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Core Decompression via the Flip Cutter Technique Using an Expandable Reamer Augmented with Platelet-Rich Plasma and Calcium Phosphate Cement for Early-Stage (ARCO 1–2) Avascular Necrosis of the Femoral Head: A Single Centre Retrospective Observational Study

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Research Article

Keywords: Avascular necrosis, femoral head, core decompression, expandable reamer, platelet rich plasma, calcium phosphate cement, total hip arthroplasty, joint preservation, Harris hip scores, visual analogue scale.

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Core Decompression via the Flip Cutter Technique Using an Expandable Reamer Augmented with Platelet-Rich Plasma and Calcium Phosphate Cement for Early-Stage (ARCO 1–2) Avascular Necrosis of the Femoral Head: A Single Centre Retrospective Observational Study

Abstract

Background

Avascular necrosis of the femoral head (AVNFH) frequently progresses to subchondral collapse and requires total hip arthroplasty if untreated. Core decompression (CD) provides a joint preserving intervention for early-stage disease. This study evaluates the short-term clinical and radiological outcomes of CD using the flip cutter technique of expandable reamer (ER), augmented with platelet-rich plasma (PRP) and calcium phosphate cement (CPC).

Methods

This uncontrolled retrospective single-centre observational study evaluated 25 hips in patients with symptomatic ARCO stage 1–2 AVNFH treated between January 2023 and January 2025. The surgical technique involved sequential debridement of necrotic bone through a minimal cortical window using ER, followed by PRP injection and sealing of the cortical defect with CPC. Patients were encouraged to bear weight immediately as tolerated. Outcomes were assessed in 6 weeks, and 3, 6, and 12 months using Visual Analogue Scale (VAS) pain scores, Harris Hip Scores (HHS), hip range of motion (ROM), and serial imaging, including a 1-year follow-up MRI.

Results

At the 12-month follow-up, the combined intervention was associated with a significant improvement in mean VAS pain scores, HHS and hip ROM ($p < 0.05$). Radiographic and MRI assessments confirmed no disease progression or subchondral collapse in any hip at one-year. The day-case procedure was performed safely with no recorded complications.

Conclusion

In this small retrospective study, ER-assisted core decompression with PRP and CPC was associated with improved short-term pain and functional scores, with no observed subchondral collapse or conversion to THA during approximately one year of follow-up. These findings should be interpreted as preliminary observations rather than evidence of definitive efficacy, and they require confirmation in adequately powered prospective comparative studies with longer-term follow-up.

Novelty Statement

By evaluating a tri-modal, minimally invasive technique combining expandable reamer debridement, platelet-rich plasma augmentation, and a calcium phosphate cement seal, this study provides preliminary evidence that this combined approach can potentially arrest disease progression and prevent subchondral collapse at one-year follow-up.

Trial Registration:

Not applicable, as this evaluation is based on retrospective clinical data and does not constitute a prospective healthcare trial.

Level of Evidence: IV (Retrospective)

Keywords:

Avascular necrosis, femoral head, core decompression, expandable reamer, platelet rich plasma, calcium phosphate cement, total hip arthroplasty, joint preservation, Harris hip scores, visual analogue scale.

Background

Avascular necrosis of femoral head (AVNFH) represents a progressive and debilitating condition that predominantly affects adults aged 20 to 50 years[1][2], with an annual incidence of 1.4 to 3.0 per 100,000 individuals[1][3]. Without early and effective intervention, AVNFH often progresses to subchondral collapse and secondary osteoarthritis, contributing substantially to the need for total hip arthroplasty (THA) in this demographic[2][4][5].

The underlying pathology is driven by disruption of the subchondral microcirculation, resulting in ischaemia, cellular death and elevated intraosseous pressure[3]. The aetiology is multifactorial, encompassing traumatic factors such as hip dislocation, femoral neck fractures, or direct vascular injury and non-traumatic causes like sickle cell anaemia, coagulation disorders, autoimmune diseases, corticosteroid overuse, excessive alcohol consumption, chemotherapy, or radiotherapy[3][6].

Joint-preserving strategies form the basis of management for early-stage AVNFH. Core decompression (CD), originally described by Ficat and Arlet[7], remains the most widely used surgical intervention. By creating a channel into the necrotic lesion, CD reduces intraosseous pressure and promotes revascularisation of the head[2][8]. However, outcomes are strongly stage dependent, with reported success rates of 78.29% in Stage I and 59.38% in Stage II disease[9]. A limitation of traditional CD is the use of static reamers, which need a larger cortical breach and can increase the risk of iatrogenic subtrochanteric fracture[10]. Expandable reamers (ER) address this issue by enabling comprehensive, targeted debridement of the necrotic focus from within, while minimising the risk of thermal necrosis and iatrogenic fractures[11].

To complement this mechanical decompression, biological adjuncts such as platelet-rich plasma (PRP) can be instilled directly into the prepared cavity. This provides a concentrated source of growth factors that stimulate angiogenesis and osteogenic differentiation of mesenchymal stem cells[4][12-15]. Finally, backfilling the entry tract with calcium phosphate cement (CPC) offers structural support and function as a biological seal to retain the injected biologics[16].

