

Dual Mobility Cup Total Hip Arthroplasty (DMC-THA) in Neck of Femur Fractures in Elderly: A Prospective Study

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ABSTRACT

Introduction: Neck of femur fracture persisted as a common hip fracture in the elderly. Various modes of treatment have been adopted with the aim of early mobilization and durability. However, conventional arthroplasty procedures have been associated with certain drawbacks which made the evolution of Dual Mobility Cup Total Hip Arthroplasty (DMC-THA) a potential selection. The present study was aimed to evaluate the functional and radiological outcomes of the use of DMC-THA in the management of neck of femur fractures in the elderly Indian population.

Materials and Methods: A prospective study including 40 patients with fractured neck of femur in elderly treated with DMC-THA in a tertiary re hospital. The patients were evaluated in terms of functional and radiological outcomes during follow-up at 6 weeks, 3 months, 6months & 2 years.

Results: Out of 40 patients, two patients were lost to follow-up and excluded from the study. The remaining 38 patients had shown good functional outcomes using the Harris hip score. Also, there was a significant improvement in the range of motion around the hip joint in the subsequent follow-ups. There were no reported complications like peri-prosthetic joint infection, dislocation, peri-prosthetic fracture.

Conclusion: DMC-THA is an alternative to conventional THA in the surgical management of fractured neck of femur in elderly patients with the advantages of increased range of motion, less risk of dislocation, and improved postoperative rehabilitation.

Keywords: Dual mobility cup, Total hip arthroplasty, Neck of femur fracture, Elderly, Indian population

INTRODUCTION

The geriatric population has significantly increased across the world due to increased life expectancy which can be attributed to improved health care, increased access to education, and economic growth. The proportion of the elderly population has been rising and will continue to grow from 8% (551 million people over 65 years) in 2010 to 21% (1964 million people over 65 years) by 2050. The projected two billion elderly people of the year 2050 are already around us as teenagers and young people ^[1]. The geriatric population is more susceptible to the neck of femur fractures due to the unsteadiness of gait and reduced bone mineral density. The incidence of fracture neck of femur in the geriatric age group has increased continuously with 1.7 million in 1990 to a projected 6.3 million in 2050 [2]. With the increasing geriatric population, geriatric hip fractures will become a substantial burden for the public health system ^[2]. India being the second-most populous country in the world and with the growing aging population, hip fracture is a matter of concern in the Indian population ^[3]. Elderly women particularly are at higher risk to sustain the neck of femur fracture as compared to men due to osteoporosis ^[4]. Surgical management of hip fractures has been the gold standard for many decades, as it can reduce prolonged immobilization and related complications such as thromboembolic disease, decubitus ulceration, respiratory infections, and loss of independence, financial burden, and mortality ^[5]. Treatment options for the neck of femur fracture in the elderly have evolved with time, from conservative to osteosynthesis to currently replacement arthroplasty, with every effort to retain the normal function of the hip joint with the least complication and morbidity ^[6,7]. Replacement arthroplasty has far better functional outcomes than osteosynthesis ^[8]. Hemi-replacement (HA) and primary total hip replacement (THA) are widely used treatment options in replacement arthroplasty. Though hemi-replacement arthroplasty has the advantages of having lesser operative time, less blood loss and lesser rate of dislocation as compared to total hip arthroplasty, the complications of acetabular erosion, pain after few years, and the re-operation rate has been a matter of concern ^[6,7,9]. Owing to these complications primary total hip arthroplasty has become an alternative for hemi-replacement arthroplasty in the neck of femur fractures ^[6,7,9]. The functional outcome and patient satisfaction after total hip arthroplasty have far succeeded that of hemi-replacement arthroplasty in long term analysis ^[6,7,9,10]. Although total hip arthroplasty has better functional outcomes, it has been plagued by a high rate of dislocation (10.7%) ^[11]. Soft tissue injury after a displaced neck of femur leads to instability and poor biomechanics which results in dislocation after total hip arthroplasty ^[11]. To address this shortcoming, dual mobility cup total hip replacement was designed. Dual articulation facilitates greater jump distance leading to increase range of motion and reduced risk of impingement hence lesser dislocation ^[12,13]. Total hip arthroplasty using dual mobility cups has shown a lesser rate of dislocation (1.4%) in revision arthroplasty due to instability in the western population ^[12,13]. Owing to a different lifestyle and cultural habits (like squatting and crossed leg sitting) in the Indian population, which requires an extreme range of movements at the hip joint unlike the western population ^[14], there is a need to assess the function and behaviour of dual mobility cup total hip arthroplasty in the displaced neck of femur fracture in Indian population. Currently, there is a lack of studies assessing the functional and radiological outcomes of total hip arthroplasty using dual mobility cups in the elderly Indian population with displaced fracture neck of femur and the complication associated with it. The present study aims to assess the functional and radiological outcomes of

