ORIGINAL RESEARCH

Bagcilar Med Bull
DOI: 10.4274/BMB.galenos.2026.96967

Lesion Size Predicts Survival After Single-stage Core Decompression with Autologous Iliac Cancellous Bone Graft and Demineralized Bone Matrix in Early Osteonecrosis of the Femoral Head

Erken Evre Femur Başı Osteonekrozunda Otolog İliyak Krest Kansellöz Greft ve Demineralize Kemik Matrisi ile Tek Aşamalı Core Dekompresyon Sonrası Sağkalımda Lezyon Boyutunun Belirleyici Rolü

Mustafa Fatih Daşcı[1], Serdar Biber[2], Abdurrahman Acar[2], Muhammed Uslu[2], Ozancan Biçer[2], Emin Can Balcı[2], Mehmet Akif Güleç[2]

[1]İstanbul Medipol University, Medipol Mega University Hospital, Department of Orthopedics and Traumatology, İstanbul, Turkey
[2]University of Health Sciences Turkey, İstanbul Bağcılar Training and Research Hospital, Department of Orthopedics and Traumatology, İstanbul, Turkey

Abstract

Objective: This study evaluated the mid- to long-term outcomes of single-stage core decompression augmented with autologous iliac crest cancellous bone graft and demineralized bone matrix (DBM) in patients with early-stage osteonecrosis of the femoral head (ONFH). It also aimed to identify predictors of treatment failure, particularly lesion size.

Method: A retrospective review was conducted on 42 patients (50 hips) with ONFH treated between January 2011 and November 2024. Inclusion criteria were Ficat stage I-III disease managed with biologically augmented core decompression. Patients over 65 years or with prior hip surgery, vascular pathology, septic arthritis, or osteomyelitis were excluded. Lesion size was evaluated preoperatively using the modified Kerboul method on MRI. The primary endpoint was conversion to total hip arthroplasty (THA), regarded as treatment failure. THA-free survival was assessed using Kaplan-Meier estimates, with group comparisons via log-rank test. Cox regression identified predictors of THA.

Öz

Amaç: Bu çalışmada, femur başı osteonekrozu (FBON) erken evresindeki hastalarda, otolog iliak krest kansellöz kemik grefti ve demineralize kemik matrisi (DKM) ile desteklenmiş tek aşamalı kor dekompresyon uygulamasının orta ve uzun vadeli klinik ve radyolojik sonuçları değerlendirilmiş; özellikle lezyon boyutuna odaklanarak tedavi başarısızlığını öngören faktörler araştırılmıştır.

Yöntem: Ocak 2011-Kasım 2024 tarihleri arasında tek merkezde Ficat evre I–III FBON tanısı ile biyolojik olarak desteklenmiş tek aşamalı kor dekompresyon uygulanan 42 hasta (50 kalça) retrospektif olarak incelendi. Altmış beş yaş üzerindeki hastalar ile daha önce kalça cerrahisi geçirmiş, vasküler hastalığı, septik artriti veya osteomiyeliti olan bireyler dışlandı. Ameliyat öncesi lezyon boyutu, manyetik rezonans görüntüleme üzerinden modifiye Kerboul yöntemiyle değerlendirildi. Birincil sonuç ölçütü, total kalça artroplastisine (TKA) geçiş olup, bu durum tedavi başarısızlığı olarak kabul edildi. TKA'sız sağkalım Kaplan-Meier yöntemiyle analiz edildi; grup farkları log-rank testi ile değerlendirildi. Cox regresyon modeliyle TKA riskini öngören faktörler belirlendi.

Address for Correspondence: Mustafa Fatih Daşcı, MD, İstanbul Medipol University, Medipol Mega University Hospital, Department of Orthopedics and Traumatology, İstanbul, Turkey
E-mail: mfatihdasci@gmail.com **ORCID:** orcid.org/0000-0002-2443-4802
Received: 04.02.2026 **Accepted:** 04.03.2026 **Epub:** 06.03.2026

Cite this article as: Daşcı MF, Biber S, Acar A, Uslu M, Biçer O, Balcı EC, et al. Lesion size predicts survival after single-stage core decompression with autologous iliac cancellous bone graft and demineralized bone matrix in early osteonecrosis of the femoral head. Bagcilar Med Bull. [Epub Ahead of Print]

Abstract

Results: Over a mean follow-up of 56.7 months, 15 hips (30%) progressed to THA. THA-free survival rates were 95.9% at 12 months, 82.0% at 24 months, and 62.6% at 60 months. Survival differed significantly by modified Kerboul category (p=0.024), with lower rates in intermediate and large lesions. No statistically significant difference was observed across Ficat stages (p=0.066). In multivariate Cox analysis, lesion size remained an independent predictor of failure [intermediate vs. small: hazard ratio (HR) 5.74; large vs. small: HR 14.20].

Conclusion: Single-stage core decompression with autologous bone graft and DBM is a safe, effective joint-preserving option in early ONFH. Lesion size, more than radiographic stage, predicted failure, highlighting the need for quantitative assessment in treatment planning.

