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Prevalence of Avascular Necrosis of Hip Joints on MRI in Post-COVID Patients in Tertiary Rural Hospital of Maharashtra, India

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ABSTRACT

Background: Avascular necrosis (AVN) of the hip is a progressive condition resulting from disruption of blood supply to the femoral head, leading to bone death and joint collapse. In the post-COVID-19 era, increasing cases of AVN have been reported, potentially related to corticosteroid use, hypercoagulability, and systemic inflammation. Early detection using MRI is essential for timely diagnosis and management.
Material and Methods: This retrospective observational study was conducted in a tertiary rural hospital in Maharashtra, India, including 300 post-COVID patients who underwent MRI of the hip joint from 2021 to 2024. Patients with hip pain and a history of COVID-19 infection were included, while those with pre-existing AVN or other known causes were excluded. Data regarding demographic factors, comorbidities, steroid use, and MRI findings were analyzed. AVN was graded using the Ficat and Arlet classification.
Results: AVN was detected in 210 patients, giving a prevalence of 70%. Most cases were in Stage II (30%), followed by Stage III (18%) and Stage IV (11.67%). Significant associations were observed between AVN and steroid use, age group, and comorbidities ($p < 0.0001$), whereas no significant association was found with gender ($p = 0.92$).
Conclusion: AVN is highly prevalent in post-COVID patients with hip pain. MRI plays a crucial role in early detection and staging. Early screening in high-risk patients is essential to prevent disease progression.

Keywords: Avascular necrosis, COVID-19, MRI, hip joint, Ficat staging.

INTRODUCTION

Avascular necrosis (AVN), also referred to as osteonecrosis, is a progressive and potentially disabling condition that results from an interruption of the blood supply to bone tissue. This vascular compromise leads to ischemia, death of bone cells, and eventual structural collapse of the affected joint if not diagnosed and managed at an early stage.[1] Although AVN can involve multiple skeletal sites, the hip joint—particularly the femoral head—is the most commonly affected location due to its unique vascular anatomy and limited collateral circulation.[2,3] The other sites that are often affected include the knee joint, humeral head, and talus. However, the less commonly affected joints include the small joints, like the carpal joint and jaw.[4]
The etiology of AVN is complex and may arise from both traumatic and non-traumatic

mechanisms.[5] Trauma in the form of bone fractures or dislocations may result in mechanical trauma to the bone, causing vascular compromise. Non-traumatic causes of AVN include excessive corticosteroid intake, heavy drinking, hyperlipidemia, exposure to radiation, and underlying medical illnesses like sickle cell disease.[6,7] All these causes lead to either vascular occlusion, elevated intraosseous pressure, or direct toxicity to the cells, resulting in impaired perfusion of the bone. There are also specific anatomical features that make some bones prone to ischemia.[8]

In the last few years, the arrival of the COVID-19 pandemic has created additional concerns in the etiopathogenesis of AVN. The disease caused by the SARS-CoV-2 virus causes the patient to suffer from prothrombotic conditions, vascular injury, and inflammation, any of which could cause problems with microcirculation.[9,10] Additionally, the administration of steroids as a treatment method for moderate to severe cases of COVID-19 has brought about an iatrogenic factor that may predispose patients to develop AVN. Therefore, more patients after their recovery from the viral infection are exhibiting symptoms relating to their bones, mainly hip pain.[11]

Diagnosis of AVN early in the course of the disease is important because treatment at an early stage may avoid the progression and collapse of joints. Imaging is important in the diagnosis and staging of the condition.[11] Although plain radiography is commonly used as the first diagnostic test, it is not very sensitive in diagnosing AVN. This is because radiographic signs of the disease only become evident when there has been considerable destruction of the bones. MRI is the most sensitive method of detecting early AVN and has been regarded as the gold standard method for diagnosis.[11,12]

Although there is increasing knowledge about AVN in post-COVID times, a dearth of information exists with regards to the incidence, radiographic staging, and risk factors of AVN, especially in rural medical environments. It is necessary to identify the demography and clinical and radiologic features of AVN in post-COVID patients to ensure early diagnosis and better patient outcomes.[12,13]

Therefore, the present study aims to evaluate the prevalence and radiological grading of avascular necrosis of the hip joint using MRI in post-COVID-19 patients presenting with hip pain at a tertiary care hospital in rural Maharashtra. In addition, the study seeks to analyze associated demographic and clinical factors such as age, gender, diabetes, and hypertension, thereby contributing to better risk stratification and management of this emerging clinical entity.

