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Original Research Article

FUNCTIONAL OUTCOME OF PRIMARY UNCEMENTED TOTAL HIP ARTHROPLASTY IN AVASCULAR NECROSIS OF THE FEMORAL HEAD: A PROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT

Background: Avascular necrosis (AVN) of the femoral head is a debilitating condition commonly affecting younger individuals. It often progresses to end-stage arthritis. In AVN cases when conservative measures fail, surgical intervention in the form of total hip arthroplasty (THA) becomes necessary. Among fixation techniques, uncemented THA has gained prominence due to its potential for osteointegration, long-term stability, and favorable outcomes in younger patients.

Materials and Methods: This prospective observational study was conducted over 18 months at a tertiary care hospital in Western Maharashtra. It included 16 patients aged up to 60 years of age with Ficat and Arlet Stage 3 or 4 AVN undergoing primary uncemented THA. Standardized preoperative planning, intraoperative techniques and postoperative rehabilitation protocols were followed. Functional outcomes were assessed by Harris Hip Score (HHS) till 3 months post-operatively. Radiographic evaluation included component positioning, limb length discrepancy and evidence of implant loosening. Data were analyzed using SPSS v29 with repeated measures ANOVA and Bonferroni correction for longitudinal assessment.

Results: The mean patient age of studied cases was 44.06 years with a male predominance (87.5%). Most patients presented with Stage 3 AVN (56.25%). Femoral alignment was neutral in 87.5%, with 12.5% showing mild varus; acetabular inclination was within the ideal range in 100% cases. Mean HHS improved significantly from 40.5 preoperatively to 87.44 at 3 months ($p < 0.001$) follow up. All (100%) of patients achieved good-to-excellent functional outcomes. Limb length discrepancy was effectively corrected and no radiographic signs of loosening were observed. Early mobilization was achieved in the majority of patients and postoperative complications were minimal.

Conclusion: Uncemented total hip arthroplasty provides excellent functional and radiological outcomes in patients under 60 years with advanced AVN. With careful surgical planning and technique this modality offers a durable and reliable solution with minimal complications and rapid postoperative recovery. However larger, long-term studies are warranted to validate these findings.

Keywords: Avascular Necrosis, Total Hip Arthroplasty, Uncemented Hip Replacement, Harris Hip Score, Osteointegration.