Keywords: Autologous bone grafting, core decompression, demineralized bone matrix, femoral head, hip joint preservation, osteonecrosis

Öz

Bulgular: Ortalama 56,7 aylık takipte 15 kalça (%30) TKA'ya dönüştü. TKA'sız sağkalım oranları 12 ayda %95,9, 24 ayda %82,0 ve 60 ayda %62,6 idi. Modifiye Kerboul kategorilerine göre sağkalım anlamlı olarak farklılık gösterdi (p=0,024); orta ve büyük lezyonlarda oranlar düşüktü. Ficat evreleri arasında anlamlı fark saptanmadı (p=0,066). Çok değişkenli analizde, lezyon boyutu bağımsız bir başarısızlık belirleyicisi olarak kaldı [orta vs. küçük: tehlike oranı (HR) 5,74; büyük vs. küçük: HR 14,20].

Sonuç: Otolog kemik grefti ve DKM ile desteklenmiş tek aşamalı kor dekompresyon, FBON'un erken evresi için güvenli ve etkili bir tedavi seçeneğidir. Radyolojik evreden ziyade lezyon boyutu, tedavi başarısını öngörmede daha belirleyicidir. Bu bulgu, preoperatif planlamada kantitatif lezyon değerlendirmesinin önemini vurgulamaktadır.

Anahtar kelimeler: Core dekompresyon, demineralize kemik matrisi, femur başı, kalça eklemi koruma, osteonekroz, otojen kemik grefti

Introduction

Osteonecrosis of the femoral head (ONFH) is a progressive and debilitating condition characterized by disruption of blood supply to the femoral head, ultimately leading to subchondral bone collapse and secondary osteoarthritis. ONFH, which most commonly affects young and middle-aged adults, imposes a significant socio-economic burden owing to the early loss of hip function and the potential need for total hip arthroplasty (THA) at a relatively young age (1,2). Therefore, early intervention aimed at preserving the native femoral head is critical for improving long-term outcomes (3).

Core decompression is an important technique for managing early stage ONFH. Among joint-preserving surgical techniques, core decompression remains the most widely utilized method in early-stage osteonecrosis. By alleviating intraosseous pressure and improving blood flow, core decompression aims to halt disease progression (4,5). However, clinical outcomes following core decompression alone can be unpredictable, especially in lesions of substantial size or in advanced stages. In response, various augmentation techniques have been proposed to enhance the biological environment within the femoral head and support its structural integrity (6-8).

Autologous cancellous bone grafting from the iliac crest provides osteoconductive and osteoinductive properties that can stimulate new bone formation within the necrotic area (9,10). Similarly, the application of demineralized bone matrix (DBM), which is rich in growth factors, offers an additional biologically active scaffold to promote healing (11-13). Combining core decompression with autologous cancellous bone grafting and DBM application may synergistically improve outcomes by addressing both mechanical support and biological stimulation.

This study aimed to evaluate the clinical and radiological outcomes of patients with early stage femoral head osteonecrosis treated with core decompression augmented with autologous iliac crest cancellous bone graft and DBM in a single-stage procedure. We hypothesized that this combined approach could enhance femoral head preservation and delay or prevent the need for total hip replacement.

Materials and Methods

This retrospective single-center study included all patients who underwent single-stage core decompression augmented with autologous iliac crest cancellous bone graft and DBM for early-stage femoral head osteonecrosis. This study adhered to the strengthening the reporting of observational studies in epidemiology guidelines for reporting observational research.

After obtaining institutional review board approval, patients were retrospectively identified from the institutional database. A total of 42 patients (50 hips) who underwent single-stage core decompression augmented with autologous iliac crest cancellous bone graft and DBM between January 1, 2011, and November 1, 2024 were included. The inclusion criteria comprised patients diagnosed with ONFH at Ficat stages I, II, or III who were treated using this single-stage joint-preserving procedure at our institution. Patients older than 65 years, those with

a history of hip surgery, documented vascular disease, or a history of septic arthritis or osteomyelitis were excluded from the study. The patient selection process, exclusion criteria, and final study cohort are shown in Figure 1.

There were 38 men (45 hips) and 4 women (5 hips), of whom 8 (19%) had bilateral ONFH. Overall, 23 and 27 hips were on the right and left sides, respectively. The mean age of the patients was 43.9±9.5 years (range, 22-62 years) at the time of surgery. Minimum follow-up was one year. The mean follow-up was 56.7 months (range 12-168 months).

The diagnosis of ONFH was established by anteroposterior radiography and conventional magnetic resonance imaging (MRI). The hip stage was categorized according to the Ficat classification system. There were 11 (22%) cases of stage I, 21 (42%) cases of stage II, and 18 (36%) cases of stage III.

Preoperative radiographs were reviewed to determine the modified Kerboul classification for each hip joint. The combined necrotic angle was measured on MRI using mid-sagittal and mid-coronal images, following the methodology described by Ha et al. (14), who evaluated the relationship between the combined necrotic angle and the risk of subsequent femoral head collapse. During postoperative follow-up, the development of femoral head collapse was recorded, along with the time to collapse. Additionally, whether patients subsequently underwent THA following the procedure was documented. For those who required THA, the interval between the index procedure and arthroplasty was noted.

