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Core Decompression with Bone Marrow Aspirate Concentrate Implantation in Osteonecrosis of the Femoral Head

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ABSTRACT
A vascular necrosis (AVN) of the femoral head is a condition where blood supply to this vital area is diminished. This leads to severe bone damage, micro fractures and ultimately the collapse of the articular surface in more advanced stages. AVN is responsible for around 10% of total hip replacements, emphasizing the need for early intervention. Core decompression is a widely accepted surgical technique for the treatment of early-stage AVN, demonstrating favourable outcomes in pre-collapse phases (FICAT and ARLET stages 0-II). However, there is a notable decline in efficacy when this procedure is performed in advanced stages (FICAT and ARLET stage III or IV). This prospective study was done in Department of Orthopaedics, Sree Mookambika institute of medical sciences with 20 AVN patient. Patients with idiopathic AVN of femoral head, stage 1, 2A, or 2B were included in the study. Patients with stage 3 or 4 AVN of femoral head were excluded from the study. Outcomes were evaluated based on the Visual Analog Scale for pain and hip function was measured using the Modified Harris Hip scores. The mean visual analog scale (VAS) scores showed a considerable decline from 8.75±0.45-3.25±0.52. Accordingly, the mean Modified Haris Hip Score increased from 47.18±3.84 preoperatively to 89.14±5.03 at 24 months, indicating significant improvement in hip range of motion and functional activities. Core decompression with BMAC is effective method to treat early stages of AVN.

INTRODUCTION

A vascular necrosis (AVN) of the femoral head is a significant condition that occurs when blood supply to this vital area is diminished, often due to coagulation in the small blood vessels within the bone. This inadequate blood flow can lead to severe bone damage, micro fractures and ultimately the collapse of the articular surface in more advanced stages[1]. Notably, alcohol consumption and corticosteroid use account for over half of AVN cases, making it essential to be aware of these risk factors. Additional contributors include trauma, radiation exposure and sickle cell disease, with approximately 40% of cases being idiopathic[2]. AVN is responsible for around 10% of total hip replacements, emphasizing the need for early intervention. In its initial stages, AVN is often asymptomatic, but it can result in limited mobility and groin pain, particularly during forced internal rotation[3]. Although anteroposterior (AP) and frog-leg lateral radiographs are typically performed, they frequently yield normal results. Hence magnetic resonance imaging (MRI) is considered the gold standard for diagnosis and should be conducted in all suspected cases of classic AVN when X-rays show no abnormalities[4]. Alarmingly, about 70% of patients present with bilateral AVN, highlighting the importance of timely diagnosis. MRI not only confirms the diagnosis but also provides valuable prognostic information regarding the size and location of lesions. Early detection is crucial for the effective management of AVN. If left untreated, 70-80% of individuals may experience a progression to bone collapse and subsequent osteoarthritis of the hip[5]. Understanding AVN and its implications can lead to improved outcomes and a better quality of life. Numerous therapeutic strategies have been proposed for the management of a vascular necrosis (AVN) of the femoral head. Non surgical interventions encompass pharmacological treatments, including lipid-lowering agents, anticoagulants, vaso active substances and bisphosphonates, as well as non-pharmacological modalities such as extra corporeal shockwave therapy, pulse electromagnetic therapy and hyperbaric oxygen therapy. Surgical options range from core decompression to total hip arthroplasty[4]. Core decompression is a widely accepted surgical technique for the treatment of early-stage AVN, demonstrating favourable outcomes when applied during the initial or pre-collapse phases (FICAT and ARLET stages 0 through II). However, there is a notable decline in efficacy when this procedure is performed in advanced stages (FICAT and ARLET stage III or IV)[6]. One potential contributing factor to the sub optimal healing observed in certain patients may be the lack of sufficient osteoprogenitor cells within the femoral head, which are critical for the regeneration of necrotic bone. As a result, the inclusion of bone marrow aspiration concentrate (BMAC) therapy has been proposed as an adjunctive treatment to core decompression. Several studies have reported improved clinical outcomes when core decompression is supplemented with BMAC, compared to the procedure performed in isolation. This technical note aims to delineate the methodology of core decompression augmented with BMAC for the treatment of early AVN of the femoral head, with the goal of optimizing patient outcomes and enhancing the overall efficacy of the therapeutic approach.