INTRODUCTION

The human hip joint is extremely complicated because of the practical demands placed on it by the body. Because of its puzzling biomechanics and substantial potential, a sturdy, effortless hip is essential for ordinary movement. The hip is largest ball and socket type of joint in human body.[1] It has two components: a femoral head ball and a pelvic bone acetabulum. Articular cartilage protects the smooth tissue that is cushioning the bone end and allows for motion of joint. inflammation in the rheumatoid arthritis, osteoarthritis, post-traumatic arthritis and connective tissue damage can cause substantial effect on joint leading to disability and pain. Furthermore, certain illnesses like avascular necrosis, can cause disintegration of head of femur.[2]
Avascular necrosis as the name suggests is caused by a decrease in blood going to the bone, this results in the loss of cells of bone. Avascular necrosis is most commonly seen in the femoral head of the hip, but it can also affect joints like ankle, shoulder and knee. Possible reasons include long-term consumption of steroids or alcohol, fractures, dislocations, coagulopathy Conservative measures or invasive methods might be used to treat avascular necrosis in the femoral head. Early on, conservative measures such as physical therapy, stopping corticosteroid treatment, using drugs that reduce inflammation, and restricting weight bearing should be considered. The clinical outcomes for avascular necrosis are improved by bisphosphonates and statins as well, particulalry during the initial phases of AVN.[3]
Total hip replacement is most common procedure used for treating joint irregularities due osteoarthritis and other conditions that impair hip joint function. Surgery falls into two categories: hemiarthroplasty and total hip arthroplasty, which replace the femoral head entirely or in part, and core decompression, osteotomy, non-vascularized and vascularized bone grafting, and autologous bone grating, which leave the femoral head intact. The most common type of treatment is called total hip arthroplasty (THA) is used in cemented or cementless avascular necrosis (stage III and IV).[4]
The method by which an implant can be fixated in a joint is still a source of discussion.
Implants which are cemented achieve stability by cement bone mechanical interlock after the polymethylmethacrylate (PMMA) has set, whereas uncemented fixation of implant relies on essential press fit strength with long-term dependability occurring secondary to endosteal miniature cracks at the time of preparation and resulting bone on development or in development.[5]
Uncemented prostheses are surface-designed in one of two ways, enabling bony interlock through on- or in-development. On-development surfaces are created by coarsely hitting or plasma spraying hydroxyapatite (HA) into the part. This results in a completed surface with many gaps for bone growth. Sintered beads, fibre mesh and porous metals can also be used to create tiny pores that allow bone to form. Ideal pore size for hard in-development is 50-400 μm. The recommended degree of voids within the covering should be 30%-half to maintain mechanical strength.[6]
The promise for improved holding and solidity by coating prosthesis with bioactive materials such as HA and tricalcium phosphate has sparked considerable attention. These mixes effectively stimulate osteoblasts rather than simply providing a substrate for adhesion.
Uncemented stems have a wide range of designs such as wedged, tightened, round and hollow, measured and anatomic shapes. Additionally, the option of proximal blades and ribs for extra strength and splines, flutes, and holes to reduce modulus of elasticity is also available. More short stem designs have recently been developed with the goal of creating a more "physiological" stacking of the proximal femur and reducing the difficulties of pressure shielding.[7]
There are certain disadvantages of cemented bone stems which has led to popularity of uncemented stems. Pieces covered in hydroxyapatite and permeable are used in uncemented implants. This creates an organic point of contact known as osteointegration, or bone ingrowth. This type of fixation is continuously evolving and is being redesigned. These newer designs and materials proves to be more durable than using up all the bone cement. This study was undertaken to evaluate functional and clinical results of an uncemented total hip replacement with use of Harris hip score.

MATERIALS AND METHODS

This prospective observational study was conducted in the Department of Orthopaedics at Bharati Vidyapeeth (Deemed to be University) Medical College and Hospital, Sangli. The duration of study was 18-month. The study enrolled patients up to 60 years of page presenting with osteoarthritis of the hip secondary to avascular necrosis (AVN) of the femoral head (Stages 3 and 4), as classified by the Ficat and Arlet staging system. The minimum sample size required for the study using the power analysis module of SPSS version 29 for a one-sample proportion test was determined to be 15. The calculation was based on an anticipated population proportion of 80% for excellent outcomes as assessed by the Harris Hip Score. A null hypothesis value of 60%, power of 80% and alpha level of 0.05 was considered. The final sample size so determined was found to have sufficient statistical power to detect a clinically meaningful difference in outcomes.
A total of 16 patients were included in this study on the basis of a predefined inclusion and exclusion criteria. After obtaining written informed consent all participants underwent detailed clinical evaluation including detailed history-taking, thorough physical

examination as well as preoperative assessment. Radiological imaging included anteroposterior (AP) views of the pelvis, lateral views of the hip, spine and thigh. A chest X-ray was also done. Patients underwent pre-anesthetic evaluation and were screened for active infections. Preoperative planning involved radiographic templating using the AP pelvis view to determine the optimal position, size and orientation of the acetabular and femoral components. Special attention was given to anatomical landmarks such as the teardrop, ilioischial (Köhler's) line and femoral head center to plan component placement. Acetabular anteversion and medialization were assessed and femoral templating included evaluation of neck-shaft angle, canal fit and anticipated neck resection level. prophylactic antibiotics (1.5 g Ceftriaxone + Sulbactam) were administered to all patients prior to surgery.

Figure 1: Radiographic evaluation of hip pathology and postoperative assessment in Total Hip Arthroplasty (THA) (Left: Preoperative AP pelvis radiograph showing hip joint pathology; Middle: Postoperative AP pelvis radiograph following uncemented THA; Right: Postoperative AP pelvis radiograph demonstrating measurement of acetabular cup inclination angle).