The study was approved by the Local Ethics Committee of University of Health Sciences Türkiye, İstanbul Bağcılar Training and Research Hospital (date: 26/07/2024, no: 2024/07/05/058). Participants were informed in detail, and verbal and written consent was obtained.

Surgical Procedure

The procedure was performed with the patient in the supine position on a radiolucent traction table under spinal or general anesthesia. A 4-5-cm longitudinal incision was made over the iliac crest, followed by subperiosteal dissection to expose the crest. A cortical window was created to access the cancellous bone, from which approximately 20 cc of cancellous bone chips were harvested using curettes. After graft collection, the cortical lid was repositioned and secured with bone wax, and the donor site was closed in layers.

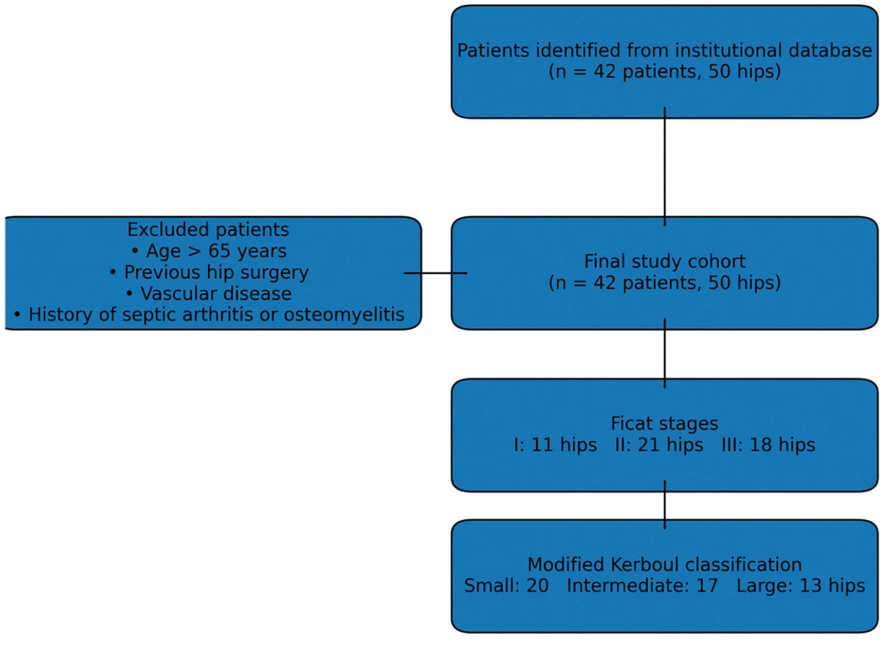

Figure 1. Flow diagram illustrating patient selection, exclusion criteria, and final study cohort.

The diagram summarizes patient identification, exclusions, and classification of hips according to the Ficat stage and the modified Kerboul classification

Attention was directed to the proximal femur. Under fluoroscopic guidance, a 4-cm longitudinal incision was made at the level of the greater trochanter. The subcutaneous tissue, fascia lata, and vastus lateralis were dissected to expose the lateral cortex of the femur. Using anteroposterior, lateral, and oblique fluoroscopic views, a Kirschner wire was advanced toward the necrotic lesion to serve as the guide. Over this guidewire, and with a soft-tissue protector in place, a 9-mm cannulated drill was used to perform core decompression under fluoroscopy. Drilling was stopped approximately 5 mm from the endosteal surface of the femoral head. The necrotic area was then thoroughly debrided using angled and sharp curettes, with fluoroscopy aiding in confirming the adequacy of debridement (Figure 2).

Following debridement, the tract was irrigated and aspirated using a cannula system. DBM was then injected into the debrided cavity through the cannula. The harvested autologous iliac crest cancellous bone graft was then placed into the cavity until the defect was fully filled. The procedure was completed with a layered closure of the soft tissue.

All patients received routine antibiotic prophylaxis with a single preoperative intravenous 2 g cefazolin dose. Patients with a known β-lactam allergy received 1 g of vancomycin. Thromboprophylaxis was initiated the evening before surgery with a subcutaneous injection of low-molecular-weight heparin and continued once daily for six weeks postoperatively.

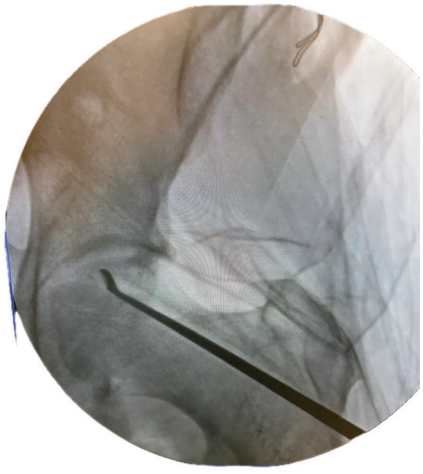

Figure 2. Intraoperative fluoroscopic image demonstrating the debridement of the necrotic area within the femoral head through the core decompression tract. A curette is advanced under fluoroscopic guidance to thoroughly remove necrotic tissue before graft placement

Postoperative Rehabilitation

Postoperative mobilization began on the first postoperative day. The rehabilitation protocol was structured as follows:

Weeks 0-6 (non-weight-bearing phase): Patients ambulated with two crutches without weight bearing on the operated extremity. Passive and active-assisted range of motion exercises of the hip were initiated immediately to prevent stiffness. Isometric quadriceps and gluteal strengthening exercises were encouraged.