This retrospective study presents our institutional experience with an integrated joint-preservation approach for early-stage AVNFH of the femoral head, evaluating the clinical and functional outcomes of combining ER decompression, PRP augmentation, and CPC backfilling at one-year follow up.

Materials and Methods

Study Design

This uncontrolled retrospective observational study was conducted at Bedford Hospital, UK, in accordance with institutional governance guidelines and the ethical principles of the 1964 Declaration of Helsinki and its later amendments. Formal

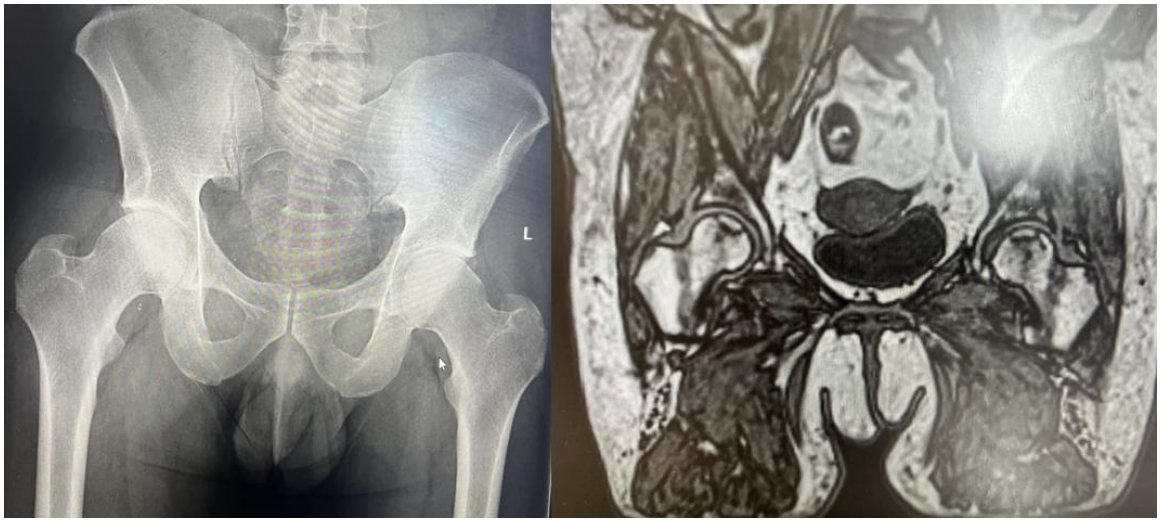
institutional review and audit approval was granted by the Clinical Audit Department of Bedford Hospital, Bedfordshire Hospitals NHS Foundation Trust. All consecutive patients who underwent CD combined with an ER, PRP, and CPC for symptomatic early-stage AVNFH of the femoral head between January 2023 and January 2025 were included. Ethical approval was obtained from the institutional audit department and informed consent for surgical treatment and data use was obtained from all participants.

Patients presenting with symptomatic AVNFH, characterised by significant groin pain and reduced range of motion, with Magnetic Resonance Imaging (MRI) confirmation of Association Research Circulation Osseous (ARCO)[17] Stage 1 or 2 disease and preservation of the subchondral bone without radiographic signs of flattening or collapse were included in this series. Individuals were excluded if imaging revealed collapse (ARCO Stage ≥3), evidence of secondary osteoarthritis, or medical reasons that precluded surgery. For those with bilateral hip involvement, the procedures were performed in stages, with the second hip treated several months after the initial operation.

