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Retrospective analysis of 5-year survivorship of dual mobility total hip arthroplasty

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Abstract
Background: The concept of Dual Mobility (DM) Total Hip Arthroplasty (THA) has been introduced to improve the range of motion in the post-operative hips. However, literature on the mid-term and long-term outcomes of DM-THA are relatively lacking.
Question / Purpose: What are the mid-term results (Minimum 5 years post-operatively) of DM THA surgeries done for various indications?
Patients and Methods: We recruited sixty participants over a period of one year who underwent DM THA surgeries. The clinical outcomes were evaluated using the Harris' Hip Score (HHS) and the Oxford Hip Score (OHS). The participant subjective assessment of the post-operative condition was classified into excellent, good, and fair. Adverse events were recorded. The radiological outcomes were evaluated using the Moore's criteria of osteointegration (MCO). The scores were determined for the various age groups and participant perceptions, and compared using the one-way Analysis of Variance (ANOVA).
Results: The mean age of our participants was 65.77±10.13 years. Thirty-six participants reported excellent subjective post-operative outcomes. The mean values for HHS, OHS, and MCO were found to be 87.38±4.41, 37.35±4.60, and 3.10±0.47 respectively. The HHS, OHS, and MCO were significantly better in participants who subjectively reported excellent outcomes (p<0.001 each). The MCO was also significantly lesser with increasing age (P=0.020). Two of our study participants experienced persistent thigh pain, while heterotrophic calcification, aseptic loosening of the hip joint prosthesis, and revision THR (At six years post-operatively) were observed in one participant each.
Conclusion: We observed reasonably good clinical and radiological outcomes in our study, with most of the study participants reporting their post-operative condition to be excellent. The HHS, OHS, and MCO correlated with the participant's subjective perceptions. The overall incidence of complications was found to be low in our study.
Level of evidence: Level II.

Keywords: Total hip arthroplasty, Retrospective, arthroplasty, survivorship, dual mobility

Introduction
Background
Total hip arthroplasty (THA) is a surgical procedure in which both the acetabulum and the femoral head in the hip joint are completely replaced by a hip prosthesis [16]. It is one of the most commonly performed orthopaedic surgeries, with approximately 1.5 million surgeries worldwide each year [8, 5]. It is performed routinely for the treatment of various hip pathologies such as osteoarthritis, rheumatoid arthritis, avascular necrosis of femoral head, traumatic arthritis, certain hip fractures, benign and malignant bone tumors, etc. A successful THA surgery is expected to result in pain relief and improvement in hip function, with a significant improvement in the quality of life [16]. Nevertheless, there are two main concerns associated with the surgery-dislocation and instability.
To address these problems of dislocation and instability, Pr. Gilles Bousquet and André Rambert developed the concept of Dual Mobility (DM) hip arthroplasty, which was patented in 1975 [3]. The introduction of DM hip arthroplasty has successfully improved the range of motion (ROM) of the post-operative hips; as well as significantly reduced the number of dislocations and the risk of instability. The dual mobility concept increases the ROM until impingement occurs through its 'double articulation' design (Fig. 1).

In the first articulation the head is "engaged", but remains mobile within the polyethylene liner and follows the typical mechanical behaviour of a hard-on-soft bearing in a standard THA. However, if the femoral neck and the rim of the PE liner come into contact, a second articulation begins to function and consists of the back of the PE liner and the metallic acetabular shell. As the PE liner articulates, effective ROM is increased until impingement of the femoral neck against the rim of the shell ultimately occurs (Fig. 1, 2).

Rationale

Although the results with DM THA have been quite encouraging, recent evidence points towards the occurrence of intra-prosthetic dislocation (IPD) as a unique complication of the procedure [2], most likely attributed to the wearing of the polyethylene liner [17]. An image of IPD is provided in Fig. 3 [2]. Studies from Europe suggest IPD to be a late complication of the procedure, usually observed between 3 to 16 years of follow-up with a mean of 9 years [13, 4]. However, IPD can also occur iatrogenically without PE wear, during closed reduction of a large articulation dislocation, as described by Loubignac and Boissier [10]. The implant-related risk factors such as pairing of femoral heads and PE liners from different manufacturers, 22.2 mm femoral heads, and skirted femoral heads may be responsible for this phenomenon [11-15].

With this background, we conducted a prospective observational study to evaluate the midterm results (minimum 5 years post-operatively) of dual mobility (DM) THA done for various indications in a tertiary care hospital, with an evaluation of the clinical and radiological outcomes.

Materials and Methods

The study was conducted as a prospective observational study over a period of one year in a tertiary care hospital. The study was initiated after obtaining the required permission from the Institutional Ethics Committee. Written informed consent was obtained from all the participants enrolled in the study. The study was conducted in adherence to relevant national and international laws and in accordance with the Good Clinical Practice Guidelines and Declaration of Helsinki, 2008.

The patients who underwent dual mobility (DM) total hip arthroplasty (THA) in our institute were evaluated during their follow up in the orthopaedics OPD. Patients of Indian origin of 18 years of age and above and of both sexes were included in the study. Those who were not willing to provide written informed consent were excluded. The clinical outcomes were evaluated using the Harris' Hip Score (HHS) and the Oxford Hip Score (OHS). The radiological outcomes were evaluated using the Moore's criteria of osteointegration.

