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ORIGINAL ARTICLE

Clinical effectiveness of platelet rich fibrin combined with core decompression and grafting in early stage femoral head avascular necrosis

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ABSTRACT

Objectives: This study aims to evaluate the clinical effectiveness of platelet-rich fibrin (PRF) therapy in combination with core decompression (CD) and grafting in patients with femoral head avascular necrosis (AVNFH).

Patients and methods: Between February 2015 and February 2020, a total of 63 patients (45 males, 18 females; mean age: 45.8±11.7 years; range, 21 to 65 years) with early-stage AVNFH (Ficat-Arlet Stages I-II) who underwent treatment were retrospectively analyzed. The patients were divided into two groups: those treated with CD and grafting (CD+grafting; n=32) and those receiving additional PRF augmentation (CD+grafting+PRF; n=31). Demographic characteristics, including age, sex, and affected side, were comparable between the groups. Clinical assessments included pre- and postoperative Visual Analog Scale (VAS) for pain, Harris Hip Score (HHS), and Merle d'Aubigné Hip Score.

Results: No significant differences were observed between the groups preoperatively regarding HHS, Merle d'Aubigné scores, and VAS scores (p>0.05). Postoperatively, the PRF group demonstrated significantly improved outcomes in HHS (83.70±14.30 *vs*. 65.90±16.72, p=0.001), Merle d'Aubigné Hip Score (15.29±2.78 *vs*. 11.94±4.31, p=0.001), and VAS (2.06±1.50 *vs*. 4.69±2.08, p=0.001). Both groups showed significant clinical improvement, but PRF augmentation was associated with superior functional recovery and pain reduction.

Conclusion: Compared to CD+grafting alone, adding PRF to CD+grafting resulted in more favorable clinical outcomes with minimal complications. These findings suggest that PRF is a promising, minimally invasive adjunct therapy for joint preservation in early-stage AVNFH.

Keywords: Avascular necrosis, core decompression, functional outcomes, platelet-rich fibrin.

Avascular necrosis of the femoral head (AVNFH) results from reduced blood flow to the femoral head, leading to pathological changes in the local articular cartilage, subchondral bone, and local vasculature. These alterations often manifest as subchondral osteonecrosis, femoral head collapse, and hip joint pain.[1] Secondary risk factors such as corticosteroid use and excessive alcohol consumption significantly contribute to many cases. Avascular necrosis of the femoral head primarily impacts individuals in their 30 to 50s and can lead to total hip arthroplasty (THA) due to osteoarthritis after femoral head collapse.[2] Given the potential for significant morbidity, effective management of early-stage osteonecrosis is crucial to alter disease progression and prevent further deterioration.[3]

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Surgical interventions, including core decompression (CD) with or without bone grafting, mesenchymal stem cell augmentation, porous tantalum implants, osteotomies, and THA, aim

to preserve joint function or address advanced disease.[4-6] Recently, biological therapies such as bone marrow aspirate concentrate, platelet-rich plasma (PRP), and bone morphogenetic protein-7 have gained attention for enhancing outcomes in early AVNFH combined with CD.[7,8]

Second-generation platelet concentrates, particularly platelet-rich fibrin (PRF), have emerged as a promising tool in regenerative medicine.[9] Enriched with growth factors and a fibrin matrix, PRF promotes osteogenesis and angiogenesis. It offers advantages including ease of application, minimal invasiveness, and a low risk of rejection due to its autologous nature.[10] Initially utilized in dentistry, PRF has since been applied in various medical fields, including the management of ulcers, medication-related osteonecrosis of the jaw (MRONJ), musculoskeletal injuries, and orthopedic bone and tendon healing.[9,11-13] Unlike first-generation platelet concentrates, PRF requires no blood manipulation, making it a straightforward and cost-effective option.[10] The biological properties of PRF, including its fibrin matrix and growth factors, may support the pathophysiological requirements of AVNFH by promoting osteogenesis and angiogenesis, potentially enhancing bone regeneration and joint preservation.[10]

In the present study, we hypothesized that PRF might serve as a supportive, minimally invasive adjunct in orthopedic treatment. We, therefore, aimed to investigate whether the addition of PRF to CD and grafting improved pain relief and functional outcomes in patients with early-stage AVNFH.