MATERIAL & METHODS

Methodology

This study was conducted as a retrospective observational study at a tertiary care hospital in rural Maharashtra, India. The study included patients who underwent MRI of the hip joint between January 2021 and December 2024.

Study Population

The study population consisted of patients with a documented history of COVID-19 infection who presented with hip pain and were referred for MRI of the hip joint.

Inclusion Criteria

Patients fulfilling the following criteria were included in the study:

- History of confirmed COVID-19 infection
- Patients presenting with hip pain and undergoing MRI of the hip joint

Exclusion Criteria

1. Patients with a documented diagnosis of avascular necrosis prior to the COVID-19 pandemic
2. Patients with other known etiologies of AVN such as trauma, chronic steroid use unrelated to COVID-19, or other established risk factors

Study Setting and Data Source

The study was carried out in the Department of Radiology of a tertiary care hospital in rural Maharashtra. Data were collected retrospectively from hospital records, including patient case files, clinical history, and MRI reports. Patients with a prior history of COVID-19 infection who underwent MRI for hip pain were identified, and imaging findings were reviewed to determine the presence and stage of AVN.

Variables

- Dependent Variable: Presence of avascular necrosis of the hip joint on MRI and its radiological grading (based on Ficat and Arlet classification)
- Independent Variables: Age, gender, duration since COVID-19 infection, history of steroid use during COVID-19 treatment, and associated comorbidities such as diabetes mellitus and hypertension
- Confounding/Interacting Variables: Severity of COVID-19 infection, dose and duration of steroid therapy, and other systemic conditions affecting vascular supply.

Sample Size

The sample size was calculated using the population proportion method. Based on preliminary estimates and feasibility, an initial sample size of 300 patients was considered. As this was a retrospective study utilizing available records, all eligible cases within the study period were included. Records with incomplete or missing data were excluded, and the final corrected sample size was determined after data screening.

Data Collection Procedure

Relevant data were extracted using a structured data collection proforma. Information regarding demographic details, clinical history, COVID-19 status, duration since infection, comorbidities, and steroid usage was recorded. MRI findings were reviewed to identify the presence of AVN, laterality, and staging according to the Ficat and Arlet classification.

Data Analysis Plan

Data were entered into Microsoft Excel and analyzed using appropriate statistical software such as SPSS. Categorical variables, including the presence of AVN, gender, and comorbidities, were expressed as frequencies and percentages. Continuous variables, such as age and duration since COVID-19 infection, were expressed as mean ± standard deviation or median, as appropriate. The prevalence of AVN was calculated as a proportion, and the distribution of Ficat stages was presented descriptively. Associations between AVN and socio-demographic or clinical variables were assessed using the Chi-square test or Fisher's exact test, as applicable. A p-value of <0.05 was considered statistically significant.

RESULTS

A total of 300 post-COVID patients who underwent MRI of the hip joint for hip pain were included in the study. The data were analyzed to determine the prevalence of avascular necrosis (AVN), its radiological grading based on the Ficat and Arlet classification, and its association with various socio-demographic and clinical factors.

Out of the total 300 post-COVID patients who underwent MRI of the hip joint, avascular necrosis (AVN) was detected in 210 patients, accounting for 70% of the study population, while 90 patients (30%) showed no evidence of AVN. (Refer Figure 1)