dual mobility cup total hip replacement in the elderly Indian population having displaced neck of femur fracture and to determine whether it is a better option for the neck of femur fracture than other available modalities.

MATERIALS AND METHODS

This is a prospective study conducted in a tertiary care level teaching hospital between September 2015 and August 2018. Patients were recruited from September 2015 to September 2017. Ethical clearance was taken from the Institute Ethical Committee. Informed written consent was taken from all the patients at the time of admission. Patients between the age of 60 to 85 years, having displaced neck of femur fractures and operated using dual mobility cup total hip replacement between September 2015 and September 2017 with a minimum two year follow up were included. Patients having other fractures in the ipsilateral limb, pre-existing neurological deficits, and patients with prior surgery on the same hip or the limb were excluded. Plain radiograph of the affected limb Antero-Posterior view was taken and the fracture was classified as per Garden's classification. Preoperative limb shortening was noted. After a thorough preoperative workup, patients were taken for the surgery. Total hip arthroplasty with dual mobility cup implants was done using the Modified Hardinge approach in lateral position. During the post-op period, limb elevation was done along with DVT prophylaxis. Intravenous antibiotics for three days along with wound inspection was done on a postoperative second day. Antero-posterior radiograph of operated limb taken on day one postoperatively. Drain removal was done within 48 hours of surgery. Complications if any were noted and classified as Intraoperative, Immediate, and Late complications. Rehabilitation started immediately with active mobilization of both lower limbs and hip range of motion exercises on postoperative day one. From day two, weight-bearing with support as tolerated was allowed. Follow up was done at 1st week for full weight-bearing with support, 2nd week for suture removal. The remaining follow ups were done at 6th week, 3rd month, 6th month, and 2 years. During these follow-ups, the functional outcome in patients was studied using Harris hip score and the Radiological outcome by evaluation of skiagram for acetabular anteversion, acetabular inclination, and peri-prosthetic lucency.

MS Excel, SPSS version 22 (IBM SPSS Statistics, Somers NY, USA) was used to analyse the data. P-value of <0.05 was considered as statistically significant after assuming all the rules of statistical tests.

RESULTS

40 patients underwent dual mobility cup total hip replacement for the displaced neck of femur fractures during the study recruitment period. Two patients were lost to follow up hence, 38 patients with two years follow up were included. In the study, 55% were females and 45% were males. Mode of injury in the majority of patients was slip and fall [82%] and 18% had a road traffic accident. The mean injury to surgery time was 2.05 days. 52.5% of patients had Garden Type 3 fracture and 47.5% of patients had Garden Type 4 fracture. All patients underwent an anterolateral approach to Hip (Modified Hardinge approach). 57.5% underwent uncemented THR and 42.5% underwent Hybrid THR. In the uncemented group, the mean Cup size was 48.4 ± 2.1 mm. In the Hybrid group, the mean Cup size was 48.6 ± 2.6 mm. There was no significant difference ($p= 0.792$) in Cup size concerning the type of

THR done. Pre-operative mean limb shortening was 1.45 ± 0.43 cm and was reduced to 0.288 ± 0.373 cm post-operatively. This decrease in limb shortening post-operatively as compared to pre-operative value was statistically significant ($p < 0.001$). The mean duration of hospitalization was found to be 5.45 days with a mean duration of intravenous antibiotics administration for 3.4 days. The mean duration for suture removal was 15.775 days.

