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NOVEL TREATMENT FOR FEMORAL HEAD OSTEONECROSIS USING MICRO-CORE DECOMPRESSION AND INTRALESIONAL ZOLENDRONIC ACID: A PROSPECTIVE STUDY

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ABSTRACT

Background

Avascular necrosis (AVN) of the hip often leads to joint collapse and necessitates total hip arthroplasty, especially in younger patients. Hip preservation strategies, such as core decompression, aim to delay disease progression. Combining micro-core decompression with local zoledronic infiltration is a novel approach with potential advantages.

Methods

This prospective study included 15 patients (19 hips) with AVN stages I to III, treated with micro-core decompression and local zoledronic acid infiltration. Patients were followed for two years, with outcomes assessed using Harris Hip Scores (HHS) and radiological evaluations. Data were analyzed using appropriate statistical tests.

Results

At two years, mean HHS improved significantly across all stages: 97.3 (stage I), 91.1 (stage IIa), 88.4 (stage IIb), and 82.5 (stage III). Radiological improvements included restoration of femoral head morphology and prevention of collapse progression. Postoperative complications were minimal, with two cases of superficial infection and two of trochanteric bursitis, all managed successfully.

Conclusion

Micro-core decompression combined with local zoledronic infiltration effectively improves outcomes in early to intermediate AVN, with minimal complications. This novel technique holds promise for hip preservation, particularly in younger patients.

Recommendation

Baseline screening of hip joints at diagnosis and then at regular intervals to screen the patients for any asymptomatic avascular necrosis and early treatment is recommended.

Keywords: *Avascular Necrosis, Micro-Core Decompression, Zolendronic acid, Harris Hip Score, Hip Preservation.*
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INTRODUCTION

Avascular necrosis (AVN), also known as osteonecrosis of the femoral head, is a debilitating hip joint condition primarily affecting younger individuals and is a leading cause of total hip replacement in this age group. The average age of onset in Asian populations typically ranges from 20 to 60 years [1-3]. While the exact cause of AVN remains uncertain, well-documented risk factors include prolonged corticosteroid use, excessive alcohol consumption, smoking, and chronic illnesses such as renal disease, hematological disorders, inflammatory bowel disease, post-organ transplantation complications, hypertension, and gout [3-6]. Early stages of AVN are often asymptomatic, but as the condition progresses, severe groin pain, restricted hip movement, and femoral head collapse can lead to end-stage joint degeneration. Early diagnosis and intervention are crucial to halting disease progression, which is a key goal of treatment efforts [3,6,7].

Currently, no single treatment protocol is considered the gold standard for managing AVN. Therapeutic approaches are typically classified based on the disease stage, with pharmacological and surgical options tailored to either early or advanced collapse stages. Surgical hip preservation techniques in later stages often yield suboptimal outcomes

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[8-10]. Core decompression is a commonly utilized surgical method in the early stages of AVN. By relieving elevated intraosseous pressure in the femoral head, this procedure enhances blood flow, fostering new bone formation and repair [7, 9, 11].

Pharmacologically, bisphosphonates, particularly alendronate, are employed to inhibit osteoclastic activity within osteonecrotic lesions, thereby supporting bone healing and minimizing the risk of subchondral bone collapse. Studies indicate that systemic administration of alendronate, typically at doses of 10 mg/day or 70 mg/week, reduces the collapse rate by over 50% compared to placebo groups [9]. Prior studies have explored the local administration of bisphosphonates to enhance drug concentration at the lesion site via multiple micro-decompression drill holes, potentially improving bioavailability and therapeutic efficacy [12].

This study hypothesizes that achieving higher concentrations of bisphosphonates like zoledronic acid at the pathological site may yield superior outcomes compared to systemic administration, which disperses the drug throughout the body. Additionally, micro-decompression drill holes may reduce intraosseous pressure while serving as channels for local zoledronic acid delivery. By integrating safe surgical dislocation, micro-core decompression, and intraosseous injection of zoledronic acid, this study aims to optimize treatment outcomes for AVN.