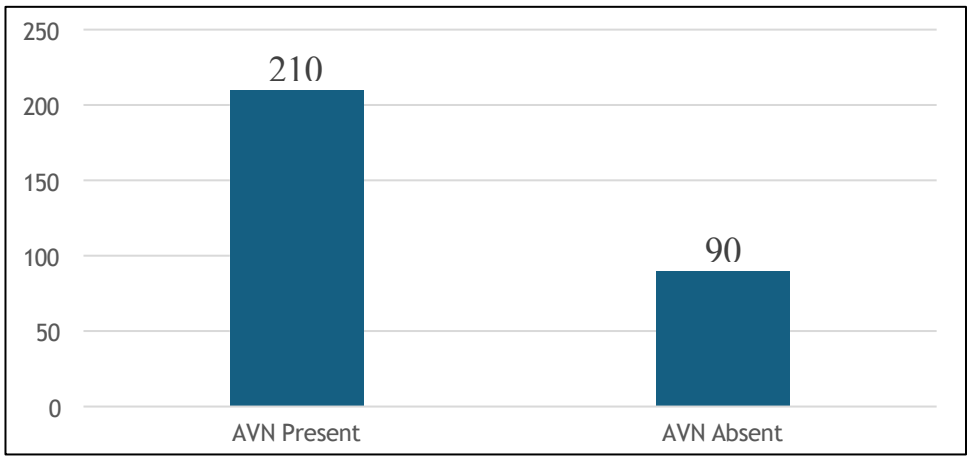

Figure 1: Prevalence of ANV in this study population

In the distribution of avascular necrosis (AVN) cases (n = 210) according to the Ficat and Arlet classification system on MRI. The majority of patients were in Stage II, accounting for 90 patients (30%), followed by Stage III with 54 patients (18%). Stage I disease was seen in 31 patients (10.33%), indicating early, pre-collapse changes detected on MRI. Stage IV AVN was observed in 35 patients (11.67%). (Refer Table 1)

Table 1: Radiological Grading of AVN Based on Ficat Staging

Ficat Stage	Number of Patients	Percentage (%)
Stage I	31	10.33
Stage II	90	30.00
Stage III	54	18.00
Stage IV	35	11.67
Total	**210**	70.00

In the laterality of avascular necrosis (AVN) involvement among the 210 affected patients detected on MRI. The left hip was most commonly involved, seen in 90 patients (43%), followed by the right hip involvement in 77 patients (37%). Bilateral hip involvement was observed in 43 patients (20 %), indicating disease affecting both femoral heads simultaneously. (Refer Figure 2)

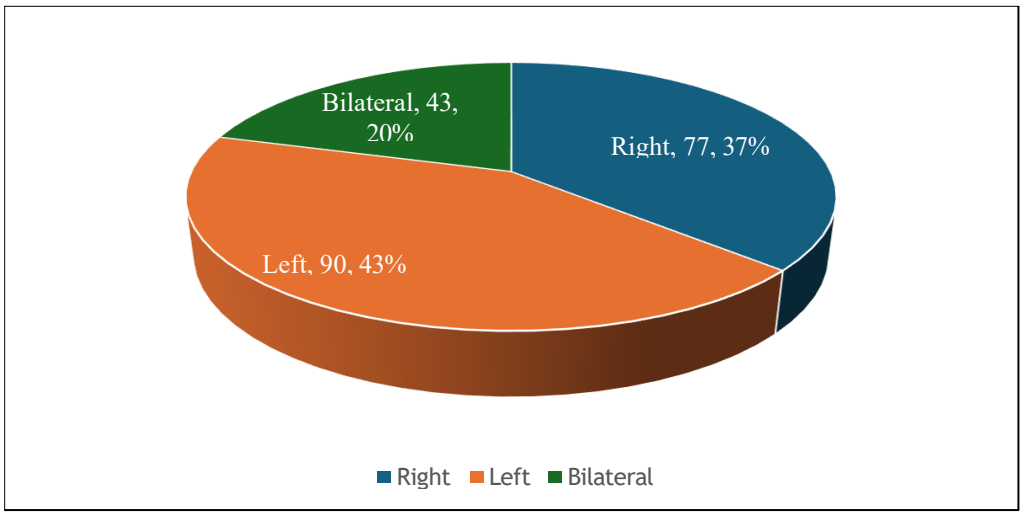

Figure 2: Distribution of Avascular Necrosis According to Side of Hip Involvement

In the relationship between steroid use during COVID-19 treatment and the development of avascular necrosis (AVN) of the hip joint. Among 179 patients who had a history of steroid use, all 179 patients (100%) developed AVN, while none were free of AVN in this group. In contrast, among 121 patients who did not receive steroids, only 31 patients developed AVN, while 90 patients remained free of AVN. The association between steroid use and AVN was found to be highly statistically significant ($p < 0.0001$). (Refer Table 2)

Table 2: Association Between Steroid Use and Occurrence of AVN

Steroid Use	AVN Present	AVN Absent	Total	P value
Yes	179	0	179	< 0.0001
No	31	90	121	
Total	**210**	**90**	**300**	

