International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Radiological Evaluation of Combined Surgical and Medical Modalities of Treatment in Precollapsed Avascular Necrosis of Femoral Head

Swapnil Mathur[1], Mahendra Solanki[2], Abhishek Pal[3]

[1]Resident, Department Of Orthopedics, M.G.M. Medical College And M.Y. Hospital, Indore
[2,3]Associate Professor, Department Of Orthopedics, M.G.M. Medical College And M.Y. Hospital, Indore

Abstract

Introduction: Avascular necrosis of the femoral head, also referred to as osteonecrosis, is a progressive and debilitating condition characterized by compromised vascular supply leading to bone ischemia, structural weakening, and eventual collapse of the femoral head. In the absence of timely intervention, the disease advances to joint dysfunction and secondary osteoarthritis. The present study aimed to arrest disease progression at an early stage through a structured interventional approach.

Material & methods: a total of 60 patients (80 hips) with early-stage avascular necrosis of the femoral head (modified Ficat-Arlet stage one and two-A), aged over 18 years, were included in the study. Following detailed history-taking and clinical examination, diagnostic confirmation was obtained through radiographic evaluation with X-ray and MRI. After obtaining informed consent, all patients underwent core decompression with autologous bone grafting in combination with pharmacotherapy. Radiological outcomes were assessed by comparing kerboul's combined necrotic angle on MRI preoperatively and at 12 months postoperatively.

Results: Our study demonstrated that kerboul's combined necrotic angle remained stable following intervention, with no statistically significant change sufficient to alter the patients' risk stratification category. Notably, the absence of progression in the necrotic angle indicates that disease advancement was effectively arrested or at least mitigated.

Conclusion: In the present cohort, the majority of patients manifested with stage one avascular necrosis, predominantly of idiopathic origin. The multimodal therapeutic strategy comprising core decompression, autologous bone grafting, and adjunctive pharmacotherapy yielded substantial clinical improvement and effectively mitigated the risk of femoral head collapse, thereby decelerating disease progression when instituted at an early stage. Radiological outcomes were systematically assessed through quantification of kerboul's combined necrotic angle on MRI, providing an objective measure of structural preservation.

Keywords: Avascular Necrosis, Bone Grafting, Core Decompression, Femoral Head, Kerboul's Combined Necrotic Angle, Pharmacotherapy, Precollapse Stage

1. INTRODUCTION

Avascular Necrosis (AVN) of the femoral head, also known as osteonecrosis, is a debilitating condition characterized by the death of bone tissue due to impaired blood supply, if left untreated leads to progressive collapse of the femoral head and results in secondary osteoarthritis [1,2].

Early diagnosis is crucial for optimizing treatment outcomes. Magnetic resonance imaging (MRI) is the most sensitive modality for detecting early-stage Avascular Necrosis of femoral head, particularly before radiographic changes appear. In contrast, X-rays are useful for identifying later stage structural collapse and joint degeneration [3]. Antero-superior quadrant of femoral head bears the highest mechanical load and is most common site for development of Avascular Necrosis of femoral head [4].

Avascular necrosis of the femoral head is a relatively frequent condition, especially among middle-aged adults. Its global prevalence varies significantly, with estimates ranging from 10 to 20 cases per 100,000 individuals each year [1]. The condition primarily affects individuals aged 30 to 50 years, with men being nearly three times more likely to be affected than women [2].

The occurrence of avascular necrosis of the femoral head has been growing, mainly attributed to the greater use of corticosteroids and improved disease detection made possible by modern imaging methods. According to past studies, corticosteroid use was the prevailing causative factor responsible for avascular necrosis of femoral head [5].

Avascular necrosis of the femoral head can result from multiple etiological factors. Among traumatic causes, femoral neck fractures and hip dislocations are the most frequently observed contributors [6]. Non-traumatic causes include corticosteroid therapy, excessive alcohol intake, a history of COVID-19 infection, sickle cell disease, and other related conditions. Ischemic damage to the femoral head is believed to be associated with the hypercoagulable state, endothelial dysfunction, and microvascular thrombosis induced by SARS-CoV-2 infection [7].

Furthermore, prolonged use of corticosteroids in severe COVID-19 cases increases the risk of Avascular Necrosis of femoral head [8]. Kerboul's combined necrotic angle was used to measure the radiological outcome of treatment [9-11]. Treatment approaches are largely determined by the stage of the disease and may involve pharmacological options - such as bisphosphonates and anticoagulants or surgical procedures like core decompression, vascularized bone grafting, and total hip arthroplasty in advanced cases. The main objective is to preserve the femoral head and postpone the need for joint replacement, especially in younger individuals.

2. Materials And Method

The study cohort comprised 60 patients (80 hips), and all participants were followed prospectively for a duration of 12 months.

All patients presenting to the outpatient department with early-stage avascular necrosis of the femoral head (Modified Ficat-Arlet Stage one and two-A) and aged over 18 years were eligible for inclusion. Patients with more advanced disease (Stage two-B, three, or four), traumatic etiology, concomitant spinal or knee pathology, sickle cell anemia, infection, autoimmune conditions, or

neurovascular/neurodegenerative disorders were excluded. Sequential sampling was employed, and the first 60 patients meeting the eligibility criteria were enrolled. Baseline imaging included pelvic radiographs (anteroposterior and frog-leg lateral views) and preoperative MRI for diagnostic confirmation.

Early stage Avascular Necrosis of femoral head may appear normal on X-ray, but later stages show sclerosis, cystic changes, and the characteristic crescent sign [12]. MRI may detect early ischemic changes even before symptoms develop [13]. Blood tests were conducted as part of the pre-anaesthetic check-up (PAC), and a sickle cell test was performed to exclude the presence of sickle cell disease.