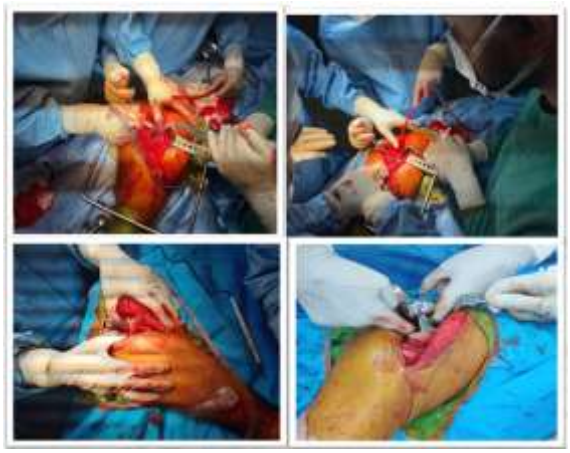

Figure 2: Intraoperative steps of uncemented Total Hip Arthroplasty (THA) (Starting clockwise from the left upper corner: Acetabular reaming; Reamed acetabulum; Femoral head insertion; Insertion of femoral stem).

Surgical Technique: All surgeries were performed using the posterior (Moore) approach under regional anesthesia (spinal or epidural). Patients were positioned in the lateral decubitus position for surgery. A 10–15 cm skin incision was made centred posterior to the greater trochanter. Following layer-wise dissection, the short external rotators were identified and released as required, and a posterior capsulotomy was performed to expose the hip joint.

The femoral head was dislocated posteriorly and excised using a head extractor and bone levers. The acetabulum was then exposed and all soft tissue remnants (osteophytes and debris) were removed. Sequential acetabular reaming was done using reamers until a hemispherical socket with bleeding cancellous bone was seen. The acetabular component was oriented and inserted maintaining approximately 45° of abduction and 15° of anteversion. This was followed by trial cup placement to ensure accurate fit and stability. The definitive acetabular component was then implanted and positioned appropriately.

Following acetabular preparation attention was shifted to the femoral side. The femoral canal was opened and sequentially prepared using progressively larger broaches and rasps until adequate axial and rotational stability was achieved. Trial reductions were performed using appropriate neck lengths to confirm leg length restoration. Moreover, soft tissue tension, range of motion and joint stability against posterior dislocation was also assessed. After final canal preparation and irrigation, the selected femoral stem was inserted in appropriate alignment. A modular femoral head was then applied and final reduction was performed.

Hemostasis was secured, and the wound was closed in layers over a drain when indicated. An abduction pillow was placed between the lower limbs postoperatively to maintain hip precautions. Clinically and radiographically assessed limb length discrepancy (true and apparent) was also documented to evaluate restoration of anatomical alignment.

All patients were followed up to 3 months post-operatively. At each follow up visit clinical examination and functional assessment (Harris Hip Score) were conducted. Radiographic evaluation was also performed to assess component positioning and detect signs of loosening or other complications if any. Limb length discrepancy and patient-reported outcomes were also documented during each follow-up.

Data analysis was performed using SPSS version 29 and Microsoft Excel. Descriptive statistics were computed for categorical variables. Continuous variables including age, true and apparent limb lengths (preoperative and postoperative), and Harris Hip Scores on different follow-up days were analyzed using mean, standard deviation and standard error. Repeated measures ANOVA was applied for longitudinal comparisons, with adjustment for post hoc analysis to determine statistically significant differences across time intervals.

Inclusion Criteria

- Patients aged up to 60 years with Stage 3 or 4 AVN of the femoral head.
- Patients who underwent primary uncemented total hip arthroplasty (THA).
- Patients willing to provide informed consent and comply with follow-up.

Exclusion Criteria

- Patients unwilling to participate despite undergoing surgery.
- Patients undergoing THA due to traumatic indications.