Weeks 6-12 (partial weight-bearing phase): After radiographic confirmation of stability, gradual partial weight bearing was initiated using crutches. Strengthening exercises were progressively advanced, and patients were encouraged to increase hip abductor and core stability exercises.

After 12 weeks (full weight-bearing phase): Patients were allowed to progress to full weight bearing as tolerated. Functional strengthening and gait normalization exercises were continued. Return to low-impact daily activities was permitted after three months, whereas high-impact sports were discouraged.

Statistical Analysis

All analyses were performed on a hip basis. Continuous data are reported as mean with standard deviation or as median with interquartile range, while categorical data are presented as frequencies and percentages. The primary endpoint was conversion to THA, which was defined as treatment failure. Hips without THA were censored during the last follow-up.

Kaplan-Meier analysis was used to estimate THA-free survival, and group comparisons were performed using the log-rank test. The time to event was calculated from the index procedure to THA or censoring.

Associations between clinical variables and THA risk were assessed using Cox proportional hazard models. The Ficat stage was analyzed as stages 1-2 versus stage 3 because of the absence of events in stage 1 hips. In the analysis, the small modified Kerboul group and Ficat stages I and II were used as reference categories. Hazard ratios were reported along with 95% confidence intervals, and statistical significance was defined as a p-value below 0.05.

Results

A total of 50 hips from 42 patients were analyzed. Table 1 summarizes the baseline demographic and clinical characteristics of the cohort. During follow-up, 15 hips (30.0%) underwent conversion to THA. The median time-to-event/censoring was 36.5 months [interquartile range (IQR), 22.0-79.8; range, 6-168]. Among the failures, the median time to THA was 24.0 months (IQR, 19.5-35.5; range, 6-60).

Kaplan-Meier estimates of THA-free survival were 95.9% at 12 months, 82.0% at 24 months, and 62.6% at 60 months; the median THA-free survival was not reached in the overall cohort. THA-free survival differed across the modified Kerboul categories (log-rank, p=0.024), with lower survival in the intermediate and large necrosis groups. In contrast, survival comparisons across Ficat stages showed a trend without statistical significance (log-rank p=0.066), and dichotomized analysis (Ficat 1-2 vs. 3) similarly did not reach significance (p=0.107). The Kaplan-Meier survival curves stratified by the Ficat stage and modified Kerboul classification are shown in Figure 3.

In the univariable Cox models, the modified Kerboul category was associated with an increased risk of THA (intermediate vs. small: HR 5.33, p=0.037; large vs. small: HR 6.87, p=0.019). In a multivariable model including age, dichotomized Ficat stage, and modified Kerboul category, the Kerboul category remained independently associated with THA (intermediate vs. small: HR 5.74, p=0.039; large vs. small: HR 14.20, p=0.026). The hip-based THA-free survival and Cox regression results are presented in Table 2.

Table 1. Baseline demographic and clinical characteristics of the study cohort (hip-based analysis)

Variable	Value
Hips, n	50
Patients, n	42
Age, years, mean ± SD (range)	43.9±9.5 (22–62)
Sex (patients), n (%)	
Male	38 (90.5)
Female	4 (9.5)
Side, n (%)	
Right	23 (46.0)
Left	27 (54.0)
Bilateral involvement, n (%)	8 patients (19.0)
Ficat stage, n (%)	
Stage I	11 (22.0)
Stage II	21 (42.0)
Stage III	18 (36.0)
Modified Kerboul classification, n (%)	
Small	20 (40.0)
Intermediate	17 (34.0)
Large	13 (26.0)
Follow-up duration, months	
Mean ± SD	56.0±44.6
Median (IQR)	36.5 (22.0-79.8)
Range	12-168

Values are presented on a hip basis unless otherwise stated. Sex and bilateral involvement are reported on a patient basis. Follow-up duration represents time to total hip arthroplasty or last clinical follow-up.
SD: Standard deviation, IQR: Interquartile range