The modified Ficat-Arlet classification is a revised staging system that incorporates advanced diagnostic tools like magnetic resonance imaging (MRI) and bone biopsy to improve the precision in staging avascular necrosis of the femoral head. It plays a crucial role in guiding treatment decisions and evaluating prognosis [14].

The surgical technique, was formulated with reference to established methodologies reported in the literature, as depicted in Figure 1.

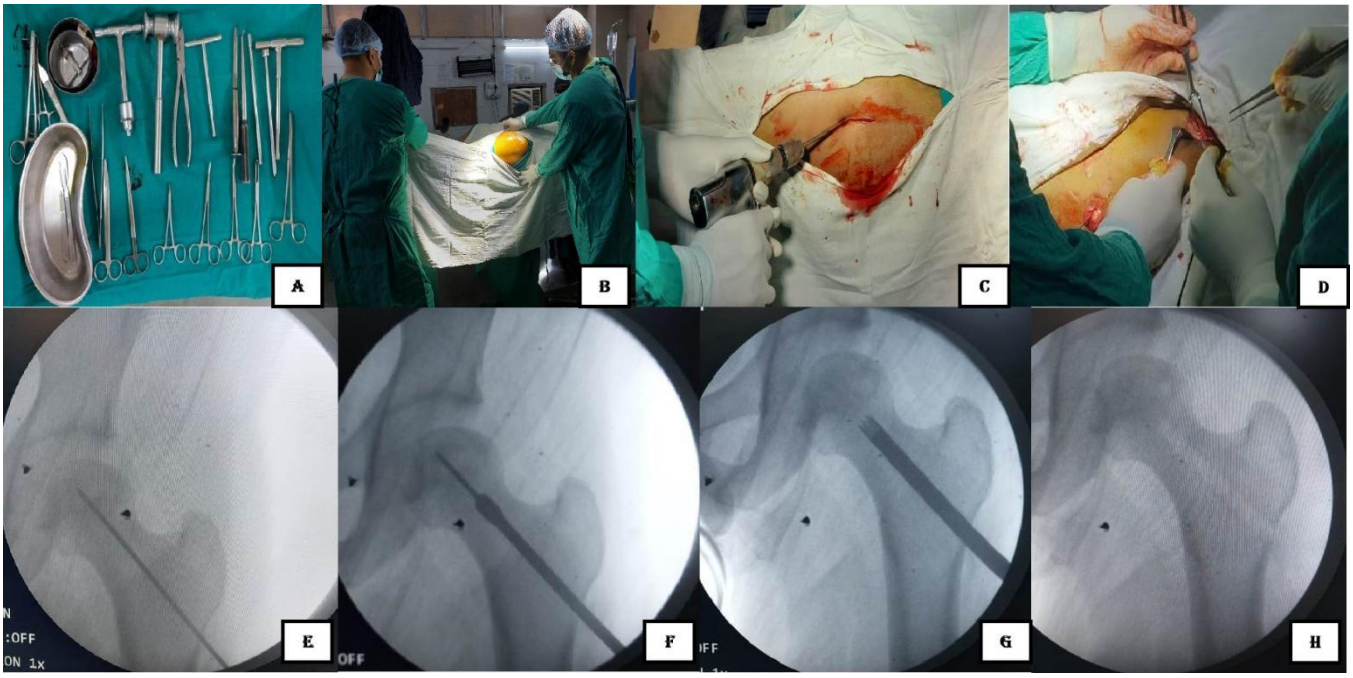

Figure 1 - Surgical Technique.

The figure illustrates the sequential steps of surgical management for early-stage avascular necrosis of the femoral head. A: instruments used for surgery. B: patient taken on fracture table for surgery. C: Small incision made 2cm below trochanter for core decompression. D: bone graft harvested from iliac crest. E: guide wire passed to address the necrotic foci. F: 8 mm reamer used for Removal of necrotic tissue. G,H: bone graft incorporated into the femur head using impactor.

Postoperative management was standardized as follows: Acetylsalicylic acid (ASA) 75 mg was administered orally once daily for two weeks, commencing on postoperative day three. Alendronate 70 mg was prescribed orally once weekly for 12 months, starting two weeks after surgery to avoid potential compromise of the fresh bone graft. Oral calcium supplementation was continued daily for 12 months, and cholecalciferol (Vitamin D3) 60,000 IU was administered weekly for 10 weeks. Ascorbic acid (Vitamin C) 500 mg was given orally once daily for 12 months. A high-protein diet was

recommended throughout the recovery period. Analgesics and proton pump inhibitors were used as needed for symptom management.

The first postoperative follow-up was scheduled at two weeks for suture removal.

In unilateral cases, partial weight-bearing was permitted from postoperative day one up to two weeks, followed by progression to full weight-bearing as tolerated. In bilateral cases, patients remained non-weight- bearing for the first two weeks, transitioned to partial weight-bearing until six weeks, and then advanced to full weight-bearing as tolerated. Radiological outcomes were assessed at 12 months postoperatively using MRI, with Kerboul's combined necrotic angle measured to evaluate structural preservation.

Data were compiled and analyzed using standard statistical software. Descriptive statistics were reported as means, standard deviations, frequencies, and percentages, with pie charts employed for visual representation. Continuous variables were compared using the Student's t-test, and Pearson's correlation was applied to assess the strength of associations between variables. A p-value <0.05 was considered statistically significant.

3. Results

A total of 60 patients with 80 hips were studied. Mean age was 30 years with male predominance(35 males, 58.3%). Unilateral AVN was more common seen in 40 patients (66.7%) while bilateral in 20 patients (33.3%). Idiopathic cause was most frequent (27 patients, 45%) followed by corticosteroid use (15 patients, 25%), alcohol (10 patients, 16.7%) and post-COVID infection (eight patients, 13.3%). According to Modified Ficat- Arlet classification majority hips were in stage one (45 hips, 56.2%) and rest in stage two-A (35 hips, 43.8%). Patients underwent a standardized treatment protocol - core decompression with bone grafting and pharmacotherapy based on established literature. The effectiveness of the intervention was assessed radiologically using Kerboul's combined necrotic angle measured on MRI.