MATERIALS AND METHODS

This prospective study was done in Department of Orthopaedics, Sree Mookambika institute of medical sciences, Kanyakumari from January 2022 to September 2024. In this study 20 patients with a vascular necrosis of femoral head were included in this study. Patients with idiopathic AVN of femoral head radiographic evidence (stage 1, 2A, or 2B depending on the modified FICAT and ARLET classification) who showed no symptomatic improvement of the conservative line of management for 6 months were included in the study.

Patients with stage 3 or 4 AVN of femoral head were excluded from the study, depending on the modified FICAT and ARLET classification and patients with other causes of AVN of femoral head were also excluded. After obtain institute ethical commission and patient who were willing to give consent were included in this study.

Procedure:

Patient Positioning: Depending on patient condition they were either inducted with spinal or general anesthesia. Patient in supine position on fracture table with both limbs in traction boots, foot in neutral position and patella facing upwards the position is checked by fluoroscopic imaging. Parts were painted and draped. The surgical site was exposed from iliac crest up to mid thigh.

Bone Marrow Aspiration: The aspiration of bone marrow done in the broadest portion of the iliac crest, also known as the anterior iliac tubercle was used to extract bone marrow. A Cook's needle was introduced for bone marrow aspiration through a 3 mm skin incision. The tip of an 8 cm long, bevelled metal trocar with a 1.5 mm bore was manually driven 6 cm deep into the iliac crest's cancellous bone, between the inner and outer tables. A 20mL syringe flushed with heparin was used for aspiration. If marrow is not obtained, the needle should be reoriented. the tip is carefully swept around a full circle with the bevelled end pointed in different directions at each step once the needle has been inserted to the desired depth. This process is repeated until sufficient amount of bone marrow have been extracted. A polypropylene

collection bag filled with an acid citrate dextrose (ACD) anticoagulant solution is used to discharge all of the aspirated bone marrow. After filtering the obtained marrow to get rid of fat clots and aggregates, bone marrow aspirate concentrate was made. To raise the aspirated material's concentration of stem cells (bone marrow aspirate concentrate), its volume must be decreased. This is accomplished by eliminating a portion of the plasma and red blood cells (the non-nucleated cells) so that only the nucleated cells - monocytes, granulocytes, lymphocytes and mononuclear stem cells-remain. This is done by filtering the marrow to remove fat and cellular debris. After that, a cell separator is used to concentrate it. The poly nuclear cell layer, which is heavier due to its nuclei, is forced to the periphery by a 5-minute, 400 G centrifugation, where it is gathered and separated from the rest of the marrow. In the centre, the RBCs are gathered and extracted along with the plasma. The mononuclear layer with stem cells is all that is left. A 120 ml bone marrow aspirate is reduced to 5 ml of stem cells using this centrifugation method. Consequently, BMAC is extracted and aspirated into a syringe. About fifteen minutes are needed for this process. (Fig. 1).

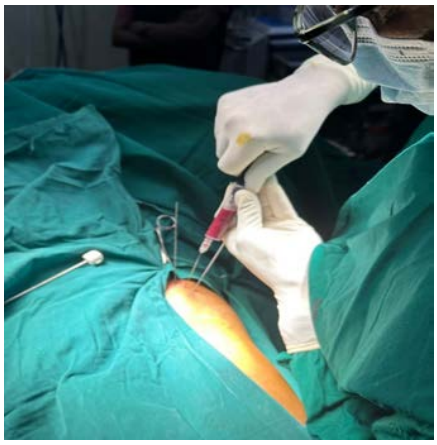


Fig. 1: Bone Marrow Aspiration from Iliac Crest

Core Decompression: At the entry location that is the base of the greater trochanter, a 3 cm incision was created. Under fluoroscopic supervision, a guide wire was placed in the middle of the head in both AP and Lateral views. Anterosuperior, anteroinferior, posterior -superior and postero-inferior necrotic regions were decompressed using a 3.2 drill till 5 mm in the subchondral bone, preventing joint violation. To remove necrotic bone, curettage was done in both directions in the reamed tract While the blood sample is being processed for BMAC, this process is started. The BMAC is injected directly into the necrotic zone using 18G spinal needle with 20 ml syringe and sealed with bone wax. Sometimes, significant resistance is encountered because of the sclerotic bone then the surgeon should remove the cannula by 2-3 mm and re attempt injection. The hip joints were passively moved throughout its range of motion immediately after the injection to disperse the fluid throughout the joint. (Fig. 2,3).

