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Avascular necrosis hips: management with core decompression bone graft and bone marrow aspirate concentrate

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ABSTRACT

Background: Avascular necrosis of the femoral head is a disorder that can lead to the collapse of the femoral head and can progress to secondary osteoarthritis, which would ultimately require a total hip replacement. It can be avoided if the disease is diagnosed at an early stage. Intra-osseous pressures can be reduced, thereby aiding in halting the disease progression by core decompression along with bone marrow aspirate concentrate with morselized bone allograft. Aim was t**o** evaluate the role of core decompression with BMAC with bone grafting for the treatment of early stage AVN of the hip by clinical and functional outcomes of the patient.
Methods: A prospective observational study done to evaluate the clinical and functional outcomes by using the Harris hip score with domains for pain, functional activity, range of motion, and gait. Pre-operative and 18-months post-operative HHS was calculated in 30 samples between 30-50 years undergoing core decompression with BMAC and bone grafting in AVN hip upto Ficat Arlet stage IIb.
Results: There was a significant increase in HHS from 67.66±9.87 pre-operatively to 92.4±7.4 post-operatively ($p<0.05$) which is statistically significant), indicates marked pain relief and functional well-being of the patients.
Conclusions: Core decompression with BMAC and bone grafting is safe and effective in the early stages of AVN of the femoral head and is helpful in delaying the progression of AVN leading to THR based on clinical and functional outcomes of the patients at 18 months follow up.

Keywords: AVN, Harris hip score, Core decompression, Bone marrow aspirate concentrate, Morselized bone graft, Clinical and functional outcomes

INTRODUCTION

Avascular necrosis (AVN) of the femoral head, characterized by the death of bone tissue due to inadequate blood supply, is a complex and multifactorial condition that often affects young patients, leading to femoral head collapse and secondary osteoarthritis. Although its etiology remains unclear, AVN poses a significant clinical challenge due to its potential for joint deterioration and functional impairment.[1] In the early stages of AVN (Ficat & Arlet stage I–IIb), preserving the integrity of the femoral head and preventing its collapse are crucial therapeutic goals.[2] Core decompression, a widely employed intervention, involves drilling into the necrotic area to reduce intra-osseous pressure and enhance blood supply, thereby potentially halting disease progression. However, despite its widespread use, there exists a subset of patients who experience suboptimal outcomes, indicating that alternative or adjunctive therapies might be required. Systematic reviews verified the significantly better head survival rates compared to non-operative treatment options. The pathogenesis of AVN hip with treatment has been shown in (Figure 1).

It has been suggested that one of the reasons for poor healing in some patients is that there might be insufficient osteoprogenitor cells in the femoral head to support the repair of the necrotic bone. One promising adjuvant therapy is the utilization of bone marrow aspirate concentrate (BMAC), in conjunction with core decompression and morselized bone grafting. BMAC, rich in osteoprogenitor cells and growth factors, holds the potential to augment bone healing and regeneration within the necrotic femoral head[3]. The combination of core decompression, morselized bone grafting, and BMAC could synergistically improve outcomes by providing mechanical support and cellular resources for bone repair. While several studies have reported positive outcomes with the combined approach of core decompression and BMAC in diverse populations, limited research has explored its efficacy within the Indian context.[4-6] This study seeks to bridge this knowledge gap by evaluating the role of core decompression with BMAC and morselized bone grafting in the treatment of AVN of the hip, with the primary focus on assessing changes in the Harris Hip Score as a measure of functional improvement. By investigating the outcomes of this combined approach in an Indian setting, this study aims to contribute valuable insights to the management of AVN and potentially provide an evidence-based therapeutic option for patients experiencing this debilitating condition.