Parameter	N	%
Mean Age (years)	30 (range 19-59)	-
Male	35	58.3
Female	25	41.7

Table 1 - Demographic details of the patients included in the study

This table summarizes the demographic characteristics of the study cohort, including the mean age, age range, and sex distribution. The cohort comprised 60 patients with a mean age of 30 years (range 19–59), including 35 males (58.3%) and 25 females (41.7%).

Category	N	%
Laterality		
Unilateral	40	66.7
Bilateral	20	33.3
Etiology		
Idiopathic	27	45
Corticosteroid Use	15	25
Alcohol Consumption	10	16.7
Post-COVID Infection	8	13.3

Table 2 - Laterality and Etiology of Avascular Necrosis

This table presents the distribution of Avascular Necrosis by laterality and underlying etiology. Of the 60 patients, 40 (66.7%) had unilateral involvement and 20 (33.3%) had bilateral involvement. Etiological analysis revealed idiopathic causes in 27 patients (45.0%), corticosteroid use in 15 (25.0%), alcohol consumption in 10 (16.7%), and post-COVID infection in eight (13.3%).

Stage	N	%
1	45	56.2
2A	35	43.8

Table 3: Distribution of Hips According to Modified Ficat–Arlet Stage

This table depicts the distribution of 80 hips based on disease stage. 45 hips (56.2%) were classified as Stage one, and 35 hips (43.8%) as Stage two-A according to the Modified Ficat–Arlet classification.

Since there is no definitive method to precisely predict the prognosis or progression of early-stage avascular necrosis of the femoral head, a review of the literature suggests that Kerboul's combined necrotic angle, as measured on MRI, serves as a reliable tool for estimating the risk of femoral head collapse.

We evaluated the pre-operative Kerboul's combined necrotic angle of each patient using Magnetic Resonance Imaging. Following a 12 months intervention protocol consisting of core decompression, bone grafting, and pharmacotherapy, the Kerboul angle and corresponding risk classification were re-assessed. Upon comparison, no statistically significant change in the Kerboul's combined necrotic angle risk group was observed post-intervention. However, the absence of progression in the angle over time suggests that the intervention may have effectively halted or slowed the progression of the disease.

Grade	Pre-op	At 48 Weeks
Low Risk	16	16
Moderate Risk	18	18
High Risk	6	6

Table 4: Kerboul Angle Grading in Unilateral Cases

This table shows the preoperative and 12 months postoperative Kerboul angle grading for unilateral hips. Stability in grading is observed across all risk categories, indicating no progression of necrosis: 16 hips (40%) were in low risk group, 18 hips (45%) in moderate risk group and six hips (15%) in high risk group, both preoperatively and at 12 months.

Grade	Pre-op		At 48 Weeks	
	Right Hip	Left Hip	Right Hip	Left Hip
Low Risk	7	6	7	6
Moderate Risk	9	9	9	9
High Risk	4	5	4	5

Table 5: Kerboul Angle Grading in Bilateral Cases

This table presents preoperative and 12 months postoperative Kerboul angle grading for bilateral hips, separately for right and left hips. The grading remained stable across all categories, with 13 hips (32.5%) remained in low risk, 18 hips (45%) remained in moderate risk and 9 hips (22.5%)

remained in high risk category, demonstrating effective stabilization of disease.

Overall, the study demonstrates that our intervention leads to significant improvement in clinical outcomes for avascular necrosis of the femoral head and effectively prevents femoral head collapse, particularly when administered during the early stages of the disease.

Representative radiological and clinical images from four cases are presented in Figures 2-10. These include preoperative, immediate postoperative, and follow-up radiographs at 6 months and 12 months, as well as preoperative and 12 month postoperative MRI scans. Clinical photographs illustrate functional recovery at the final follow-up. It should be noted that static images cannot fully capture the complete arc of hip motion or demonstrate the maximal range of movement achieved.