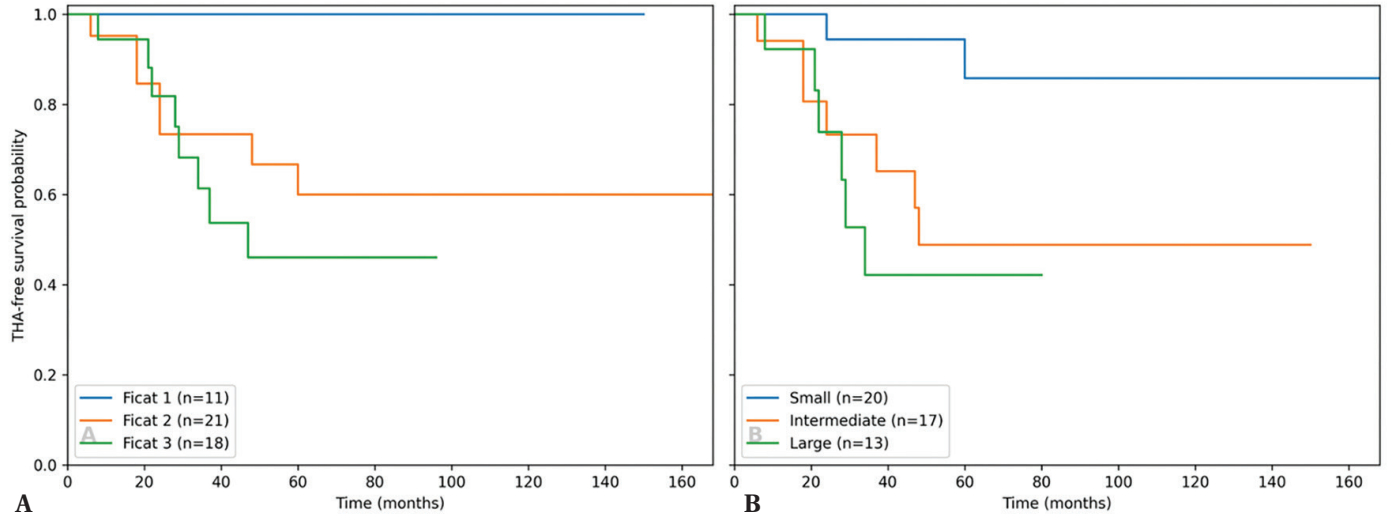

Figure 3. Kaplan-Meier estimates of THA-free survival. (A) Survival curves stratified by the Ficat stage. (B) Survival curves stratified by the modified Kerboul classification. Conversion to total hip arthroplasty was defined as the event. Hips without THA were censored at the last follow-up

THA: Total hip arthroplasty

Table 2. Hip-based survival and risk of conversion to total hip arthroplasty after core decompression with iliac cancellous autograft and DBM

Variable	Hips, n	THA, n (%)	HR (95% CI)	p-value
Overall cohort	50	15 (30.0)	–	–
Ficat stage				
Ficat 1	11	0 (0.0)	Reference	–
Ficat 2	21	7 (33.3)	–	–
Ficat 3	18	8 (44.4)	–	–
Ficat (1-2 vs. 3)	–	–	2.25 (0.81-6.24)	0.118
Modified Kerboul				
Small	20	2 (10.0)	Reference	–
Intermediate	17	7 (41.2)	5.33 (1.10-25.67)	**0.037**
Large	13	6 (46.2)	6.87 (1.38-34.23)	**0.019**
Age (per year)	–	–	1.02 (0.97-1.08)	0.412

Analyses were performed on a hip basis, with each hip considered an independent unit. Failure was defined as conversion to total hip arthroplasty (THA). Hips without THA were censored at the last clinical or radiographic follow-up. Hazard ratios (HRs) were calculated using Cox proportional hazards models. Reference categories were Ficat stage 1 and small modified Kerboul classification. Kaplan-Meier analysis demonstrated overall THA-free survival rates of 95.9% at 12 months, 82.0% at 24 months, and 62.6% at 60 months; median survival was not reached. CI: Confidence interval, DBM: Demineralized bone matrix

Discussion

The present study evaluated the mid- to long-term outcomes of single-stage core decompression augmented with autologous iliac crest cancellous bone graft and DBM in patients with early-stage ONFH. The principal findings of this study are as follows. First, the overall THA-free survival rate of approximately 70% at a mean follow-up of nearly five years supports the effectiveness of this biologically augmented joint-preserving strategy. Second, lesion size assessed using the modified Kerboul classification emerged as a strong and independent predictor of failure, whereas the Ficat stage showed only a non-significant association with conversion to THA. Third, patients with small necrotic lesions derived the greatest benefit from this approach, highlighting the importance of careful selection.

Our results demonstrate that single-stage core decompression augmented with autologous cancellous iliac crest bone graft and DBM can achieve favorable

joint preservation outcomes in early-stage ONFH. At the mid-term follow-up, approximately 70% of the treated hips remained free of conversion to THA. This THA-free survival rate aligns with the success range reported for core decompression in pre-collapse ONFH. Historical series and meta-analyses have shown roughly 60-65% of hips avoid arthroplasty after core decompression alone in Ficat stage I-II disease (15,16). The slight improvement in the survivorship of our cohort (approaching 70%) is consistent with the known benefits of biological augmentation. In a large review of 32 studies (2441 hips), adding autologous bone graft or bone marrow cells to core decompression significantly increased success rates compared to decompression alone (16). Similarly, a 2024 meta-analysis of 15 studies (954 hips) confirmed that core decompression combined with regenerative therapy yields better outcomes than decompression alone (pooled risk ratio ~0.55 for disease progression), with the most pronounced benefit seen when bone marrow aspirate concentrate (BMAC) was used (17). Thus, our THA-free survival findings are consistent with current evidence that biologically augmented decompression is an effective joint preserving strategy for appropriately selected early-stage ONFH.

