Mid-term results of Core Decompression and Stem Cell 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 evaluates the midterm efficacy of core decompression with bone marrow aspirate concentrate in early-stage avascular necrosis of hip.

Method

This retrospective observational cohort study was conducted on 28 hips from 20 patients with MRI-confirmed avascular necrosis, Association Research Circulation Osseous (ARCO) stage I-IIIa of hip, treated with core decompression and bone marrow aspirate concentrate 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

The average mHHS improved from 57.65 ± 16.11 to 85.25 ± 10.86 ($p < 0.001$ at -34.67 to -20.52 confidence interval), and the average VAS decreased from 7.15 ± 1.31 to 2.10 ± 1.58 ($p < 0.001$ at 4.18-5.91 confidence interval). Five hips progressed to the next stage, out of which two required arthroplasty and three were on conservative management. Kaplan-Meier survival analysis showed 75% of the patients had their femoral head preserved for at least 70 months.

Conclusion

Core decompression augmented with bone marrow aspirate concentrate is a safe and effective treatment for early-stage avascular necrosis of the hip. It provides significant and rapid symptomatic relief, improves functional capacity, and demonstrates promising midterm survival of 75% in preventing femoral head collapse and delaying the need for total hip arthroplasty.

KEY WORDS

Avascular necrosis of hip, Bone marrow aspirate, Core decompression

INTRODUCTION

Avascular necrosis (AVN) of the 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 is less suitable for younger patients due to implant longevity concerns. Core decompression (CD) is a standard treatment for early-stage AVN, but 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 superior long-term results with CD + BMAC compared to CD alone.[6,7] This study aims to evaluate the durability and stage-specific effectiveness of CD and BMAC, helping define its role in preserving the femoral head and delaying THA in younger patients with AVN of hip.

METHODS

This retrospective observational study included 28 hips from 20 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 the institute (IRC-KUSMS No. 111/25), and patients were enrolled after obtaining their informed consent.

Participants with MRI-confirmed AVN of the hip (stage I–III) for which no prior surgical intervention was performed were included in the study. The data, including demographics, risk factors (smoking, alcohol, steroid use, comorbidities), AVN stage classified according to Association Research Circulation Osseous (ARCO) classification, 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 1 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 the latest VAS pain score. 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.

Core decompression

All the patients were kept on the fracture table so that the true AP 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. 2017.[11] Under spinal anesthesia, nearly 100 to 150 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 tube was then centrifuged at 3200 rpm for 15 minutes.[11] After this process was complete, the buffy coat layer (rich in mononuclear cells and hematopoietic stem cells) and platelet-rich plasma layer (distal 1/4th of the plasma) were extracted.[11] Finally, a total of 10 ml to 12 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 for at least six weeks. Patients who underwent B/L 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 (X-ray ± MRI) were evaluated at three, six, and twelve months. The patients were subsequently kept on yearly follow-up. Survivability 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 SPSS 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. A non-parametric test was used to calculate the average difference between the pre and post-procedure VAS pain scores and MHHSs.

RESULTS

Among the twenty participants (12 with unilateral hips and 8 with bilateral hips), 15 (75%) were male and five (25%) were female, with an average 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: 1-7 years). The cause of the AVN

was unknown in 8 (40%) participants, whereas in 5 (25%) participants, the cause of the AVN was found to be due to steroid intake (Table 1).

Table 1. Demographic and Epidemiologic Parameters (n = 20)

Gender	n (%)
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	
I	4 (14.28)
II	16 (57.14)
IIIa	8 (28.57)
IIIb	0

Preoperative staging of osteonecrosis of the femoral head was performed via the ARCO classification. Among the 28 hips, four (14.28%) were classified as Stage I, 16 (57.14%) as Stage II, eight (28.57%) 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 average mHHS before surgery was 57.65 ± 16.11, which increased to 85.25 ± 10.86 ($p < 0.001$ at -34.67 to -20.52 confidence interval).

The average VAS pain score before surgery was 7.15 ± 1.31, which reduced to 2.10 ± 1.58 ($p < 0.001$ at 4.18-5.91 confidence interval). The average time to pain relief following surgery was 2.1 months, and it took approximately 3.5 months for the patients to achieve almost complete pain-free status. Significant pain relief was achieved in 13 patients (65%), whereas the remaining patients reported either no pain or very minimal pain during the recovery period.