RESULTS

Majority of patients were male (14 cases, 87.5%) with only 2 females (12.5%). The most commonly affected age group was 51–60 years (43.75%), followed by 21–30 years (25%), 41–50 years (18.75%), and 31–40 years (12.5%). Over half of the patients (56.25%) had no associated conditions, while hypertension and diabetes mellitus were present in 25% and 18.75% of cases. Right hip was more frequently involved (56.25%) compared to the left (43.75%). A slight majority had Grade 3 disease (56.25%) while the remaining 43.75% had Grade 4 involvement [Table 1].

Table 1: Baseline profile (Demography + Clinical variables) in studied cases.

Variable	Category	Number (n)	Percentage (%)
Gender	Male	14	87.5
	Female	2	12.5
Age group (years)	10–20	0	0
	21–30	4	25
	31–40	2	12.5
	41–50	3	18.75
	51–60	7	43.75
	61–70	0	0
Co-morbidities	None	9	56.25
	Diabetes Mellitus (DM)	3	18.75
	Hypertension (HTN)	4	25
Laterality	Right	9	56.25
	Left	7	43.75
AVN Grade	Grade 3	9	56.25
	Grade 4	7	43.75

The analysis of implant positioning parameters in the studied cases showed that the femoral component was aligned neutrally in the majority of hips (14 cases, 87.5%). A varus alignment was observed in 2 cases (12.5%) and no cases of valgus alignment were reported. Regarding acetabular inclination all implants (100%) were placed within the optimal range of 35–50°with no cases falling below 35° or exceeding 50° [Table 2].

Table 2: Implant positioning parameters in studied cases.

Parameter	Category	Number (n)	Percentage (%)
Femoral component alignment	Neutral	14	87.5
	Varus	2	12.5
	Valgus	0	0
Acetabular inclination	< 35°	0	0
	35–50°	16	100
	> 50°	0	0

Preoperatively, most patients (14 cases, 87.5%) had limb lengths between 86–90 cm. 2 patients (12.5%) had shorter limbs measuring 80–85 cm. Postoperatively the majority (87.5%) remained within the 86–90 cm range. 2 patients (12.5%) showed an increase in limb length to 91–95 cm. No patients remained in the 80–85 cm range [Table 3].

Table 3: True limb length (Affected limb) pre-operative vs post-operative.

True limb length (cm)	Pre-op n (%)	Post-op n (%)
80–85	2 (12.5)	0 (0)
86–90	14 (87.5)	14 (87.5)
91–95	0 (0)	2 (12.5)
Total	16 (100)	16 (100)

The analysis of apparent limb length before and after surgery revealed that preoperatively, the majority of patients (14 cases, 87.5%) had limb lengths between 110–115 cm. Only 2 patients (12.5%) had lengths between 116–120 cm. Postoperatively, this pattern reversed with 13 patients (81.25%) showing an apparent limb length of 116–120 cm. Only 3 patients (18.75%) remaining in the 110–115 cm range [Table 4].

Table 4: Apparent Limb Length (Affected limb) pre-operative vs post-operative.

Apparent limb length (cm)	Pre-op n (%)	Post-op n (%)
110–115	14 (87.5)	3 (18.75)
116–120	2 (12.5)	13 (81.25)
Total	16 (100)	16 (100)

Preoperatively, most patients had poor Harris Hip scores with 50% scoring between 31–40 and 37.5% between 41–50. Preoperatively only 12.5% were in the 51–60 range. By postoperative day 45 functional status had significantly improved. Postoperatively 68.75% of patients scored between 81–90 and 31.25% between 71–80. Further improvement was noted by postoperative day 90 where 75% of patients remained in the 81–90 range and 12.5% reached the highest score bracket of 91–100. Only 12.5% were in the 71–80 range. No patients scored below 70 at either postoperative follow-up [Table 5].

Table 5: Harris Hip Score (HHS) category distribution preoperative and during follow up.