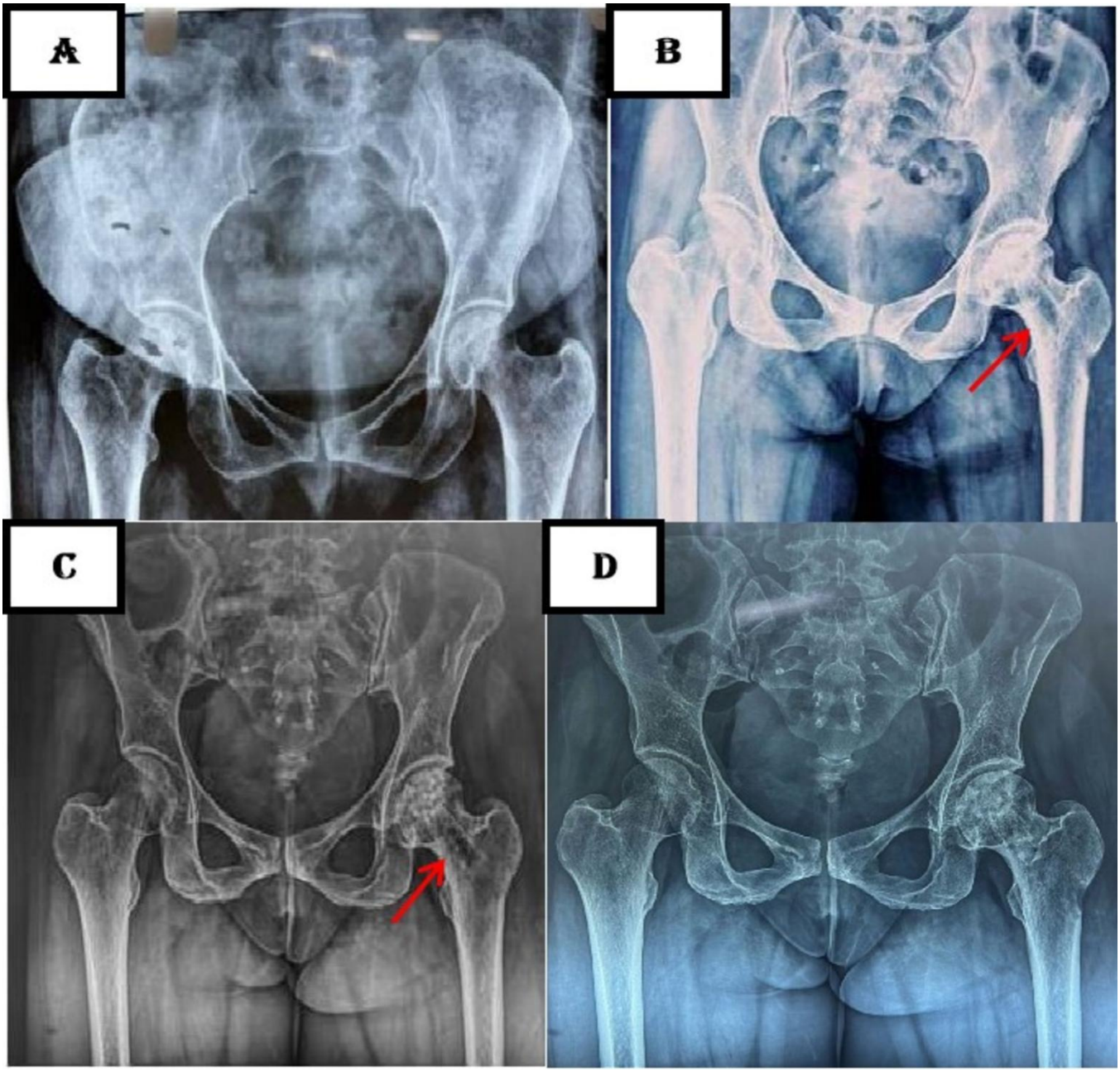

Figure 2: Case 1 - Radiograph. A: preoperative X-ray. B: immediate postoperative X-ray. C: postoperative X-ray at 6 months. D: postoperative X- ray at 12 months. Arrows pointing the femoral tunnel formed during the surgery and gradual healing on sequential radiographs.

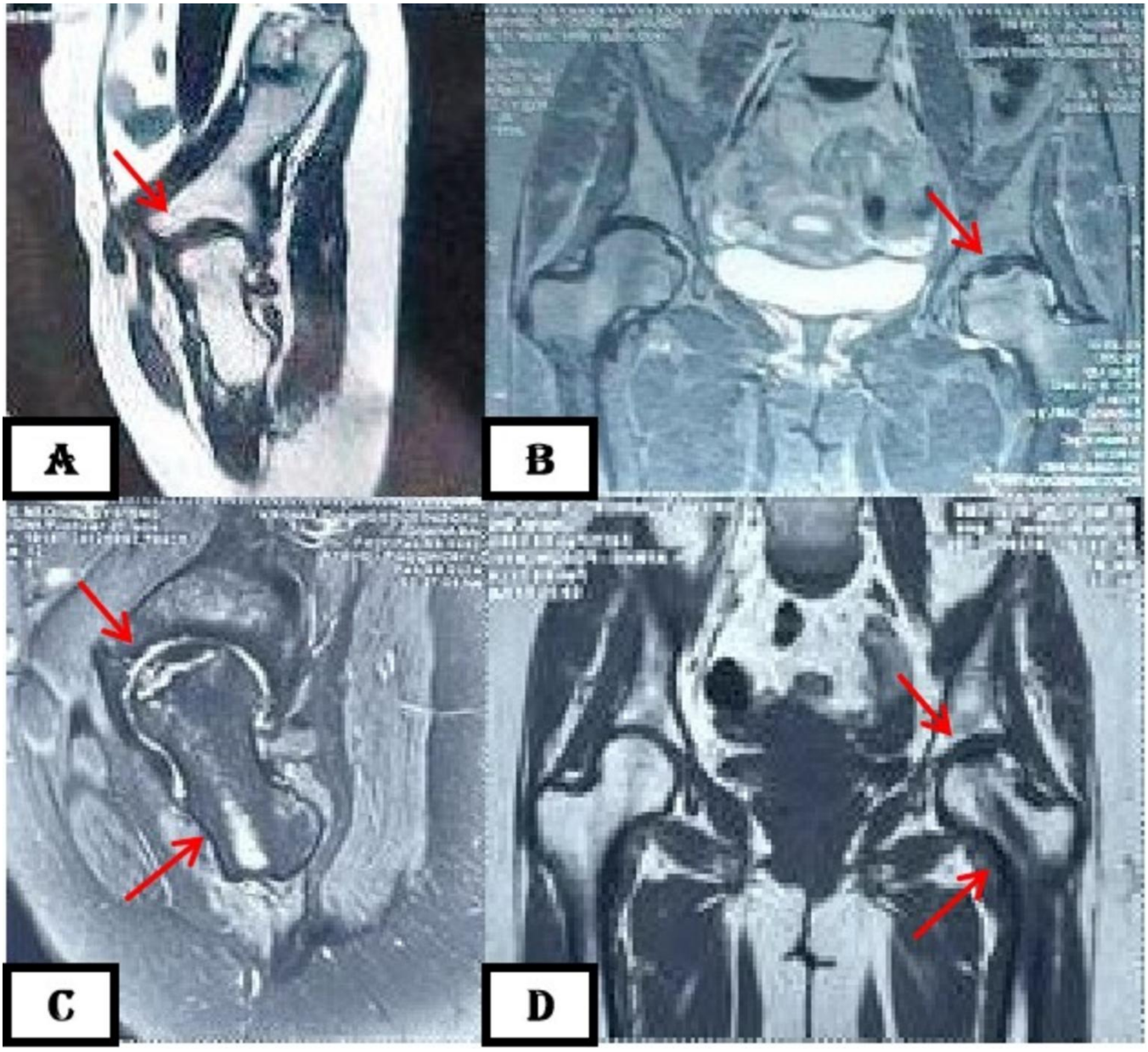

FIGURE 3: Case 1 - MRI. A,B: preoperative MRI showing areas of avascular necrosis of femur head pointed by arrows. C,D: postoperative MRI showing bony canal created during surgery and arrows pointing to the area of avascular necrosis of femoral head.