MATERIALS AND METHODS

Study Design

This study was a prospective study.

Study Setting

This study was carried out in the Department of Orthopaedics at Indira Gandhi Institute of Medical Sciences, Patna, Bihar, India over two years.

Ethical Clearance

The study was conducted following approval from the institutional ethics committee, ensuring adherence to ethical research standards. Informed written consent was obtained from all participants.

Inclusion and Exclusion Criteria

The study included 15 patients diagnosed with avascular necrosis (AVN) of the femoral head. Patients in Ficat-Arlet stages I and IIA were selected, as well as those in stages IIB and III provided their hip flexion was not restricted beyond 50%. Patients with a history of prior hip trauma, sickle cell anemia, or local bone pathologies such as osteogenesis imperfecta or neoplastic conditions were excluded. A minimum follow-up period of two years was mandatory for inclusion.

Preoperative Assessment

All patients underwent a detailed clinical interview, physical examination, and baseline X-ray imaging to confirm the diagnosis and establish preoperative baselines. Magnetic resonance imaging (MRI) was performed to precisely stage the disease. Patients were evaluated for anesthetic fitness before surgery, and intraoperative findings, including any complications, were meticulously documented.

Postoperative Follow-Up

Patients were monitored at regular intervals: every three months during the first postoperative year, every six months in the second year, and annually thereafter. Treatment outcomes were assessed using the Harris Hip Score (HHS), comparing preoperative scores with those obtained at the final follow-up. Out of the initial cohort of 15 patients (19 hips), 2 patients (3 hips) were lost to follow-up, leaving 13 patients (16 hips) for the final analysis.

Surgical Procedure

Preparation and Exposure

Patients were placed under general anesthesia in the lateral decubitus position. A linear incision was made over the greater trochanter, followed by an incision of the fascia lata. The interval between the gluteus medius and maximus muscles was identified and retracted. After incising the trochanteric bursa, the piriformis tendon was located. Care was taken to avoid injury to the medial circumflex femoral artery by limiting dissection proximal to the piriformis and distal to the lesser trochanter.

Trochanteric Flip Osteotomy

The greater trochanter was osteotomized and retracted anteriorly along with its muscle attachments. The gluteus minimus was elevated to expose the joint capsule. A Z-shaped capsulotomy, as described by Ganz, was performed, allowing the femoral head to be dislocated anteriorly through flexion, external rotation, and adduction.

Inspection and Decompression

The femoral head was examined for loose cartilage flaps, cam deformities, osteophytes, and acetabular erosions. Areas with loose cartilage, indicative of avascularity, were targeted for micro-core decompression. Multiple drill holes (3.5 mm) were created in these regions until fresh bleeding was observed, indicating revascularization.

Zolendronic acid Infiltration

A solution of 4 mg zoledronic acid (two vials diluted in 100 mL of normal saline) was injected into the decompressed holes to promote localized bone healing. Peripheral osteophytes and cam lesions were removed using rongeurs and osteotomes, and the joint was thoroughly irrigated with saline to clear debris.

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Closure and Stabilization

The femoral head was anatomically relocated into the acetabulum. The capsule was repaired, and stability was confirmed. The osteotomized trochanter was fixed using 4 mm cancellous screws, or stainless-steel wires were used if the fragment was thinner than 1 cm. A suction drain was placed, and the wound was closed in layers.

Postoperative Care

Patients were encouraged to begin non-weight-bearing ambulation immediately after surgery, progressing to full weight-bearing at six weeks postoperatively.

Data Collection and Analysis

Data were recorded in Microsoft Excel and analyzed using IBM SPSS Statistics (version 21, released in 2012). Quantitative variables were presented as mean ± standard deviation, and qualitative variables were expressed as proportions. Statistical analysis included the student's *t*-test for parametric data and the Mann-Whitney *U* test for nonparametric data.