HHS range	Pre-op n (%)	POD 45 n (%)	POD 90 n (%)
0–10	0	0	0
11–20	0	0	0
21–30	0	0	0
31–40	8 (50)	0	0
41–50	6 (37.5)	0	0
51–60	2 (12.5)	0	0
61–70	0	0	0
71–80	0	5 (31.25)	2 (12.5)
81–90	0	11 (68.75)	12 (75)
91–100	0	0	2 (12.5)

The analysis of Harris Hip Score (HHS) over time demonstrated a significant improvement in functional outcomes following surgery. The mean preoperative HHS was 40.5 (SD = 7.483), indicating poor function. By postoperative day 45 the mean score had more than doubled to 82.13 (SD = 4.129). These findings were indicative of substantial early recovery. Further improvement was observed by postoperative day 90 with the mean HHS rising to 87.44 (SD = 3.54) [Table 6].

Table 6: Mean Harris Hip Score (HHS) with dispersion, preoperative and during follow up.

Time point	Mean	SD	SE	95% CI (Lower–Upper)
Pre-op	40.5	7.483	1.871	36.512 – 44.488
POD 45	82.13	4.129	1.032	79.925 – 84.325
POD 90	87.44	3.54	0.885	85.551 – 89.324

Majority of patients began walker-assisted mobilisation within the first 21 days (87.5%). Remaining patients started walker-assisted between days 22–30. Cane-assisted mobilisation was started between days 22–45 in majority of patients (81.25%). Mobilisation without support was achieved by day 46 in 87.5% of cases. Analysis of Postoperative complications showed that only one patient (6.25%) experiencing limb length discrepancy. Anterior thigh pain was reported by 1 (6.25%) patient. The vast majority (87.5%) of patients had no complications. The final functional outcome was graded as good in 62.5% and excellent in 37.5% of patients [Table 7].

Table 7: Recovery milestones, complications and overall outcome

Domain	Parameter	Category / Statistic	Number (n)	Percentage (%)
Mobilisation Timeline (Time represents first independent use of the respective assistive device. Categories are not mutually exclusive.)	Walker mobilisation	Day 1–21	14	87.5
		Day 22–28	1	6.25
		Day 28–30	1	6.25
	Cane mobilisation	Day 22–45	13	81.25
		Day 45–49	1	6.25
		Day 31–50	1	6.25
		Day 51–55	1	6.25
	Mobilisation without support	Day 46 onwards	14	87.5
		Day 51 onwards	1	6.25
		Day 56 onwards	1	6.25
Post-operative Complications	Limb length discrepancy	Present	1	6.25
	Anterior thigh pain	Present	1	6.25
	No complications	None	14	87.5
Final Outcome (Post-surgical)	Outcome grade	Excellent	6	37.5
		Good	10	62.5
		Total	16	100

In terms of limb length measurements, the true limb length improved from a preoperative mean of 87.19 cm to 89.06 cm postoperatively, closely matching the normal limb (mean 89.13 cm). Apparent limb length also improved from a preoperative mean of 114.19 cm to 116 cm postoperatively, achieving symmetry with the normal limb. These findings highlight effective anatomical restoration and strong functional recovery following uncemented total hip arthroplasty [Table 8].

Table 8: Descriptive statistical outcome in studied cases.

Statistics	AGE	True Length Normal LIMB	PRE OP True Length	POST OP True Length	Normal Apparent Limb Length	PRE OP Apparent length	POST OP Apparent length
Mean	44.06	89.13	87.19	89.06	116	114.19	116
Std. Error of Mean	2.97	0.36	0.37	0.35	0.42	0.38	0.42
Std. Deviation	11.89	1.46	1.47	1.39	1.67	1.52	1.67
Minimum	24	86	84	86	111	110	111
Maximum	56	91	89	91	118	116	118
Q1	31.5	88	86	88	116	114	116
Median	50	89	87.5	89	116	114.5	116
Q3	54.75	90	88	90	117	115	117

DISCUSSION

This prospective observational study was undertaken to evaluate the clinical and functional outcomes of uncemented total hip arthroplasty (THA) in patients under 60 years of age with avascular necrosis (AVN) of the femoral head. Our study supports the existing body of evidence that shows that the uncemented THA as an effective surgical option for advanced AVN. The mean patient age in our study was 44.06 years. There was a significant male predominance (87.5%). This demographic characteristic was similar to the patient demographics of patients in study by Karimi et al who reported a similar mean age of 43.9 years and a male predominance of 73% in AVN cases undergoing THA.[8] Similarly Hamilton TW et al also demonstrated a comparable demographic pattern.[9] Majority of cases with late-stage AVN underwent uncemented THA in these studies.

