# Mid-term Results of Core Decompression and Bone Marrow Aspirate Concentrate Therapy for Avascular Necrosis of Hip: A Retrospective Observational Cohort Study

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## ABSTRACT

**Background**

Core decompression is a surgical procedure done in the early stage of avascular necrosis (AVN) of hip. The addition of bone marrow aspirate concentrate (BMAC) may enhance the outcome compared to the decompression alone.

**Objective**

To evaluate the midterm efficacy of core decompression with bone marrow aspirate concentrate therapy in the pre-collapse stage of avascular necrosis of hip.

**Method**

This retrospective observational cohort study was conducted on patients with MRI-confirmed avascular necrosis, Association Research Circulation Osseous (ARCO) stage I to IIIa of hip, treated with core decompression and bone marrow aspirate concentrate therapy between 2017 and 2024. Functional outcome and severity of pain were assessed using Modified Harris Hip Score (MHHS) and Visual Analogue Scale (VAS) respectively. Progression of the necrosis and the need for hip replacement were assessed in the regular follow-ups. Kaplan-Meier survival analysis was used to assess survival duration of the femoral head.

**Result**

There were 28 hips from 20 patients. The median Modified Harris Hip Score improved from 63.0 (IQR 46-68) to 87.5 (IQR 84-91) ($p < 0.001$ at -34.67 to -20.52 confidence interval), and the average VAS decreased from 7.5 (IQR 6-8) to 1.5 (IQR 1-2) ($p < 0.001$ at 4.18 to 5.91 confidence interval). Five hips progressed to the next stage, out of which two required total hip arthroplasty and three were on conservative management. Kaplan-Meier survival analysis showed a cumulative stage progression free survival of 76.7% at 41 months and sustained through 84 months of follow-up.

**Conclusion**

Core decompression augmented with bone marrow aspirate concentrate is an effective treatment for pre-collapse stage of avascular necrosis of the hip. It provides significant and rapid symptomatic relief, improves functional outcome, and demonstrates a promising midterm, stage progression-free survival of 76.7%, sustained from 41 to 84 months.

## KEY WORDS

*Avascular necrosis of hip, Bone marrow aspirate, Core decompression*

## INTRODUCTION

Avascular necrosis (AVN) of hip predominantly affects young to middle-aged adults, often leading to progressive pain, joint dysfunction, and eventual collapse of the femoral head.[1,2] Without early intervention, it often progresses to osteoarthritis, necessitating total hip arthroplasty (THA), which carries implant longevity concerns in younger patients, making femoral head preservation the primary treatment goal.

Core decompression (CD) is a standard treatment for pre-collapse stage of AVN, but it shows variable success rates (40–70%).[3,4] To enhance outcomes, regenerative therapies such as bone marrow aspirate concentrate (BMAC) have been introduced as adjuncts, promoting bone regeneration and revascularization.[5] Different studies have shown promising long-term results with CD and BMAC therapy.[6,7]

The midterm clinical effectiveness of this combined approach across different ARCO stages remains incompletely defined. This study aims to evaluate the midterm efficacy of CD and BMAC injections in pre-collapse stage of AVN of the hip, assessing pain relief, functional outcomes, and femoral head preservation.

## METHODS

This retrospective observational study included patients with nontraumatic AVN of the femoral head treated with CD and BMAC injection at a tertiary care center between 2017 and 2024. Ethical clearance was taken from the institutional review committee of Kathmandu University School of Medical Sciences (IRC-KUSMS No. 111/25), and patients were enrolled after obtaining their informed consent.

Participants with MRI-confirmed AVN of the hip in the pre-collapse stage for which no prior surgical intervention was performed were included in the study. The revised version of Association Research Circulation Osseous (ARCO) staging system of osteonecrosis of the femoral head was used to stage the AVN of the hip.[8] The stages I, II and IIIa were defined as pre-collapse stages. The data, including demographics, risk factors (smoking, alcohol, steroid use, and comorbidities), ARCO stages of AVN of hip, preoperative visual analogue scale (VAS) for pain, and Modified Harris Hip Score (MHHS), were extracted from electronic medical records and a structured Excel database.[8-10] Patients who had less than one year of follow-up or those with incomplete records, concurrent hip pathologies, or prior surgeries were excluded from the study.