Our study supports the consensus that the size of the necrotic lesion is a critical prognostic factor, often outweighing the nominal stage of the disease in predicting outcomes (18). We observed markedly better results in hips with small necrotic lesions, whereas larger lesions had a higher risk of collapse and subsequent THA. Notably, the modified Kerboul combined necrotic angle was strongly predictive of treatment success in our cohort, whereas the Ficat stage (I vs. II) was not statistically significant. This finding underscores the clinical relevance of quantifying lesion size and location for accurate prognostication. It is well established that the extent of necrosis drives the likelihood of femoral head collapse and should be a major determinant in management (18). Our findings align with Boontanapibul et al. (19), who showed that core decompression success is strongly influenced by lesion size based on the modified Kerboul angle. In their study, lesions ≥250° had high failure rates despite BMAC use, while lesions <250° showed significantly better outcomes. Notably, BMAC improved 3-year survival in smaller lesions, but its benefit diminished in larger necrotic areas (19). These data, together with our findings, highlight that the modified Kerboul classification is more informative than the Ficat stage for early disease: A Ficat stage II lesion can have a wide prognostic spectrum depending on its size and location. In practical terms, a small stage II lesion may remain intact under joint-preserving treatment, whereas a large stage II lesion (e.g., a Kerboul angle >250°) is likely to fail despite intervention. Our lack of outcome difference between Ficat I and II hips is consistent with other studies focused on precollapse disease (20) and suggests that within early stages, lesion volume is the dominant driver of outcome. In contrast, once collapse occurs (Ficat III), the success rates of head-sparing procedures drop precipitously (21). This reinforces that while Ficat staging distinguishes precollapse vs. collapsed disease, it is the quantitative lesion assessment (e.g., combined necrotic angle or volume) that refines risk stratification among precollapse hips.

When comparing our augmented core decompression results with other treatment modalities and adjuncts, several points emerge. First, core decompression without any graft or biological adjunct has shown only moderate long-term efficacy in early ONFH. Mont et al. (22) reported that roughly 36% of hips continued to progress after core decompression alone, and a comprehensive meta-analysis documented an overall 65% success rate for core decompression in early stage ONFH (16). Our 70% THA-free survival is at least as good as, if not slightly better than, these outcomes for isolated core decompression, which we attribute to the added osteogenic stimulus and structural support from the autologous iliac crest bone graft and DBM. Our approach is analogous to the so-called “light bulb” decompression and grafting techniques, and recent studies using autograft alone have reported comparable mid-term results. For example, Ansari et al. (20) observed a 5-year collapse-free survival of 68.2% after core decompression with a trochanteric bone graft, with only 9% of hips requiring arthroplasty by 5 years. They also noted that smaller lesions (combined angle <200°) had a much lower collapse rate (~17%) than larger lesions (20). These similarities suggest that our single-center findings are generalizable: augmented decompression yields approximately 65-75% survival at 5 years in early ONFH, particularly when necrotic involvement is limited to the femoral head.

Second, the use of cell-based regenerative adjuncts, such as BMAC or cultured stem cells, appears to confer additional benefits beyond what morselized grafts alone can provide. Numerous studies have shown improved outcomes when BMAC is injected into the decompression tract. In the classic trial by Gangji et al. (23) and subsequent long-term follow-ups by Hernigou et al. (24), BMAC significantly delayed or prevented femoral head collapse compared to core decompression alone (21). Remarkably, Hernigou’s

25-year data showed that 72% of hips treated with core decompression plus concentrated bone marrow grafting were still intact, whereas 76% of hips treated with core decompression alone collapsed over time (21,24). More recent evidence continues to favor BMAC; a systematic review reported that adding bone marrow concentrate roughly halved the risk of ONFH progression or THA conversion relative to decompression alone (17). Our study did not utilize BMAC; however, by combining autologous iliac crest cancellous bone graft (which contains osteoblast progenitors) with DBM (rich in bone growth factors), we aimed to simulate a pro-regenerative environment. The biological rationale for combining autologous cancellous bone graft with DBM is supported by both experimental and clinical evidence (25,26). Autologous cancellous bone provides osteogenic cells and an osteoconductive scaffold, while DBM contributes osteoinductive growth factors that may enhance local bone regeneration. The 70% joint survival we achieved is comparable to the ~72% 5-year survivorship reported in controlled trials of core decompression with BMAC (24), albeit direct comparisons should be made with caution. It is worth noting that not all cell-based therapies have shown success; for instance, a recent randomized trial of autologous expanded osteoblast implantation found no significant benefit over standard core decompression (27). This suggests that the type of biological augmentation matters; concentrated marrow (with its mix of mesenchymal stem cells, hematopoietic cells, and growth factors) appears more efficacious than isolated *ex vivo*-expanded cell populations (28). The complex cellular and cytokine milieu in BMAC, including MSCs and supportive macrophages, likely orchestrates a more robust repair response (29,30). The use of fresh autograft and DBM is a practical alternative that provides both osteogenic cells and an osteoconductive scaffold. Our outcomes confirm that this approach can achieve meaningful joint preservation, consistent with the outcomes of cell therapies.

