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OPEN CORE DECOMPRESSION WITH ALLOGRAFT IMPACTION FOR FEMORAL HEAD OSTEONECROSIS: A LIGHT BULB TECHNIQUE APPROACH

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Background: Osteonecrosis of the femoral head (ONFH), also known as avascular necrosis (AVN), is a debilitating condition characterized by the death of bone tissue due to an inadequate blood supply. This pathology predominantly affects young adults, with the average age at treatment ranging from 33 to 38 years, and often leads to the destruction of the hip joint, necessitating total hip arthroplasty (THA)

Methods: The study was conducted as a prospective observational analysis of patients diagnosed with femoral head osteonecrosis (Stages 2B and 3 Ficat) who underwent open core decompression combined with cancellous allograft impaction using the light bulb technique. The inclusion criteria were patients aged between 20 and 55 years with symptomatic osteonecrosis of the femoral head, classified as Stage 2B or 3 according to the Ficat and Arlet classification.. Exclusion criteria consisted of patients with advanced arthritis (Stage 4 ONFH), previous surgical intervention for osteonecrosis, significant hip deformity, inflammatory arthropathies, metabolic bone disease.

Results: A total of 46 patients (58 hips) were included in the study. The mean follow-up duration was 5 years (range: 3–7 years). Of the total patients, 28 were male (60.9%) and 18 were female (39.1%), with a mean age of 37.5 years (range: 24–54 years). The most common etiology of osteonecrosis was corticosteroid use (43.5%), followed by alcohol consumption (30.4%) and idiopathic causes (26.1%).

Conclusion: Open core decompression with allograft impaction using the light bulb technique is an effective treatment for intermediate-stage FHO. This approach provides significant functional improvement, pain relief, and delays the need for THA, particularly in stage 2B cases. Future studies with larger sample sizes and longer follow-up periods are needed to further validate these findings.

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Keywords: Avascular necrosis , femoral head.

Introduction

Osteonecrosis of the femoral head (ONFH), also known as avascular necrosis (AVN), is a debilitating condition characterized by the death of bone tissue due to an inadequate blood supply. This pathology predominantly affects young adults, with the average age at treatment ranging from 33 to 38 years, and often leads to the destruction of the hip joint, necessitating total hip arthroplasty (THA).(1)

The etiology of ONFH is multifactorial, encompassing both traumatic and non-traumatic factors. Traumatic causes include femoral neck fractures and hip dislocations that disrupt the blood supply to the femoral head. Non-traumatic etiologies are more common and involve various risk factors such as prolonged corticosteroid use, chronic alcohol consumption, coagulopathies, autoimmune diseases, and hyperlipidemia. The pathogenesis of non-traumatic osteonecrosis appears to involve vascular compromise, bone and cell death, or defective bone repair as the primary event.(2)

Patients with ONFH typically present with groin pain that may radiate to the buttock or knee. The pain is often exacerbated by weight-bearing activities and relieved by rest. As the disease progresses, patients may experience limited range of motion and a limp. Early-stage ONFH may be asymptomatic, underscoring the importance of high clinical suspicion in at-risk populations. Diagnostic imaging plays a pivotal role in the evaluation of ONFH. X-rays may appear normal in the early stages, but as the disease advances, findings such as sclerosis, cystic changes, and the classic "crescent sign" indicative of subchondral collapse become evident. Magnetic Resonance Imaging (MRI) is the gold standard for early detection, as it can identify bone marrow edema and delineate the extent of necrosis before changes become apparent on X-rays.(3) Computed Tomography (CT) scans provide detailed information about the bony architecture and are useful in preoperative planning.

The Ficat and Arlet classification is commonly used to stage ONFH.(4) Stage 0 is preclinical and pre-radiographic; MRI may show abnormalities. Stage I presents with normal X-rays; MRI positive for osteonecrosis. Stage II shows sclerotic or cystic lesions without femoral head collapse. Stage III is characterized by subchondral fracture ("crescent sign") with potential early flattening of the femoral head. Stage IV indicates advanced osteoarthritis with joint space narrowing and acetabular involvement.