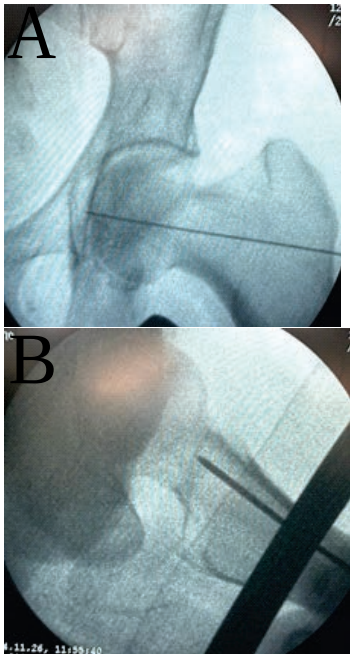


Fig. 2: Fluoroscopic Fig Showing Core Decompression of Hip in AP (A) and Lateral View(B)

Fig. 3: Delivery of Bone Marrow Aspiration Concentrate (BMAC) Through a Disposable Cannula with Spinal Needle Directly in Necrotic Area

Post Operative Care: Following the surgery all patient received intravenous antibiotics for three days, which were then switched to oral antibiotics for an additional five days. Six weeks of partial weight-bearing with a walker following which patients were eventually advanced to full weight. Patients were discharged on postoperative day 3. Follow-up appointments were scheduled at two weeks, one month, three month, six months, one year and two years. Physiotherapy included quadriceps and hamstring strengthening

exercises and patients were permitted to do light activities as tolerated. After 6-8 weeks, patients were permitted to resume full activity. Outcomes were evaluated based on the Visual Analog Scale for pain and hip function was measured using the Modified Harris Hip scores. Analysis of statistics Clinical features and patient demographics were compiled using descriptive statistics. Using the proper statistical procedures, changes in the Modified Harris Hip Score were examined., p values below 0.05 were deemed statistically significant.

RESULTS AND DISCUSSIONS

This study includes 20 patients diagnosed with traumatic a vascular necrosis of femoral head. This study includes patients mostly in age group 31-40 years (75%) followed by 41-50 years (25%) (Fig. 4).

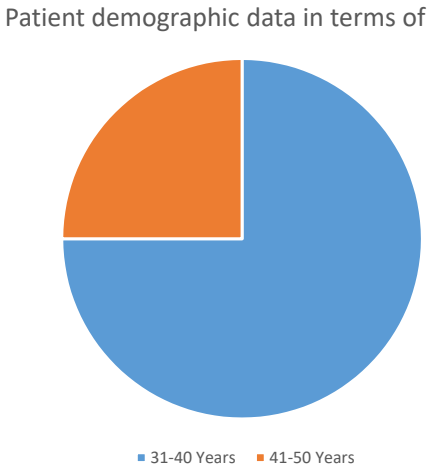


Fig. 4: Patient Demographic Data in Terms of Age

This study includes 17 male patients and 3 female patients. Male to female ratio 5.6:1 (Fig. 5).

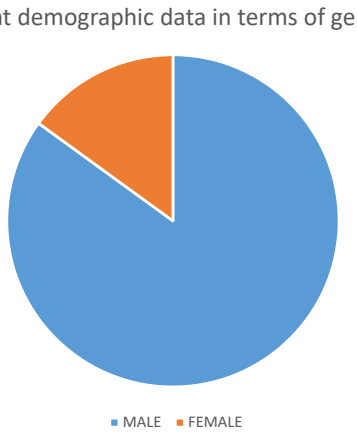


Fig. 5: Patient Demographic Data in Terms of Gender

In this study most of the cases 13 (65%) of study population were affected with osteochondrosis in bilateral hip followed by right hip (20%) and left hip (15%) (Fig. 6).