PATIENTS AND METHODS

This single-center, retrospective study was conducted at Erciyes University Faculty of Medicine, Department of Orthopedics and Traumatology between February 2015 and February 2020. Patients diagnosed with AVNFH who underwent surgical treatment were screened. Initially, medical records of 75 patients treated with CD plus grafting, with or without PRF augmentation, were reviewed. Data were collected from hospital records during pre- and postoperative follow-ups. Preoperative magnetic resonance imaging (MRI) and X-ray images were available for all patients, and the Ficat-Arlet classification was used to grade osteonecrosis. Inclusion criteria included age between 18 and 65 years, Ficat-Arlet Stages I-II, and a minimum follow-up of two years. Patients with inflammatory joint disease, trauma, or prior hip surgery were excluded. Of the initial 75 patients, four patients showed suspicious advanced degenerative changes during intraoperative fluoroscopic evaluation. Subsequently, diagnostic hip arthroscopy was performed, which confirmed extensive chondral damage inconsistent with Stage I-II disease, leading to their exclusion from the study. Five patients were lost to follow-up, and three patients who underwent THA during follow-up due to disease progression were also excluded due to incomplete postoperative clinical data. Among these three patients, one belonged to the PRF (+) group and two to the PRF (–) group. After applying these exclusion criteria, 63 patients (45 males, 18 females; mean age: 45.8±11.7 years; range, 21 to 65 years) remained in the final analysis. The patients were classified into two groups based on the surgical procedures performed: 32 patients received CD with grafting alone, and 31 patients received CD with grafting plus PRF augmentation. The study flowchart is shown in Figure 1. Written informed consent was obtained from each patient. The study protocol was approved by the Health Sciences Research Ethics Committee (Date: 04.09.2024, No: 2024/161). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Surgical technique

All surgeries were performed under general anesthesia on a traction table by senior surgeons in our clinic. The decision to use PRF augmentation was initially based on the clinical judgment of one experienced surgeon. Preoperative MRI and radiographs were analyzed to locate the necrotic lesion. A 10-cm incision was made, starting distal to the greater trochanter and extending further distally. Under fluoroscopy guidance, the lesion was targeted from the distal greater trochanter. The lateral femur was penetrated with a 2 mm Kirschner wire (K-wire), and its position within the necrotic core was confirmed in anteroposterior and lateral views using fluoroscopy. A 10-mm cannulated drill created a channel over the K-wire, and necrotic tissue margins were measured and removed using a flexible curette. Complete excision of the assessed necrotic areas was verified fluoroscopically. In the PRF group, prepared PRF was inserted into the channel, and the site was sealed with an allogeneic bone graft to support structural integrity and avoid donor site morbidity associated with autografts. In the non-PRF group, a chip allograft was placed instead. The procedure concluded with meticulous hemostasis. Allogeneic grafts were preferred over

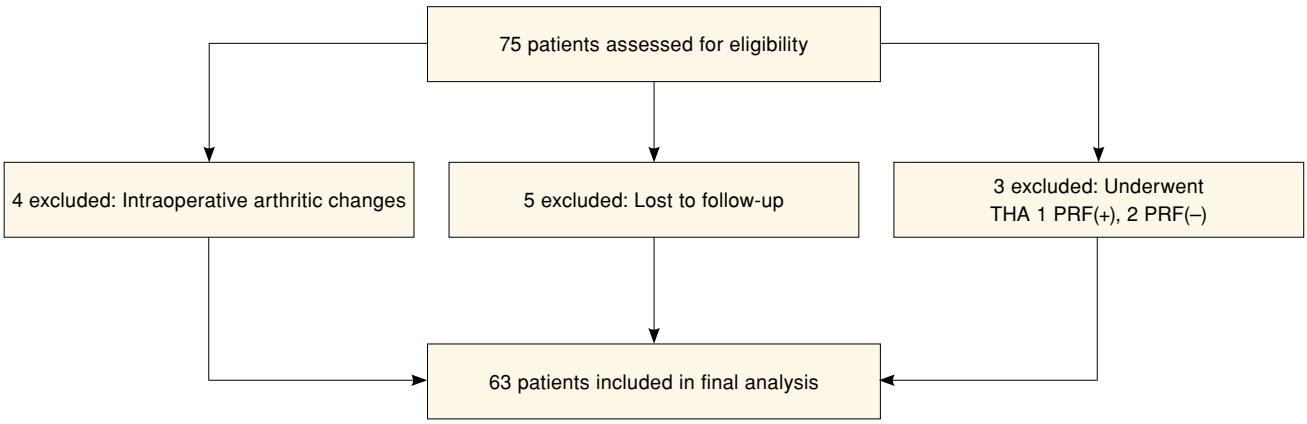

FIGURE 1. Patient enrollment and exclusion flowchart.
PRF: Platelet-rich fibrin.

autografts to standardize the grafting material across patients and eliminate variability from donor site differences (Figure 2).

