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Effect of adding bone marrow aspirate injection to core decompression on clinical outcomes in the treatment of femoral head avascular necrosis

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MAIN POINTS

- This study compares clinical and radiological outcomes of core decompression (CD) alone versus CD combined with bone marrow aspirate concentrate (BMAC) injection in patients with avascular necrosis of the femoral head (ANFH).
- BMAC group showed a higher proportion of patients with improved Harris Hip Scores and decreased Visual Analog Scale scores at 1-year follow-up.
- Although differences were not statistically significant, BMAC injection demonstrated a trend toward better joint preservation and functional outcomes.
- The procedure is simple, safe, and may be recommended as a routine adjunct to CD in selected ANFH patients.

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ABSTRACT

Aim: Avascular necrosis of the femoral head (ANFH) is a progressive condition that often affects young individuals and may ultimately require total hip arthroplasty (THA). Core decompression (CD) is a widely used joint-preserving surgical technique, and bone marrow aspirate concentrate (BMAC) injection has been proposed as an adjunct to enhance outcomes by promoting vascularization and cartilage repair.

To compare the clinical and radiological outcomes of patients treated with CD alone versus CD combined with BMAC injection for ANFH.

Materials and Methods: Patients diagnosed with ANFH who underwent CD with or without BMAC injection were retrospectively analyzed. Demographic characteristics, preoperative and 1-year Harris Hip Score (HHS), Visual Analog Scale (VAS) score, Steinberg stage, and the need for THA during follow-up were recorded. All diagnoses were confirmed by MRI and radiography.

Results: A total of 42 hips (30 males, 12 females; mean age 41.8 years, range 14–66) were analyzed. BMAC injection was performed in 28 hips (66.7%) and not performed in 14 hips (33.3%). At 1-year follow-up, Steinberg stage progression was observed in 73.8% of hips, while 26.2% showed regression. THA was required in 14.3% of patients overall—7% in the BMAC group versus 28% in the CD-only group ($p = 0.1$). VAS scores decreased in 32% of BMAC-treated hips versus 21% in CD-only hips ($p>0.05$). Improvement in HHS was seen in 60% of the BMAC group versus 50% of the CD-only group ($p>0.05$).

Conclusion: Although statistical significance was not reached, the addition of BMAC to core decompression showed a trend toward reduced THA conversion and improved hip function. These findings suggest a potential benefit that warrants further investigation in larger, prospective studies before routine use can be recommended.

Keywords: Avascular necrosis, Femoral head, Core decompression, Bone marrow aspirate concentrate, Total hip arthroplasty, Hip preservation

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INTRODUCTION

Avascular necrosis of the femoral head (ANFH), which develops due to impaired circulation in the femoral head, is a common condition in orthopedics [1]. This disease, frequently encountered in young individuals, occurs as a result of disrupted blood supply to the femoral head, leading to collapse of the articular cartilage, hip pain, and restricted joint motion [2]. Although its exact etiology has not been clearly established, total hip arthroplasty (THA) has shown successful outcomes in treating the condition after articular cartilage deterioration. However, due to the relatively young age of most patients and the potential need for revision surgeries after THA, joint-preserving surgical interventions, as well as conservative approaches such as physical therapy and weight-bearing restrictions, are also widely employed [3, 4].

Among joint-preserving surgeries, core decompression (CD) is the most frequently performed technique, aiming to reduce intraosseous pressure and improve the blood supply to

the articular cartilage. While successful outcomes have been achieved in early stages, CD alone is often insufficient to prevent progression to THA, leading to the use of additional procedures to preserve joint function. Various treatment modalities, including vascularized fibular grafting (as a standalone surgical approach), stem cell therapies, and pharmacologic adjuncts such as bisphosphonates, have also been explored for joint-preserving treatment in early-stage ANFH [4,5,6]. Previous studies have demonstrated a reduction in osteoprogenitor cells in the pathogenesis of ANFH, and it has been suggested that stem cells may contribute to recovery by differentiating into both vascular structures and chondroblasts, thereby improving femoral head pathology [5, 7].

