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Original Article

Functional Outcome of Management of Avascular Necrosis of Femoral Head by Core Decompression and Non-vascularized Fibular Grafting: A Prospective Observational Study

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Abstract

Background: In patients with avascular necrosis of femoral head (ANFH), core decompression (CD) and non-vascularized fibular grafting (NVFG) are used in the early stage of ANFH. However, the functional and clinical outcomes have not be sufficiently evaluated in Indian population. To evaluate the combined effect of CD and NVFG on clinical and functional outcomes in patients with ANFH.

Materials and Methods: This prospective observational study was performed in the Department of Orthopaedics of a tertiary care institute over a period of 18 months (August 2022 to January 2024). The study included 25 young adult patients aged 18–50 years, of either sex, presenting with signs and symptoms of ANFH with up to stage IIa. Clinical and functional outcomes were evaluated at 1, 3, and 6 months with Visual Analogue Scale (VAS) and Harris Hip Score (HHS), respectively.

Results: The mean VAS score decreased significantly at 1, 3, and 6 months compared to the preoperative values ($p < 0.001$). At 6 months, 44.00% and 20.00% patients had good and excellent HHS, respectively. Thus, the proportion of patients with good and excellent HHS increased significantly at 6 months ($p < 0.001$). The mean HHS increased significantly at 1, 3, and 6 months compared to the preoperative score ($p < 0.001$). Five (20%) patients had complications, including collapse of femoral head (n=3), femur neck fracture (n=1), and crescent sign (n=1).

Conclusion: In patients with ANFH, combined use of CD and NVFG results in significant pain relief and improved hip function.

Keywords: Avascular necrosis femoral head, Core decompression, Non-vascularized fibular grafting

INTRODUCTION

Avascular necrosis of the femoral head (ANFH) is a progressive, disabling condition that ultimately results in femoral head fracture and collapse.[1] ANFH has a yearly incidence of 20,000 patients in the United States;[1] however, it is unknown in India[2]. It affects young adults, occurring more commonly in men than women at a ratio of 4:1.[3]

ANFH can be managed non-surgically and surgically. However, the non-surgical modalities are ineffective in halting progression. Among various surgical modalities, core decompression (CD) is reported to

outperform non-surgical modalities for pre-collapse lesions.[4] Total hip arthroplasty is the standard treatment for femoral head collapse. However, ANFH commonly occurs in young adults, and the finite life span of the prosthesis requires frequent revisions.[5] Thus, early diagnosis using magnetic resonance imaging is crucial to identify pre-collapse lesions to initiate hip-preserving surgeries to protect the normal femoral head and arrest the progression.[6]

CD is a safe, minimally invasive, and effective method for intraosseous pressure reduction, necrotic bone removal, bone regeneration, and increased blood flow promotion, thereby, improving the vascularity and slowing the progression.[7] However, the clinical outcomes of using CD alone are often unsatisfactory due to the lack of structural support for the subchondral plate. Thus, to prevent femoral head collapse, non-vascularized fibular grafting (NVFG) may be beneficial, and in combination with CD may provide adequate mechanical support because the straight, elongated shape of the fibula and its cylindrical structure allows maximum contact with the neighbouring bone, thereby matching well with the subchondral bone.[8]

Prospective studies in India evaluating combination of CD and NVFG report improvement in either functional,[3,9] or both clinical and functional outcomes.[6,10,11] However, further studies are required to validate these findings. Thus, this study aimed to evaluate the combined effect of CD and NVFG on clinical and functional outcomes in patients with ANFH.

MATERIALS AND METHODS

This prospective observational study was conducted, over 18 months (August 2022 to January 2024), in the Department of Orthopaedics of a tertiary care institute. The study was approved by the Institutional Ethics Committee and written informed consent was obtained from the patients.

The study included younger adult patients aged 18– 50 years, of either sex and presenting with signs and symptoms of ANFH with up to stage IIa based on the Modified Ficat and Arlet classification. While the patients were excluded if they had history of hip trauma, were medically unfit for surgery, or did not consent to participate in the study.