Surgical Technique

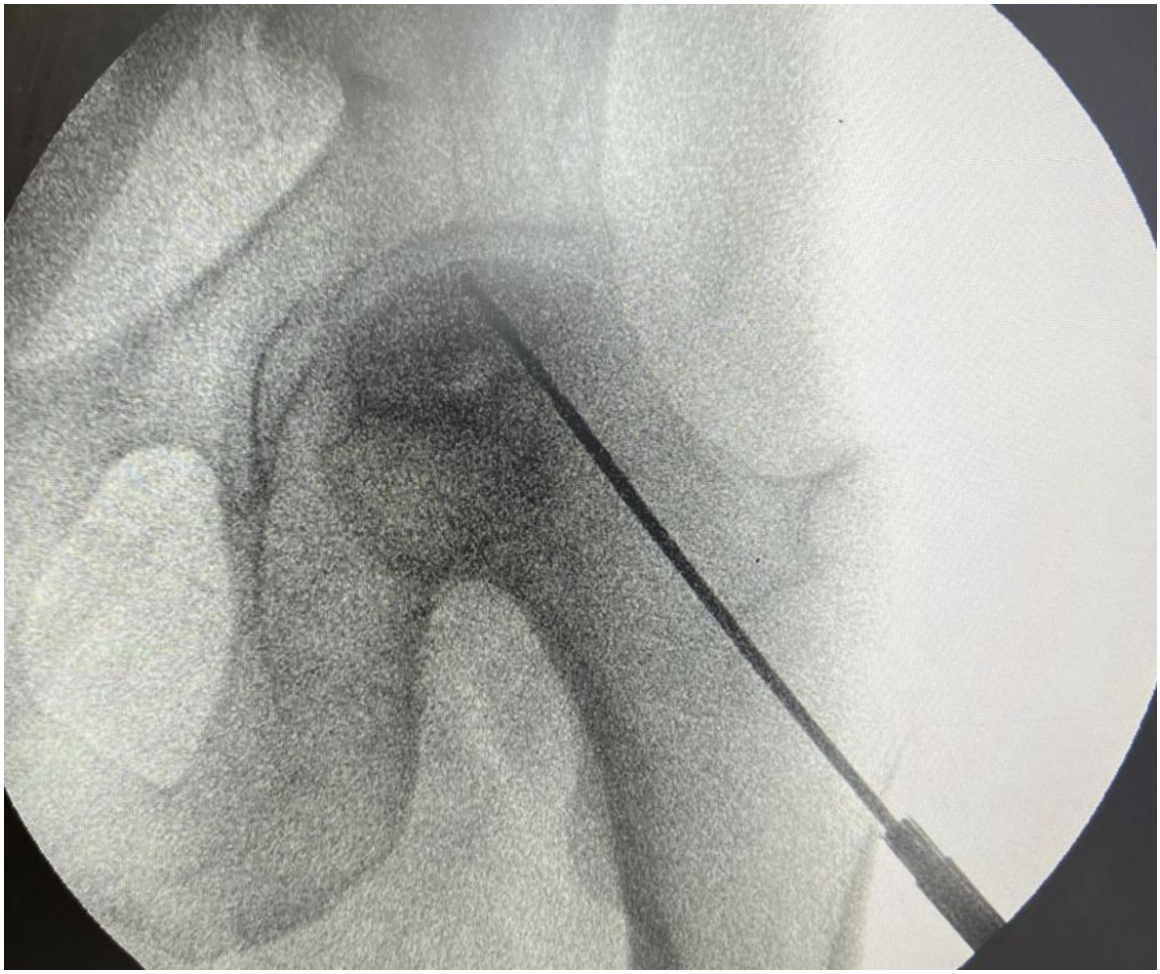
All procedures were performed by a single senior orthopaedic consultant at Bedford Hospital, or by registrars under the direct supervision of the same consultant under general or spinal anaesthesia with continuous fluoroscopic guidance. Patients were positioned supine on a radiolucent operating table. AVNFH lesion was localised using anterior-posterior (AP) and lateral fluoroscopic views, with these findings correlated with preoperative scans (Fig. 1).

Fig. 1 Pre-operative radiological and MRI scans assessing early-stage AVNFH. Left image: AP radiograph of the pelvis demonstrating osteonecrosis in left femoral head. Right image: Coronal MRI of the same patient revealing bilateral AVNFH



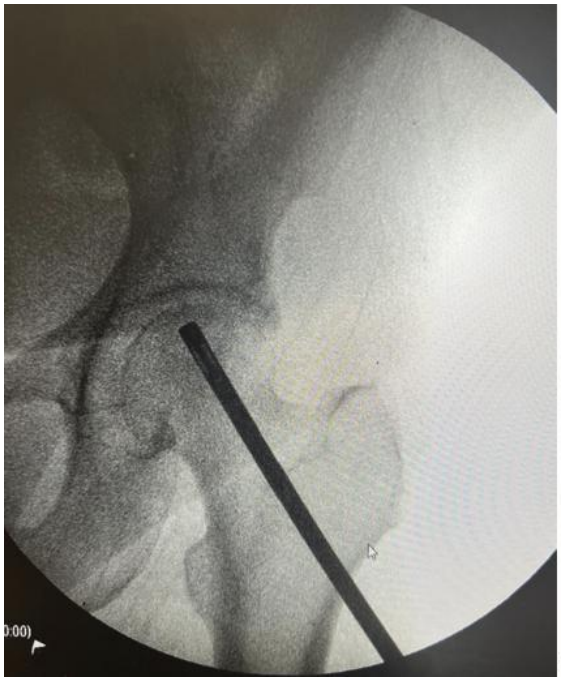
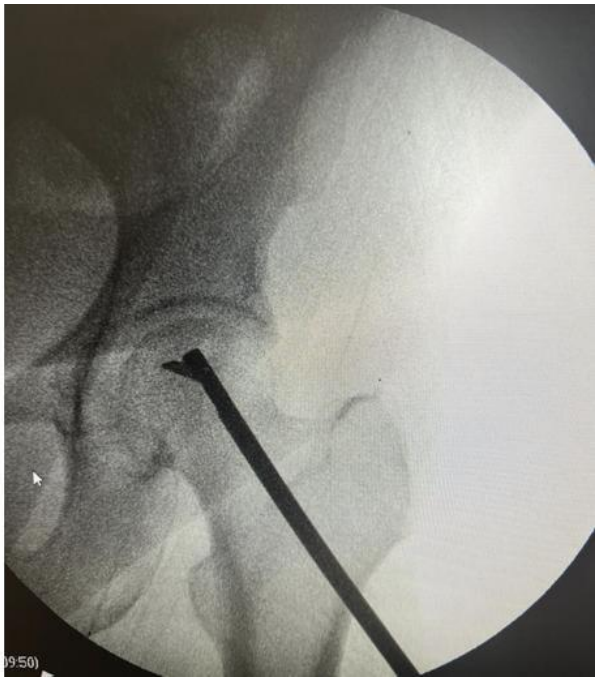
A 2 cm lateral skin incision was made. The entry point was established proximal to the lesser trochanter. With the hip internally rotated 15° to 20°, a 2.4 mm guide pin was advanced into the necrotic zone, stopping 5 mm short of the articular surface (Fig. 2). A 5-mm cannulated reamer and drill sleeve were then used to over-drill the guide pin. The depth was referenced off the calibrated 5-mm sleeve to ensure accurate trajectory. Cannulated reamer was removed, leaving the 5-mm drill sleeve securely impacted in the lateral cortex.