RESULTS

The study included 15 patients (19 hips) with a mean age of 54.3 years (range: 42–63 years) over the two-year study period (2016–2018). Among the participants, 11 (73.3%) were male, and 4 (26.7%) were female. The average duration of symptoms before treatment was 16.7 months (range: 6–27 months). Risk factors for AVN included a history of steroid use in 5 patients (33.3%), smoking in 9 (60%), and alcohol use in 8 (53.3%). Four patients had no identifiable risk factors. Comorbidities were present in 9 cases, including diabetes and hypertension (6 cases), chronic obstructive pulmonary disease (COPD; 2 cases), and coronary artery disease (CAD; 1 case) (Table 1).

Table 1: Patient Demographics and Characteristics:

Variable	Frequency	Percentage (%)
Sex		
Male	11	73.3
Female	4	26.7
Side Affected		
Right	11	57.9
Left	8	42.1
Bilateral	4	—
Risk Factors		
Steroid Use (Yes)	5	33.3
Smoking (Yes)	9	60.0
Alcohol Use (Yes)	8	53.3
Comorbidities		
Diabetes + HTN	6	40.0
COPD	2	13.3
CAD	1	6.7
None	6	40.0

Of the 19 hips, 11 were on the right side, and 8 were on the left. Four patients had bilateral involvement; however, 1 case (3 hips) was lost to follow-up, leaving 16 hips for the final analysis. Staging based on the Ficat-Arlet classification revealed 4 hips in stage I, 10 in stage IIA, 3 in stage IIB, and 2 in stage III. All stage III hips retained at least 50% of hip movement. The mean preoperative range of motion included flexion (68.9° ± 10.3°), abduction (12.9° ± 6.1°), adduction (6.7° ± 3.1°), and arc of rotation (45.3° ± 15.1°). The average hospital stay was 7.5 ± 3.2 days (range: 5–14 days).

The mean preoperative HHS for stages I, IIA, IIB, and III were 81.9, 72.7, 68.8, and 59.2, respectively. Postoperatively, HHS improved across all stages and follow-up intervals. Significant improvements were observed at 6 months, 1 year, and 2 years post-surgery ($p < 0.05$ for all comparisons) (Table 2).

Table 2: Harris Hip Score (HHS) Results:

HHS Scores	Stage I	Stage IIA	Stage IIB	Stage III
Preoperative	81.9	72.7	68.8	59.2
6 Months Postoperative	89.6	80.2	79.5	72.1
1 Year Postoperative	92.6	87.1	84.6	77.3
2 Years Postoperative	97.3	91.1	88.4	82.5

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Radiological follow-up revealed gradual restoration of femoral head morphology, increased bone density, and prevention of further collapse in all cases. Five patients (26.7%) experienced surgery-related complications. Superficial infections occurred in 2 patients at 6 months, which resolved with antibiotic treatment and wound care. Trochanteric bursitis was observed in 2 patients at the 1-year follow-up; both cases required implant removal after union of the trochanter. One patient experienced delayed union at the osteotomy site. No cases of heterotopic ossification were reported (Table 3).

Table 3: Post-operative complications:

Complications	6 Months	1 Year	2 Years
Superficial Infection	2 (13.3%)	0	0
Trochanteric Bursitis	0	2 (13.3%)	0
Delayed Union	0	1 (6.7%)	0
None	13 (86.7%)	12 (80%)	15 (100%)

DISCUSSION

Early diagnosis and timely intervention in osteonecrosis of the hip are critical to preventing disease progression and avoiding the need for total hip arthroplasty (THA). Over the years, various hip-preserving surgical techniques have been explored, with outcomes differing based on disease stages. However, there remains no universally accepted treatment for avascular necrosis (AVN) of the hip, especially in younger patients, where preserving the joint is crucial to mitigating complications like implant loosening or the need for revision surgeries [13]. This study reflects the growing emphasis on hip preservation, utilizing a novel combination of micro-core decompression and local zoledronic acid administration.