The latest functional status was assessed via MHHS and VAS pain score by an independent research assistant blinded to preoperative scores. The X-ray was graded as either normal or with changes like sclerosis, cysts, or further collapse of the femoral head and was compared with the preoperative X-ray. For those patients who had new onset pain in the hip during the follow-up period, an MRI of the hip was suggested and compared with the preoperative MRI.

**Surgical Procedure:**

**Core decompression**

All the patients were kept on the fracture table so that the true antero-posterior and lateral views could be easily obtained while the procedure was performed. Under the guidance of an image intensifier, a 1.8 mm K-wire was passed to reach the center of the AVN area of the hip. A 6.5 mm cannulated drill bit was used to drill through the K-wire. Curettage was performed along all the walls of the canal. The curetted material was sent for histopathological examination (HPE).

**Bone Marrow Aspiration and Processing**

Bone marrow aspirate concentrate was processed using the technique given by Chahla et al.[11] Under spinal anesthesia, nearly 100 ml of bone marrow was aspirated from the anterior superior iliac crest with a 10 ml syringe mounted on a bone marrow aspirate needle each time the site or direction of aspiration was changed. The aspirate was collected in a 10 ml test tube, each rinsed with a heparinized solution (1000 U/ml dilution). The collected test tubes were then centrifuged at 3200 rpm for 15 minutes. After this process was complete, the buffy coat layer (rich in mononuclear cells and hematopoietic stem cells) and platelet-rich plasma layer (distal 1/4$^{th}$ of the plasma) were extracted.[11] Finally, a total of 10 ml of BMAC was retracted from 100 ml of aspirated bone marrow and kept in a sterile 10 ml syringe rinsed with 0.5 ml of heparinized solution. The BMAC solution was instilled into the predrilled tract, and the opening of the core tract on the lateral cortex was sealed with bone wax.

**Postoperative protocol and follow-up**

All the patients were kept on the same postoperative protocol. Those patients who had surgery performed on one hip at a time were mobilized with protected weight bearing on crutches for at least six weeks. Patients who underwent bilateral hip decompression in a single setting were on wheelchair mobilization for the first six weeks. Then, full weight bearing was allowed. Subsequent courses of clinical and radiological progression were evaluated at three, six, and twelve months. The patients were subsequently kept on yearly follow-up. Survivorship of the hip at the latest follow-up was determined on the basis of the need for THA. The progression of hip collapse, as observed via X-ray, was recorded, and the duration of the progression was recorded.

All the statistical analyses were performed with Statistical Package for the Social Sciences (SPSSS) version 23 (IBM Armonk, NY: IBM Corp). Continuous variables are reported as the means with standard deviation (SD) or 95% confidence intervals (CI) if normally distributed, or medians with interquartile ranges if skewed. Categorical variables are

reported as frequencies (n) and percentages. Based on the normality check, a non-parametric test (Wilcoxon signed-rank test) was used to calculate the average difference between the pre and post-procedure VAS pain scores and MHHSs. Kaplan-Meier survival analysis was used to assess survival duration of the femoral head, with progression to the next ARCO stage as the event of interest. Individual hip follow-up trajectories and disease progression events were visualized using a timeline chart generated with Python (version 3.12; Matplotlib library), with coding assistance from an AI language model (Claude, Anthropic). A p-value of less than 0.05 was considered statistically significant.

## RESULTS

A total of 28 hips (twelve unilateral hips and eight bilateral hips) from the 20 participants met the eligibility criteria and were included in the study. Fifteen were males and five were female, with a median age of 38.5 years (IQR: 26.25-52.25 years). The participants had an average follow-up of 3.16 ± 1.80 years (range: one to seven years). The cause of the AVN was idiopathic in eight participants, whereas in five participants, it was due to steroid intake (Table 1).

**Table 1. Demographic and Epidemiologic Parameters (n = 20 participants for demographic data; n = 28 hips for ARCO staging)**

| Characteristic | n (%) |
|---|---|
| **Gender** | |
| Male | 15 (75) |
| Female | 5 (25) |
| **Side** | |
| Bilateral | 8 (40) |
| Unilateral | 12 (60) |
| **Age** | |
| 25-35 | 9 (45) |
| 36-45 | 4 (20) |
| 46-55 | 4 (20) |
| 56-65 | 3 (15) |
| **Etiology** | |
| Idiopathic | 8 (40) |
| Steroid intake | 5 (25) |
| Alcohol + Steroid | 3 (15) |
| Alcohol | 4 (20) |
| **ARCO stage of AVN of hip (n = 28 hips)** | |
| I | 4 (14.28) |
| II | 16 (57.14) |
| IIIa | 8 (28.57) |