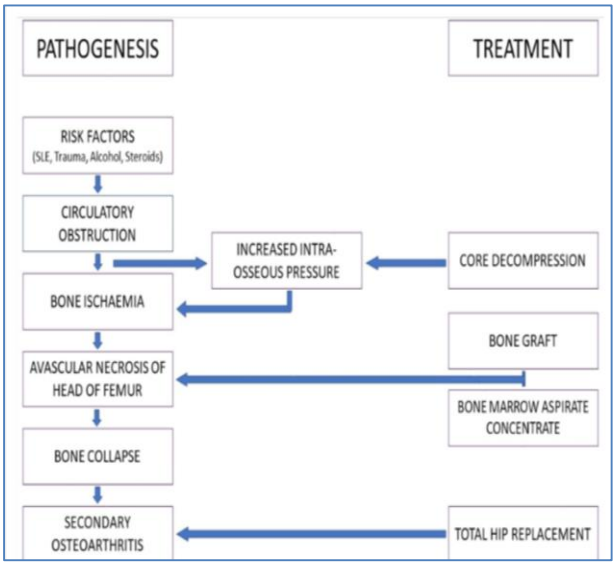

Figure 1: Pathogenesis of AVN of head of femur with treatment.

Objectives

Objectives were to assess the change in Harris Hip Score (HHS) following core decompression with bone marrow aspirate concentrate (BMAC) and morselized bone grafting for aseptic non-traumatic avascular necrosis of the femoral head and to contribute to the existing body of knowledge regarding the use of core decompression with BMAC in an Indian population.

METHODS

Study design

This study employed a prospective observational design to assess the outcomes of core decompression with bone marrow aspirate concentrate and morselized bone grafting for aseptic non-traumatic avascular necrosis of the femoral head. Patient follow-up was conducted at 18 months postoperative (January 2019 to July 2023).

Inclusion and exclusion criteria

The study included patients who met the following inclusion criteria: Skeletally mature individuals diagnosed with AVN of the hip. Age between 30 and 50 years. Ficat and Arlet Stage I, IIa, or IIb and Patients with a good range of motion of the hip, characterized by a spherical femoral head. Patients were excluded based on the following criteria: Patient refusal to participate. Presence of peadiatric hip disorders. Deformed femoral head and Stiff hip.

Sample size

A sample size of 30 patients was determined based on previous studies with similar methodologies. Patients diagnosed with AVN of the hip and meeting the inclusion and exclusion criteria were selected from the orthopedics outpatient department of Bombay Hospital Institute of Medial Scienes, Mumbai. All patients provided informed consent before participating in the study. Detailed medical histories were collected from patients and their attendants, with particular attention to alcohol and steroid intake. Comprehensive systemic and local examinations were conducted. Radiological assessments, including X-rays and MRI scans, were performed to aid in clinical diagnosis. Routine preoperative investigations were conducted to assess fitness for surgery.

Outcome measure

The primary outcome measure was the change in Harris Hip Score (HHS), which is a comprehensive scoring system encompassing pain, functional activity, range of motion, deformity, and gait of the patient. The scoring domains included pain severity, functional ability, gait quality, and range of motion of the hip joint.

Surgical technique

Patient positioning: Patients underwent induction with general or spinal anesthesia based on individual suitability. The patient was positioned supine on a fracture table with both limbs in neutral, patella facing upward, and feet secured in traction boots. Fluoroscopy was used to ensure appropriate positioning for both AP and lateral views. Sterile draping done exposing the iliac crest proximally and mid-thigh distally (Figure 2).

Figure 2: Patient positioning: Supine over fracture table.

Bone marrow aspiration

Bone marrow harvesting was performed from the anterior iliac tubercle, the widest part of the iliac crest. Using a 3-mm skin incision, a Cook's needle was inserted for bone marrow aspiration. A bevelled metal trocar of 8 cm length and a bore of 1.5 mm was pushed deep by hand, about 6 cm into the cancellous bone of the iliac crest so that the tip lay between the inner and outer tables. Aspiration was conducted using a 50 mL syringe flushed with heparin (Figure 3).