Fig. 2 Intraoperative guidewire placement. AP fluoroscopic view of left hip demonstrating the precise trajectory of the 2.4-mm guidewire



An ER (Arthrex) was introduced through the drill sleeve and advanced to the proximal end of the tract. Cutting blade was deployed by twisting the knurled portion of the handle clockwise until a distinct click was felt (Flip cutter technique). The instrument was manually rotated clockwise and counterclockwise to clear the necrotic bone. The blade diameter was incrementally increased one click at a time, expanding from 9 mm up to 18 mm, until no resistance was met (Fig. 3).

Fig. 3 Intraoperative fluoroscopic views demonstrating the expandable reamer technique. Left image: The closed expandable reamer is introduced through the minimal 5 mm cortical tract and accurately positioned within the targeted necrotic lesion in the femoral head. Right image: In situ deployment of the cutting blades

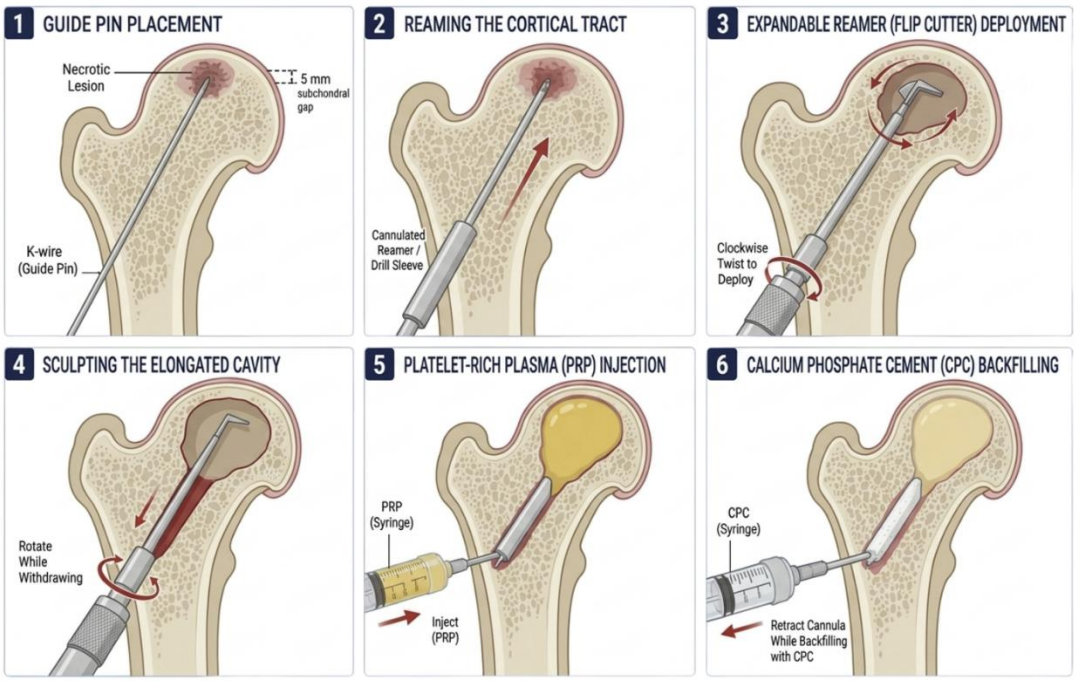



Once maximum expansion achieved, the reamer was slowly withdrawn distally while rotating the handle to sculpt an elongated, contained cavity down to the femoral head-neck junction. Strict care was taken to avoid reaming within the femoral neck to prevent stress risers. Blade was then retracted and the instrument removed. The newly created void was flushed with saline and suctioned to clear all residual necrotic debris. Bone samples obtained during debridement were sent for histological examination to confirm the diagnosis of AVNFH and exclude other pathologies, including neoplastic processes.