In the distribution of avascular necrosis (AVN) according to associated comorbid conditions. Among patients with diabetes mellitus, 89 out of 99 patients developed AVN, while only 10 patients were free of AVN. In the hypertension group, 90 out of 106 patients had AVN, whereas 16 patients did not show AVN. In contrast, among patients with no comorbidities, only 31 out of 95 patients developed AVN, while a majority of 64 patients were free of the disease. The association between comorbidities and AVN was found to be highly statistically significant ($p < 0.0001$). (Refer Table 3)

Table 3: Association Between Comorbidities and Occurrence of AVN

Comorbidity	AVN Present	AVN Absent	Total	P value
Diabetes Mellitus	89	10	99	< 0.0001
Hypertension	90	16	106	
None	31	64	95	
Total	**210**	**90**	300	

In the distribution of avascular necrosis (AVN) according to different age groups among the study population. In patients aged less than 40 years, 12 out of 87 developed AVN, while the majority (75 patients) did not show AVN. In the 40–60 years age group, a significantly higher number of patients were affected, with 171 out of 186 patients showing AVN and only 15 patients being free of the condition. In the above 60 years age group, 27 patients were included, and all of them were found to have AVN, with no AVN-negative cases recorded. The association between age and occurrence of AVN was found to be highly statistically significant ($p < 0.0001$). (Refer Table 4)

Table 4: Association Between Age Group and Occurrence of AVN

Age Group (Years)	AVN Present	AVN Absent	Total	P value
< 40	12	75	87	< 0.0001
40–60	171	15	186	
> 60	27	0	27	
Total	**210**	**90**	300	

In the distribution of avascular necrosis (AVN) according to gender among the study population. Among 151 male patients, 108 were found to have AVN while 43 patients did not show evidence of AVN. In the female group, 102 out of 149 patients had AVN, whereas 47 patients were AVN negative. The statistical analysis showed a p-value of 0.92, indicating that there is no statistically significant association between gender and the occurrence of AVN.