In the study, the mean Pain Score at 6 weeks was 30.0 ± 6.2 , at 3 months 39.5 ± 4.1 , at 6 months and 2 years was 43.4 ± 1.4 . The mean Function Score at 6 weeks was 26.2 ± 4.3 , at 3 months 33.1 ± 4.5 , at 6 months 38.9 ± 4.4 and at two years was 39.4 ± 3.8 . The mean Flexion at 6 weeks was 78.7 ± 8.0 degree, at 3 months 92.5 ± 9.1 degrees, at 6 months 100.0 ± 9.4 degrees, and at two years was 101.3 ± 8.8 . The mean Abduction at 6 weeks was 24.9 ± 5.1 degree, at 3 months 32.9 ± 4.3 degrees, at 6 months 36.2 ± 3.9 degree and at two years was 36.2 ± 3.9 . The mean Adduction at 6 weeks was 6.5 ± 4 degree, at 3 months 10.0 ± 4.0 degree, at 6 months 10.8 ± 3.9 degrees, and at two years was 11.2 ± 3.8 . The mean External rotation at 6 weeks was 17.4 ± 5.2 degree, at 3 months 26.2 ± 5.0 degree, at 6 months 30.3 ± 4.6 degrees, and at two years was 30.7 ± 4.2 . The mean Final Harris Hip Score at 6 weeks was 64.8 ± 9.7 , at 3 months 81.5 ± 8.0 , at 6 months 91.5 ± 5.1 and at two years was 92.1 ± 4.3 . There was a significant increase in the mean Pain score, mean Functional score, mean flexion, abduction, adduction, external rotation and Final Harris Hip Score at 3 months, 6 months, and two years as compared to 6th-week values (**Table I**).

Pain Score	Mean	Media n	SD	P value
6 weeks	30.0	30.0	6.2	
3 months	39.5	40.0	4.1	<0.001*
6 months	43.4	44.0	1.4	<0.001*
One year	43.4	44.0	1.4	<0.001*

Table 1: Harris Hip Pain Score comparison at 6 weeks, 3 months, 6 months and one year post-operative period

In our study mean Function Score at 6 weeks was 26.2 ± 4.3 , at 3 months 33.1 ± 4.5 , at 6 months 38.9 ± 4.4 and at one year was 39.4 ± 3.8 . There was significant increase in Function Score at 3 months, one year and one year compared to one-year values i.e. there was improvement in Function (**Table 2**).

Duration	Mean	Median	SD	P value
6 weeks	26.2	26.0	4.3	
3 months	33.1	32.0	4.5	<0.001*
6 months	38.9	40.0	4.4	<0.001*
One year	39.4	40.0	3.8	<0.001*

Table 2: Harris Hip Function Score comparison at 6weeks , 3 months, 6 months and one year post-operative period

In the study mean Flexion at 6 weeks was 78.7 ± 8.0 degree, at 3 months 92.5 ± 9.1 degree, at 6 months 100.0 ± 9.4 degree and at one year was 101.3 ± 8.8 . There was significant increase in degree of Flexion at 3 months, 6 months and one year compared to 6 weeks values i.e. there was improvement in Function (**Table 3**).

	Mean	Median	SD	P value
6 weeks	78.7	80.0	8.0	
3 months	92.5	90.0	9.1	<0.001*
6months	100.0	100.0	9.4	<0.001*
One year	101.3	100.0	8.8	<0.001*

Table 3: Range of Flexion (degree) comparison at 6 weeks, 3 months, 6 months and one year post-operative period.

In the study mean Abduction at 6 weeks was 24.9 ± 5.1 degree, at 3 months 32.9 ± 4.3 degree, at 6 months 36.2 ± 3.9 degree and at one year was 36.2 ± 3.9 . There was significant increase in degree of Abduction at 3 months, 6months and one year i.e. there was improvement in Function (**Table 4**).

Follow up	Mean	Median	SD	P value
6 weeks	24.9	25.0	5.1	
3 months	32.9	35.0	4.3	<0.001*

6 months	36.2	35.0	3.9	<0.001*
One year	36.2	35.0	3.9	<0.001*

Table 4: Range of Abduction (degree) comparison at one year, 3 months, 6months and one year post-operative period

In the study mean Adduction at 6 weeks was 6.5 ± 4 degree, at 3 months 10.0 ± 4.0 degree, at 6 months 10.8 ± 3.9 degree and at one year was 11.2 ± 3.8 . There was significant increase in degree of Adduction at 3 months, 6 months and one year compared to 6 weeks values i.e. there was improvement in function (**Table 5**).

