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Magnetic Resonance Imaging in Evaluation of Avascular Necrosis of Femur

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2. To evaluate the demographic profile with emphasis on risk factors for AVN.
3. To evaluate the most common quadrant of the femoral head affected in AVN.
4. To analyze the MRI findings in AVN of the femoral head.

Methods: This single-center retrospective observational study was conducted in the department of radiodiagnosis in a tertiary care institute situated in an urban area. 70 patients of all age groups with clinical suspicion of AVN were evaluated over a period of one and a half years between January 2020 to June 2021. Of these, 6 patients with osteoarthritis were excluded with 64 patients included in this study. Demographic and clinical details with particular emphasis on risk factors and relevant lab parameters were collected from records and reviewed for all patients. Scans were performed on 3-Tesla MRI scanner, Seimens SkyraTM. Ficat and Arlet classification was used to stage the disease.

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Magnetic Resonance Imaging in Evaluation of Avascular Necrosis of Femur

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Results: In this study of 64 patients, 70% were males and 30% were females. Bilateral disease was found in 83% patients and unilateral involvement in 17% patients. The associated risk factors of AVN in our study were alcohol(36%), steroids(27%), idiopathic(19%), sickle cell disease, SLE, trauma, diabetes. Of the 117 femoral heads affected, stage I AVN was found in 1 femoral head, stage II in 45 heads, stage III in 50 whereas stage IV in 21 femoral heads. Anterosuperior quadrant was involved in 62% of the femoral heads.

Conclusion: Our study demonstrates that MRI is the imaging of choice in clinically suspected cases of AVN and in proper staging. It helps in early diagnosis and better outcome.

I. Introduction

Avascular necrosis(AVN) is the cellular death of the bone due to various factors causing vascular compromise. This vascular compromise leads to ischemia and cell death which will result in relentless progression of the disease. Femoral head is the most commonly affected site as it is the weight bearing part of the bone and due to its precarious bloodsupply.AVN of the femur is one of the common causes of hip pain presenting in young age. Some of the common risk factors associated with AVN include trauma, corticosteroid use, chronic alcoholism, pancreatitis, sickle cell disease, gout, radiation, SLE(1,2).

Radiologic staging of the disease is of crucial importance in the identification and risk stratification in pre-collapse stages, prognosis, treatment planning, and post-operative follow-up. Radiograph of the pelvis with both hips is the first imaging usually done in a suspected case of AVN, but unfortunately, plain radiographs are of no much use in early stages of AVN(3). MRI is the most sensitive imaging modality in diagnosing AVN. It is the investigation of choice for the definitive staging of AVN, because images clearly portray the size of the lesion, and overall estimates of the stage of disease can be made. CT is usually done to assess the extent of disease and to look for subchondral fractures or collapse.(4) SPECT scanning has a role in determining the radioactivity of the organ and it is beneficial in early cases to spot the avascular focus that can be un noticed with routine plain MRI sequences. Bone scanning is advised in cases where MRI is contraindicated or equivocal, and it is useful in quantifying the physiologic data i.e., uptake in static and perfusion states. Bone biopsy is accurate, and can diagnose early, however, usually avoided as it is invasive(7).

II. Materials and Methods

This single-center retrospective observational study was conducted in the department of radiodiagnosis in a tertiary care institute situated in an urban area. 70 patients of all age groups with clinical suspicion of AVN were evaluated over a period of one and a half years between January 2020 to June 2021. Of these, 6 patients with features of osteoarthritis were excluded. Demographic details like age, gender and clinical symptoms were collected. Clinical details with particular emphasis on the risk factors for AVN and relevant lab parameters were collected from records and reviewed for all patients. Scans were performed on 3 Tesla MRI scanner, Siemen's SkyraTM. Ficat and Arlet classification was used to stage the avascular necrosis of the femoral head.

III. Results

In this study of 64 patients with osteonecrosis of femoral head, 41(69%) were males and 18 (31%)were females with male to female ratio of 2.2:1.