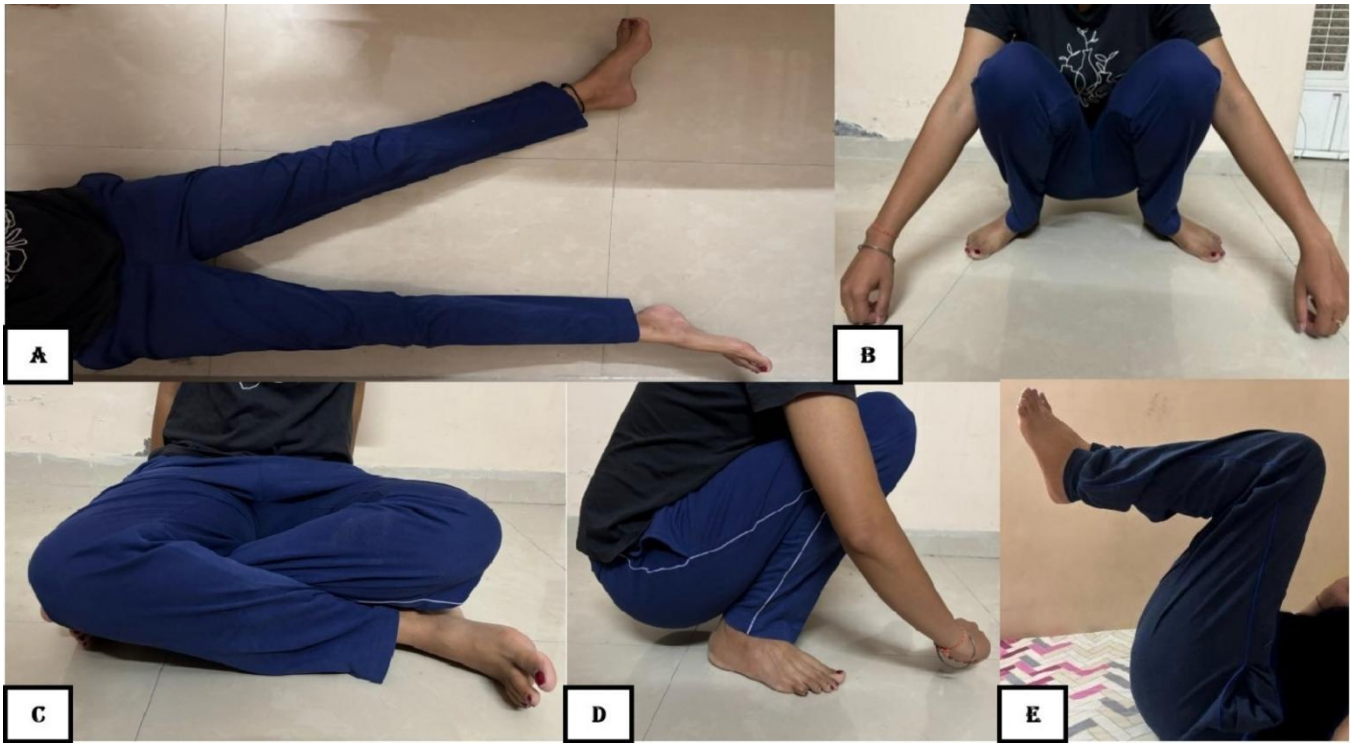

Figure 4: Case 1 - Clinical Picture. A-E: Clinical assessment and hip ROM at 12 months.