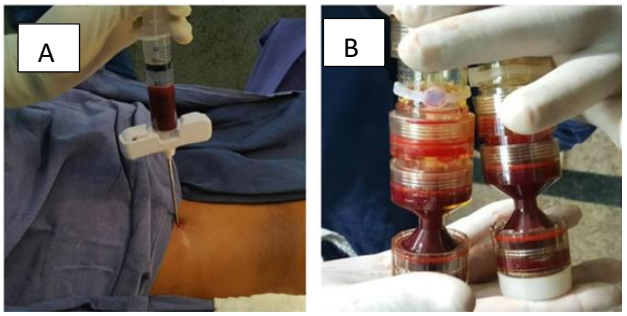

Figure 3: A): A 50 ml syringe that was flushed with heparin was used to aspirate the marrow from Anterior Iliac Crest, B) The aspirated bone marrow was collected in a bottle and centrifuged to separate heavier nucleated portion of the bone marrow, rich in stem cells, which is BMAC.

If marrow is not obtained, the needle should be reoriented. Once the needle is inserted to the desired depth, the tip is swept around a full circle slowly, with the bevelled end pointing in different directions at each step. This procedure is continued until a sufficient quantity of bone marrow 120 ml have been harvested. All the marrow aspirated is discharged into a plastic collection bag containing acid citrate dextrose (ACD) anticoagulant solution. This collected marrow is then filtered to remove fat aggregates and clots, and bone marrow aspirate concentrate was prepared. The aspirated material has to be reduced in volume in order to increase its stem cell concentration (bone marrow aspirate concentrate).

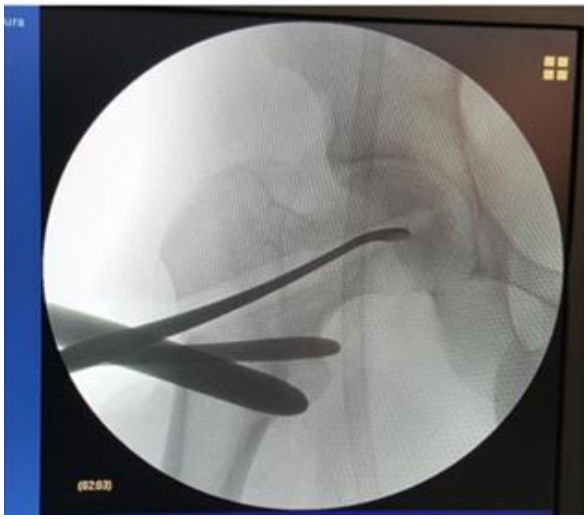

Figure 4: AP Radiograph of Hip Joint showing a tract made by inner drill of the triple reamer for Core Decompression. Tract is then curetted in all four directions i.e., Anterior, Posterior, Superior and Inferior to remove dead necrotic bone.

Figure 5: After centrifugation, BMAC was taken in a syringe and added to morselized bone allograft.

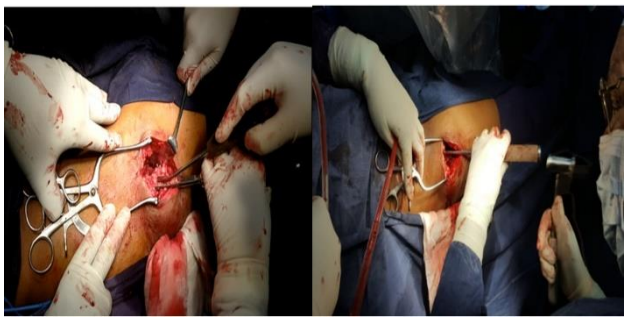

Figure 6: Demonstrating the pushing of bone graft with BMAC in the reamed tract with the help of round punch and gauge.