On admission, a detailed history was taken, and thorough physical examination was performed. Routine preoperative laboratory investigations were conducted. Bilateral hip radiographs were taken in anteroposterior and frog leg views with magnetic resonance imaging of hip for classification and diagnosis of uninvolved hip. Diagnosis was established by clinical and radiological examination. The ANFH was classified according to Modified Ficat and Arlet classification.[12]

Preoperatively, Inj. Tetanus Toxoid and test dose of Inj. Xylocaine were given. Affected limb, and private parts were prepared on the day of surgery. IV antibiotic was given one hour before the surgery. The patients were placed on a traction table in a supine position. Sterile painting and draping were done. Under spinal and/or epidural anaesthesia, a 7-10 cm mid-lateral longitudinal incision was made over the subtrochanteric region. The tensor fascia lata was split in the direction of its fibres and the vastus lateralis muscle was

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elevated. Under C-arm guidance,

a 3.2 mm threaded guide pin was inserted through the
lateral cortex into the affected part of the femoral head, with the entry point between the lesser trochanter and greater trochanter. The guide pin was directed towards the centre of the necrotic area of the femoral head. The guide pin was over-reamed with a dynamic hip screw reamer. Multiple holes were drilled targeting the necrotic area with the help of 6.4 mm reamer after confirming both in anteroposterior was permitted after 3 months postoperatively. Clinical, radiological, and functional evaluations were done using Visual Analogue Scale (VAS), x- rays, and Harris Hip Score (HHS), respectively.

Sample size calculation

The sample size was calculated by the following formula:

and lateral c-arm images.$Z^{2\alpha}p(1-p)$

After these procedures, fibular graft was harvested$1-_2$

$d^2$from the ipsilateral limb approximately 13 cm in length leaving at least 10 cm of fibula proximal to ankle joint mortise and distal to the knee joint unharvested. The harvested graft was trimmed to the appropriate length and all the attached soft tissues were removed. The fibular graft was inserted into the core and its position was checked by image intensifier. The position of the graft was best when its proximal end was within the necrotic lesion and no more than or less than 10 mm beneath the subchondral bone. Negative suction drain placed at operated site. Closure was done in layers.

All patients received postoperative antibiotics for 24- to 48-hours and deep venous thrombosis prophylaxis was reserved for high-risk patients. The patients were allowed to sit up in bed on the first postoperative day. The drain, if placed, was removed after 48-hours of surgery. Static quadriceps exercises were started on the second and third postoperative day. Sutures were removed after 10- to 14-days. The patients were mobilized non-weight bearing as soon as the pain or general condition permitted.

The patients were assessed and followed-up at 1, 3, and 6 months. The patients were evaluated clinically, functionally, and radiologically. The weight bearing As per Shah et al., 67.8% of patients had good to excellent outcome using HHS.[13] Thus, considering a prevalence (p) of 67.8% (0.678), $Z_{0.025}$ = 1.96 for 95% confidence interval, and absolute precision on either side of the proportion (d) of 0.185, the required sample size was calculated to be 25.

Statistical analyses

The data analyses were conducted using Epi Info version-6. The qualitative data was presented as frequencies (percentages), and the quantitative data was presented as mean (standard deviation). The Chi-square test was used as a test of significance for the HHS. Repeated measures ANOVA was performed to assess the association of VAS score at various intervals. Statistical significance was determined at a $p < 0.05$.

RESULTS

The patients were predominantly male (56.00%) and the mean age was 39.2 ± 9.31 years (range: 20–50 years). The majority of the patients had left-sided avascular necrosis of femur head (68.00%) with a VAS score of 7-10 (84.00%) and HHS of <70 (92.00%). The history of steroid use (32.00%) and alcohol consumption (28.00%) were the most common contributing factors resulting in avascular necrosis of femur head (Table 1).

Table 1: Demographic and clinical characteristics

Characteristics	n = 25
Age, years, mean ± SD	39.2 ± 9.31
Gender, n (%)	
Female	11 (44)

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Male	14 (56)
Side of injury, n (%)	
Right	8 (32)
Left	17 (68)
Contributing factors, n (%)	
Post-COVID-19	5 (20)
Idiopathic	5 (20)
Alcohol intake	7 (28)
Steroid intake	8 (32)
VAS score, n (%)	
≤ 3	0 (0)
4 – 6	4 (16)
7 – 10	21 (84)
HHS, n (%)	
90 – 100	0 (0)
80 – 90	0 (0)
70 – 80	2 (8)
<70	23 (92)

HHS: Harris Hip Score

During the study period the mean VAS score decreased significantly at 1, 3, and 6 months compared to the preoperative values ($p < 0.001$) (Table 2).

Table 2: VAS score over the study period

Mean VAS score	Preoperative	Postoperative			p
		1 month	3 months	6 months	
	7.32	5.64	4.72	4.60	<0.001

At 3 and 6 months, 4.00% and 44.00% patients had good HHS, respectively. Moreover, at 6 months, 20.00% of patients had excellent HHS (none at 3 months). Thus, the proportion of patients with good and excellent HHS increased significantly at 6 months ($p < 0.001$). Moreover, the mean HHS increased significantly at 1, 3, and 6 months compared to the preoperative values ($p < 0.001$) (Table 3).