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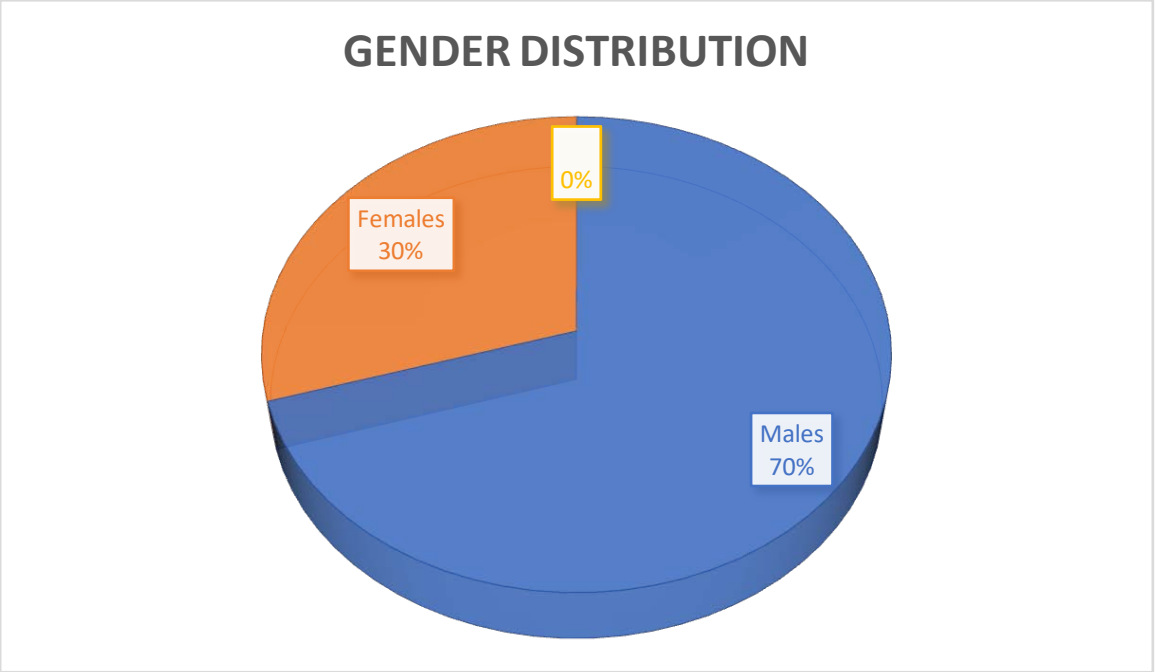
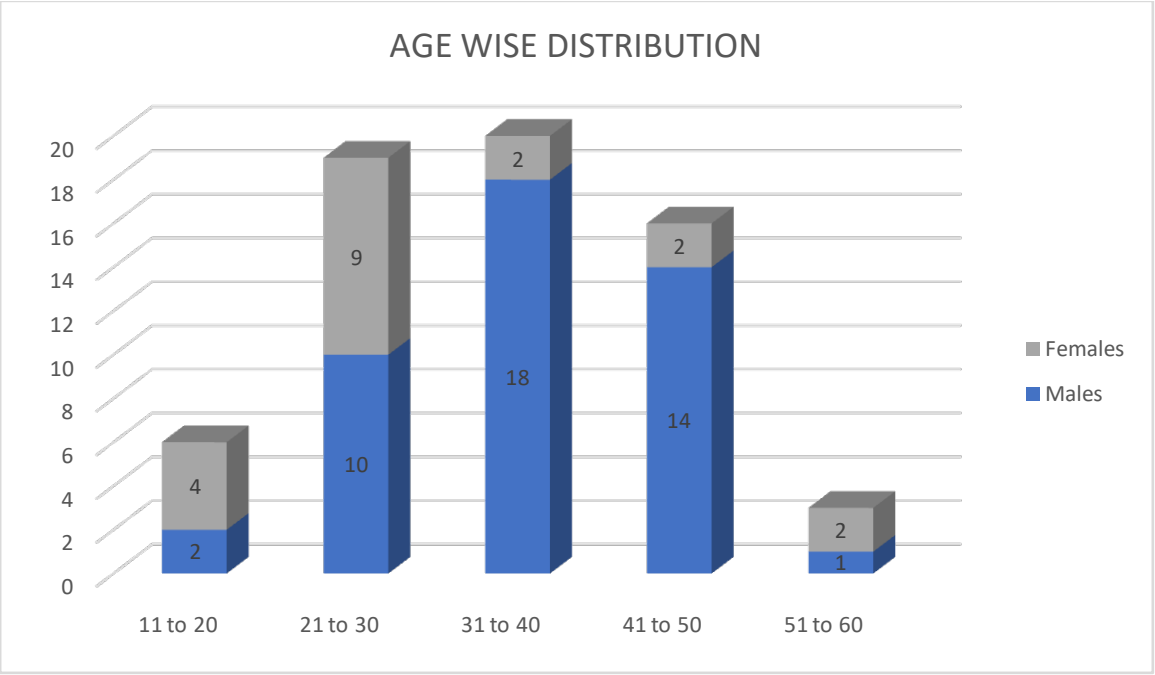