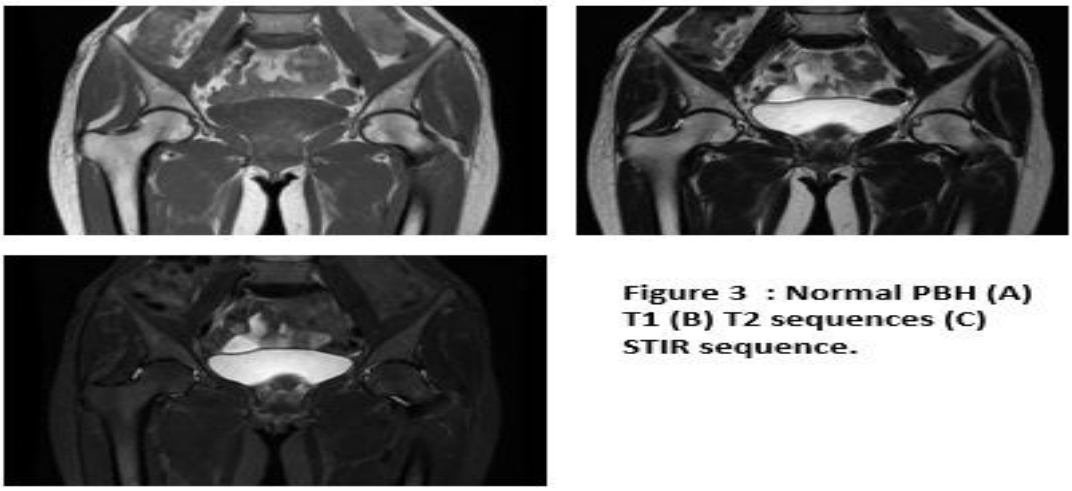

Figure 3: Normal PBH(A) T1 (B) T2 sequences (C) STIR sequence

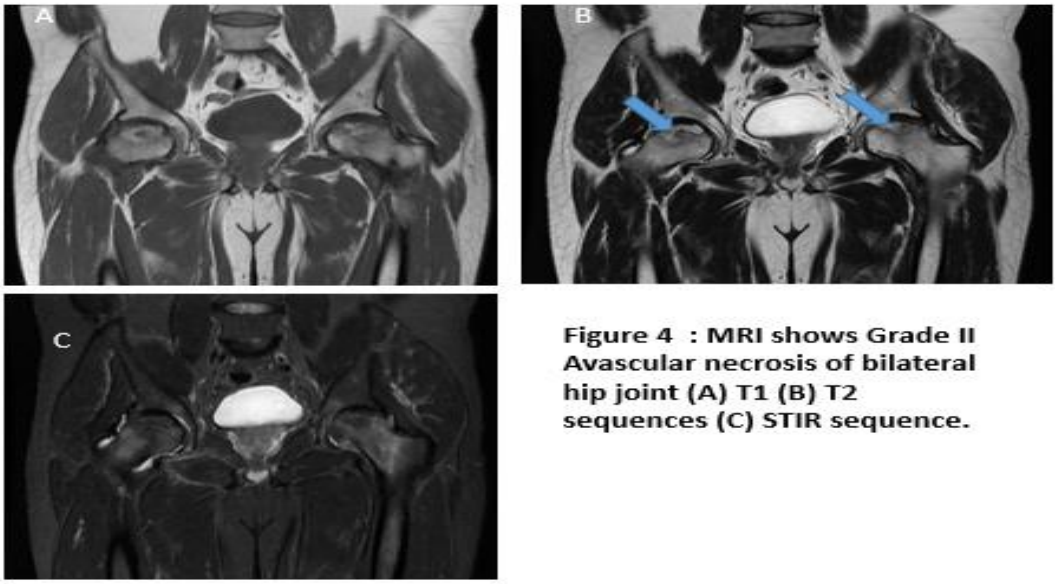

Figure 4: MRI shows Grade II Avascular necrosis of bilateral hip joint (A) T1 (B) T2 sequences (C) STIR sequence.

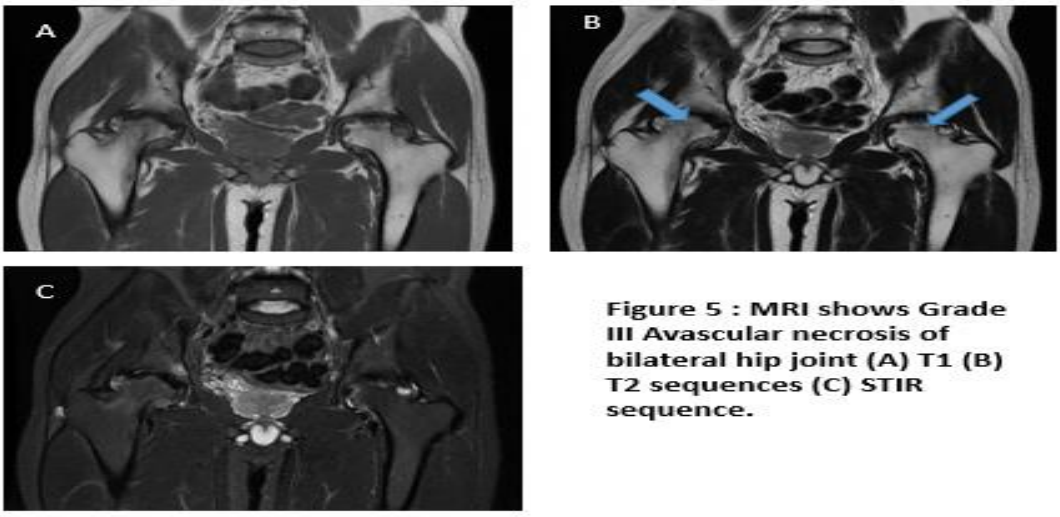

Figure 5: MRI shows Grade III Avascular necrosis of bilaterial hip joint (A) T1 (B) T2 sequences (C) STIR sequence.