To prepare the biological augment, 50 mL of the patient's whole blood was processed under strict aseptic conditions. Following centrifugation in a tabletop unit (1500 rpm for 15 minutes) and leukocyte filtration, 8 mL of PRP was obtained per hip. With drill guide still in place, delivery cannula was inserted. The operating table was tilted 30° to promote gravity-assisted delivery. PRP, activated with calcium chloride (4:1 ratio), was attached via syringe and slowly injected into cannula, using stylet to ensure complete expulsion into the decompressed cavity under fluoroscopic visualisation.

Finally, CPC was injected through the cannula. As cement was expelled, delivery cannula was gradually retracted to backfill the 5-mm cortical tract (Fig. 4). Blood loss was negligible throughout, allowing all patients to be safely managed as day cases.

Fig. 4 Schematic illustration of the core decompression technique using expandable reamer, augmented with platelet-rich plasma and calcium phosphate cement. Created in BioRender. Sutar, S. (2026) https://BioRender.com/0z7jksv

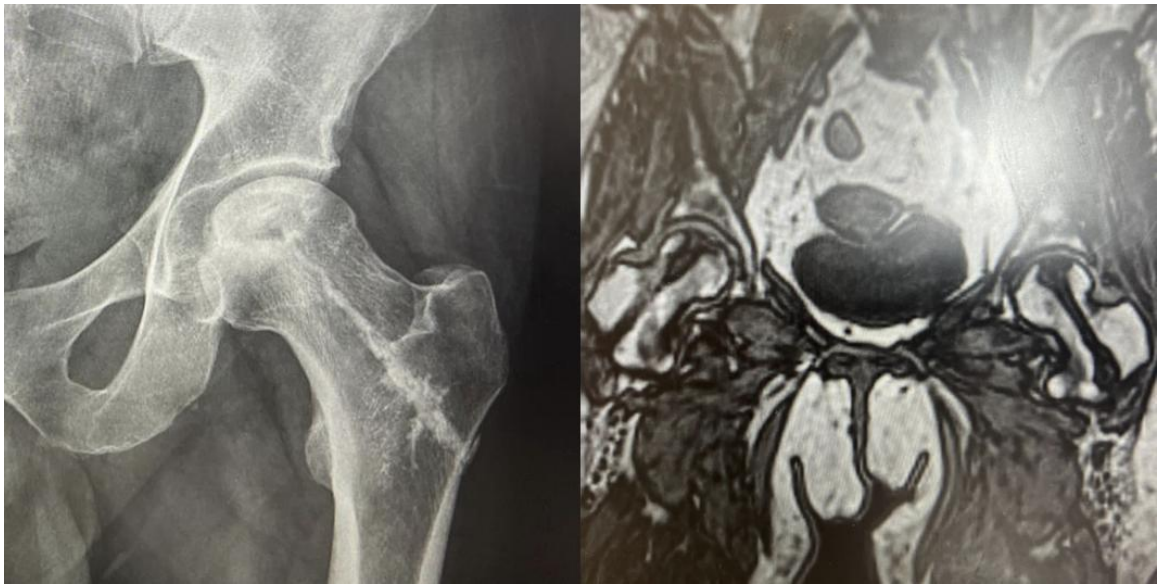


Postoperative Protocol

Patients were permitted to bear weight immediately as tolerated. Standard thromboprophylaxis was administered in accordance with local guidelines. Isometric exercises were introduced in the immediate postoperative period, with passive and active mobilisation of the hip commenced as soon as pain became tolerable.

Clinical and radiological follow-up assessments were scheduled for 6 weeks, 3, 6, and 12 months post-procedure. These assessments included evaluation of Visual Analogue Scale (VAS) pain scores[18], Harris Hip Scores (HHS)[19], and hip range of motion (ROM)[20]. Baseline VAS, HHS and ROM were recorded preoperatively for all hips. Serial plain radiographs were obtained at each follow-up to monitor for any signs of disease progression or subchondral collapse. A 1-year MRI scan was planned for all patients (Fig. 5) to precisely assess changes in necrotic lesion size and marrow signal characteristics by using modified Kerboul angle[21].

Fig. 5 Postoperative radiological assessment. Left image: AP radiograph of the left hip at the 1year follow-up, demonstrating the radio-opaque CPC plug securely sealing the minimal cortical entry tract. Right image: Coronal MRI of the pelvis at the 1-year follow-up interval. The bilateral surgical decompression tracts extending through the femoral necks are clearly visualised



Outcomes

The primary outcome measures were improvement in VAS, ROM and HHS scores from baseline, and the absence of radiographic or MRI evidence of disease progression, particularly subchondral collapse. Secondary outcome measures incidence of procedure-related complications (e.g., infection, iatrogenic fracture, heterotopic ossification), and need for THA.

Statistical Analysis

Descriptive statistics were used to summarise patient demographics and baseline clinical characteristics. Study size was determined by the number of consecutive patients who met the eligibility criteria and underwent the procedure within the defined two-year recruitment window. Continuous variables were reported as means with standard deviations and ranges, while categorical data were expressed as frequencies and percentages. To resolve the unit-of-analysis issue regarding within-patient clustering for the three patients with bilateral hip involvement, a sensitivity analysis was performed. One hip from

each of these three patients was randomly excluded to create a strictly independent cohort of 22 hips. Within-group comparisons of continuous outcome variables (VAS, HHS, ROM, and Kerboul angle) between the preoperative baseline and the 12-month follow-up were then performed using paired t-tests. Statistical significance was defined as $P < 0.05$.