Table 3: Functional outcome (HHS)

HHS, n = 25 (%)	Preoperative	Postoperative			p
		1 month	3 months	6 months	
90 – 100	0 (0)	0 (0)	0 (0)	5 (20)	<0.001
80 – 90	0 (0)	0 (0)	1 (4)	11 (44)	
70 – 80	2 (8)	5 (20)	10 (40)	4 (16)	
<70	23 (92)	20 (80)	14 (56)	5 (20)	
Mean	57.64	64.52	67.68	77.80	<0.001

Of five (20%) patients with complications, three (12.00%) had collapse of femoral head, of which two patients underwent total hip replacement after 1 year of core decompression. One patient sustained femur neck fracture at 8-weeks due to early weight bearing. The patient was immediately immobilized and skin traction with 2 kg weight was applied, subsequently the patient was evaluated and underwent total hip replacement within a week, following which his symptoms subsided and was gradually mobilized with walking aid. Finally, one patient had progression of disease from 2a to stage 3 showing crescent sign (subchondral fracture) for which the patient was immobilized and started on Tablet Alendronate (70 mg once weekly) and symptoms were carefully observed (Table 4).

Table 4: Complications

Complications	**n = 25 (%)**
No complication	20 (80)
Collapse of femoral head	3 (12)
Crescent sign	1 (4)
Neck of femur fracture	1 (4)

Figure 1 illustrates findings on radiological (x-ray) examination: preoperative (a), 1 month (b), 3 months (c) and 6 months (d).

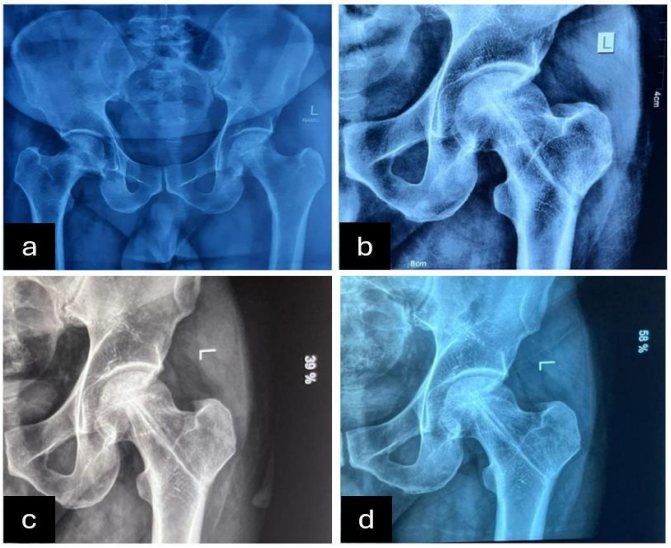

Figure 1: Radiological (x-ray) examination (a) Preoperative. (b) 1 month. (c) 3 months. (d) 6 months.

Figure 2 illustrates findings on clinical examination at 6 months: standing (a), cross leg sitting (b), squatting (c), hip flexion (d), abduction (e) and adduction (f).

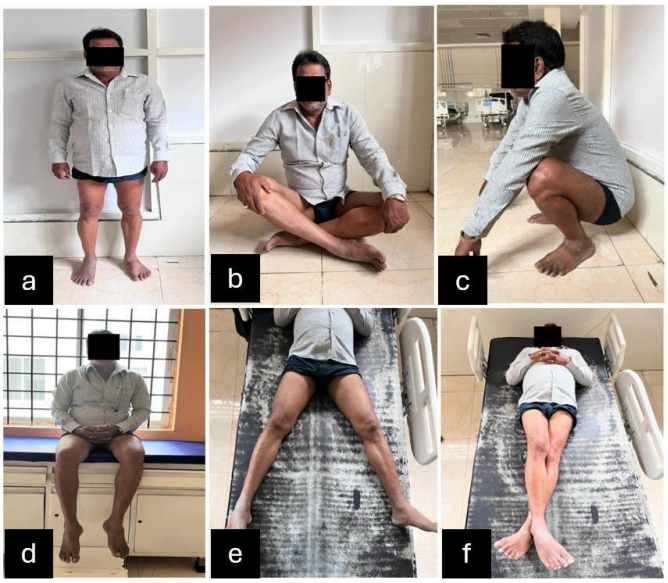

Figure 2: Clinical examination (a) Standing. (b) Cross leg sitting. (c) Squatting. (d) Hip flexion. (e) Abduction. (f) Adduction.

DISCUSSION

The principal findings of the study suggest that management of ANFH by CD and NVFG led to a significant decrease in VAS score at each of the follow-up visits compared to the preoperative VAS score. Similarly, the HHS increased significantly at every follow-up visit compared to the preoperative HHS. Thus, CD and NVFG provided significant pain relief and improved the hip function.