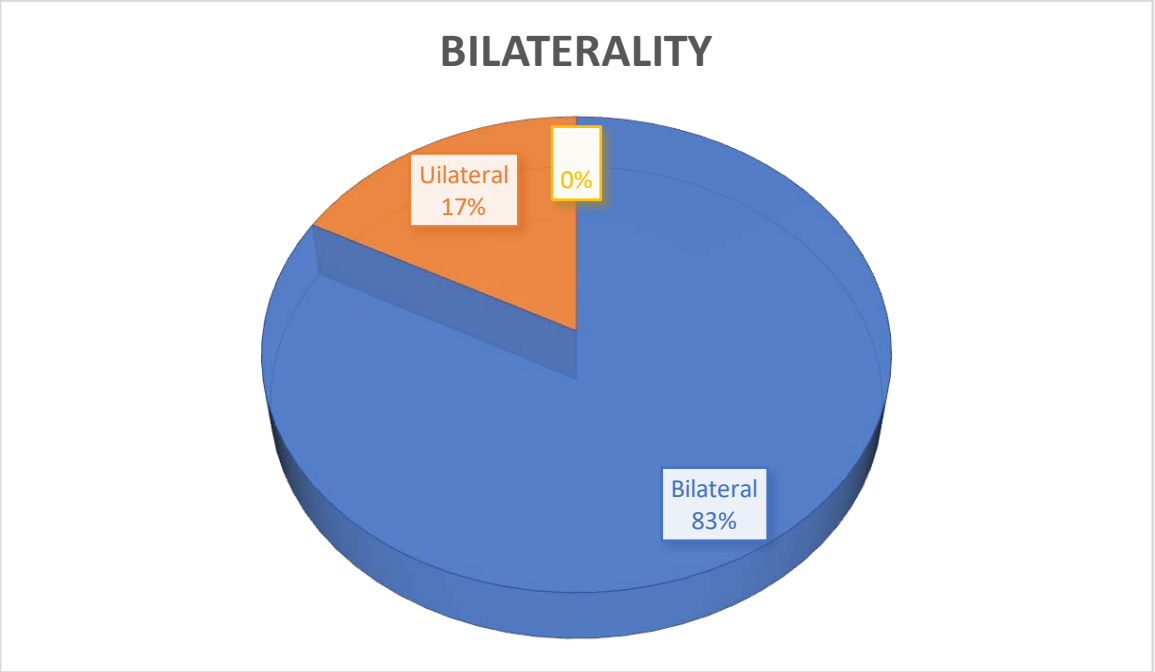
Graph 1: Gender distribution of the cases

Prevalence of AVN was found to be highest in the economically productive age group of 21 to 40 years (62.7%) i.e 37 cases, 5(8.4%) cases belongs to age group of 11-20 years,14 (23.7%) cases belongs to the age group of 41-50 years and 3(5%) cases belongs to the age group of 51-60 years. The mean age of presentation was found to be 33.98+/-10.03. There is no statistical significance between the mean ages of presentation in males and females (M=35.05,F=30.67).