PRF preparation

The PRF was prepared following the protocol described by Dohan et al.[14] Intravenous blood was collected in 10 mL glass tubes without anticoagulant and immediately centrifuged at 3,000 rpm for 10 min using a standard laboratory centrifuge. This process yielded three distinct layers: a bottom red blood cell (RBC) layer, a middle fibrin clot layer (PRF), and a top serum layer (platelet-poor plasma, PPP). The absence of anticoagulant allowed spontaneous coagulation upon blood contact with the glass tube, ensuring consistent PRF formation.

Rehabilitation

Rehabilitation began on postoperative Day 1 with hip isometric exercises, including passive and active mobilization, supervised by a physiotherapist. On Day 2, patients initiated ambulation with crutches. After six weeks, gradual weight-bearing was introduced, progressing to full weight-bearing by eight weeks. Clinical follow-ups were conducted monthly for the first six months and every six months thereafter to monitor recovery and functional outcomes.

Evaluation of results

Clinical and functional outcomes were assessed preoperatively and at the patients' final postoperative follow-up to evaluate the effectiveness of the interventions. The Visual Analog Scale (VAS; range: 0-10, with 0 indicating no pain and 10 severe pain) was used to quantify pain intensity at baseline and the last recorded follow-up visit, ensuring a consistent measure of patient-reported pain relief over time. The Harris Hip Score (HHS; range: 0-100) evaluated hip function, pain, and daily activity capacity during these assessments, with higher scores reflecting superior outcomes. Similarly, the Merle d'Aubigné Hip Score (range: 0-18) measured pain, mobility, and ambulation capabilities, providing a comprehensive functional profile; higher scores indicated better hip performance. These standardized tools were selected for their validated reliability in assessing AVNFH outcomes and were administered by trained clinicians at both time points to ensure

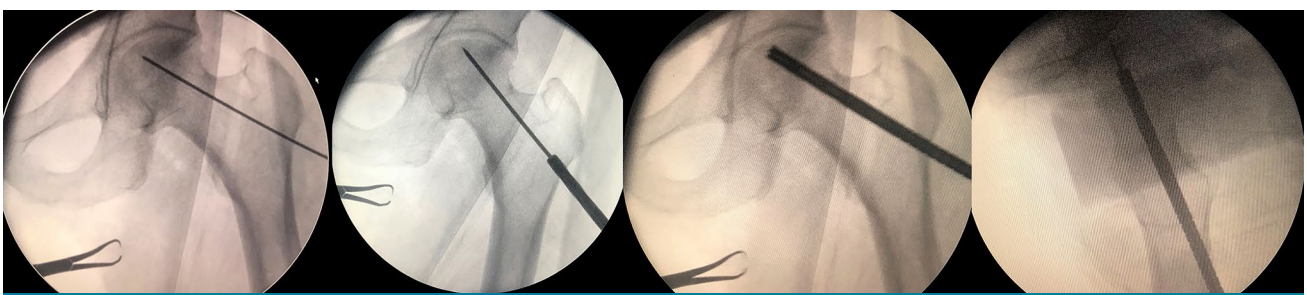

FIGURE 2. Intraoperative fluoroscopic demonstration of core decompression technique.

consistency. The final follow-up at least two years post-surgery (mean: 71.78±8.50 months) allowed for a robust evaluation of long-term treatment effects, capturing sustained improvements in pain and function critical to joint preservation.

Statistical analysis

Study power analysis and sample size calculation were performed using the G*Power version 3.1 software (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany). The sample size was based on available records meeting the inclusion criteria. To ensure that this sample was sufficient to detect clinically meaningful differences, a post-hoc power analysis was performed based on the postoperative HHS the variable showing the most prominent intergroup difference. This analysis revealed a statistical power of 99.8% (Cohen's d=1.15; mean±SD: 83.70±14.30 *vs.* 65.90±16.72; α=0.05; n=31 and n=32), confirming the adequacy of the sample size.