Follow up	Mean	Median	SD	P value
6 weeks	6.5	5.0	4.0	
3 months	10.0	10.0	4.0	<0.001*
one year	10.8	10.0	3.9	<0.001*
One year	11.2	10.0	3.8	<0.001*

Table 5: Range of Adduction (degree) comparison at 6 weeks, 3 months, 6 months and one year post-operative period

In the study mean External rotation at 6 weeks was 17.4 ± 5.2 degree, at 3 months 26.2 ± 5.0 degree, at 6 months 30.3 ± 4.6 degree and at one year was 30.7 ± 4.2 . There was significant increase in degree of External rotation at 3 months, 6 months and one year compared to 6 weeks values i.e. there was improvement in function (**Table 6**).

	Mean	Median	SD	P value
6 weeks	17.4	20.0	5.2	
3 months	26.2	25.0	5.0	<0.001*
6 months	30.3	30.0	4.6	<0.001*
One year	30.7	30.0	4.2	<0.001*

Table 6: Range of External Rotation (degree) comparison at 6 weeks, 3 months, 6 months and one year post-operative period

In the study mean Final Harris Hip Score at 6 weeks was 64.8 ± 9.7 , at 3 months 81.5 ± 8.0 , at 6 months 91.5 ± 5.1 and at one year was 92.1 ± 4.3 . There was significant increase in degree of Final Harris Hip Score at 3 months, 6 months and one year compared to 6 weeks values i.e. there was improvement in function (**Table 7**).

	Mean	Median	SD	P value
6 weeks	64.8	64.5	9.7	
3 months	81.5	80.8	8.0	<0.001*
6 months	91.5	92.8	5.1	<0.001*
One year	92.1	93.0	4.3	<0.001*

Table 7: Final Harris Hip Score comparison at 6 weeks, 3 months, 6 months and one year post- operative period.

Post-Operative Complications

In the study at immediate post op period, 7.5% had Infection and other intervals of follow up none of them had infection (**Table 8**).

Infection	No		Yes	
	Count	%	Count	%
Immediate Post Op	37	92.5%	3	7.5%
6 weeks	40	100.0%	0	0.0%
3 months	38	100.0%	0	0.0%
6 months	38	100.0%	0	0.0%
One Year	38	100.0%	0	0.0%

Table 8: Infection at different period of follow up among subjects who underwent THR

In our study none of subjects had any dislocation at all the intervals of follow up (**Table 9**).

Dislocation	None	
	Count	%
Immediate Post Op	40	100.0%

6 weeks	40	100.0%
3 months	38	100.0%
6 months	38	100.0%
One Year	38	100.0%

Table 9: Dislocation at different period of follow up among subjects who underwent THR

In the study none of subjects had any peri-prosthetic Fracture at all the intervals of follow up (**Table 10**).

Peri-Prosthetic Fracture	No	
	Count	%
Immediate Post Op	40	100.0%
6 weeks	40	100.0%
3 months	38	100.0%
6 months	38	100.0%
One Year	38	100.0%

Table 10: Peri-Prosthetic Fracture at different period of follow-up among subjects who underwent THR.

None of the subjects at one year had Peri-Prosthetic Lucencies (**Table 11**).

		Count	%
One Year Peri-Prosthetic Lucencies	No	38	100.0%

Table 11: One Year Peri-Prosthetic Lucency among subjects

Mean Acetabular Anteversion at one year was 22.076 ± 4.1732 and Acetabular Inclination at one years was 40.045 ± 1.83 (**Table 12**).

	Mean	N	SD
One Year Acetabular Anteversion	22.076	38	4.1732
One Year Acetabular Inclination	40.045	38	1.8352

Table 12: One Year Acetabular anteversion and Acetabular inclination among subjects

In the study there was no significant difference in mean Final Harris Hip Score at 6 weeks, 3 months, 6 months and one year with respect to type of THR done (**Table 13**).

Final HHS	Type of THR						P value
	Uncemented		Hybrid		Total		
	Mean	SD	Mean	SD	Mean	SD	
6 weeks	65.8	8.9	63.3	10.9	64.8	9.7	0.433
3 months	82.5	7.3	79.8	8.9	81.5	8.0	0.314
6 months	91.6	4.6	91.4	5.9	91.5	5.1	0.915
One year	92.1	4.1	92.0	4.8	92.1	4.3	0.926

Table 13: Comparison of Final Harris Hip Score at 6 weeks, 3 months, 6 months and one year with respect to Type of THR.