Results

A total of 22 consecutive patients (25 hips) met the inclusion criteria and underwent CD using the ER technique augmented with PRP and CPC between January 2023 and January 2025. No potentially eligible patients were excluded, and no patients were lost to follow-up. The mean follow-up period was 13.8 ± 1.5 months.

The cohort had a mean age of 44 years (range: 33 to 55 years). The demographic distribution was predominantly male, comprising 68% of the study population (15 males, 7 females). Unilateral AVNFH was present in 19 patients, while 3 patients underwent bilateral interventions. Regarding aetiology, a history of excessive alcohol consumption was identified as the main risk factor in 9 cases (41%). The remaining aetiologies included corticosteroid overuse in 4 cases (18%), radiotherapy in 3 cases (14%), post-traumatic causes in 2 cases (9%), and idiopathic origins in the remaining 4 cases (18%). Full baseline demographics, lesion characteristics, and preoperative classifications are summarised in Table 1.

Table 1 Summary of baseline comorbidities, aetiology of AVNFH, laterality, and ARCO staging distribution across the cohort.

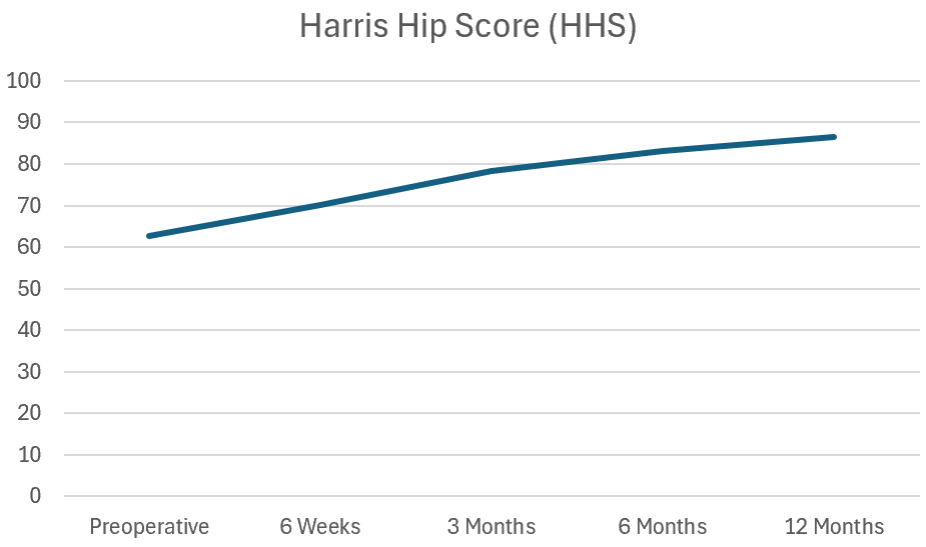
Characteristic	Value (Mean ± Standard deviation or Percentage)
Age (years)	44 ± 7.5
Gender (Male/Female)	15(68%)/7(32%)
Hip involved (Patients)	
Unilateral	19 (86.4%)
Bilateral	3 (13.6%)

Ficat grade	
Grade I	17 (68%)
Grade II	8 (32%)
ARCO stage (Hips)	
Stage I	17 (68%)
Stage II	8 (32%)
Lesion location	
Medial	7 (28%)
Central	11 (44%)
Lateral	7 (28%)
Area involvement	
<15%	13 (52%)
15%–30%	12 (48%)
Platelet count in PRP (millions/μL)	354.00 ± 99.65

A sensitivity analysis restricted to the 22 strictly independent hips confirmed that all functional and clinical improvements, including VAS, HHS, and ROM, remained statistically significant ($P < 0.05$). The mean preoperative VAS score decreased significantly from 7.4 ± 1.2 to 2.1 ± 1.5 at the final follow-up ($P < 0.05$). Concurrently, hip ROM demonstrated marked recovery following the intervention. Mean hip flexion improved from 85.2° ± 12.4° preoperatively to 112.5° ± 8.6° postoperatively ($P < 0.05$), alongside significant improvements in internal rotation, which increased from a mean of 12.4° ± 5.1° to 28.6° ± 6.3° ($P < 0.05$).

Overall functional capacity, as measured by HHS, improved significantly from a preoperative baseline of 62.7 ± 9.8 to 86.5 ± 11.6 at the final assessment, representing a mean improvement of 23.8 points ($P < 0.05$) (Fig. 6).

Fig. 6 Line graph illustrating the functional recovery of patients, as measured by the mean Harris Hip Score (HHS). The data demonstrates a continuous upward trend in clinical outcomes from the preoperative baseline to 12 months following the described core decompression technique.