Statistical analysis was performed using the SPSS version 28.0.1.0 software (IBM Corp., Armonk, NY, USA). The Kolmogorov-Smirnov and Shapiro-Wilk tests assessed variable normality; all continuous variables were normally distributed. Continuous data were expressed in mean ± standard deviation (SD) or median (min-max), while categorical data were expressed in number and frequency. Intra-group comparisons of constant outcomes were performed using the Student t-test, while categorical variables were analyzed using the chi-square test or Fisher exact test, depending on sample size and expected frequencies. Test selection was based on variable distribution and study design. A *p* value of <0.05 was considered statistically significant.

RESULTS

Baseline demographic and clinical characteristics were statistically similar between the groups (p>0.05). The mean follow-up was 71.78±8.50 (range, 57 to 90) months. No significant differences were observed in age (p=0.724), sex (p=0.164), or other baseline variables between the PRF (+) and PRF (–) groups. Detailed demographics are presented in Table I.

Preoperative assessments showed no significant differences between the PRF (+) and PRF (–) groups in HHS (p=0.215), Merle d'Aubigné Hip Score (p=0.439), or VAS (p=0.297) values. At the

TABLE I

Patients' demographics

	Total (n=63)			PRF (+) (n=31)			PRF (–) (n=32)			
Variables	n	%	Mean±SD	n	%	Mean±SD	n	%	Mean±SD	*p*
Age (year)			45.8±11.7			45,3±10.1			46.3±13.3	0.724
Follow-up time (month)			71.78±8.50			70.29±6.74			73.22±9.80	0.174
Sex										0.164
Female	18	28.6		6	19.4		12	37.5		
Male	45	71.4		25	80.6		20	62.5		
Affected side										0.782
Right	18	28.6		8	25.8		10	31.3		
Left	45	71.4		23	74.2		22	68.8		
Stage										0.970
Grade 1	4	6.3		2	6.5		2	6.3		
Grade 2	59	93.7		29	93.5		30	93.7		
Etiology of AVN										0.188
Steroid	29	46.0		12	38.7		17	53.1		
Chemotherapy	4	6.3		0	0.0		4	12.5		
Immunosuppressive	3	4.8		3	9.7		0	0.0		
Unclear	27	42.9		16	51.6		11	34.4		
Comorbidity										0.207
No	27	42.9		16	51.6		11	34.4		
Yes	36	57.1		15	48.4		21	65.6		

PRF: Platelet-rich fibrin; SD: Standard deviation; AVN: Avascular necrosis, Percentages are rounded to one decimal place for clarity.

TABLE II
Patients' clinical and functional outcomes

	PRF (+) (n=31)	PRF (–) (n=32)	
	Mean±SD	Mean±SD	*p*
Preoperative HHS	57..04±15.22	52.30±14.81	0.215
Postoperative HHS	83.70±14.30	65.90±16.72	**0.001**
Preoperative Merle d'Aubigné Score	8.87±1.83	8.31±3.56	0.439
Postoperative Merle d'Aubigné Score	15.29±2.78	11.94±4.31	**0.001**
Preoperative VAS	8.13±1.54	8.50±1.24	0.297
Postoperative VAS	2.06±1.50	4.69±2.08	**0.001**

PRF: Platelet-rich fibrin; SD: Standard deviation; HHS: Harris Hip Score; VAS: Visual Analog Scale. HHS ≥80 indicates a good functional outcome.

final follow-up, the PRF (+) group demonstrated significantly greater improvements in HHS (p=0.001), Merle d'Aubigné Hip Score (p=0.001), and VAS (p=0.001) compared to the PRF (–) group. Clinical outcomes are summarized in Table II.

DISCUSSION

In the present study, we evaluated the clinical effectiveness of PRF therapy in combination with CD and grafting in patients with AVNFH. The key findings of this study demonstrated that the addition of PRF augmentation to CD and grafting might offer significant advantages in the management of early-stage AVNFH. Patients treated with PRF augmentation exhibited superior pain control and more favorable hip function compared to those treated with CD and grafting alone. These results highlight the potential role of PRF as a supportive biological adjunct that could enhance tissue healing and help delay disease progression in early-stage AVNFH. Furthermore, our findings align with the growing body of evidence advocating for the integration of regenerative therapies into orthopedic surgical practice, particularly for joint preservation strategies.[15,16]

The enhanced clinical outcomes observed with PRF augmentation in our study are likely attributable to its regenerative properties. As a second-generation platelet concentrate, PRF provides a fibrin matrix enriched with growth factors such as platelet-derived growth factor, transforming growth factor-beta, and insulin-like growth factor, which promote cellular proliferation, differentiation, and angiogenesis.[17,18] These biological effects may enhance osteoconductive and osteogenic activity in the necrotic femoral head, facilitating tissue regeneration and contributing to joint preservation. In a rabbit model of femoral head avascular necrosis, Zhang et al.[19] demonstrated that PRP administration led to increased expression of osteoblast and angiogenesis-related factors, indicating the regenerative potential of platelet-based therapies. Moreover, in our clinical cohort, no significant differences in complication rates were observed between groups, supporting the safety profile of PRF, as also previously noted by other authors.[17,20] These collective results suggest that PRF can serve as a minimally invasive, biologically active adjunct in the treatment of early-stage AVNFH.