Among the 28 hips, four were classified as Stage I, 16 as Stage II and eight as Stage IIIa. Preoperatively, the status of the patient was assessed using the MHHS, which revealed that 15 patients (75%) had poor scores, whereas five patients (25%) had fair scores. The postoperative MHHS was also assessed at 12 months and at the latest follow-up (ranging from 12 months to seven years). At the latest follow-up, seven patients (35%) demonstrated excellent outcomes, 10 patients (50%) had good outcomes, and the remainder had fair to poor outcomes.

The median MHHS improved from 63.0 (IQR 46-48) to 87.5 (IQR 84-91). The median VAS pain score decreased from 7.5 (IQR 6-8) preoperatively to 1.5 (IQR 1-2) post-operatively. Both improvements were statistically significant ($p < 0.001$, Wilcoxon signed-rank test) with a large effect size (Table 2).

The mean time to achieve near-complete pain-free status after surgery was approximately 3.5 months. Significant pain relief was achieved in 13 participants (65%), whereas the remaining patients reported either no pain or very minimal pain during the recovery period.

**Table 2. Comparison of pain and functional outcome**

| Outcome Measure | Before Surgery | After Surgery at latest follow-up | p-value | 95% CI |
|---|---|---|---|---|
| **VAS pain score** | Median: 7.5 (IQR 6-8) | Median: 1.5 (IQR 1-2) | < 0.001* | 4.18 to 5.91 |
| **Modified Harris Hip Score** | Median: 63.0 (IQR 46-48) | Median: 87.5 (IQR 84-91) | < 0.001* | -34.67 to -20.52 |

*Wilcoxon signed-rank test

Five (17.85%) hips showed progression of one grade ARCO stage by 12 to 84 months. Among them, the three hips progressed from stage II to stage IIIa and are still being managed nonoperatively; however, these patients are considered potential candidates for total hip replacement (THR) in the near future, and the two hips progressed from stage IIIa to stage IV and underwent THR.

No intraoperative complications were reported. Postoperative complications were reported in two hips; both had subtrochanteric fractures of the right hip at three-month and four-month postoperative periods following fall injuries at ground level. Both were managed with closed reduction and internal fixation with a long proximal femoral nail, and they were not included for final analysis of pain and functional outcome.

The Kaplan-Meier survival analysis showed a cumulative hip preservation rate of 96.4% at 12 months, 91.4% at 28 months, and 85.3% at 36 months. The survival probability subsequently decreased to 76.7% at 41 months and remained stable up to 84 months (Fig. 1). However, median progression-free survival time (50% survival threshold) was not reached. The numbers at risk, censored observation, and events (progression of ARCO stage of AVN of the hip) at each follow-up are displayed beneath the X-axis in figure 1.

The events and timeline chart illustrates a case-by-case visual representation of the follow-up course of all 28 hips (Fig. 2). Among the four Stage I hips, all remained stable and had no progression throughout the entire follow-up period. Among the 16 Stage II hips, three showed progression to stage IIIa at 36, 41, and 84 months and were

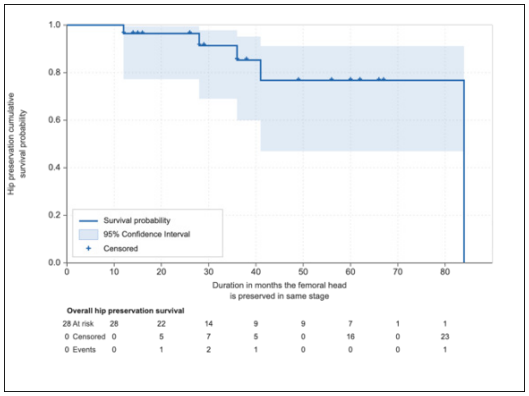


**Figure 1. The Kaplan-Meier survival curve showing the cumulative femoral head survival probability of the femoral head after CD and BMAC therapy.**