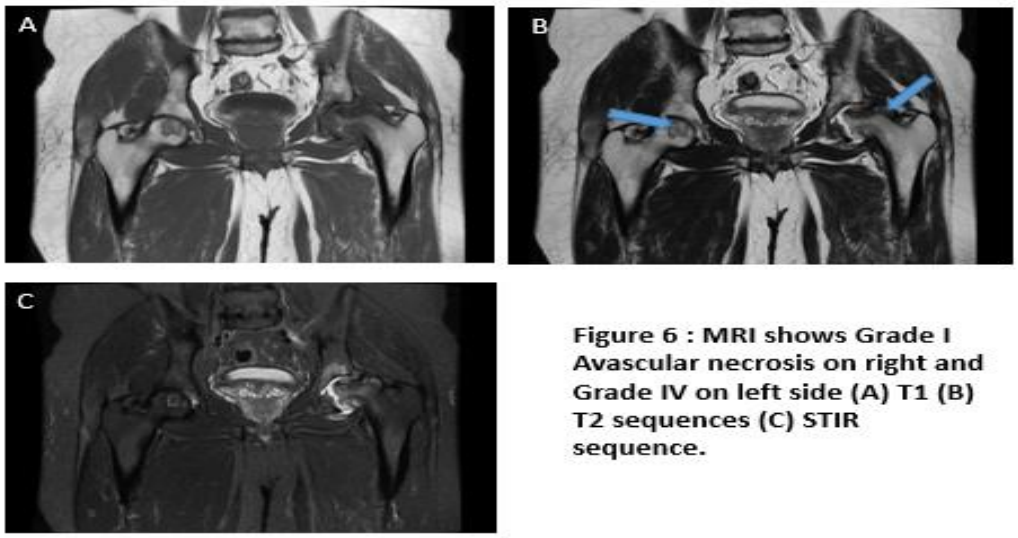

Figure 6: MRI shows Grade I Avascular necrosis on right and Grade IV on left side (A) T1 (B) T2 sequences (C) STIR sequence.

DISCUSSION

Avascular necrosis refers to a pathological state marked by the disruption of the blood flow into the bone cells, leading to their death and subsequent destruction of the bones in question. One of the bones most frequently impacted by AVN includes the hips, particularly after trauma to the hip joints such as femur neck fractures and hip dislocation. Other than trauma, there are many causes of non-traumatic avascular necrosis, such as metabolic and vascular disorders.[14]

Infection with COVID-19, patients can present with a wide variety of clinical symptoms, which range from being asymptomatic to having a severe systemic disease that affects more than one system of the body. The hypercoagulability, endothelial dysfunction, and inflammatory response caused by infection with SARS-CoV-2 virus, as well as the use of steroids, which is common when dealing with COVID-19, can lead to poor circulation of blood into the bones. This predisposes the patient to have AVN, especially those with musculoskeletal symptoms like hip pain.[15]

In the present study, 300 patients with post-COVID syndrome who had an MRI done for their hip joint to assess their hip pain, 210 of these patients were found to have avascular necrosis (AVN), giving a prevalence of 70%. The other 90 patients did not have any signs of avascular necrosis (AVN), indicating that they had a prevalence of 30%.

These results are consistent with the work done by Mohamed M et al, which found a very high percentage of AVN in early stages (I–II in 86%) in patients with post-COVID symptoms of hip pain[16]. The authors have stressed the importance of MRI in diagnosing early bone marrow alterations, which are often overlooked on radiography. Likewise, in the current study, MRI was very sensitive in detecting AVN in all stages (early and intermediate), thus endorsing its utility as the ideal imaging tool.

Moreover, these results are also in line with the research conducted by George J et al., who described the novel link between COVID-19 disease and the musculoskeletal system, especially AVN, probably due to inflammation, coagulation, and steroid intake.[13]

From all 210 participants diagnosed with AVN using MRI, the highest number belonged to Stage II (30%), while there were 18% in Stage III, 11.67% in Stage IV, and 10.33% in Stage I. This suggests that most of the patients had their diagnoses made at early and intermediate stages, but a significant portion of them was diagnosed at an advanced stage of AVN (Stages III and IV).

When compared with the study by Mohamed MM et al., a different pattern was observed,

where Stage I (47%) and Stage II (39%) predominated, and no Stage IV cases were reported.[16] Their findings suggest that patients in their cohort presented at an earlier stage of disease, which they attributed to early imaging evaluation. Similarly, the study by Tarun Sehgal et al. also reported a predominance of early-stage disease, with Stage I in 45% and Stage II in 40% of cases, while Stage III accounted for only 15% of cases, mainly in older age groups.[17]

In the present study, a strong and statistically significant association was observed between steroid use, comorbidities, and age with the occurrence of AVN ($p < 0.0001$ for all). AVN was seen predominantly in patients with a history of steroid exposure, diabetes mellitus, hypertension, and in the 40–60 years age group, indicating these as important risk factors. However, no significant association was found between gender and AVN ($p = 0.92$), suggesting equal susceptibility among males and females.

This is aligned with results found in the study conducted by Mohamed M. et al., whereby there was also a high occurrence of early AVN among post-COVID individuals, especially due to the use of corticosteroids and systematic risks like metabolic conditions.[16] This is because inflammation and vasculature were majorly involved in the causation of AVN.