Our study demonstrated right hip predominance (56.25%). This was consistent with the findings of Rama M et al who also noted right-sided involvement in 56.67% of their patients undergoing THR.10 Regarding disease severity 56.25% of our patients had AVN Grade 3 and 43.75% had Grade 4. These staging patterns was similar with the observations of Kakaria HL et al who reported a higher proportion of Grade 4 AVN in their cohort.[10,11] This staging justifies the selection of THA as the treatment of choice in such advanced disease states. As emphasized by Davey and Harris in their study AVN remains a principal non-traumatic cause of femoral head collapse necessitating joint replacement.[12] This is more so in younger populations. These authors also highlighted the relevance of avoiding delay in surgical intervention to preserve joint function and optimal outcomes.

Radiographic parameters in our study indicated precise surgical execution. The femoral stem alignment was neutral in 87.5% of cases. All acetabular components were placed within the inclination range of 35–50 degrees. These findings were found to be comparable with those reported by other authors. For example, Wade et al reported that 82.14% of femoral components were neutrally aligned and 95% of acetabular components were within 40–50 degrees.[13] Additionally our analysis of limb length restoration postoperatively showed that significant improvements were seen in both true and apparent limb length. Restoration of limb length symmetry is crucial in these cases because it ensures proper biomechanics and avoid gait abnormalities. Similar outcomes were also reported by Chang CY who additionally underscored the importance of radiological assessment for accurate implant placement and postoperative functionality in cases of AVN of hip undergoing THR.[14]

Our study observed minimal postoperative complications. Only one patient (6.25%) experienced limb length discrepancy and one (6.25%) patient reported anterior thigh pain. No major intraoperative or postoperative issues were noted in other cases. These rates are better as compared to the complications reported by Haenle M et al,[15] who reported superficial wound infections requiring secondary suturing and intraoperative calcar fractures. Goldberg et al16 also noted that 5% of patients undergoing hip arthroplasty reported thigh pain. The low incidence of complications in our study may point towards meticulous standards of procedural safety and technical feasibility of uncemented THA in experienced hands. Furthermore, in this study functional recovery was significant with the Harris Hip Score (HHS) improving from a mean of 40.5 to 87.44 by postoperative day 90. These findings were similar to the findings reported by Celebi L et al17 and Vissers MM et al.[18]

Postoperative mobilization timelines in our cohort indicated early recovery with 87.5% of patients achieving ambulation without any support by day 46. In our study, 62.5% of patients had good outcomes, and 37.5% had excellent outcomes by final follow-up. These results were similar to the study by Singh V et al,[19] and Jayaram BS et al,[20] who also reported significant improvement in HHS in cases of AVN undergoing cementless THR.

Our findings conclude that uncemented THA offers excellent clinical and functional results in patients under 60 years of age with AVN of the femoral head. The osteo-integrative properties of uncemented hip prostheses along with their long-term durability make these prostheses a superior choice for younger patients. Therefore, we advocate for the use of uncemented THA as a reliable treatment modality in advanced AVN, especially in middle-aged individuals with preserved bone quality. Further large-scale, multicenter randomized controlled trials are needed to further validate these findings.

CONCLUSION

In cases of AVN of hip, total hip arthroplasty (THA) significantly improves pain relief, walking ability and overall quality of life in carefully selected patients. In this study functional outcomes were assessed using the Harris Hip Score with most patients showing excellent postoperative improvement. Early mobilization with mild weight bearing was initiated on day one. No radiographic signs of loosening were observed during the 3-month follow-up. Although limited by a small sample size and short follow-up absence of radiological loosening supports THA as a reliable treatment option in these cases.

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