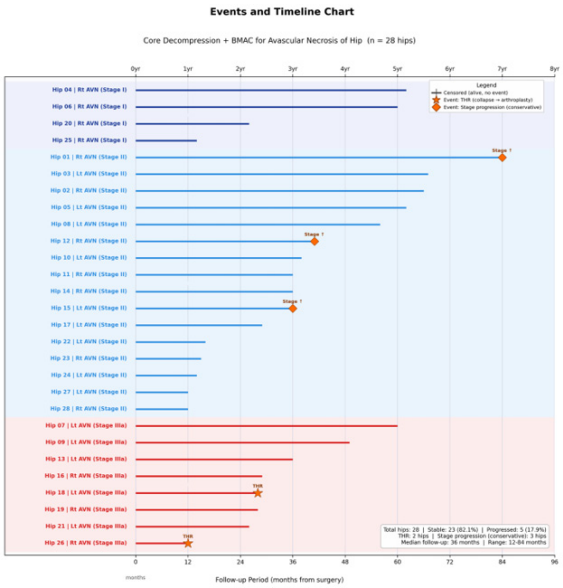


**Figure 2. Events and timeline chart of 28 hips treated with CD + BMAC for avascular necrosis. Bars represent follow-up. Diamond marker ( ♦ ): hips that progressed in stage but were managed conservatively (Stage II ➔ IIIa). Star marker (★): hips that underwent THR. Censored observations: hip stable at last follow-up**

managed conservatively. Out of eight stage IIIa hips, two showed progression to stage IV at 12 and 28 months and required total hip arthroplasty.

## DISCUSSIONS

This retrospective observational cohort study demonstrated that the combination of core decompression (CD) and bone marrow aspirate concentrate (BMAC) injection is an effective femoral head-preserving procedure for early-stage avascular necrosis (AVN) of the hip, suggesting significant improvements in pain and functional outcomes and 76.6% femoral head survival at 41 months and sustained up to 84 months follow-up period.

The substantial improvement in the median MHHS from 63.0 preoperatively to 87.5 at the latest follow-up and the

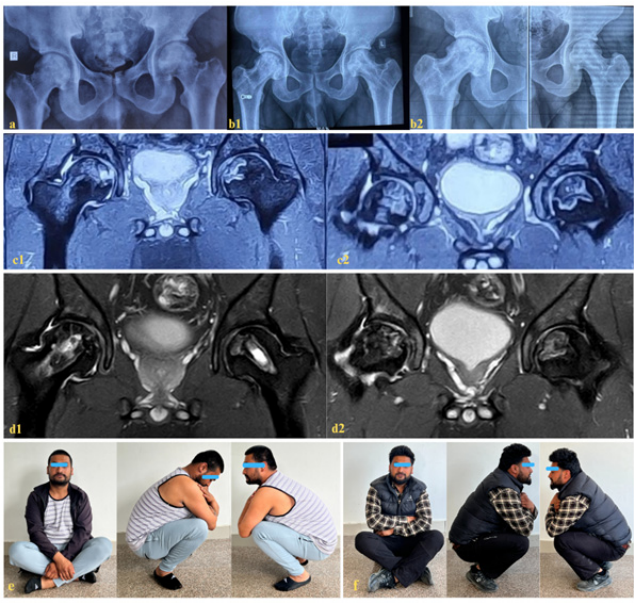


**Figure 3. A 34-years male with bilateral ARCO stage II AVN of hip. (a) Preoperative radiograph (b1) One-year postoperative radiograph showing maintained femoral head architecture. (b2) Four-year postoperative radiograph showing progression of AVN of right hip to stage IIIa, while the left hip has healed. (c1, c2) Preoperative MRI of bilateral hips demonstrating a greater necrotic area in right hip with well-maintained sphericity bilaterally. (d1, d2) Four-year post-operative MRI showing an increase in the area of the necrotic region in right hip along with a crescent sign, while in the left hip, the necrotic area has decreased.**

corresponding reduction in the median VAS pain score from 7.5 to 1.5 highlights the potent analgesic and functional restorative potential of this combined procedure. Recent clinical studies increasingly favour CD combined with BMAC over CD alone, particularly in pre-collapse stage of AVN of hip.[12,13] Feder et al. reported that 75% of their stage II hips remained radiographically stable at a mean of 27 months following CD and BMAC.[12] Similarly, Ferozkhan et al. observed significant functional improvement and prevention of collapse in most stage II hips treated with this combination, confirming its short- to mid-term effectiveness.[14] Compared with CD alone, other biologic augmentation methods, such as platelet-rich plasma or retrodrilling with BMAC, have also demonstrated superior outcomes.[13,15] Collectively, these findings support the role of biologic augmentation in enhancing hip survival, pain relief, and functional outcomes.