However, despite promising early results, the magnitude of clinical benefit from adding BMAC to CD remains controversial due to variability in techniques, disease stages, and follow-up durations. Therefore, further studies are needed to determine whether this combined approach significantly improves outcomes compared to CD alone.

The aim of this study was to clinically and radiologically compare the outcomes of patients treated with CD alone and those treated with CD combined with autologous BMAC injection, which is an adjunctive procedure frequently performed in our clinic for ANFH.

We hypothesized that the addition of BMAC to CD would enhance hip function, reduce pain, and decrease the rate of progression to total hip arthroplasty compared with CD alone.

MATERIALS AND METHODS

This study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Institutional Ethics Committee (Approval No: B.10.1.TKH.4.34.H.GP.0.01/226, Date: 10.07.2025). As this was a retrospective analysis of routinely performed surgical procedures, a specific informed consent form was not required; the standard preoperative surgical consent obtained from all patients was considered sufficient.

This study was designed as a retrospective comparative study conducted in a single tertiary orthopedic center. This retrospective comparative study was conducted and reported in accordance with the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines. The medical records and radiological data of patients who underwent core decompression (CD) with or without autologous bone marrow aspirate concentrate (BMAC) injection for avascular necrosis of the femoral head (ANFH) were reviewed and analyzed.

A non-probability (convenience) sampling method was used. All patients who met the inclusion criteria and had complete clinical and radiological follow-up data were included in the study.

Inclusion criteria

Patients diagnosed with avascular necrosis of the femoral head (ANFH) who underwent core decompression (CD) with or without autologous bone marrow aspirate concentrate (BMAC) injection and had a minimum follow-up of 1 year were included in the study.

Exclusion criteria

- Patients with incomplete clinical or radiological data,
- Patients with less than 1 year of follow-up,
- Those with secondary osteonecrosis due to infection, or malignancy,

Patients with advanced femoral head collapse (beyond Steinberg stage IV) at presentation.

No randomization method was used in this study. Patients were included based on the inclusion criteria, and grouping was determined according to whether bone marrow aspirate concentrate (BMAC) injection was performed. The decision to perform BMAC injection was made at the discretion of the operating surgeon during surgery. Since this was not an interventional study but rather a retrospective analysis of clinical outcomes, the grouping was considered independent of treatment effect bias.

As this was a retrospective study based on the review of patient records and radiological data, no blinding or masking method was used. The surgeons performing the procedures and the researchers analyzing the data were aware of the treatment groups (CD only vs. CD + BMAC). A prior sample size calculation was not performed. All eligible patients who met the inclusion criteria and had a minimum of 1-year follow-up were included in the analysis.

Demographic data, preoperative and 1-year postoperative Steinberg stage, Harris Hip Score (HHS), Visual Analog Scale (VAS) score, and whether total hip arthroplasty (THA) was performed during follow-up were recorded. The diagnosis in all patients was confirmed by magnetic resonance imaging (MRI) and direct radiography, and differential diagnoses were excluded. All measurements were performed together with the senior author to minimize errors. Harris Hip Scores and VAS assessments were recorded preoperatively and repeated at the 1-year follow-up.

The primary outcome parameters that were investigated included pre- and postoperative changes in HHS and VAS scores, while the secondary outcome was the change in Steinberg stage on radiological evaluation.

Surgical procedure

In all patients, the necrotic area of the femoral head was localized preoperatively using MRI. With the patient in the supine position, under fluoroscopic guidance, multiple drill holes

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were created using a 3 mm K-wire. Anteroposterior and lateral fluoroscopic views were used to confirm that the preoperatively identified target region had been reached. In patients undergoing BMAC injection in addition to CD, bone marrow was aspirated from the iliac crest using a bone marrow biopsy needle and syringe. The surgeon advanced the needle through the cortex into the medullary cavity, a step that can be clearly felt once the cortex is penetrated. Approximately 15–20 mL of bone marrow aspirate was obtained for each hip. The aspirate was injected immediately into the decompression tract under fluoroscopic control without delay to prevent clot formation and maintain the viability of the concentrate. The syringe was held in position for about two minutes to allow partial coagulation within the tract and minimize backflow or leakage. No special technique was used to prevent BMAC discharge, and no leakage was observed during the procedure. All patients were discharged after 1 day of postoperative observation in the ward. The decision to perform BMAC injection was entirely at the discretion of the operating surgeon, and patient selection for the procedure was also based on the surgeon's preference.