ANFH presents a significant clinical challenge, particularly in terms of preserving hip function and preventing joint collapse. CD and NVFG are two surgical interventions commonly employed to address ANFH.[7] CD is primarily aimed at alleviating intraosseous pressure and enhancing blood supply to the necrotic area, which can lead to pain relief and improved function. However, the efficacy of CD alone has been questioned, with failure rates reported between 20% and 70% in various studies.[14] The addition of bone grafting, particularly NVFG, has been shown to improve outcomes significantly. Changjun et al. demonstrated that modified NVGF combined with CD resulted in a significantly improved HHS, indicating substantial functional recovery.[15] This finding aligns with the assertion that combining CD with grafting techniques enhances the biological stability of the femoral head and promotes healing.[9,15]

Contrarily, NVFG has been highlighted for its ability to provide structural support and promote revascularization of the femoral head. Studies have shown that NVFG can lead to better functional outcomes compared to CD alone. For example, a systematic review indicated that NVFG resulted in superior clinical outcomes and durability compared to CD, with some studies reporting success rates of up to 80%.[16] In the present study, 64% patients had excellent-good functional outcome at 6 months.

Moreover, the combination of CD with NVFG has been associated with a lower incidence of subsequent hip replacement surgeries.[17] We observed that only three (12%) patients required total hip replacement, thus emphasizing its role in preserving hip function over the long-term.

The functional outcomes measured by HHS following these interventions reveal a trend favouring the combination of CD and NVFG. Yousif et al. noted that while CD alone can reduce pain and promote capillary regeneration, it does not fully address the structural integrity of the femoral head.[18] Contrarily, studies involving NVFG have reported significant improvements in HHS, with many patients achieving scores indicative of normal hip function postoperatively.[9] Moreover, the incorporation of advanced techniques such as autologous bone marrow grafting alongside CD has shown promise in enhancing functional outcomes, further supporting the need for multimodal approaches in treating ANFH.[19] Similarly, we observed significant improvements in HHS at 6 months compared to preoperative values.

Rackwitz et al. noted that CD provides significant pain relief, with many patients reporting substantial reductions in VAS scores postoperatively.[20] In a systematic review, Zhao and Yu reported that CD resulted in a significant reduction in VAS score from preoperative values to last follow-up, indicating a clinically meaningful reduction in pain.[21] Furthermore, Li et al. demonstrated that patients undergoing CD alone experienced a significant improvement in VAS scores at 10 years follow-up, although some patients eventually required total hip arthroplasty due to disease progression.[19] Contrarily,

NVFG has been shown to provide favourable outcomes compared to CD alone. A systematic review by Ali et al. highlighted that NVFG not only addresses the structural integrity of the femoral head but also contributes to pain relief, with reported significant reduction in VAS score.[16] This finding is corroborated by a meta-analysis that found that patients who underwent NVFG had significantly lower VAS scores compared to those who received CD alone.[22]

Moreover, the combination of CD and NVFG appears to yield the best clinical outcomes. A recent RCT demonstrated that patients receiving both interventions reported a mean VAS score of 1.5 at the 12 months follow-up, significantly lower than the scores reported for either treatment alone.[19] This suggests that the synergistic effect of combining CD with NVFG may enhance pain relief and improve overall functional outcomes. Additionally, the long- term follow-up of patients who underwent this combined approach showed sustained improvements in VAS scores, with many patients maintaining low levels of pain even years after surgery.[23]

Compared with the complexity of vascularised fibular grafting and the high costs of tantalum rod implantation, CD with modified non-vascularized allogeneic fibula grafting is a cost-effective and efficient procedure.[15] Moreover, CD with autogenous fibular grafting reduces surgical costs compared with allogeneic fibular graft.[8]

This study has some limitations. First, this was a single-centre study with a small sample size. Second, the follow-up period was short, so the long-term outcomes could not be assessed. Third, this study focuses on the clinical and functional outcomes, notthe radiographic survival rates using MRI to assess AVNF progression, graft incorporation and femoral head integrity. Fourth, this method is unsuitable for middle- to late-stage AVNF, and thus, not recommended when a femoral head collapse is confirmed. A randomized controlled multi-centre trial with a larger sample size is required to confirm these results and achieve a definitive conclusion.

CONCLUSION

In patients with ANFH, management with CD and NVFG resulted in significant decrease in VAS score and improvement in HHS. Only a few patients developed complications, suggesting that combination of CD and NVFG provides significant pain relief with improved hip function. Thus, combination of CD and NVFG contributes to the long-term preservation of hip function and reduction in the need for total hip arthroplasty.

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Conflicts of interest

There are no conflicts of interest.

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