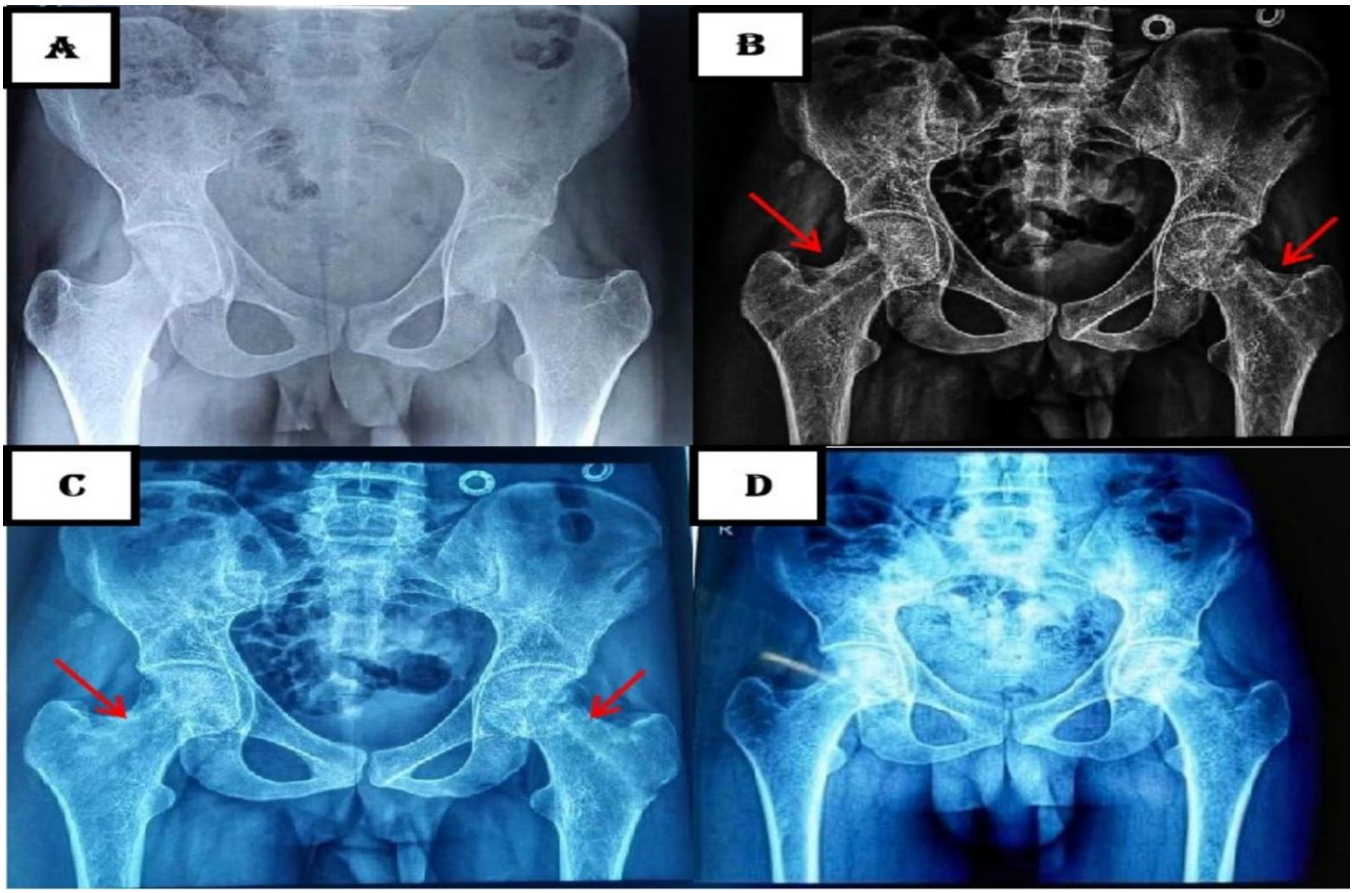

Figure 5: Case 2 - Radiograph. A: preoperative X-ray. B: immediate postoperative X-ray. C: postoperative X-ray at 6 months. D: postoperative X- ray at 12 months. Arrows pointing the femoral tunnel formed during the surgery and gradual healing on sequential radiographs.

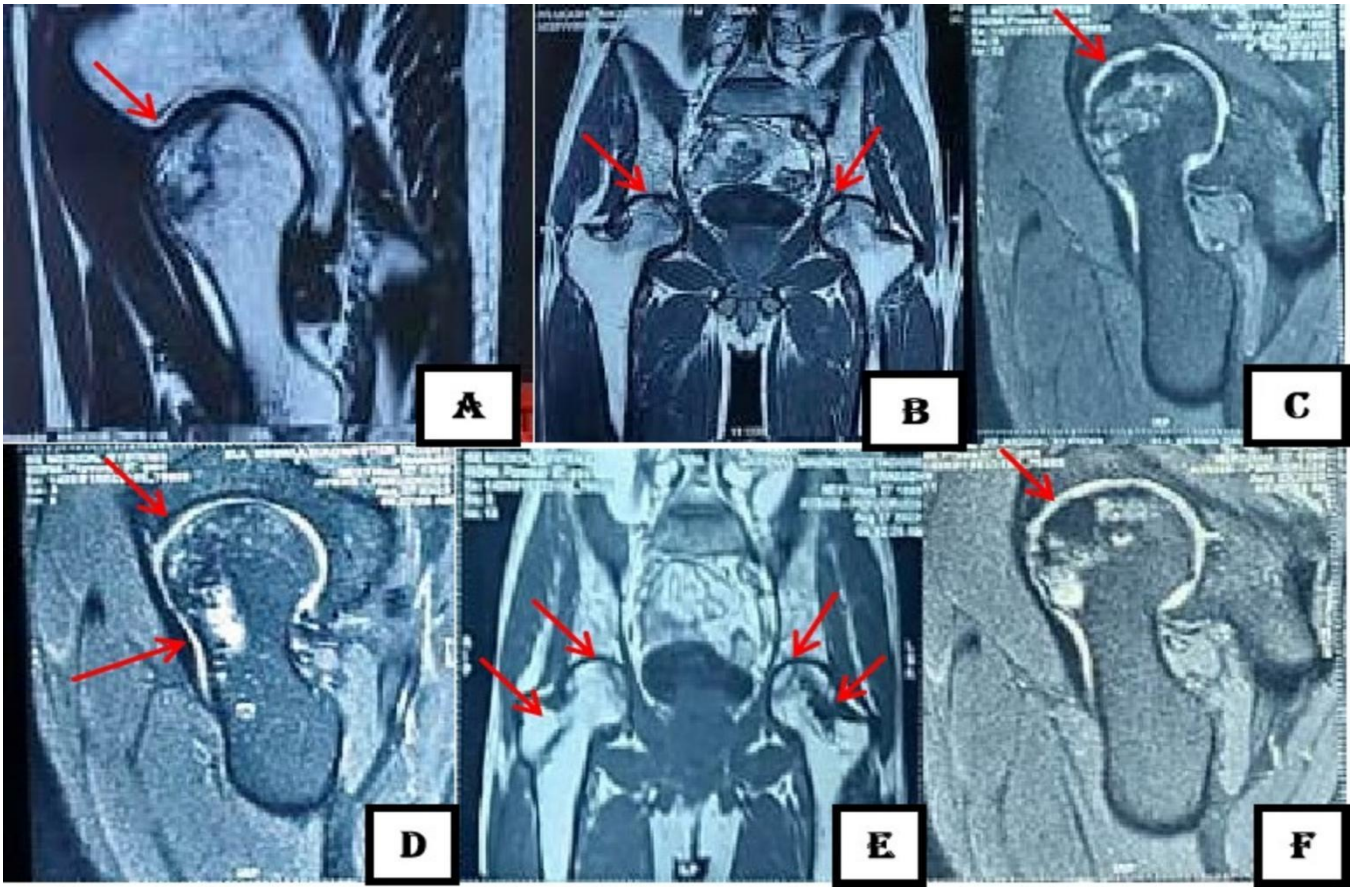

Figure 6: Case 2 - MRI. A,B: preoperative MRI showing areas of avascular necrosis of femur head pointed by arrows. C,D: postoperative MRI showing bony canal created during surgery and arrows pointing to the area of avascular necrosis of femoral head.