Wang et al. (26) employed a similar approach using single-stage core decompression augmented with fresh cancellous autograft and DBM in patients with ONFH. However, their surgical technique differed notably, utilizing the Watson-Jones approach with anterior capsulotomy and a 1.5 cm osteotomy at the femoral head-neck junction to access the lesion. This method involves direct violation of the joint capsule and risks compromising femoral head vascularity due to potential injury to the retinacular vessels. In contrast, our approach allows access to the necrotic area via a lateral cortical window, avoiding capsular violation and femoral neck osteotomy. This technique may offer a safer alternative that reduces the risk of compromising femoral head vascularity.

Study Limitations

This study had several limitations. First, its retrospective design and single-center nature may affect the generalizability of our findings. Second, the relatively small sample size also limited the inclusion of variables in the multivariate analyses. Third, the use of a hip-based analysis, although common in osteonecrosis research, may have introduced bias in patients with bilateral involvement. Additionally, clinical outcome scores were not consistently recorded and could not be evaluated as part of the analysis. Finally, the absence of a control group treated with core decompression alone limits direct comparison of the added value of biological augmentation.

Nonetheless, the findings of this study offer meaningful clinical insights. The results suggest that patient selection based on lesion size, as determined by the modified Kerboul classification, is crucial when considering core decompression augmented with biological grafting. Patients with small necrotic lesions appear to benefit most from this approach, whereas those with larger lesions remain at a higher risk of eventual conversion to THA.

Conclusion

Single-stage core decompression with autologous iliac crest cancellous bone graft and DBM is a safe, effective joint-preserving strategy for early-stage osteonecrosis of the femoral head. Results show favorable mid-term outcomes, particularly in small necrotic lesions, with lesion size being more prognostic than radiographic staging. The modified Kerboul classification predicted treatment success and may guide preoperative planning. While biologic augmentation showed encouraging results, future studies must compare augmentation strategies and include functional outcomes to improve patient selection and joint preservation.

Ethics

Ethics Committee Approval: The study was approved by the Local Ethics Committee of University of Health Sciences Türkiye, İstanbul Bağcılar Training and Research Hospital (date: 26/07/2024, no: 2024/07/05/058).

Informed Consent: Participants were informed in detail, and verbal and written consent was obtained.

Footnotes

Authorship Contributions

Surgical and Medical Practices: M.F.D., S.B., A.A., M.U., O.B., E.C.B., M.A.G., Concept: M.F.D., M.A.G., Design: M.F.D., A.A., M.U., Data Collection or Processing: S.B., O.B., E.C.B., Analysis or Interpretation: M.F.D., S.B., A.A., E.C.B., Literature Search: M.F.D., M.U., O.B., Writing: M.F.D., S.B., M.A.G.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