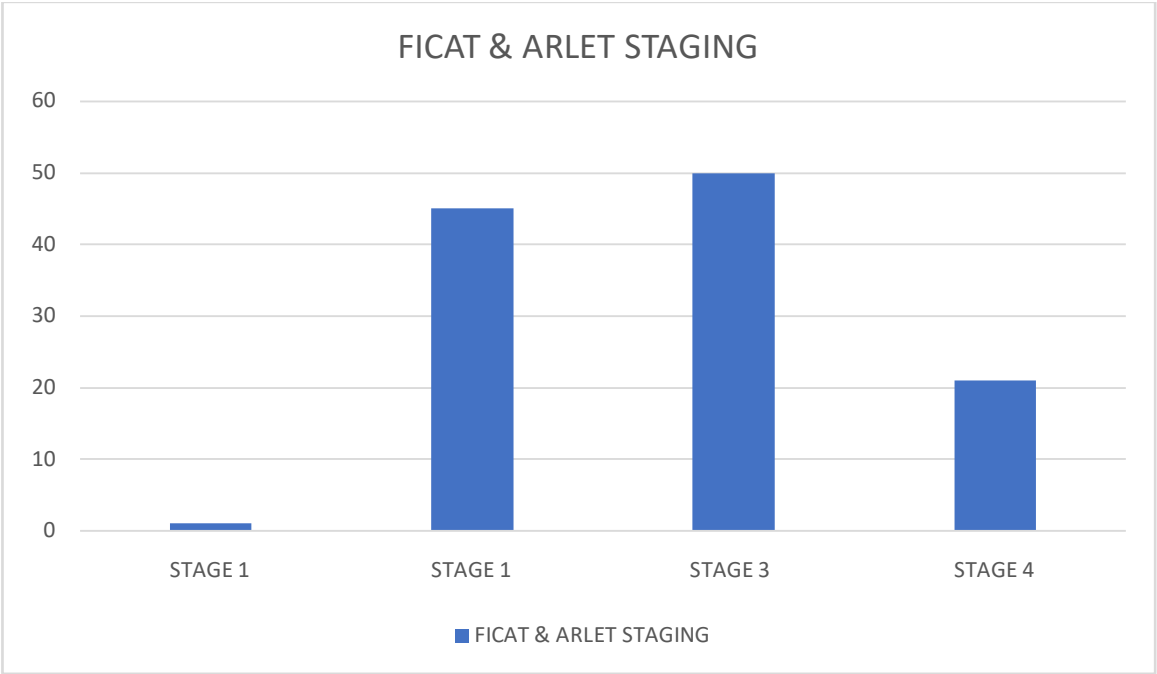
Graph 2: Age wise distribution of cases.

In the present study, The presentation was bilateral in 48(81.3%) and unilateral in 11(18.6%) cases.



Graph 3: Chart showing the side affected.

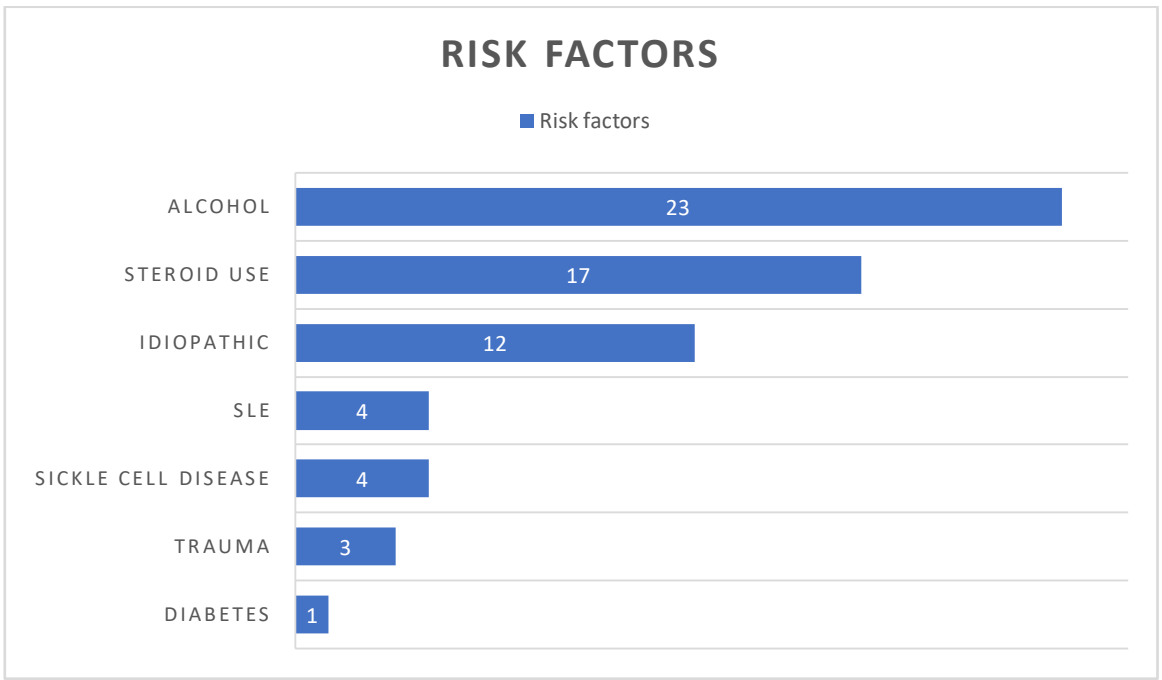
We detected stage I AVN of Ficat and Arlet staging system in 1 femoral head, stage II in 44 femoral heads, stage III in 46 heads and stage IV in 20 femoral heads.