Our results build on the established role of CD and grafting in AVNFH management. Previous studies have demonstrated varying radiographic progression rates following CD alone. Smith et al.[21] reported progression rates of 41%, 66%, 96%, and 100% for Steinberg Stages I, II, III, and IV, respectively, over a 2.6-year follow-up period, while Fairbank et al.[22] observed 16%, 58%, and 90% progression rates for Stages I, II, and III-IV. Similarly, Hernigou and Beaujean[15] reported THA rates of 3%, 8%, 41%, and 63% across progressive stages, highlighting the stage-dependent prognosis of CD treatment.

A meta-analysis by Hua et al.[23] further confirmed that treatment success diminished with the advancing disease stage (Stage 1 > Stage 2 > Stage 3) and that biological augmentation enhanced efficacy. Given that most of our patients were Stage II, their significant improvement with PRF suggests this approach is particularly effective in this subgroup, where joint preservation remains achievable. Unlike studies relying solely on CD or CD with grafting, our combination of CD, grafting,

and PRF offers a novel, synergistic strategy that leverages biological regeneration to optimize clinical results, distinguishing our work from existing protocols.

Autologous bone harvested from the iliac crest remains the gold standard for grafting; however, associated donor site morbidity and limited tissue availability are significant concerns.[24] To address this, our study utilized allograft bone. We have discovered that PRF with bone chips helps slow disease progression and promote tissue regeneration.

Moreover, similar positive outcomes have been reported in the surgical management of MRONJ, where adjunctive use of platelet concentrates, including PRP and PRF, significantly improved healing rates.[13,25-27] Although the underlying pathology differs, these results emphasize the regenerative potential of platelet concentrates across various skeletal tissues.

Compared to first-generation concentrates such as PRP, PRF offers advantages including enhanced safety, prolonged growth factor release, and a stable fibrin scaffold, making it particularly suitable for regenerative applications.[14] Despite its widespread use in dental surgery,[28] PRF has been underutilized in orthopedic practice. Our study contributes to filling this gap, suggesting that PRF may serve as a valuable adjunct for joint preservation in early-stage AVNFH. While our findings are promising, further research is necessary to evaluate the long-term survivorship of hips treated with CD and PRF augmentation, and to determine its definitive role in delaying or avoiding THA.

Despite these strengths, our study has limitations which warrant consideration. The sample size of 63 patients, although adequate to detect significant differences in clinical outcomes, may still restrict the generalizability of findings to broader and more diverse populations, particularly as this was a single-center study. A multi-center approach could enhance the applicability of these results across varied patient demographics and clinical settings. Nevertheless, this cohort strengthens the evidence for PRF's efficacy and supports the need for larger, multi-center trials to validate these findings. Additionally, the absence of postoperative radiographic evaluation precludes assessment of structural changes in the femoral head, such as progression of collapse or bone regeneration. Future studies incorporating imaging alongside clinical metrics could provide a more comprehensive understanding of PRF's effects. Finally, while our follow-up period is substantial, it may not fully capture the durability of joint preservation beyond five to six years. Long-term studies with extended observation are needed to confirm PRF's sustained benefits and its role in preventing THA. These limitations should be taken into account when interpreting the clinical implications of our findings.

In conclusion, our study results demonstrate that adding PRF to CD and grafting improves early-stage AVNFH (Ficat-Arlet I-II) outcomes. The PRF enhances pain relief, hip function, and joint preservation, and may contribute to delaying the need for arthroplasty. Its fibrin matrix and growth factors promote osteogenesis and angiogenesis without increasing complications, making it a safe, minimally invasive option. Our findings highlight PRF's potential in orthopedic surgery, supporting further research into its long-term benefits.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Idea/concept, design, analysis and interpretation: B.Ç.; Data collection: R.A., A.A., M.F.U.; Writing the article, critical review, materials: B.Ç., R.A.; Literature review, final approval: B.Ç., M.F.U., A.A.

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