References

1. Park JW, Won SH, Moon SY, Lee YK, Ha YC, Koo KH. Burden and future projection of revision total hip arthroplasty in South Korea. BMC Musculoskelet Disord. 2021;22(1):1-9.
2. Petek D, Hannouche D, Suva D. Osteonecrosis of the femoral head: pathophysiology and current concepts of treatment. EFORT Open Rev. 2019;4(3):85-97.
3. Dasci MF, Yaprak Sarac E, Gok Yurttas A, Atci T, Uslu M, Acar A, et al. The effects of thymoquinone on steroid-induced femoral head osteonecrosis: an experimental study in rats. Jt Dis Relat Surg. 2022;33(3):553-566.
4. Xu S, Zhang L, Jin H, Shan L, Zhou L, Xiao L, et al. Autologous stem cells combined core decompression for treatment of avascular necrosis of the femoral head: a systematic meta-analysis. Biomed Res Int. 2017;2017:6136205.
5. Andronic O, Weiss O, Shoman H, Kriechling P, Khanduja V. What are the outcomes of core decompression without augmentation in patients with nontraumatic osteonecrosis of the femoral head? Int Orthop. 2021;45(3):605-613.
6. Arbeloa-Gutierrez L, Dean CS, Chahla J, Pascual-Garrido C. Core decompression augmented with autologous bone marrow aspiration concentrate for early avascular necrosis of the femoral head. Arthrosc Tech. 2016;5(3):e615-e620.
7. D'Ambrosi R, Biancardi E, Massari G, Ragone V, Facchini RM. Survival analysis after core decompression in association with platelet-rich plasma, mesenchymal stem cells, and synthetic bone graft in patients with osteonecrosis of the femoral head. Joints. 2018;6(1):16-22.
8. Tabatabaee RM, Saberi S, Parvizi J, Mortazavi SMJ, Farzan M. Combining concentrated autologous bone marrow stem cells injection with core decompression improves outcome for patients with early-stage osteonecrosis of the femoral head: a comparative study. J Arthroplasty. 2015;30(9):11-15.
9. Marino JT, Ziran BH. Use of solid and cancellous autologous bone graft for fractures and nonunions. Orthop Clin North Am. 2010;41(1):15-26.
10. Schmidt AH. Autologous bone graft: Is it still the gold standard? Injury. 2021;52(Suppl 2):S18-S22.
11. Lim L, Bobyn JD, Bobyn KM, Lefebvre LP, Tanzer M. The otto aufranc award: demineralized bone matrix around porous implants promotes rapid gap healing and bone ingrowth. Clin Orthop. 2012;470(2):357-365.
12. Adkisson HD, Strauss-Schoenberger J, Gillis M, Wilkins R, Jackson M, Hruska KA. Rapid quantitative bioassay of osteoinduction. J Orthop Res. 2000;18(3):503-511.
13. Thordarson DB, Kuehn S. Use of demineralized bone matrix in ankle/hindfoot fusion. Foot Ankle Int. 2003;24(7):557-560.
14. Ha YC, Jung WH, Kim JR, Seong NH, Kim SY, Koo KH. Prediction of collapse in femoral head osteonecrosis: a modified Kerboul method with use of magnetic resonance images. J Bone Joint Surg Am. 2006;88(Suppl 3):35-40.
15. Konarski W. Effectiveness of different types of core decompression in early-stage osteonecrosis of the femoral head: a systematic review and meta-analysis. Med Sci. 2025;13(4):258.
16. Hua KC, Yang XG, Feng JT, Wang F, Yang L, Zhang H, et al. The efficacy and safety of core decompression for the treatment of femoral head necrosis: a systematic review and meta-analysis. J Orthop Surg Res. 2019;14(1):306.
17. Tang H, Ling T, Zhao E, You M, Chen X, Chen G, et al. The efficacy of core decompression combined with regenerative therapy in early femoral head necrosis: a systematic review and meta-analysis involving 954 subjects. Front Pharmacol. 2025;15:1501590.
18. Hines JT, Jo WL, Cui Q, Mont MA, Koo KH, Cheng EY, et al. Osteonecrosis of the femoral head: an updated review of ARCO on pathogenesis, staging and treatment. J Korean Med Sci. 2021;36(24):e177.
19. Boontanapibul K, Huddleston JI, Amanatullah DF, Maloney WJ, Goodman SB. modified kerboul angle predicts outcome of core decompression with or without additional cell therapy. J Arthroplasty. 2021;36(6):1879-1886.
20. Ansari S, Gupta K, Bondarde P, Madhusudan CRBV, Kalia RB. Outcomes of single-incision-augmented core decompression using trochanteric autograft in osteonecrosis of femoral head—a mean 5-year follow-up study. J Hip Preserv Surg. 2024;11(4):280-286.
21. Li M, Ma Y, Fu G, Zhang R, Li Q, Deng Z, et al. 10-year follow-up results of the prospective, double-blinded, randomized, controlled study on autologous bone marrow buffy coat grafting combined with core decompression in patients with avascular necrosis of the femoral head. Stem Cell Res Ther. 2020;11:287.
22. Mont MA, Salem HS, Piuzzi NS, Goodman SB, Jones LC. Nontraumatic osteonecrosis of the femoral head: where do we stand today?: a 5-year update. J Bone Joint Surg Am. 2020;102(12):1084-1099.
23. Gangji V, Hauzeur JP, Matos C, De Maertelaer V, Toungouz M, Lambermont M. Treatment of osteonecrosis of the femoral head with implantation of autologous bone-marrow cells. A pilot study. J Bone Joint Surg Am. 2004;86(6):1153-1160.
24. Hernigou P, Dubory A, Homma Y, Guissou I, Flouzat Lachaniette CH, Chevallier N, et al. Cell therapy versus simultaneous contralateral decompression in symptomatic corticosteroid osteonecrosis: a thirty year follow-up prospective randomized study of one hundred and twenty five adult patients. Int Orthop. 2018;42(7):1639-1649.

25. Gruskin E, Doll BA, Futrell FW, Schmitz JP, Hollinger JO. Demineralized bone matrix in bone repair: history and use. Adv Drug Deliv Rev. 2012;64(12):1063-1077.

26. Wang BL, Sun W, Shi ZC, Zhang NF, Yue DB, Guo WS, et al. Treatment of nontraumatic osteonecrosis of the femoral head using bone impaction grafting through a femoral neck window. Int Orthop. 2010;34(5):635-639.

27. Jayankura M, Thomas T, Seefried L, Dubrana F, Günther KP, Rondia J, et al. Does adjunction of autologous osteoblastic cells improve the results of core decompression in early-stage femoral head osteonecrosis? A double-blind, randomized trial. Clin Orthop. 2023;481(8):1527-1540.

28. Tabatabaee RM, Saberi S, Parvizi J, Mortazavi SMJ, Farzan M. Combining concentrated autologous bone marrow stem cells injection with core decompression improves outcome for patients with early-stage osteonecrosis of the femoral head: a comparative Study. J Arthroplasty. 2015;30(Suppl 9):11-15.

29. Aggarwal AK, Poornalingam K, Jain A, Prakash M. Combining platelet-rich plasma instillation with core decompression improves functional outcome and delays progression in early-stage avascular necrosis of femoral head: a 4.5- to 6-year prospective randomized comparative study. J Arthroplasty. 2021;36(1):54-61.

30. Kim J, Hematti P. Mesenchymal stem cell-educated macrophages: a novel type of alternatively activated macrophages. Exp Hematol. 2009;37(12):1445-1453.