Graph 4: Bar chart showing Ficat & Arlet staging of AVN of the femoral head.

Fig. 1: AP radiograpgh pelvis (A) showing flattening and sclerosis of right femoral head and normal left head. Axial (B,C)T1,T2 and coronal STIR (C)) images with Geographic area of T1 hypointense, T2 heterogeneous hypointense, STIR heterogeneously hyperintensity involving head of the right femur with flattening, associated with mild right hip joint effusion. F/S/O right Grade – III AVN. T2 hyperintense area noted in ant sup aspect of left femoral head – S/o Edema – Grade – I AVN.

The analysis of risk factors in our study demonstrated that chronic alcoholism (35.5%) was the most common risk factor associated with AVN of femoral head followed by chronic steroid use (25.4%). other risk factors include Idiopathic(16.9%), sickle cell disease(6.7%), systemic lupus erythematosus(6.7%), trauma (5.08%), diabetes(1.69%).



Graph 5: Bar chart showing risk factors of avn.

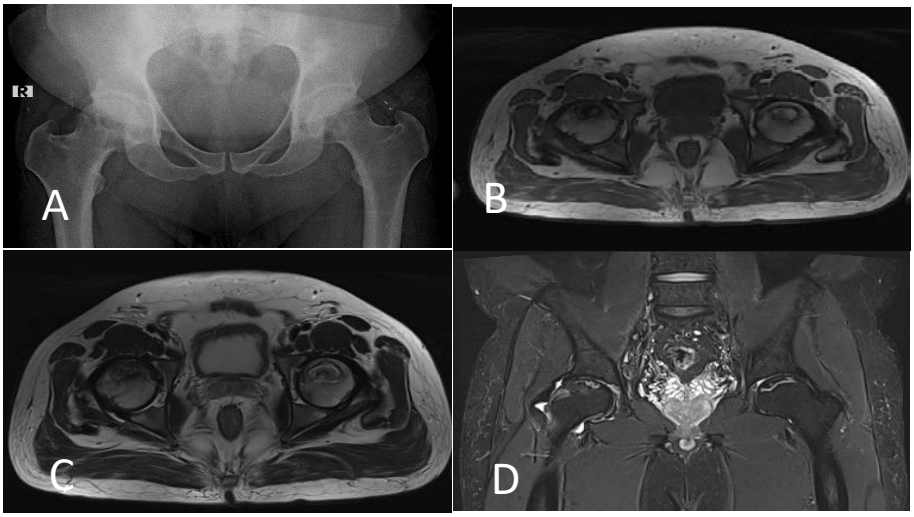


Fig. 2: AP radiograph pelvis(A) showing mild sclerosis of bilateral femoral heads with normal contour.MRI T1,T2 axial (B,C)and STIR coronal images(D) showing Geographical areas of altered signal intensity areas which are heterogeneously hyperintense on T1,T2 with surrounding hypointense rim with central suppression and peripheral hyperintense rim on STIR in both femoral heads. F/S/O bilateral grade II AVN.