Overall, 21 hips (84%) achieved a good to excellent outcome, comprising 12 excellent and 9 good results. Of the remaining cohort, 4 hips (16%) were graded as fair. A comprehensive summary of these clinical and functional outcomes across the follow-up intervals is detailed in Table 2.

Serial plain radiographs and MRI scans obtained at 1 year consistently revealed no evidence of disease progression or subchondral collapse in any of the treated hips. The mean preoperative modified Kerboul angle improved significantly from 202.4 ± 19.5 to 184.2 ± 16.3 postoperatively at the final follow-up (mean change, 18.2 ± 4.1; $P < 0.05$).

Table 2: Clinical and Functional Outcomes Across the Follow-up Period

Outcome Measure	Preoperative	6 Weeks	3 Months	6 Months	12 Months	P-value at 12 months
Visual Analogue Scale (VAS)	7.4 ± 1.2	4.5 ± 1.4	3.2 ± 1.3	2.5 ± 1.4	2.1 ± 1.5	0.02
Harris Hip Score (HHS)	62.7 ± 9.8	70.2 ± 8.5	78.4 ± 9.1	83.1 ± 10.4	86.5 ± 11.6	0.03
Range of Motion (ROM, degrees)						
Flexion	85.2 ± 12.4	92.4 ± 10.5	101.5 ± 9.2	108.3 ± 8.8	112.5 ± 8.6	0.02
Internal Rotation	12.4 ± 5.1	16.5 ± 4.8	22.1 ± 5.5	26.4 ± 6.1	28.6 ± 6.3	0.03
Abduction	24.5 ± 6.2	28.2 ± 5.5	34.6 ± 6.1	38.5 ± 5.4	41.2 ± 5.8	0.04
Kerboul angle	202.4 ± 19.5	Not assessed	Not assessed	Not assessed	184.2 ± 16.3	0.03

Mean surgical time was 52 ± 6.4 minutes, and mean intraoperative blood loss was 80 ± 15.8 ml. All procedures were executed on a day-case basis. No perioperative or postoperative complications were recorded, specifically no instances of infection, iatrogenic fracture (including subtrochanteric fractures), or heterotopic ossification. None of the patients required conversion to THA within the follow-up period.

Discussion

This retrospective study reports encouraging short-term observations for CD augmented with PRP and CPC using an ER technique. In our cohort, we observed a significant clinical improvement at the 1-year follow-up. The mean VAS score for pain decreased from 7.4 to 2.1 ($P < 0.05$), and the mean total HHS improved by 23.8 points, from 62.7 to 86.5 ($P < 0.05$). Radiologically, the intervention was highly effective in arresting disease progression, as none of the treated hips showed subchondral collapse at 1 year, and the mean modified Kerboul angle improved significantly ($P < 0.05$). Given that AVNFH primarily affects young, active adults (mean age 44 years in our cohort), these early results suggest that this integrated technique may offer a viable joint-preserving option to delay the need for THA[14].

CD reduces internal pressure within the necrotic area, allowing blood flow to return and promote bone regeneration[8]. Ficat et al. originally described satisfactory results in 90% of patients with grade I and II disease[7], and Mont et al. showed clinical success rates of 63.5% compared with 22.7% for non-operative management[22]. However, these static instruments require a larger cortical breach, which increases the risk of iatrogenic subtrochanteric fracture, and they often provide limited, isobaric decompression that may fail to clear the necrotic lesion adequately[10]. While this pressure reduction is beneficial for pain relief and local circulation, the debridement capability remains limited. These static instruments either remove a cylindrical core of bone or simply create channels, with a risk of pushing diseased bone further into the femoral head rather than extracting it[3].

In contrast, the ER permits a minimally invasive 5 mm cortical entry portal. Once positioned within the necrotic focus, the blades expand to actively scrape and remove devitalised bone using the Flip Cutter technique[23]. This active removal of necrotic bone creates a larger, more favourable environment for revascularisation and osteoneogenesis. This technique enables comprehensive internal debridement while preserving the structural integrity of the surrounding healthy femoral neck[11][24]. Furthermore, the contained nature of the expansion reduces the potential for thermal necrosis compared with repeated drilling using static reamers[24]. By minimising mechanical weakening of the proximal femur, load-bearing capacity is maintained, which safely permitted the immediate weight-bearing protocol observed in our study.

The active removal of necrotic bone creates a contained environment suitable for revascularisation, which we augmented biologically. PRP has an eight-fold higher platelet load than whole blood, along with elevated levels of regenerative cytokines such as platelet-derived growth factor, transforming growth factor β, basic fibroblast growth factor, endothelial growth factor, insulin-like growth factor and vascular endothelial growth factors[2][16]. These biomolecules are critical for driving angiogenesis, cellular proliferation, and osteogenic differentiation directly within the decompression tunnel.

Beyond promoting tissue regeneration, PRP actively downregulates the local inflammatory cascade, a mechanism that helps arrest disease progression and alleviates joint pain. The clinical superiority of this biological adjunct is strongly validated by Aggarwal et al., who demonstrated that augmenting CD with PRP provides significantly better pain relief and midterm functional outcomes compared to isolated mechanical decompression[4]. Crucially, their prospective trial showed that PRP instillation actively retards radiographic disease progression, yielding a 92% joint survivorship free from THA, compared to only 78% for patients treated with CD alone[4].