Among the 28 (14 right and 14 left) operated hips, only two patients underwent revision surgery via core decompression and BMAC. Five (17.85%) progressed the ARCO stage

Table 2. Pain and Functional outcome

	Before Surgery	After Surgery at latest follow-up
VAS pain score	7.15 ± 1.31	2.10 ± 1.58
Modified Harris Hip Score	57.65 ± 16.11	85.25 ± 10.86

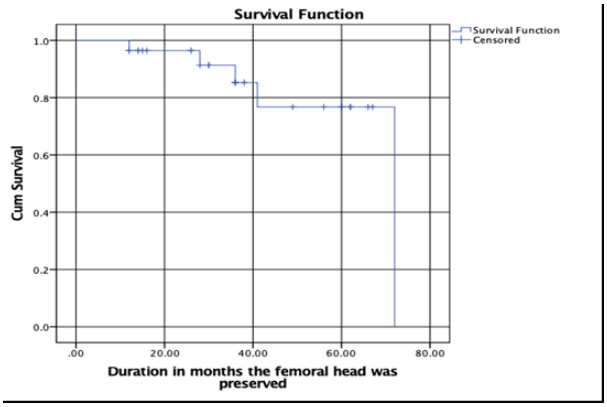

Figure 1. The Kaplan-Meier survival curve (time in months) shows the survival of the femoral head after CD+BMAC.

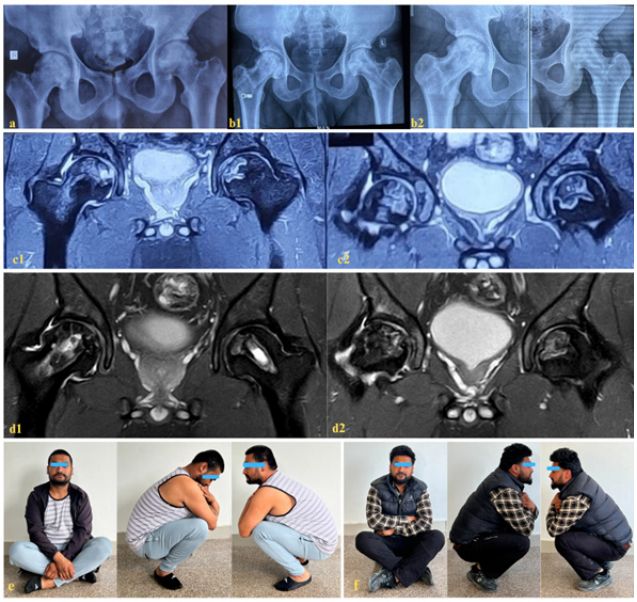

Figure 2. 34 years male with B/L AVN of hip, ARCO stage II (a), (b1) 1 year post-op x-ray, (b2) 4 year post of x-ray showing progression of AVN of rt hip to stage IIIa whereas lt hip has healed, (c1,c2) preoperative MRI of B/L hip showing greater area of necrotic area in rt hip the left hip, with well-maintained shape of both hips, (d1,d2) 4 years post-operative MRI showing increase in area of necrotic region in rt hip along with crescent sign while in lt hip the area of necrotic area has decreased.

by one grade by the end of the 14-month to 24-month duration. 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. The two hips progressed from stage IIIa to stage IV and underwent THR.

No intraoperative complications were reported. Postoperative complications were reported in only two hips; both had subtrochanteric fractures of the Rt 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 PFN.

The radiological progression of the AVN of the femoral head occurred at 12 months, 28 months, 36 months, 41 months, and 72 months. The Kaplan-Meier survival curve was plotted to evaluate the duration and number of femoral heads that were preserved in the same stage, which showed 90% of the hips were preserved for the initial 36 months. At 41 months, 85% of the hips were preserved, and by 72 months, 76% of the hips were preserved. However, median progression-free survival (50% survival) was not reached.

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 with 76% survival of the femoral head by the 72 month time period.

The substantial improvement in the mean MHHS from 57 preoperatively to 85 at the latest follow-up and the corresponding reduction in the mean VAS pain score from seven to two 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 early-stage AVN.[12,13] Feder et al. reported that 75% of Steinberg stage II hips remained radiographically stable at a mean of 27 months following CD + 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 fact that 85% of patients achieved either an excellent or good outcome (mHHS) further reinforces its clinical utility. 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 theorized 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 femoral head preservation rate of 90% at 36 months and a 76% survival at 72 months. 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 + BMAC, as reported by Bozkurt et al.[13] The median progression-free survival 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 72 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 + 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 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. Furthermore, 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. While our study was not powered for a multivariate analysis to

identify independent predictors of failure, this observation reinforces the critical importance of early diagnosis and intervention before significant collapse occurs.

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 + 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.

CONCLUSION

Core decompression augmented with bone marrow aspirate concentrate is a safe and effective treatment for early-stage avascular necrosis of the hip. It provides significant and rapid symptomatic relief, improves functional capacity, and demonstrates promising midterm survival of 76% in preventing femoral head collapse and delaying the need for total hip arthroplasty.

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