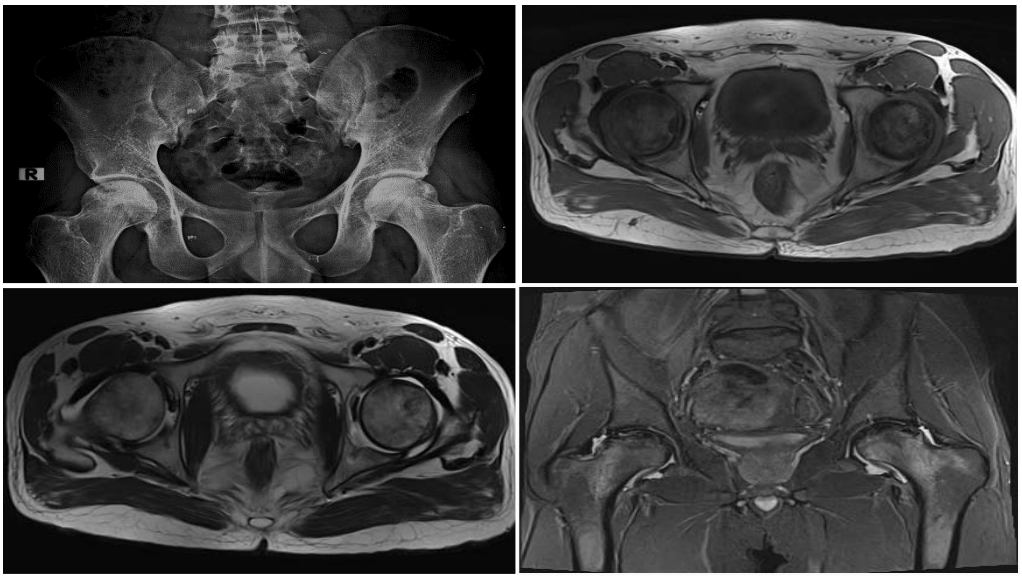
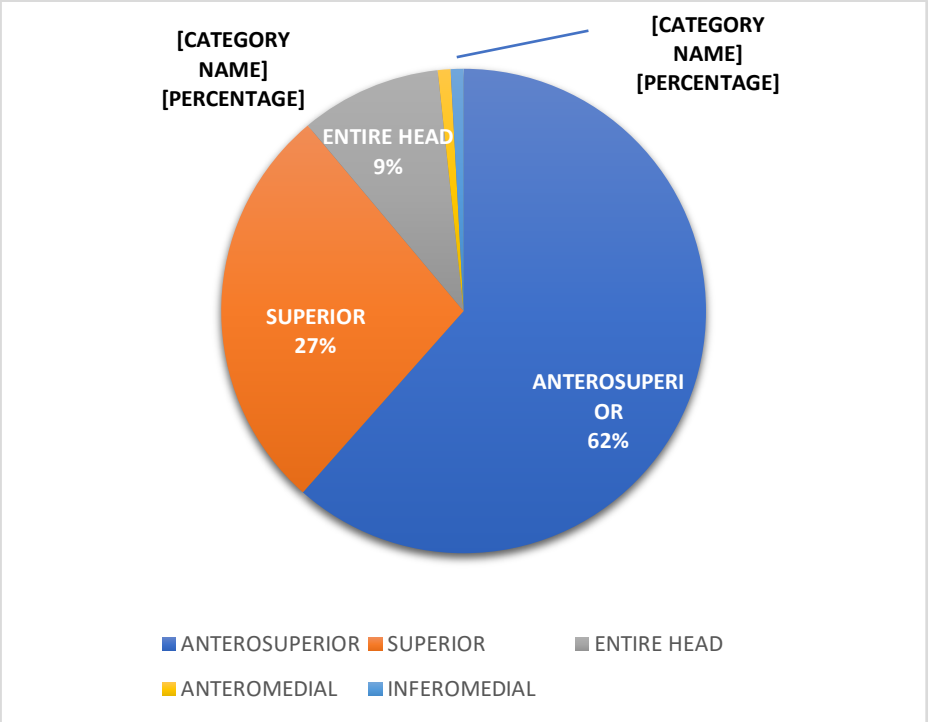


Fig. 3: AP radiograph pelvis(A) showing sclerosis of bilateral femoral heads with mild flattening.MRI t1,t2 axial (B,C) and coronal STIR images (D) showing Geographical altered signal intensity lesions in bilateral antero-superior aspect of femoral head, which appear heterogenous hyperintense on T1,T2 with surrounding hypointense rim, showing central suppression with peripheral hyperintense rim on stir in both heads with mild flattening and ass bilateral mild jointeffusion.
F/C/W Bilateral AVN of femoral heads – Stage III.

In this study, anterosuperior quadrant was involved in 72 (62%) of femoral heads followed by superior quadrant in 32 (27%), entire head was involved in 11(9%) heads, anteromedial and infero medial quadrants were involved in1 (1%) femoral heads each.



Graph 6: Pie chart showing quadrants involved AVN.