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The management of ONFH aims to preserve the native hip joint, alleviate pain, and maintain function. Treatment strategies are often stage-dependent. Non-operative management in the early stages (I and II) includes conservative measures such as activity modification, pharmacologic agents (e.g., bisphosphonates), and physical therapy; however, these approaches have limited efficacy in altering disease progression. Core decompression is a surgical procedure that involves drilling into the necrotic area to reduce intraosseous pressure, promote revascularization, and stimulate healing, and is most effective in pre-collapse stages (I and II).(5)

Bone grafting augments core decompression by providing structural support and enhancing osteogenesis; both autografts and allografts have been utilized, with varying success rates. Vascularized bone grafts, which include their own blood supply, aim to enhance revascularization and provide structural support, and have shown promise in younger patients. Osteotomies are realignment procedures that redistribute weight-bearing forces away from the necrotic segment, potentially delaying the progression of collapse. In advanced stages (III and IV) with significant femoral head collapse and joint degeneration, Total Hip Arthroplasty (THA) remains the definitive treatment to relieve pain and restore function.(6)

The "light bulb" technique is a surgical approach used in the treatment of ONFH, particularly in the intermediate stages of the disease.(7) This technique involves an open core decompression combined with the impaction of cancellous allograft into the necrotic area of the femoral head. The goal is to provide structural support, promote revascularization, and stimulate bone healing, thereby delaying or preventing the progression to femoral head collapse and the need for THA. Studies have shown that this technique can be effective in improving joint function and reducing pain in patients with ONFH.(8) This study aims to evaluate the clinical and radiographic outcomes of open core decompression combined with allograft impaction using the light bulb technique in patients with stage 2B and 3 Ficat femoral head osteonecrosis.

Materials and Methods

The study was conducted as a prospective observational analysis of patients diagnosed with femoral head osteonecrosis (Stages 2B and 3 Ficat) who underwent open core decompression combined with cancellous allograft impaction using the light bulb technique. Ethical clearance

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was obtained from the institutional review board, and all patients provided informed written consent prior to participation in the study. The inclusion criteria were patients aged between 20 and 55 years with symptomatic osteonecrosis of the femoral head, classified as Stage 2B or 3 according to the Ficat and Arlet classification. Patients with bilateral hip involvement were included, provided that both hips met the inclusion criteria. Exclusion criteria consisted of patients with advanced arthritis (Stage 4 ONFH), previous surgical intervention for osteonecrosis, significant hip deformity, inflammatory arthropathies, metabolic bone disease, or severe comorbidities that precluded surgical intervention.

Preoperative assessment included a detailed clinical history, physical examination, and imaging studies. Hip pain severity, functional status, and range of motion were documented. The Harris Hip Score (HHS) and Visual Analog Scale (VAS) were used to assess preoperative hip function and pain levels, respectively. Radiological evaluation included standard anteroposterior (AP) and lateral radiographs of the hip joint, as well as magnetic resonance imaging (MRI) to determine the extent of osteonecrosis and confirm the diagnosis.

All surgeries were performed under spinal or general anesthesia by the same team of orthopedic surgeons. The patient was positioned in the supine position on a radiolucent operating table to allow intraoperative fluoroscopic guidance. A direct anterolateral approach was used to access the femoral head. A carefully planned cortical window was created in the femoral neck to expose the necrotic lesion while preserving as much healthy bone as possible. The necrotic bone was thoroughly debrided using curettes until viable, bleeding bone was encountered. The cavity was then filled with morselized cancellous allograft, which was carefully impacted to provide structural support and promote osteointegration. Care was taken to avoid overstuffing, which could lead to increased intraosseous pressure and compromise revascularization.