The concurrent use of CPC serves a dual purpose. Firstly, it mechanically seals the cortical entry point, preventing the egress of the liquid PRP injectate and ensuring its sustained presence within the targeted necrotic cavity[25]. This biological seal function is critical for optimising the local concentration and prolonged activity of the growth factors supplied by PRP[16]. Secondly, CPC itself acts as an osteoconductive scaffold, facilitating bone ingrowth and providing immediate structural support to the decompressed region, which may further contribute to the stability of the femoral head and permit early weight-bearing[26].

We acknowledge several limitations in this study. First, this is a single-centre, retrospective series with a small cohort of 22 patients (25 hips), and no formal a priori power or sample-size calculation was performed. Second, the absence of a control or comparison group prevents any definitive conclusions regarding whether the observed improvements are attributable to the investigated technique or simply reflect the expected outcomes following standard management. Third, our mean follow-up period of 13.8 months is relatively short for AVNFH. Because femoral head collapse and the subsequent need for conversion to THA frequently occur several years after treatment, our 1-year data cannot support claims that this technique permanently halts disease progression. Therefore, longer-term survivorship data, with a minimum follow-up of 5 years, are required to

determine whether this technique permanently halts, or merely delays, the need for eventual arthroplasty. Furthermore, while high-quality MRI and intraoperative fluoroscopy were used for lesion targeting, some contemporary studies advocate concurrent hip arthroscopy to directly assess chondral integrity[4]; this was not used in our cohort. Most importantly, because this intervention combines three distinct modalities (ER decompression, PRP augmentation, and CPC backfilling), it is impossible to determine the independent contribution of each individual component to the observed clinical improvements. Finally, because all procedures were performed or directly supervised by a single senior consultant, the external validity of these findings is limited; the learning curve is not captured, and it remains unclear if these outcomes are broadly reproducible by surgeons with varying levels of experience.

Moving forward, our primary research objectives are to expand the current patient series and extend follow-up to a minimum of five years to accurately evaluate long-term joint survivorship. A prospective comparative study against established techniques, such as traditional CD or CD augmented with bone marrow aspirate concentrate (BMAC), is planned. Ultimately, randomised controlled trials are essential to establish rigorously the superiority of this combined technique over existing treatment modalities and to refine patient selection criteria. Further investigation of the optimal concentration and delivery method of PRP, as well as the individual contribution of CPC and PRP, will also be valuable.

Conclusion

In this small retrospective uncontrolled observational study, ER-assisted CD with PRP and CPC was associated with improved short-term pain and functional scores, with no observed subchondral collapse or conversion to THA during approximately one year of follow-up. These findings should be interpreted as preliminary observations rather than evidence of definitive efficacy, and they require confirmation in adequately powered prospective comparative studies with longer-term follow-up.

List of Abbreviations

AP: Anterior-posterior

ARCO: Association Research Circulation Osseous

AVNFH: Avascular necrosis of the femoral head

CD: Core decompression

CPC: Calcium phosphate cement

ER: Expandable reamer

HHS: Harris Hip Score

MRI: Magnetic Resonance Imaging

PRP: Platelet-rich plasma

ROM: Range of motion

THA: Total hip arthroplasty

VAS: Visual Analogue Scale

Declarations

Ethics to approval**:** This retrospective clinical audit and service evaluation was conducted in accordance with the ethical principles originating in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Under United Kingdom Health Research Authority (HRA) regulations, retrospective clinical audits and service evaluations assessing standard clinical care are exempt from formal Research Ethics Committee (REC) / Institutional Review Board (IRB) review, and as such, formal ethics committee approval numbers were not generated. Local institutional clinical audit and data protection guidelines were adhered to at Bedford Hospital, Bedfordshire Hospitals NHS Foundation Trust.

Consent to participate**:** Not applicable. All patient data presented in this study are fully anonymised, and no individual patient identifiable images or details are included.

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Availability of data and materials: The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request.

Conflict of Interest/Competing Interests**:** The authors declare that they have no conflict of interest or competing interests related to the work presented in this manuscript.

Author Contributions

Swastik Sutar and Naufal Ahmed contributed equally to this work and shared joint first authorship; both participated in the conceptualisation, data collection, formal analysis, and drafting of the manuscript. Mr. Yadu Shankarappa provided expert clinical supervision, surgical guidance, and critical review of the manuscript. All authors have reviewed and approved the final submitted version.

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Author Contributions

Mr Naufal Ahmed: Conceptualisation and idea of article, Methodology, Investigation, Data Extraction, Formal Analysis, Writing – Review & Editing.

Dr Swastik Sutar: Conceptualisation and idea of article, Methodology, Investigation, Data Extraction, Formal Analysis, Writing – Original Draft Preparation.

Mr. Yadu Shankarappa: Supervision, Formal Analysis, Validation, Writing – Review & Editing

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