Statistical analysis

Data were analyzed using SPSS software (ver. 22.0; IBM Corp., Armonk, NY, USA). Quantitative variables are expressed as mean ± standard deviation and minimum and maximum values. Qualitative variables are expressed as frequencies or ratios. Continuous variables were analyzed using the Student's t-test when normally distributed and the Mann–Whitney U test when non-normally distributed.The Chi-square test was used to assess the qualitative parameters. P-values < 0.05 were considered to indicate statistical significance.

RESULTS

A total of 42 hips were included in the study. The mean patient age was 41.8 years (range: 14–66). The operated side was the right hip in 24 patients (57.1%) and the left hip in 18 patients (42.9%). Of the patients, 30 (71.4%) were male and 12 (28.6%) were female. BMAC injection was not performed in 14 hips (33.3%), whereas it was performed in 28 hips (66.7%). The mean preoperative VAS score was 4.6 (range: 2–6), while the mean VAS score at 1 year was 5.1 (range: 2–10). The mean preoperative HHS was 67.6 (range: 16–93), while the mean HHS at 1 year was 63.2 (range: 23–97). At 1-year follow-up, Steinberg stage had progressed in 31 patients (73.8%) and regressed in 11 patients (26.2%). THA was performed in 6 patients (14.3%) during postoperative follow-up due to persistent symptoms and development of joint arthrosis. VAS scores decreased in 12 patients (28.6%), increased in 14 patients (33.3%), and remained unchanged in 16 patients (38.1%) at 1 year. HHS increased in 24 patients (57.1%) and decreased in 18 patients (42.9%) at 1 year (Table 1).

Table 1. Demographic characteristics of the patients included in the study.

		N (%)
Age		41.8
Gender	Female	12 (28%)
	Male	30 (72%)
Treatment	CD	14 (33%)
	CD and BMAI	28 (67%)
		Mean
Age		41.8
Preoperative VAS	CD	4.5
	BMAI	4.7
VAS in the 1st year	CD	5.4
	BMAI	5
Preoperative Harris Hip Score	CD	67.1
	BMAI	67.9
Harris Hip Score in the 1st year	CD	63
	BMAI	63.3

CD: Core decompression; BMAI: Bone Marrow Aspirate Injection.

Table 2. Comparison of demographic and clinical outcomes between the study groups.

Parameter	BMAC Group (n = 28)	Non-BMAC Group (n = 14)	p-value
Age (years)	45.1 (± 14.40)	40.1 (± 15.51)	>0.05
Steinberg stage decreased (%)	28%	21%	>0.05
Preoperative VAS score	4.7	4.5	>0.05
VAS score in the 1st year	5.0	5.4	>0.05
Improvement in the VAS (%)	32%	21%	>0.05

The mean age was 45.1 years in the BMAC group and 40.1 years in the non-BMAC group, with no significant demographic differences between the two. Improvement in Steinberg stage was observed in 28% of the BMAC group compared to 21% of the non-BMAC group. Mean VAS scores in the BMAC group changed from 4.7 preoperatively to 5.0 at 1 year, whereas in the non-BMAC group, they changed from 4.5 to 5.4. Improvement in VAS scores was noted in 32% of the BMAC group and 21% of the non-BMAC group ($p > 0.05$) (Table 2).

Regarding functional outcomes, the mean HHS decreased from 67.9 to 63.3 at 1 year in the BMAC group, and from 67.1 to 63.0 in the non-BMAC group. Although the difference between groups was not statistically significant, HHS improved in 60% of the BMAC group and 50% of the non-BMAC group at 1 year ($p>0.05$). Conversion to THA occurred in 7% of the BMAC group and 28% of the non-BMAC group ($p = 0.1$).

DISCUSSION

In the present study, we compared the outcomes of patients treated with CD alone versus those treated with CD com-

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bined with BMAC injection for ANFH. Although statistical significance was not reached, the BMAC group demonstrated a trend toward greater improvement in HHS and VAS scores, as well as a lower rate of conversion to THA compared to the CD-only group.

