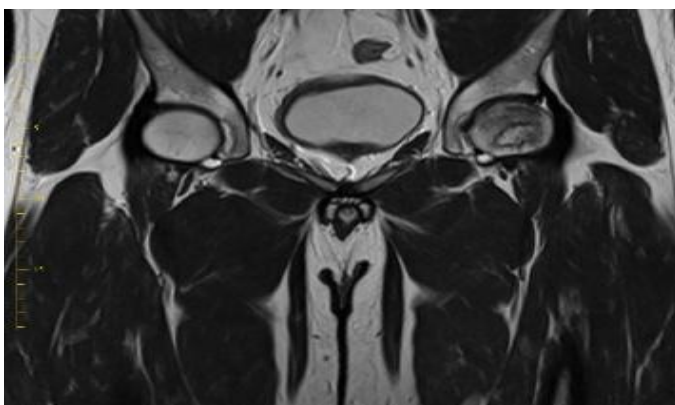


Figure 7: T2W coronal imaging showing serpiginous hypointense line with adjacent hyperintense line (Double line sign) in left femoral head – stage II AVN

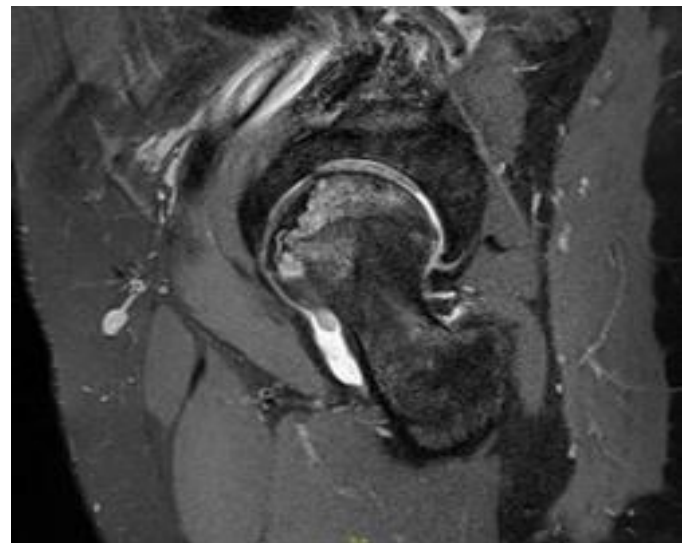


Figure 8: T2W saggital imaging showing geographical defect in the anterosuperior quadrant with contour abnormality of the femoral head- stage III AVN

### Discussion

The majority of COVID-19 patients are asymptomatic, but some have mild to severe symptoms that affect multiple organ systems.<sup>4</sup>

The various causes of femoral head osteonecrosis include direct trauma and alcohol abuse. Sometimes the causative factors are unknown, but there may be associated risk factors that can predispose to the disease.

The present study showed the occurrence of AVN of the femoral head in 19 patients among the total sample size, with the suspicion of AVN post-COVID-19 infection. AVN of the femoral head is asymptomatic in the beginning, there is segmental collapse, and pain and hip become stiffer, which is reflected in the gait of the patient when they starts to limp while all patients in this study presented with hip pain only.

Among the 33 diseased hips, 51.5% were grade 2, 33.3% were grade 3, 9% were grade 1, and 6% were grade 4 according to the Ficat and Arlet classification of avascular necrosis of the femoral head. There was bilateral hip involvement in the majority of patients.

According to Sushil G. Kachewar et al., there was an incidence of 6% cases of AVN among the patients who received standard treatment for COVID-19 and later developed hip pain.<sup>5</sup>

#### **Limitations of the study**

The information about the exact duration of symptom onset and the duration of MRI findings couldn't be added because this was a retrospective study.

#### **Conclusion**

MRI, being nonionizing, non-invasive, superior in soft tissue contrast, and highly sensitive, is now the modality of choice for diagnosing and staging avascular necrosis of the femoral head. With the global increase in COVID-19 cases, AVN of the femoral head is a new musculoskeletal manifestation of post-COVID-19 infection.

The multiorgan effects of COVID-19 include clinical manifestations pertaining to the cardiovascular, pulmonary, renal, and neuropsychiatric organ systems, although the duration of these multiorgan system effects is unclear.

Corticosteroid use has been associated with 10–30% of AVN cases in retrospective studies.<sup>6</sup> The use of corticosteroids in severe COVID-19 infection is supported by clinical trials.<sup>7</sup> A prolonged use of corticosteroids in COVID-19 infection might predispose to AVN. Currently, avascular necrosis (AVN) as a sequela of 'long COVID-19' has yet not been documented. By large-scale usage of corticosteroids as standard treatment in COVID-19 cases, there is an anticipation of the resurgence of AVN cases.<sup>8</sup>

The current study recommends larger studies to delineate the potential risk factors, clinical involvement, and long-term management outcomes for AVN associated with the COVID-19 infection.

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