In the same vein, in the study conducted by Sehgal et al., it was revealed that AVN was prevalent in middle-aged people and was significantly linked to steroid use but there was no statistical significance found in relation to gender.[17] These findings agree with the findings of this study, which indicate that systemic risk factors and age have more weight in comparison to gender in the formation of post-COVID AVN.

Figure 3. Normal PBH (A) T1-weighted, (B) T2-weighted, and (C) STIR MRI sequences of bilateral hip joints showing normal morphology of the femoral heads with preserved marrow signal intensity. No evidence of subchondral sclerosis, marrow edema, crescent sign, cortical irregularity, or collapse is noted. The hip joint spaces are maintained, suggestive of a normal MRI appearance of both hip joints.

Figure 4. MRI showing Grade II Avascular Necrosis of Bilateral Hip Joints (A) T1-weighted images demonstrate focal hypointense areas in the femoral heads bilaterally, while

(B) T2-weighted and (C) STIR sequences show corresponding hyperintense marrow edema and the characteristic double-line sign. There is no evidence of femoral head collapse or articular surface irregularity, consistent with Grade II avascular necrosis involving both hip joints.

Figure 5. MRI showing Grade III Avascular Necrosis of Bilateral Hip Joints (A) T1-weighted, (B) T2-weighted, and (C) STIR sequences reveal heterogeneous signal intensity involving both femoral heads with the presence of a subchondral crescent sign indicating subchondral fracture. Early flattening of the femoral heads is observed without significant secondary osteoarthritic changes, consistent with Grade III avascular necrosis bilaterally.

Figure 6. MRI showing Grade I Avascular Necrosis on Right Side and Grade IV on Left Side (A) T1-weighted images show subtle marrow signal alteration in the right femoral head suggestive of early avascular necrosis (Grade I), while the left femoral head demonstrates marked hypointensity with collapse and deformity. (B) T2-weighted and (C) STIR sequences reveal marrow edema and joint effusion, more pronounced on the left side. Advanced degenerative changes with femoral head collapse and secondary osteoarthritic changes on the left are consistent with Grade IV avascular necrosis.

The present study has certain limitations. Being a single-center, hospital-based retrospective study, the findings may not be fully generalizable to the broader population. In addition, the relatively limited sample size may affect the strength of external validity and the ability to detect smaller associations between variables.

Despite its limitations, this study contributes important evidence by systematically assessing the prevalence and radiological

staging of avascular necrosis (AVN) in post-COVID patients presenting with hip pain. Employing the MRI method to diagnose patients for avascular necrosis and applying the Ficat and Arlet staging system makes it possible to accurately evaluate AVN's occurrence and stages. Moreover, the study shows the role of significant clinical parameters like exposure to steroids, age, and other comorbidities in determining the risk of developing AVN.

The findings of this study have several important clinical implications. Patients recovering from COVID-19 who present with persistent hip pain should be promptly evaluated with MRI to facilitate early diagnosis of AVN, as radiographs may fail to detect early disease. Clinicians should also exercise caution regarding corticosteroid use during COVID-19 management, given its strong association with AVN development. Furthermore, individuals with risk factors such as diabetes mellitus, hypertension, and middle to older age groups should be considered high-risk and may benefit from closer clinical monitoring and early imaging. Early identification and intervention in such patients can help prevent disease progression, reduce the risk of femoral head collapse, and ultimately improve long-term functional outcomes.

CONCLUSION

The present study successfully achieved its aim of assessing the prevalence and radiological grading of avascular necrosis (AVN) of the hip joint on MRI in post-COVID patients. The study demonstrated a high prevalence of (70 %) AVN in the post-COVID cohort, with most cases detected in early to intermediate stages on MRI. Radiological evaluation using the Ficat and Arlet classification showed that Stage II AVN was the most common, indicating that MRI plays a crucial role in early disease detection.

The study also fulfilled its objectives by identifying significant associations between AVN and key clinical factors. Steroid use, age (particularly 40–60 years), and comorbidities such as diabetes mellitus and hypertension were found to be significantly associated with AVN development, whereas gender showed no statistically significant association.

Overall, the study concludes that post-COVID patients, especially those with hip pain and relevant risk factors, represent a high-risk group for AVN. MRI is an essential diagnostic tool for early detection and staging, enabling timely intervention to prevent progression to advanced joint destruction.

Declaration by Authors

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