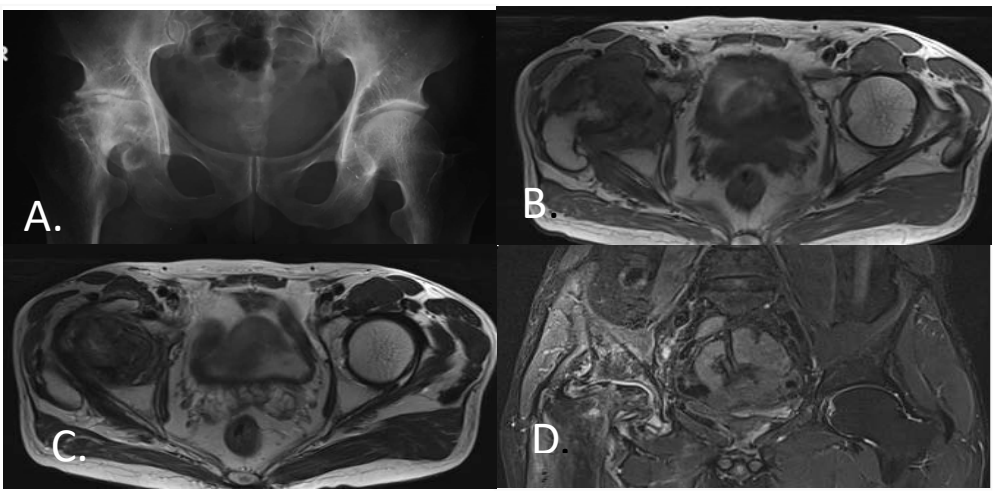


Fig. 4: This is Ap radiograph pelvis(A) showing reduced joint space and collapse of right femoral head with secondary osteoarthritic changes. (B,C) MRI T1,T2 axial and (D.) coronal STIR images showing altered signal intensity geographical area involving right femoral head which appears hypointense on T1,T2 and STIR with significant flattening and secondary osteoarthritic changes in femoral head and acetabulum associated with joint effusion and edema- F/S/O right stage IV AVN.

Analysis of MRI findings revealed that double line sign was most common finding seen in 85%femoral heads followed by loss of contour in 62%of heads, joint effusion was seen in 60% heads,bonemarrow edema in 50% and joint space reduction was noted in 18% of femoral heads.

Table 1: Analysis of MRI findings in AVN

MRI findings	No. of Femoral heads
Double line sign	99(84.6%)
Joint effusion	70(59.8%)
Bone marrow edema	59 (50.4%)
Subchondral collapse	33(28.2%)
Loss of joint space	21(17.9%)

Association of Joint effusion with staging showed that joint effusion was more common in stage 3and 4 that is 77% and 47.6% respectively followed by stage 2 in 46.5 %of femoral heads. A total of 70 out of 117 femoral heads showed joint effusion ie; 59.8%.

Table 2: Association of joint effusion with staging

Stage	Joint effusion	No of femoral heads	percentage
I	0	01	0%
II	20	43	46.5%
III	40	52	77%
IV	10	21	47.6
Total	70	117	59.8%

Association of marrow edema with staging showed that marrow edema was more common in stage 4 seen in 57.1% followed by stage 2 and 3 ie; 49 and 48 percent respectively.

Table 3: Association of marrow edema with staging

Stage	Bone marrow edema	No of femoral heads	percentage
I	1	1	100%
II	21	43	48.8%
III	25	52	48%
IV	12	21	57.1%
Total	59	117	50.4%

IV. Discussion

In this retrospective observational study of 64 patients, 45(70%) were males and 19(30%) were females with male to female ratio of 2.2:1. It shows higher prevalence of AVN in male than female population. This observation was similar to the study conducted by Jyothi choudary et al(1) in which 69% of the affected cases were males and 31% were females.

In our study AVN was found between age groups of 13 to 6o years with most of the patients 39(61%) belong to the age group of 21-40 years as the risk factors for AVN such as alcohol and steroids use most frequently occur in this age group. 16(25%) patients belong to the age group of 41 -50, 3(4.6%) patients belong to the age group of 51- 60 years and 6(9.3%)patients belongs to the age group of 11 -20.

The mean age of presentation was 34.2 years which is similar to the study conducted by Harsha vardhan et al(7) where the mean age was 34.7 years. There is statistically significant difference in the mean age of males and females with females being affected at a relatively younger age than males ($P<0.05$).

Bilateral disease 53 (83%) was more common than unilateral involvement 11(17%) in this study.

According to Ficat & Arlet classification of AVN, out of 117 femoral heads involved, we observed stage III was the commonest stage seen in 52 (44.4%) femoral heads followed by stage II in 43(36.7%) femoral heads. This was similar to study conducted by Jyothi choudary et al(1), in which stage III AVN was found in 39.4% femoral heads followed by stage II in 30.4% heads.

In this study, we found that alcohol was the most common associated risk factor for the avascular necrosis of femoral head seen in 23 patients (36%).

This finding is consistent with the study conducted by Mohammad Zeeshan Saleem et al(2) and Jacobs et al (6), in which alcohol was the most common associated risk factor in 56% and 39% respectively. The mean duration of intake of alcohol was 82 months in our study. In a study conducted by Harshavardhan et al(7), the mean duration of alcohol intake was 88months.