Postoperatively, patients were allowed toe-touch weight-bearing with crutches for the first six weeks, followed by partial weight-bearing as tolerated. Full weight-bearing was permitted after radiographic evidence of bone healing was observed. Patients underwent regular follow-up evaluations at 6 weeks, 3 months, 6 months, 12 months, and yearly thereafter. At each follow-up visit, clinical assessments included pain evaluation using the VAS, hip function assessment using the HHS, and measurement of the hip joint's range of motion. Radiographic evaluations were conducted at each visit to assess graft incorporation, femoral head integrity, and any signs of disease progression or collapse.

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The primary outcome measures included improvements in the HHS and VAS scores, radiographic evidence of femoral head preservation, and the need for conversion to total hip arthroplasty. Secondary outcomes included complication rates such as infection, graft resorption, nonunion, or further progression of osteonecrosis. Statistical analysis was performed using SPSS software, with preoperative and postoperative outcome measures compared using paired t-tests for continuous variables. A p-value of <0.05 was considered statistically significant.

This methodology ensured a standardized approach to patient selection, surgical technique, postoperative care, and outcome assessment, allowing for a comprehensive evaluation of the effectiveness of open core decompression with allograft impaction in the treatment of femoral head osteonecrosis.

Results

A total of 46 patients (58 hips) were included in the study. The mean follow-up duration was 5 years (range: 3–7 years). Of the total patients, 28 were male (60.9%) and 18 were female (39.1%), with a mean age of 37.5 years (range: 24–54 years). The most common etiology of osteonecrosis was corticosteroid use (43.5%), followed by alcohol consumption (30.4%) and idiopathic causes (26.1%).

Postoperative functional outcomes were assessed using the Harris Hip Score (HHS) and Visual Analog Scale (VAS) at different follow-up intervals. Preoperatively, the mean HHS was 56.2 (range: 42–68), which improved to 82.4 (range: 72–92) at the final follow-up. The mean VAS score showed significant improvement from 6.8 (range: 5–9) preoperatively to 2.3 (range: 0–5) at the final follow-up.

Radiographic assessment revealed that 40 hips (69%) showed successful bone graft incorporation with no further femoral head collapse, while 18 hips (31%) demonstrated progression of osteonecrosis despite surgical intervention. A total of 8 patients (13.8%) eventually underwent total hip arthroplasty (THA) due to worsening hip pain and radiographic deterioration.

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Complications included two cases of superficial surgical site infection, both of which resolved with oral antibiotics. No cases of deep infection, graft failure, or avascular necrosis at other skeletal sites were observed.

Table 1: Patient Demographics and Etiology of Osteonecrosis

Parameter	**Value (n=46 patients, 58 hips)**
Mean Age (years)	37.5 (Range: 24–54)
Gender	Male: 28 (60.9%), Female: 18 (39.1%)
Etiology of ONFH	
Corticosteroid use	20 patients (43.5%)
Alcohol use	14 patients (30.4%)
Idiopathic	12 patients (26.1%)
Affected Hip	Unilateral: 34 (73.9%), Bilateral: 12 (26.1%)

Table 1 provides an overview of patient demographics and the underlying causes of osteonecrosis. The majority of patients were male, with corticosteroid-induced ONFH being the most common etiology.

Table 2: Harris Hip Score (HHS) and Visual Analog Scale (VAS) Before and After Surgery

Timepoint	**Harris Hip Score (Mean ± SD)**	**VAS Score (Mean ± SD)**
Preoperative	56.2 ± 6.4	6.8 ± 1.2
6 Months	71.5 ± 5.8	4.1 ± 1.0
12 Months	78.3 ± 6.2	3.0 ± 0.9
Final Follow-up	82.4 ± 7.1	2.3 ± 1.1

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Table 2 presents functional outcome measures before and after surgery. Both the Harris Hip Score and VAS score showed significant improvement at final follow-up, indicating reduced pain and enhanced joint function.