Figure 7: Case 2 - Clinical Picture. A-E: Clinical assessment and hip ROM at 12 months.

4. Discussion

Avascular necrosis (AVN) of the femoral head remains a challenging orthopedic condition, with various etiological factors, clinical presentations, and treatment modalities being explored extensively in the literature. This study aimed to evaluate the short-term outcomes of combined surgical and medical treatments in pre-collapsed AVN of femoral head and compare the findings with previous studies.

Steinberg ME et al [15]. evaluated the outcomes of core decompression combined with bone grafting in a cohort of 285 patients, accounting for 406 affected hips. The follow-up duration ranged from two to 14 years, with an average of 48 months. Outcome measures included the Harris Hip Score (HHS), radiographic disease progression, and the incidence of total hip arthroplasty (THA). The findings indicated that patients treated at earlier stages (Stage I/II) experienced significantly more favorable results. Notably, only 14% of patients (57 hips) with small lesions progressed to THA, in contrast to 42-48% (170-195 hips) of those with larger lesions. The study concluded that this intervention could effectively postpone the need for total hip arthroplasty.

Nishii T et al [16]. conducted a study involving 25 patients (36 hips) to examine the effects of Alendronate over a 12-month follow-up period. The evaluation was based on radiographic imaging, biochemical markers, and pain assessment scores. Results demonstrated that Alendronate significantly lowered the incidence of femoral head collapse (two hips; five % compared to 17 hips; 46%, $p = 0.008$) and was effective in slowing the progression of pain ($p = 0.003$). These findings support its potential usefulness in the treatment of early- stage osteonecrosis.

Villa JC et al [17]. carried out a systematic review of 12 randomized controlled trials, encompassing 592 hips at Stage I/II and 186 hips at Stage three, with an average follow-up duration of 24 months. The review compared the efficacy of core decompression with bone marrow mesenchymal stem cells (BMMCs), core decompression alone, and bisphosphonate therapy. Outcomes were evaluated using radiographic risk of femoral head collapse, rates of total hip replacement (THR), and functional assessment tools including the Harris Hip Score (HHS), Visual Analog Scale (VAS), and WOMAC index. The analysis showed that adding BMMCs to core decompression significantly lowered the risk of femoral head collapse ($p = 0.002$-0.003), although it did not reduce the rate of THR. Bisphosphonate therapy produced inconsistent results, and the authors emphasized the need for additional randomized trials to better define optimal treatment strategies.

Mantri D et al [18]. conducted a study involving 18 patients (25 hips) who underwent core decompression combined with autologous cancellous bone grafting, with follow-up over a nine month period. Functional outcomes were assessed using the Harris Hip Score (HHS) and Visual Analog Scale (VAS) for pain. The findings showed a marked improvement in function, with the HHS rising from 37.2 to 82, and a notable decrease in pain levels, with VAS scores dropping from seven to three. The authors concluded that this approach is an effective treatment option for young individuals presenting with early-stage avascular necrosis of the femoral head.

Our study included a total total of 60 patients with 80 hips undergoing core decompression with bone grafting and pharmacotherapy with a follow up period of 48 weeks. Mean age was 30 years (range 19-59) with male predominance of 35 patients (58.3%). Unilateral AVN was more common seen in 40 patients (66.7%) while bilateral in 20 patients (33.3%). Idiopathic cause was most frequent found in 27 patients (45%) followed by corticosteroid use in 15 patients (25%), alcohol consumption in 10 patients (16.7%) and post- COVID infection in 8 patients (13.3%). According to Modified Ficat-Arlet classification 45 hips (56.2%) were in stage one and 35 hips (43.8%) in stage two-A showing patients

mainly presented in precollapse stage. Patients underwent a standardized treatment protocol - core decompression with bone grafting and pharmacotherapy based on established literature. The effectiveness of the intervention was assessed radiologically using Kerboul's combined necrotic angle measured on MRI. At the 12 months follow-up, MRI scans showed a reduction in the Kerboul angle by approximately four ± two degree in some hips compared to preoperative measurements. However, this change was not substantial enough to shift the patients into a different risk category. Nonetheless, the absence of an increase in the angle over time suggests that progression toward femoral head collapse was effectively prevented.

The study concluded that core decompression combined with autologous bone grafting and pharmacotherapy in pre-collapsed avascular necrosis of the femoral head results in significant clinical improvement in both unilateral and bilateral cases and effectively prevents femoral head collapse, particularly when implemented at an early stage.

The strength of this study is that it was prospective with same surgical technique and fixed drug protocol in all cases. We had sixty patients and eighty hips which is bigger than many single center reports. The main limitation is that it was single center and follow up only till 12 months so late collapse and conversion to arthroplasty could not be seen. Detailed assessment of imaging changes was limited due to the resource- constrained nature of this study conducted in a developing country setting such as India and there was no control group for direct comparison with conservative care.