his is done by removing some of the red blood cells (the non-nucleated cells) and the plasma, in such a way as to retain only the nucleated cells, i.e., the mononuclear stem cells, monocytes, lymphocytes, and granulocytes. The marrow is first filtered to separate cellular aggregates and fat. It is then concentrated in a cell separator. A 5-minute centrifugation at 400 G forces the polynuclear cell layer, which is heavier because of its nuclei, to the periphery where it is collected and separated from the remainder of the marrow. The RBCs are collected in the centre and recovered with the plasma. All that remained is the mono-nuclear layer containing stem cells as shown in (Figure 3). This centrifugation technique reduces a 120 ml bone marrow aspirate to 5 ml of stem cells. BMAC is therefore obtained and aspirated into a syringe. This procedure takes about 15 minutes.

Core decompression

A 3-cm incision was made at the entry point located at the base of the greater trochanter. A guide wire was inserted in the centre of the head in both AP and Lateral views under fluoroscopic guidance. Necrotic areas were decompressed using a 3.2 drill in the anterosuperior, anteroinferior, posterior-superior, and postero-inferior, till 5 mm in the subchondral bone avoiding joint violation. Curettage was performed in the reamed tract in all the directions to remove necrotic bone (Figure 4). This procedure is initiated while the blood sample is getting processed for BMAC.

Bone grafting

Morselized bone graft (allograft) mixed with BMAC was filled into the decompressed tunnel (Figure 5). Impaction was done using a gouge and round punch until the tunnel was completely filled (Figure 6). A bone block was used at the lateral cortex to prevent graft extrusion (Figure 7).

Figure 7: Inserting the Bone block at the lateral cortex to prevent the backout of the bonegraft from the reamed tract.

Other side

The same procedure can be done on the other hip if needed, using the remaining morselized graft and BMAC.

Post-operative care

Patients were initially mobilized with partial weight-bearing using a walker for 6 weeks, followed by partial weight-bearing with a cane for 3 weeks, and finally progressed to full weight-bearing.

Statistical analysis

Descriptive statistics were used to summarize patient demographics and clinical characteristics. Changes in Harris Hip Score were analyzed using appropriate statistical tests, and p values less than 0.05 were considered statistically significant.

RESULTS

The study included a total of 30 patients diagnosed with aseptic non-traumatic avascular necrosis of the hip. The demographic distribution of the study population revealed that the majority of patients were within the age range of 30 to 40 years (70%), followed by those aged 41 to 50 years (30%). The mean age of the study participants was 38.2±6.3 years. The (Figure 8-9) represents patient demographic distribution.

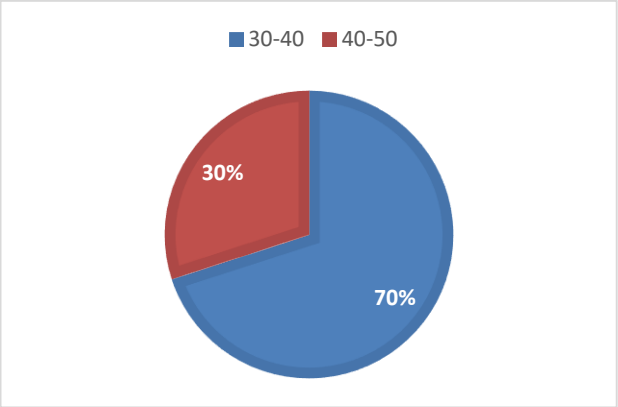

Figure 8: Patient demographic data in terms of age.

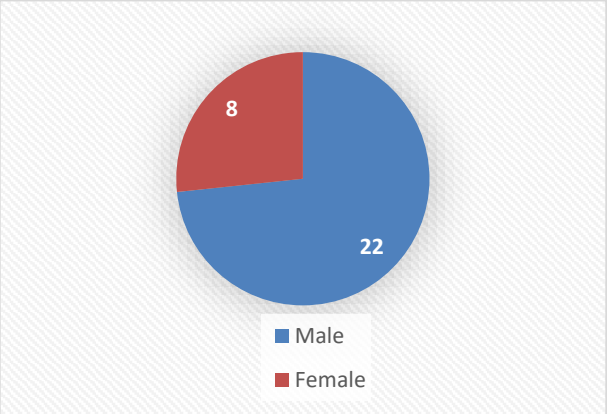

Figure 9: Patient demographic data in terms of gender.