The exact mechanism of alcohol causing AVN is not known. However several studies have concluded that fat embolism linked to hyperlipidaemia which in turn leads to the blockage of blood supply to femoral head and eventually bone death.

The next common associated risk factor in our study is corticosteroid use in 17 patients (27%). Harsha Vardhan et al (7) in their study concluded that steroid was the most common risk factor associated with AVN.

The most common indication for steroid intake in out institute was SLE. Other indications include rheumatoid arthritis, glomerular nephritis, nephrotic syndrome, renal transplant, auto immune haemolytic anaemias, paraquet poisoning.

Though the pathogenesis of steroid induced AVN is not fully understood, the postulated mechanisms include fat hypertrophy, fat emboli and intravascular coagulation that leads to the impaired blood supply to bones.

Other risk factors in our study were sickle cell disease in 4(6%) patients, SLE in 4(6%) patients, trauma in 3(5%) patients, diabetes in 1(2%) patients and no identifiable cause was observed in 12 (19%) patients.

In this study 2 patients of sickle cell disease showed multiple bone infarcts involving iliac bones in addition to the AVN of femoral head.

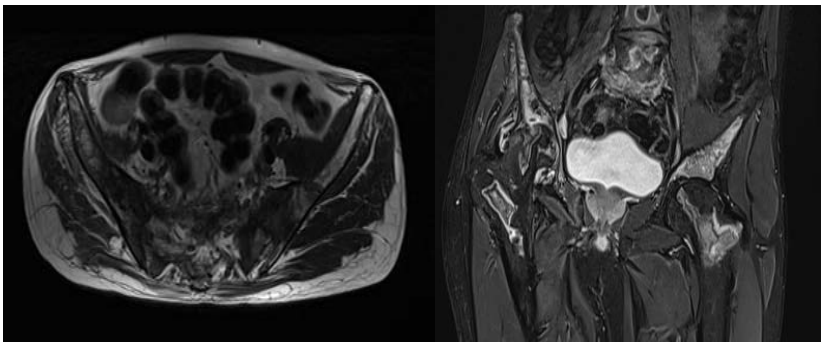


Fig. 5: Axial T2(A), and STIR coronal (B) images showing bilateral AVN with pelvic bone involvement.

The most common quadrant involved in our study is anterosuperior quadrant seen in 62% of the heads followed by superior quadrant in 27 % cases.

Gabriel et al(5), in their study showed that involvement of anterosuperior quadrant is specific for AVN. Nishii et al(3), in their study showed that location and size of the lesion are the prognostic indicators of collapse and large necrotic lesions have likelihood to involve anterosuperior quadrant.

In this study most common MRI finding of AVN is double line sign seen in 99 femoral heads (85%) which is considered pathognomic of AVN.

Other common findings are contour loss(62%), joint effusion (70%), bone marrow edema(50%), joint space reduction(18%).

In our study, joint effusion is seen in 70 out of 117 femoral heads(60%). The results of our study indicate that joint effusion is more prevalent in advanced stages of disease ie. stage III and stage IV. Out of 52 heads in stage III, 40 heads had joint effusion(76.9%) and out of 21 heads in stage IV, 10 heads had joint effusion(47.6%). 20 out of 43 heads of stage II heads had joint effusion(46.5%). Gou Chu Huang et al(8) and Mohammad Zeeshan Saleem et al(2), showed that stage III disease was most common to have joint effusion.

Bone marrow edema is seen in 50 out of 117 femoral heads(50.4%).

The results of our study showed that marrow edema is more prevalent in stage IV(51.1%) followed by stage II(48.8%) and stage III(48%).

In this study we have observed that 41 out of 59 osteonecrotic hips with marrow edema (81.3%) had associated joint effusion. The presence of joint effusion and bone marrow edema are prognostic factors for collapse. S Iida et al(4),In their study concluded that bone marrow edema was highly correlated with subsequent collapse.

V. Conclusion

As osteonecrosis of femoral head is increasingly becoming the cause of Musculoskeletal disability especially in younger age group, its early diagnosis is crucial because early interventions are associated with better prognosis.

This study shows that MRI is the imaging modality of choice. It helps in early diagnosis and better outcome and can also visualize the bone marrow changes, location and extent of area involved which are helpful when ascertaining patient prognosis and formulating plan of care.

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