In future longer follow up beyond five years is needed to see true hip survival, as well as to explore the relationship between Kerboul's combined necrotic angle classification and risk stratification in predicting disease progression. Multicentric trials should compare simple decompression with augmentation like bone marrow cells, vascularized grafts and bisphosphonates. Patient selection based on necrotic angle and etiology and cost effectiveness in Indian set up should also be studied further.

5. Conclusions

The study indicates that the majority of patients presented in Modified Ficat-Arlet stage one avascular necrosis of the femoral head, with the most prevalent etiology being idiopathic. The applied intervention - core decompression with bone grafting and pharmacotherapy in cases of pre-collapsed Avascular necrosis of femoral head resulted in notable clinical improvement. Although Kerboul's combined necrotic angle risk classification remained largely unchanged at 12 months post intervention, the lack of disease progression indicates that the treatment effectively stabilized the condition. These findings underscore the importance of early intervention in preventing further femoral head collapse. No complications, including femoral head collapse, bone graft failure, surgical site infection or the need for total hip replacement, were observed during the follow-up period.

Despite its limitations, this study provides prospective data from a tertiary care center in India, emphasizing the importance of timely intervention in the management of early-stage avascular necrosis. These findings are particularly relevant for surgeons practicing in resource-constrained settings, where cost-effective strategies and favorable short-term outcomes can play a critical role in clinical decision-making.

References

1. Matthews AH, Davis DD, Fish MJ, et al.: Avascular Necrosis. [Updated 2023 Aug 28]. In. StatPearls [Internet, Treasure Island (FL): StatPearls Publishing:2025.

2. Barney J, Piuzzi NS, Akhondi H: Femoral Head Avascular Necrosis. [Updated 2023 Jul 3]. In. StatPearls [Internet, Treasure Island (FL): StatPearls Publishing:2025.
3. Moya-Angeler J, Gianakos AL, Villa JC, Ni A, Lane JM: Current concepts on osteonecrosis of the femoral head. World J Orthop. 2015, 18:590-601.
4. Mont MA, Cherian JJ, Sierra RJ, Jones LC, Lieberman JR: Nontraumatic Osteonecrosis of the Femoral Head: Where Do We Stand Today? A Ten-Year Update. J Bone Joint Surg Am. 2015, 7:1604-27. 10.2106/JBJS.O.00071
5. Weinstein RS: Glucocorticoid-induced osteonecrosis. Endocrine. 2012, 41:183-90. 10.1007/s12020-011- 9580-0
6. Zalavras CG, Lieberman JR: Osteonecrosis of the femoral head: evaluation and treatment . J Am Acad Orthop Surg. 2014, 22:455-64. 10.5435/JAAOS-22-07-455
7. Cheng EY, Thongtrangan I, Laorr A, Saleh KJ: Spontaneous resolution of osteonecrosis of the femoral head . J Bone Joint Surg Am. 2004, 86:2594-9. 10.2106/00004623-200412000-00002
8. Agarwala SR, Vijayvargiya M, Pandey P: Avascular necrosis as a part of 'long COVID-19' . BMJ Case Rep. 2021, 2:242101-10. 10.1136/bcr-2021-242101
9. Ha YC, Jung WH, Kim JR, Seong NH, Kim SY, Koo KH: Prediction of collapse in femoral head osteonecrosis: a modified Kerboul method with use of magnetic resonance images. J Bone Joint Surg Am. 2006, 88:35-40. 10.2106/JBJS.F.00535
10. Kerboul M, Thomine J, Postel M, Merle d'Aubigné R: The conservative surgical treatment of idiopathic aseptic necrosis of the femoral head. J Bone Joint Surg Br. 1974, 56:291-6. 10.1302/0301-620X.56B2.291
11. Yoon BH, Mont MA, Koo KH, et al.: The 2019 Revised Version of Association Research Circulation Osseous Staging System of Osteonecrosis of the Femoral Head. Iorio R, Jo WL, Jones LC, Khanduja V, Kim HKW, Kim SY, Kim TY, Lee HY, Lee MS, Lee YK, Lee YJ, Nakamura J, Parvizi J, Sakai T, Sugano N, Takao M, Yamamoto T, Zhao DW. The. 20192020, 35:933-940. 10.1016/j.arth.2019.11.029
12. Ehman RL: MR imaging with surface coils . Radiology. 1985, 157:549-50. 10.1148/radiology.157.2.4048470
13. Hauzeur JP, Pasteels JL, Schoutens A, Hinsenkamp M, Appelboom T, Chochrad I, Perlmutter N: The diagnostic value of magnetic resonance imaging in non-traumatic osteonecrosis of the femoral head. J Bone Joint Surg Am. 1989, 71:641-9.
14. Malizos KN, Karantanas AH, Varitimidis SE, Dailiana ZH, Bargiotas K, Maris T: Osteonecrosis of the femoral head: etiology, imaging and treatment. Eur J Radiol. 2007, 63:16-28. 10.1016/j.ejrad.2007.03.019
15. Steinberg ME, Brighton CT, Corces A, et al.: Osteonecrosis of the femoral head. Results of core decompression and grafting with and without electrical stimulation. Clin Orthop Relat Res. 1989, 199:2582668.
16. Nishii T, Sugano N, Miki H, Hashimoto J, Yoshikawa H: Does alendronate prevent collapse in osteonecrosis of the femoral head?. Clin Orthop Relat Res. 2006, 443:273-9. 10.1097/01.blo.0000194078.32776.31
17. Villa JC, Husain S, van der List JP, Gianakos A, Lane JM: Treatment of Pre-Collapse Stages of Osteonecrosis of the Femoral Head: a Systematic Review of Randomized Control

Trials. HSS J. 2016, 12:261-271. 10.1007/s11420-016-9505-9

18. Mantri D, Thora A, Garg SP, Saraf A, Kushwah B: Osteonecrosis of femoral head managed with core decompression and autologous bone grafting. Int J Sci Res. 2022, 11:1-5. 10.36106/ijar/8609483