ANFH is a serious orthopedic condition that predominantly affects young adults and frequently necessitates THA as the definitive treatment. Poor prognostic factors reported in the literature include male sex, prolonged symptom duration prior to treatment, lower HHS, and higher VAS scores [8]. Core decompression is the most common joint-preserving surgical procedure, and numerous clinical studies have investigated the use of stem cell therapy as an adjunct to CD [9]. Song et al. [10] reported survival rates of 79%, 77%, and 35% at a minimum 5-year follow-up for patients with Ficat stage I, II, and III disease, respectively, following CD.

Stem cell therapy has gained traction in regenerative medicine due to its potential to facilitate remodeling and repair [11]. When combined with CD, stem cell therapy has shown promise in improving graft survival. Gangji et al. [12] demonstrated that stem cell application improved hip function and slowed radiological progression. Similarly, a meta-analysis by Li et al. [13] reported that the stem cell group exhibited longer survival, slower radiological progression, and a 2.85-fold reduction in conversion to THA. Consistent with the literature, our study observed better outcomes regarding Steinberg stage and a lower rate of conversion to THA in the injection group, although these findings were not statistically significant. Notably, the BMAC used in this study was not processed to isolate or purify stem cells; therefore, the procedure represents a biological augmentation technique using unprocessed autologous bone marrow aspirate rather than a standardized stem cell therapy.

Regarding Harris Hip Scores, previous studies have indicated that lower preoperative values are associated with a negative impact on survival [8, 14]. In our study, the injection group showed greater improvement when comparing pre- and postoperative HHS changes. In patients who required conversion to THA, the mean preoperative VAS score was 5.0, and the mean preoperative HHS was 55.3. Furthermore, at the 1-year follow-up, VAS scores increased and HHS decreased in all these patients. Conversely, patients who did not undergo THA had lower mean preoperative VAS scores (4.6) and higher mean HHS (76.4). These findings align with Migliorini et al. [8], suggesting that preoperative VAS and HHS are critical prognostic indicators. While the BMAC group showed greater HHS improvement than the CD-only group, the difference did not reach statistical significance. Thus, while BMAC may provide a functional benefit, larger studies are required to confirm its clinical relevance.

Hauzeur et al. [15] compared changes in VAS scores between a stem cell injection group and a CD-only group and found no significant difference. Similarly, our study did not demonstrate a statistically significant reduction in VAS scores; however, a higher proportion of patients in the injection group experienced decreased pain. Despite the lack of statistical significance, we believe that BMAC injection may contribute to pain reduction.

Although the BMAC group demonstrated a trend toward reduced THA conversion and improved hip function, these differences were not statistically significant and should be interpreted with caution regarding clinical impact. Nevertheless, when CD is planned as a joint-preserving procedure, we recommend the routine addition of BMAC injection, as it presents no adverse effects and may positively contribute to hip preservation.

Limitations

The main limitations of this study include its retrospective design, relatively small sample size, and short follow-up period. Additionally, the lack of histological evaluation and the absence of a standardized protocol for BMAC preparation may limit the generalizability of the findings. Further prospective studies with larger patient cohorts and longer follow-up periods are needed to validate these results.

CONCLUSION

While ANFH remains a serious health problem in young patients, the addition of BMAC injection to core decompression may contribute to improved joint preservation and a lower tendency toward conversion to THA. However, this finding did not reach statistical significance, and further studies with larger cohorts are warranted to confirm these results.

Ethics Committee Approval: This study was conducted in accordance with the Declaration of Helsinki and received approval from local Instutional Review Board (University of Health Sciences Umraniye Training and Research Hospital Scientific Research Ethics Committee, Approval No: B.10.1.TKH.4.34.H.GP.0.01/226, Date: 10.07.2025).

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[4o]) was used solely for language editing and improving the clarity and readability of the manuscript. The AI tool did not contribute to the study design, data analysis, interpretation of results, or scientific conclusions. All content was critically reviewed and approved by the authors, who take full responsibility for the manuscript.

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