Core decompression, introduced by Ficat and Arlet in 1964, remains one of the most widely practiced techniques for hip preservation. Their early reports showed favorable results in 79% of cases based on radiographic evaluations [14]. Traditional core decompression methods involve removing a single large core, which, despite its benefits, poses risks such as inadequate decompression, structural instability, and damage to the articular cartilage. To address these issues, alternative approaches such as multiple small-diameter drill hole decompression have been developed. Studies like those by Kim et al have demonstrated the superiority of this method, showing delayed progression to femoral head collapse compared to single-core techniques [15-17]. Consistent with these findings, the present study achieved effective decompression with minimal structural compromise using a micro-core approach.

Various adjunctive methods have been explored to improve core decompression outcomes, including the use of bone morphogenetic proteins (BMPs), mesenchymal stem cells (MSCs), and bone grafts. MSCs from bone marrow have shown promising early results in AVN treatment due to their ability to promote bone regeneration [9,18]. However, their routine use is limited by the need for specialized equipment for isolation and preparation. Similarly, vascularized fibular grafts have shown mixed results, with significant improvements in some cases, but poorer outcomes in AVN associated with steroid use. Moreover, the technical complexity and risk of complications, such as arterial insufficiency from pedicle kinking, limit the widespread adoption of these techniques [19,20].

The use of bisphosphonates like zoledronic acid in AVN treatment has been extensively studied due to their ability to inhibit osteoclastic activity, thereby delaying subchondral collapse and facilitating bone healing. Most studies have focused on oral or intravenous administration, which, while effective, results in lower localized concentrations at the site of necrosis due to systemic distribution [21-25]. This study utilized local infiltration of zoledronic acid, which ensures a higher concentration at the target site, reducing systemic wastage and enhancing localized efficacy.

The outcomes of this study highlight the potential of the described approach. At the two-year follow-up, mean Harris Hip Scores (HHS) improved significantly: from 81.9 to 97.3 in stage I, from 72.7 to 91.1 in stage IIa, from 68.8 to 88.4 in stage IIb, and from 59.2 to 82.5 in stage III. These findings align with prior studies, such as Agarwala et al., who reported successful outcomes in 68% of stage I-IIb hips treated with core decompression and bone grafting [22]. Wei et al similarly observed excellent results in over 90% of cases treated with core decompression and grafting, emphasizing the importance of early intervention [26].

Despite these promising results, the study has certain limitations. The small sample size, short duration of follow-up, and absence of a control group limit the generalizability of the findings. Additionally, the study did not evaluate the impact of lesion size or etiology on outcomes. Future research with larger sample sizes, randomized controlled designs, and longer follow-ups is necessary to validate these results further. Comparative studies investigating adjunct therapies like MSCs and vascularized grafts could provide additional insights.

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CONCLUSION

This study demonstrates the effectiveness of combining micro-core decompression with local bisphosphonate (zoledronic acid) administration in managing AVN of the hip. This approach yielded significant clinical and radiological improvements while minimizing complications associated with traditional methods. By preserving hip function and delaying disease progression, this novel technique offers a promising treatment option for early and intermediate stages of AVN, particularly in younger patients.

Limitations

The limitations of this study include a small sample population who were included in this study. Furthermore, the lack of a comparison group also poses a limitation for this study's findings.

Recommendation

Baseline screening of hip joints at diagnosis and then at regular intervals to screen the patients for any asymptomatic avascular necrosis and early treatment is recommended.

Acknowledgment

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Data Availability

Data is available upon request.

Author contributions

All authors contributed to the design of the research. KR and WA collected and analyzed the data. NKA and IK wrote the manuscript. MP and SK edited the paper. All authors read and approved the paper.

List of abbreviations

AVN- Avascular necrosis
HHS- Harris Hip Scores
MRI- Magnetic resonance imaging
COPD- chronic obstructive pulmonary disease
CAD- coronary artery disease
THA- total hip arthroplasty
BMP- bone morphogenetic proteins
MSC- mesenchymal stem cells

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Conflict of interest

The authors have no conflicting interests to declare.

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