Harris Hip Score was calculated for each patient both before the surgical intervention and at the 18-month postoperative follow-up. The assessment encompassed various domains including pain, functional activity, range of motion, and gait, culminating in the calculation of the overall mean HHS.

The (Table 1) represents the HHS scores for each domain before and after 18 months of surgery, along with the corresponding standard deviations and the calculated p-values. The data presented in (Table 1) demonstrates significant improvements across various HHS domains following the surgical intervention. Specifically, the pain domain exhibited a statistically significant decrease in pain and increase in the score from a preoperative mean of 23.6±4.9 to a postoperative mean of 41.4±4.2 ($p<0.05$). Similarly, functional activity scores improved from 9.1±2.05 to 12.9±1.4 ($p<0.05$), range of motion scores increased from 5.2±0.55 to 6.06±0.78 ($p<0.05$), and gait scores showed enhancement from 29.6±2.37 to 32.06±1.72 ($p<0.05$).

Table 1: HHS among the study population.

Parameters	Pre-operative	Post-operative (18 months)	P value
Pain	23.6±4.9	41.4±4.2	<0.05
Functional activity	9.1±2.05	12.9±1.4	<0.05
Range of motion	5.2±0.55	6.06±0.78	<0.05
Gait	29.6±2.37	32.06±1.72	<0.05
Final HHS	67.66±9.87	92.4±7.4	<0.05

The most notable change was observed in the final HHS, which increased significantly from a preoperative mean of 67.66±9.87 to a postoperative 18 months mean of 92.4±7.4 ($p<0.05$). This comprehensive score, reflecting the overall functional outcome, signifies that those patients experienced substantial improvements in functional status, pain reduction, gait pattern, and range of motion following the surgical intervention.

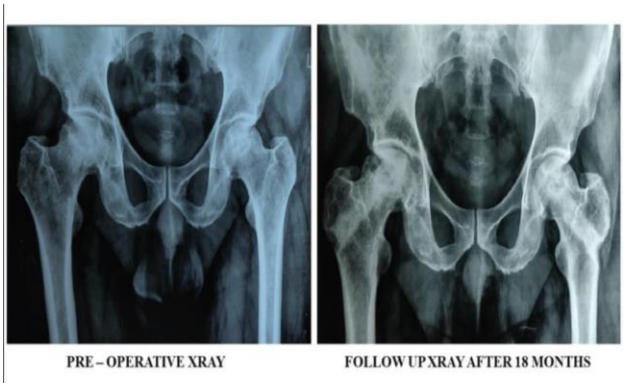

Figure 10: The preoperative and the postoperative X-ray with maintained sphericity of the femoral head.

Follow up radiograph of a patient who was operated for bilateral AVN of the femur head clearly shows that progression of the disease process was arrested as shown in (Figure 10). There were signs of healthy bone regeneration and remodelling. In summary, the results highlight excellent functional outcomes for patients undergoing core decompression with BMAC and morselized bone grafting for aseptic non-traumatic AVN of the hip. The observed reductions in pain, along with improvements in functional activity, gait pattern, range of motion, and the overall Harris Hip Score underscore the positive impact of the surgical approach on patients' quality of life and functional well-being. Remarkably, none of the patients in this study required total hip replacement during the follow-up period.