In the study there was no significant correlation between implant size (Cup size) and range of movement (Flexion, abduction, adduction and external rotation) (**Table 14**)

		Flexion	Abduction	Adduction	External Rotation
No of subjects		38	38	38	38
Cup size	Pearson Correlation	0.062	0.179	0.187	-0.039
	P value	0.713	0.283	0.260	0.817

Table 14: Correlation between Size of Implant and Range of Movements at one year

In the study there was no significant correlation between implant size (Cup size) with Final Harris Hip Score at 6 weeks, 3 months, 6 months and one year (**Table 15**).

Final Harris Hip Score		one year	3 months	one year	One year
No of subjects		38	38	38	38
Cup size	Pearson Correlation	-0.044	-0.063	-0.053	-0.032
	P value	0.792	0.707	0.750	0.851

Table 15: Correlation between Implant size and Final Harris Hip Score at 6 weeks, 3 months, 6 months and one year

In the present study at the immediate post-op period, three patients (7.5%) including the two who were lost to follow up had Infection and were cured completely at 6 weeks follow-up. No signs of infection in the remaining 37 patients until two years follow up. During two years follow up, none of the patients had any dislocation at all the intervals of follow up. In the study, none of the patients had any peri-prosthetic fracture. None of the subjects at two years had Peri-Prosthetic Lucencies. Mean Acetabular Anteversion at two years was 22.076 ± 4.1732 and Acetabular Inclination at two years was 40.045 ± 1.83 . In the study, there was no significant difference in mean Final Harris Hip Score at 6 weeks, 3 months, 6 months, and two years concerning the type of THR done (**Table 2**). Besides, there was no significant correlation between implant size (Cup size) and range of movement (flexion, abduction, adduction, and external rotation) (**Table 3**). Also, there was no significant correlation between implant size (Cup size) with Final Harris Hip Score at 6 weeks, 3 months, 6 months, and two years (**Table 4**).

DISCUSSION

In virtue of advancement in the state of public health and better living conditions, the population of elderly people is growing faster than any other population. Due to awareness and better lifestyles, there is an increasing demand for independence in the aging population ^[1]. As the age increases the risk of fracture neck of femur increases substantially ^[2]. Joint replacement surgeries allow early ambulation and return to daily activities. Despite the advantages, it has complications like dislocation and re-operations due to loosening and adds to morbidity. To avoid these complications, dual articulation arthroplasty has been designed. The goal of this study was to find out whether dual articulation total hip arthroplasty could alter the course of the standard of care in the fracture neck of the femur of elderly patients in the Indian population. The age of the patients in the present study ranged from 60 to 85 years with the mean age at the time of surgery 70.33 years, which was similar to other previous studies ^[6,11]. This could be attributed to an age-related decrease in bone mass in the proximal femur as well as an increased incidence of falls in the elderly age group ^[2]. Majority of the patients (82%) had slip and fall that resulted in the neck of femur fracture, as similar to in other studies ^[15]. The mean 'time from injury to surgery' was 2.05 days as compared to 3 days demonstrated by Adam et al ^[16] and 29 hours by Bensen et al ^[17]. This can be attributed to exhaustive pre-operative workup required for the geriatric age group and also delayed presentation to the emergency department.

In this study, 23 patients underwent Uncemented and 17 patients has hybrid dual mobility cup total hip replacement with cemented stems. The mean external diameter of the acetabular cup in the present study was 48.5 ranging from 44 to 54 mm. In a similar study by Adam et al ^[16], a mean of 51mm was observed ranging from 44 to 59mm in 214 patients operated with dual mobility cup total hip replacement. Limb length discrepancy was measured and compared before and after the surgery. Mean shortening of 1.450cm was observed pre-operatively which improved to a mean of 0.288cms post-operatively. This significant improvement can be attributed to the appropriate size of the implant.