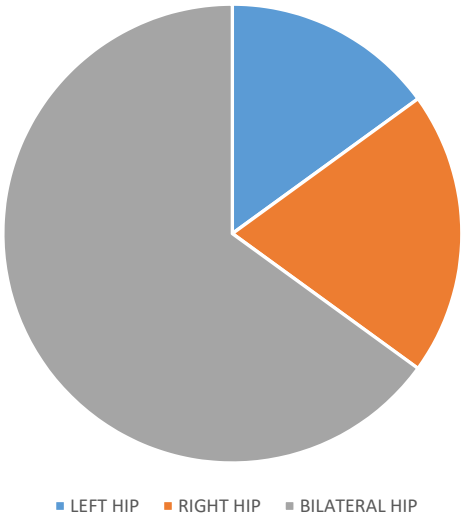


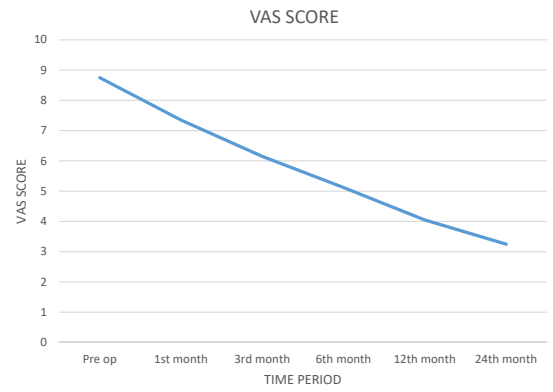
Fig. 6: Patient Demographic Data in Terms of AVN Affected Side

Each patient's Modified Harris Hip Score was determined prior to surgery and during the 24-month postoperative follow-up. The evaluation covered a number of areas, such as gait, range of motion, functional activity and pain and it ended with the computation of the overall mean Modified Harris Hip Score. Over the course of the trial, the mean visual analog scale (VAS) scores showed a considerable decline. At the 24-month follow-up, the scores dropped from a pre-operative mean of 8.75±0.45-3.25±0.52. Accordingly, the mean (±SD) Modified Harris Hip Score increased from 47.18±3.84 preoperatively to 89.14±5.03 at 24 months, indicating significant improvement in hip range of motion, functional activities (stairs, squatting, sitting cross-legged and public transportation), function (limp, support and distance walked) and pain. (Table 1) shows Distribution of visual analog scores and modified Harris hip scores among the study participants.

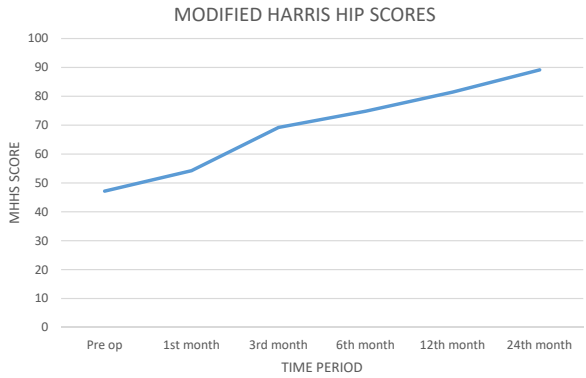
Table 1: Distribution of Visual Analog Scores and Modified Harris Hip Scores Among the Study Participants (N=20)

Time period	Visual analog scores (Mean ±SD)	Modified Harris Hip scores (Mean ±SD)
Pre op	8.75±0.45	47.18±3.84
1st month	7.35±0.62	54.28±8.65
3rd month	6.15±0.33	69.24±6.38
6th month	5.12±0.14	74.85±4.42
12th month	4.05±0.68	81.48±4.89
24th month	3.25±0.52	89.14±5.03
P-value	<0.001	<0.001

(Graph 1) shows the trend of visual analog scale scores over time and (graph 2) show trend of modified Harris hip scores over time. Both VAS and MHHS scores showed a significant shift over time, according to the statistical analysis (P<0.001 for both). In terms of consequences, we noted that one patient had a 5% recurrence of symptoms and one patient had a 5% persistent hip discomfort.