The finding that 17 (85%) patients achieved good to excellent outcomes (MHHS) further reinforces the clinical utility of this procedure. These results are consistent with those reported by Hernigou et al., who, in a long-term study with a mean follow-up of 15 years, reported a survival rate of 80% for hips treated with CD and bone marrow-derived stem cells.[7] While CD reduces intraosseous pressure and improves blood flow, it does not fully address the biological deficits in osteoprogenitor cells and angiogenic factors characteristic of AVN.[5,16] The injection of BMAC, which is rich in mesenchymal stem cells (MSCs), osteogenic precursors, and growth factors, is believed to promote osteogenesis and

angiogenesis within the necrotic lesions.[4,16,17] Thus, the two techniques function synergistically: CD creates a conducive mechanical environment, whereas BMAC provides a biological substrate for bone repair and regeneration.[1,4,18,19]

Kaplan-Meier survival analysis provides critical midterm efficacy data, demonstrating a cumulative femoral head preservation rate of 85.3% at 36 months and 76.6% at 41 months, sustained through 84 months of follow-up. This survival rate is greater than the 40-60% rates historically reported for CD alone at similar time points. However, our findings align with the 78% 5-year hip survival rate with CD and BMAC therapy, as reported by Bozkurt et al.[13] The median progression-free survival time was not reached, indicating more than half of the hips remained stable throughout the follow-up, which is a favourable outcome.

The pattern of progression in the curve suggests rare events of progression at 12 months and 84 months. The few progressions occurred between 28 and 41 months. This survival curve provides a crucial visual representation of the procedure's midterm durability. This finding indicates that for the majority of patients, CD and BMAC effectively halts the progression of the disease and preserves the native joint for a substantial period. However, the curve also acknowledges the reality of treatment failure in a subset of patients, as seen in our cohort, where two hips (7.14%) progressed to collapse (stage IV) and required THA. The curve trajectory suggests that while the procedure offers a significant protective effect, particularly in the first few years, the risk of collapse, although diminished, persists over the long term. This signifies the importance of continued patient surveillance even after a successful initial outcome. The events and timeline chart (Fig. 2) provides an individual hip's visual representation of this durability, confirming the pattern observed in the Kaplan-Meier analysis.

The progression of disease in five hips (17.85%), including the two that required THA, invites analysis of potential risk factors for failure. All progressing hips were in the more advanced stages preoperatively (Stages II and IIIa). This finding is consistent with the established literature indicating that the success of joint-preserving procedures is highly dependent on the structural integrity of the femoral head before intervention.[20,21] Larger lesion size and the presence of subchondral fractures (which may begin in late Stage III) are known negative prognostic factors.[22,23]

There are certain limitations inherent to our study design. The retrospective nature of this study introduces the potential for selection and information bias. The sample size, although substantial in terms of hips (n=28), is derived from a relatively small cohort of patients (n=20), which may limit the generalizability of the findings and the power for robust subgroup analyses. The mean follow-up period of 3.16 years, while providing valuable midterm data, is insufficient to draw definitive conclusions about the very long-term (> 10 years) efficacy of the procedure in delaying THA, especially in this young patient population. The absence of a control group (e.g., patients treated with CD alone or nonoperative management) makes it impossible to definitively attribute the positive outcomes solely to BMAC augmentation, although the results are favorable compared with those of historical controls. Additionally, no subgroup analysis was performed for steroid-induced versus idiopathic AVN; lesion size was not systematically recorded; and the impact of postoperative subtrochanteric fracture on final outcome measures was not separately analyzed.

Our recommendations for future directions would be to include prospective, randomized controlled trials with larger sample sizes and longer follow-up periods to directly compare CD and BMAC with other treatment modalities. Further research is needed to standardize BMAC processing protocols, identify the most predictive biomarkers of success, and refine patient selection criteria to maximize outcomes for individuals with this challenging condition. The authors intend to continue prospective follow-up of the current cohort to monitor long term survivorship and radiological progression of collapse of the femoral head. This will enable a more definitive and long term evaluation of the effectiveness of the CD and BMAC therapy.

## CONCLUSION

Core decompression augmented with bone marrow aspirate concentrate is a promising treatment for early-stage avascular necrosis of the hip. It provides significant and rapid symptomatic relief, improves functional capacity, and demonstrates promising midterm, stage progression-free survival of 76.6%, sustained from 41 to 84 months.

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