The mean duration of hospitalization was 5.45 days in our study, which was comparable to study by Bensen et al ^[17]. In the present study, 37 patients out of 40 received an intravenous antibiotic for 3 days. Intravenous antibiotics were continued for 3 patients for 8-9 days due to wound dehiscence and superficial infection. Suture removal of 37 patients was done within 3 weeks (ranging from 13 to 18 days). The remaining 3 patients had delayed suture removal (22 to 24 days) due to wound dehiscence and superficial infection. The mean Harris hip pain score at 6 weeks was found to be 30.0 which improved to 43.4 at the end of two years. This significant increase in pain score can be attributed to biological and biomechanical intolerance to implant in the immediate post-operative period and physiotherapy rehabilitation over time. A similar study by Shukla et al ^[18] in 47 fracture neck of femur patients had mean Harris hip pain score as 40.0 and 39.2 in THR and HA group respectively. No sufficient literature is available on Harris hip pain score for primary dual mobility cup total hip arthroplasty for fracture neck of femur. In this study, the mean Harris hip function score showed significant improvement with a mean of 26.2 at 6 weeks and 39.4 at two years follow up. These results were better as compared to Shukla et al ^[18] who studied patients with fractured neck of femur and found mean Harris hip function score as 36 and 30.96 in THR and HA group respectively at the end of two years. The mean flexion improved from 78.7 at two years to 101.3 at two years follow up. There was a significant improvement in other range of motion (abduction, adduction, and external rotation) too at two years as compared to 6 weeks follow up. This improvement in the range of movements can be attributed to the design of dual articulation which facilitates an increased range of movements ^[12]. Excellent Harris hip scores were observed at the end of two-year follow-up, mean score increased to 92.1 at the end of two years as compared to 64.8 at 6 weeks. These results were comparable with the study by Boyer et al ^[19], Blomfeldt et al ^[20], and Van Den Bekerom et al ^[21]. The mean external cup size was 48.5mm ranging from 44mm to 54mm. All the acetabular cups were implanted within the safe zone (25-50) with a mean acetabular inclination of 40.045. Two patients had anteversion more than 25 (28 and 39) but no complication in terms of pain or function were observed at two years follow up.

There was no significant correlation of implant size (Cup size) either with the final Harris Hip Score or with a range of motion at the end of two years in consistence with Martino ^[12] et al. Three patients had superficial infection post-operatively which was addressed with dressing and IV antibiotics. The mean rate of infection was 7.5% at immediate post-op and none were infected at remaining follow-ups. None of the patients required any additional procedures for infection. Bensen et al ^[17] showed a 2.3% infection in 175 patients operated with dual mobility cup arthroplasty for fracture neck of femur who underwent re-operation for the same. In their study, 4 patients had a deep infection which required re-operation. None of the patients had a peri-prosthetic fracture at the end of two years. Adam et al ^[16] studied 214 patients prospectively for 9 months and observed 5 cases of periprosthetic fracture. In a retrospective study by Bensen et al ^[17], 6 cases of peri-prosthetic were observed while reviewing 175 patients for 21.7 months operated with dual mobility cup arthroplasty in 2009 and 2010. None of this study patients had dislocation within two years, similar to study by Tarasevicius et al ^[11] Adam et al ^[16] observed three dislocations in 214 patients within 3 months of surgery. All three patients were operated on using a posterior approach, and all the three dislocations were between the cup and the liner. There was no incidence of dislocation in patients operated on using an anterior, anterolateral, or direct lateral approach. Also, in all cases cup was inserted without ante-version, unlike our study. The absence of any dislocation in this study can be explained by the in-built stability of the dual

articulation implant design which prevents impinging due to increase effective range of motion, appropriately inserted acetabular cup and the approach used ^[8,19]. This study has certain limitations too. A short-term follow-up study may be too early to draw strong conclusions. The sample size was relatively smaller compared to other similar studies. However, to best of our knowledge, the present study is the first one to prospectively evaluate the radiological and functional outcomes of DMC-THA in elderly neck of femur fractures in Indian population. Based on the study outcome analysis, it would be recommended to use the dual mobility cup total hip arthroplasty as a primary treatment for the displaced neck of femur fracture in elderly patients with cup positioning within the safe zone as quoted by Goyal et al ^[22].

CONCLUSION

The incidence of the neck of femur fracture was more prevalent in the female population. Implant size or type of total hip replacement did not affect the outcome. The functional outcomes observed at the end of the study were found to be excellent which were comparable to similar available studies. Better results were obtained than conventional THR and HA in terms of functional outcomes and complications. Excellent Harris hip score in all our patients point towards the compatibility of dual mobility cup total hip replacement with Indian standard of living, although long term studies will be required to further evaluate and fortify this fact.

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