DISCUSSION

Avascular necrosis, also referred to as osteonecrosis, is a pathological condition characterized by the death of trabecular bone cells due to ischemia. As the disease progresses, the affected femoral head may experience collapse of the articular surface. Autologous bone marrow grafting has been identified as a viable method for achieving long-lasting repair in cases of femur head osteonecrosis. While some repair can occur after core decompression, this repair often remains incomplete. One possible explanation for this incomplete repair could be the insufficient number of progenitor cells in the femoral head of patients with osteonecrosis.[7] The reparative osteogenic potential appears to be low in osteonecrosis, and studies have demonstrated a reduction in bone progenitor cell numbers in the uninvolved part of the femoral head and the trochanteric region of AVN hips compared to healthy individuals. While the direct causative relationship between reduced progenitor cells and AVN remains to be fully established and requires further investigation, treatment strategies aimed at preserving femoral head integrity should focus on stimulating new bone formation and remodeling at the necrotic site. This stimulation can be facilitated through the utilization of BMAC.[8] Early detection of AVN and the application of less invasive treatment approaches offer promising avenues for preserving the femoral head, resulting in improved outcomes and potentially delaying or avoiding the need for total hip replacement (THR). Among these treatment options, core decompression has emerged as a superior approach to non-operative conservative therapy. Previous studies have demonstrated that core decompression, especially when performed in the early stages of AVN, leads to significant post-operative pain reduction.[9-11] When combined with BMAC and morselized bone grafting, as introduced by Hernigou et al this treatment modality has shown improved head survival rates compared to cases where only core decompression was performed. In our study, the majority of participants fell within the age group of 31 to 40 years (70%), followed by the 41 to 50 years age group (30%). This age distribution aligns with previous findings that AVN tends to affect individuals aged 20 to 40 years, with an average age at presentation around 38

years. Similar studies by Mont et al, Hernigou et al, Vardhan et al have reported comparable age distributions, further corroborating these observations.[8,12,14,15] Assessing pain relief, studies such as Martin et al and Wojciech et al have reported significant reductions in pain postoperatively. Our study also demonstrated a marked increase in the pain domain of the Harris Hip Score (HHS), from 23.6±4.9 preoperatively to 41.4±4.2 postoperatively, indicating a substantial decrease in hip joint pain throughout the observation period.[16,17] The significant improvements observed in range of motion (ROM), functional activity, and gait are consistent with the enhanced outcomes associated with the surgical intervention. These improvements are evident in the increase in ROM from 5.2±0.55 to 6.06±0.78, the rise in functional activity scores from 9.1±2.05 to 12.9±1.4, and the elevation in gait scores from 29.6±2.37 to 32.06±1.72. Notably, the final HHS demonstrated a substantial increase from a mean preoperative score of 67.66±9.87 to a mean postoperative score of 92.4±7.4. These findings are consistent with similar studies, including Agarwal et al which reported improvements in mean HHS scores following similar interventions.[19]

Limitations

Limitations were; long term results are to be evaluated to assess the outcome of the procedure and multicentric studies are required. Postoperative MRI evaluation and its co-relation with the functional outcome was not done. The reporting systems were highly variable, from different clinical scores HHS/D'Aubigne/VAS to differing classifications used for staging disease (Ficat or its modification, Steinberg, ARCO). Further, large sample size is required in order to reach the final conclusion.

CONCLUSION

In conclusion, our study adds to the growing body of evidence supporting the efficacy of core decompression with BMAC and morselized bone grafting for AVN of the hip. The results suggest that this combined approach leads to reduced pain, enhanced functional activity, improved range of motion, and superior gait patterns. These outcomes underline the potential of this treatment modality in achieving favourable functional results and preserving femoral head integrity, offering patients a promising alternative to conventional management and potentially delaying the need for total hip replacement. While recognizing the need for a larger sample size and extended follow-up duration to more comprehensively assess the treatment's long-term viability, the clinical and functional outcomes to strongly advocate for its consideration as a viable treatment option. Further research in this direction holds the potential to refine and enhance this treatment approach, offering lasting benefits to individuals suffering from AVN of the femoral head. Further research in evaluating the radiological outcomes is needed to observe if there is reversal in progression of the AVN.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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