Table 3: Radiographic Outcomes After Surgery

Radiographic Outcome	Number of Hips (n=58)	Percentage (%)
Successful graft incorporation	40	69%
Disease progression	18	31%
Femoral head collapse	10	17.2%
Total hip arthroplasty required	8	13.8%

Table 3 highlights the radiographic findings post-surgery. Successful graft incorporation was observed in 69% of hips, while 31% exhibited progression of osteonecrosis, and 13.8% of cases eventually required THA.

Table 4: Postoperative Complications

Complication	Number of Cases (n=46)	Percentage (%)
Superficial infection	2	4.3%
Deep infection	0	0%
Graft failure	0	0%
Further ONFH progression	18	31%
Need for THA	8	13.8%

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Table 4 presents postoperative complications. The most common adverse event was ONFH progression in 31% of hips. Only 4.3% of patients experienced superficial infections, while no deep infections or graft failures were recorded.

Discussion

The management of femoral head osteonecrosis (ONFH), particularly in its early stages, remains a clinical challenge, with the primary goal being the preservation of the native hip joint and delay of disease progression. Among various joint-preserving procedures, open core decompression combined with allograft impaction using the light bulb technique has emerged as a viable treatment option. This discussion delves into the efficacy of this combined approach, comparing our study's findings with existing literature, and highlighting factors influencing outcomes.

Our study demonstrated significant improvements in both functional outcomes and pain relief following the combined surgical intervention. The mean Harris Hip Score (HHS) improved from 56.2 preoperatively to 82.4 at the final follow-up, while the Visual Analog Scale (VAS) for pain decreased from 6.8 to 2.3. These findings align with those reported by Yıldız et al., who observed an increase in mean HHS from 52.66 to 74.33 post-treatment, with 75% of cases achieving excellent-to-good outcomes.(9)

Additionally, Mei et al. reported a clinical survival rate of 86.4% at an average of 29.2 months post-allogenic non-vascularized bone grafting, indicating that while the light bulb technique offers substantial benefits, a subset of patients may still experience disease progression.(10)

The rate of conversion to THA in our cohort was 13.8%, reflecting the challenges in halting disease progression in certain cases. This rate is consistent with findings by Landgraeber et al., who reported a 24.1% conversion rate to THA following advanced core decompression techniques. (11) The variability in conversion rates across studies underscores the importance of patient selection and the potential need for adjunctive therapies to enhance outcomes.

Complication rates in our study were low, with only 4.3% of patients experiencing superficial infections, all of which resolved with conservative management. Notably, there were no cases of deep infection or graft failure. These findings are in line with those of Landgraeber et al., who reported no significant complications following modified core decompression

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procedures.(11) The low complication rates associated with the light bulb technique highlight its safety and feasibility as a joint-preserving procedure for early-stage ONFH.

Several factors may influence the outcomes of the light bulb technique. The extent of necrotic involvement, as classified by systems such as the Association Research Circulation Osseous (ARCO), plays a pivotal role in prognosis. Mei et al. identified ARCO stage III as a risk factor for femoral head collapse or conversion to THA following core decompression, suggesting that patients with more advanced disease may require alternative or adjunctive treatments. (10)

Additionally, patient-related factors such as body mass index (BMI) have been implicated in influencing outcomes, with higher BMI associated with increased risk of disease progression.

The choice of graft material is another consideration. While our study utilized cancellous allograft, other studies have explored the use of autologous bone grafts or synthetic substitutes. The optimal graft material remains a topic of debate, with factors such as osteoinductive potential, mechanical stability, and availability influencing the decision. Further research is warranted to compare the efficacy of different graft materials in the context of the light bulb technique.

Conclusion

Open core decompression with allograft impaction using the light bulb technique is an effective treatment for intermediate-stage FHO. This approach provides significant functional improvement, pain relief, and delays the need for THA, particularly in stage 2B cases. Future studies with larger sample sizes and longer follow-up periods are needed to further validate these findings.

Recommendations

1. Early intervention in stage 2B cases is crucial to optimize outcomes.
2. Regular follow-up with radiographic assessment is recommended to monitor disease progression.

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3. Future research should compare different grafting materials to enhance bone regeneration.

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