Graph 1: Trend of Visual Analog Scale Scores Over Time



Graph 2: Trend of Modified Harris Hip Scores Over Time

A vascular necrosis, also referred to as osteonecrosis, is a pathological condition caused by ischemia leading to the death of trabecular bone cells. As the disease progresses, the affected femoral head may experience collapse of the articular surface. 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]. Ortho biologics are crucial to the care of osteonecrosis of femoral head, a complicated illness with substantial morbidity. High levels of MSCs, growth factors and cytokines found in BMAC, a possible Ortho biologic, speed up the body's natural healing and tissue regeneration process. BMAC implantation is inexpensive, low-risk and minimally intrusive. It has been effective in lowering pain, boosting patient engagement and enhancing general results. As a result, BMAC implantation is a treatment option that can potentially improve the quality of life for people with osteonecrosis of femoral head. According to one theory, osteonecrosis of femoral head might be caused by a lack of progenitor cells in the proximal femur and femoral head, which would prevent tissue remodeling. Crucially, it contributes to hip joint preservation by maintaining the articular cartilage and normal hip joint geometry. Furthermore, more recent therapies address possible progenitor cell deficits by introducing stem cells to necrotic regions and concentrating on restoring the architecture of the femoral head. 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)[4,8]. Among these treatment options, core decompression has emerged as a superior approach to non-operative conservative therapy. When compared to previous research, our investigation into the effectiveness of Core decompression in conjunction with autologous BMAC offers unique and corroborating findings. Hence this present study was undertaken in Department of Orthopaedics, Sree Mookambika Institute of Medical Sciences from January 2022 to September 2024 to assess the functional outcome using Modified Harris Hip score. In our present study the age of 31-40 years was prevalent which is similar to study done by Ferozkhan[9] and Jhunjhunwala[10]. This study includes 17 male patients and 3 female patients. Male to female ratio 5.6:1. This clearly indicates males are most commonly affected in AVN hip. This is similar to study done by Jhunjhunwala[10]. This study clearly indicates most of the case bilateral hip is affected making it significant that AVN affects bilaterally mostly. In our study there is fall in VAS score in two years follow up period. Preoperative VAS score was 8.75±0.45 which is reduced to 3.25±0.52 which is similar to study done by Ferozkhan[9]. Similarly, the Modified Harris hip score was improved significantly. Preoperative Modified Harris hip score was 47.18±3.84 preoperatively it was improved to 89.14±5.03. This goes in accordance with Ferozkhan[9]. Hernigou and Beaujean were the first to describe core decompression enhanced with BMAC[7]. He showed 189 hips that had undergone bone marrow grafting and core decompression using a 3-mm trocar had better outcome in early phases of AVN. After treatment, all groups showed higher Harris Hip Scores. The AVN stage at the time of the surgery turned out to be quite important. While 41% and 63% of patients needed THR in stages III and IV, respectively, just 2% and 8% of patients needed THR in stages I and II which coincides with our study. Gangji and Hauzeur found that bone marrow implantation significantly reduced discomfort and postponed the advancement of AVN from stages I and II to stage III at 60 months of follow-up[11]. Which is similar to our study. However, they did not note any appreciable variation in the two groups' times to arthroplasty. 51 cases of stage I and II AVN hips were described by Sen[12]. Although there were no discernible variations in imaging between the two groups, their investigation demonstrated that bone marrow implantation improved hip survival. In a prospective randomized clinical trial including 28 hips, Tabatabaee *et al* compared bone marrow

augmentation with unilateral core decompression[13]. At 24 months, the group supplemented with bone marrow reported much less pain. The outcomes of 51 hips that had core decompression and 53 hips that had core decompression enhanced with bone marrow were studied by Zhao[14]. The above-mentioned literature clearly highlights the importance of core decompression with BMAC which is again proved by our study.

CONCLUSION

Core decompression with bone marrow concentrate infiltration is a minimally invasive treatment which potentially delays the need of interventions like Total hip replacement. This study clearly indicated reduced pain (VAS) and improved functional outcome (MHHS). This result clearly suggest that thus combined approach leads to reduced pain, enhanced functional activity, improved range of motion and superior gait patterns. However, limitation of this study is the small sample size and limited follow up period. Postoperative MRI evaluation and its co-relation with the functional outcome was not done indicating the need for further research with a larger group and longer follow-up periods to validate the long-term advantages.

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