The Harris' hip score is a validated score for the assessment of the results of hip surgery, and is intended to evaluate various hip disabilities and methods of treatment in an adult population, covering the domains of pain, function, absence of deformity and range of motion. Soderman and Malchau have determined the agreement on the Harris Hip score in 58 patients who had undergone total hip replacement 2 to 10 years earlier when evaluated independently by an orthopaedic surgeon and an experienced physiotherapist and reported that the score demonstrated high validity and reliability [19]. Similarly, an excellent inter-observer reliability has been reported by Kirmit *et al*. among the physical therapists (kappa value: 0.77-0.95) for evaluation of patients with coxarthrosis and scheduled for total hip arthroplasty [9].

The Oxford hip score is another score frequently used to assess outcome after total hip replacement by measuring patient's perceptions in adjunction to surgery. It assesses pain (6 items) and function (6 items) of the hip in relation to daily activities such as walking, dressing, sleeping etc.

In the Moore's criteria for osteointegration, one point is given for the presence of each of the following radiographic signs of acetabular osteointegration: Absence of radiolucent lines, presence of a superolateral buttress, medial stress-shielding, radial trabeculae and presence of an inferomedial buttress [14]. These criteria were originally evaluated by Moore *et al*. for their ability to predict acetabular osseointegration by reviewing the post-primary and pre-revision radiographs from a series of 119 total hip arthroplasties that had revision surgery. When three or more signs were present, the positive predictive value of the radio-graphic test was 96.9%, the sensitivity was 89.6%, and the specificity was 76.9% [14].

Sample size calculation

No formal sample size calculation was done in our study. Based on previous years' figures, about 12-15 patients are treated with this technique in our Orthopaedic Department annually. Hence, we collected the data on a total of 60 patients (considering 10% drop-out rate and loss to follow-up).

Statistical analysis

Quantitative data were represented as Mean ± Standard Deviation (S.D.). Categorical and nominal data were expressed in numbers (percentages). The comparison among the age groups and participant perception categories for the Harris' hip score, Oxford hip score and Moore's criteria for osteointegration was done with the one-way Analysis of Variance (ANOVA). All the statistical analyses were carried out using SPSS software version 21.0. p values of less than 0.05 were considered to be statistically significant.

Results

We recruited 60 participants in our study. The demographic characteristics of our study population are outlined in Table 1. The mean age of our participants was observed to be 65.77±10.13 years. 32 out of our 60 participants (53%) were females (Table 1, Fig. 4), while the mean post-operative duration was 6.15 years±0.77 years. The age distribution of the population is given in Table 1 and Fig. 5.

Clinical outcomes

When evaluated for post-operative complications, we observed that two of our study participants experienced persistent thigh pain, while heterotrophic calcification, aseptic loosening of the hip joint prosthesis, and revision THR (at six years post-operatively) were observed in one participant each (Table 2). When evaluated for participant perception regarding the post-operative outcomes, 36 of them (60%) reported excellent subjective outcomes, 13 (21.7%) good, and 11 (18.3%) fair (Table 2, Fig. 6).

We evaluated the Harris hip score, Oxford hip score and Moore's criteria of osteointegration in our study participants across the classifications of age and participant perception of outcomes; whose mean values were found to be 87.38±4.41, 37.35±4.60, and 3.10±0.47 respectively (Table 3). As depicted in Table 3, the Harris hip score was significantly better in participants who subjectively reported excellent outcomes (p<0.001), (Table 3). However, we did not observe any significant difference in the Harris hip score among the age groups (P=0.771), (Table 3). Similar to Harris hip score, the Oxford hip score and Moore's criteria for osteointegration

were also found to be significantly greater in participants reporting an excellent outcome (p<0.001) (Table 3). However, although, the Oxford hip score was not significantly different across the age groups (p = 0.757) (Table 3), the Moore's criteria for osteointegration was significantly greater in the 41-50 years age group (p = 0.020) (Table 3).

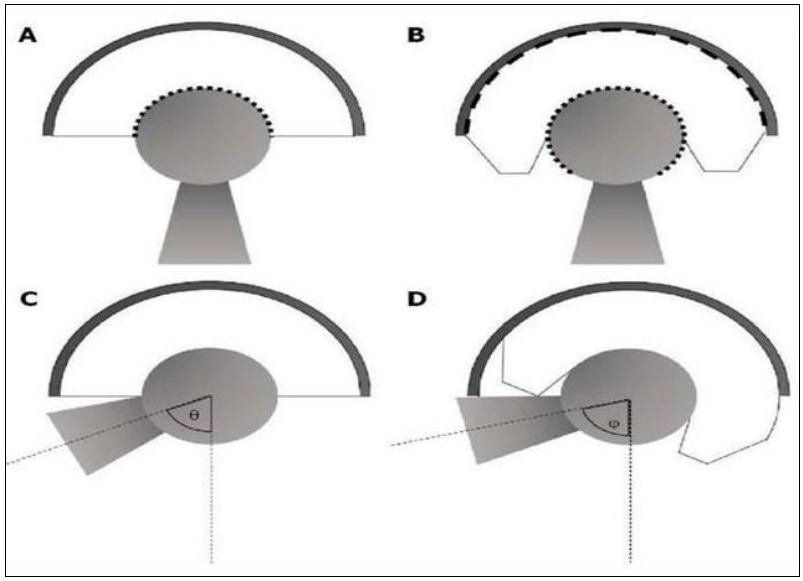

Fig 1: Standard cup (A) versus dual mobility cup (B). Standard metal-on polyethylene implants (A) include one articulation between the femoral head and the acetabular liner (dashed line). A dual mobility cup (B) consists of two distinct articulations, one between the femoral head and the liner, and another one between the liner and the shell. This configuration allows for greater range of motion before impingement of the femoral neck occurs (C and D, angle φ > angle θ)

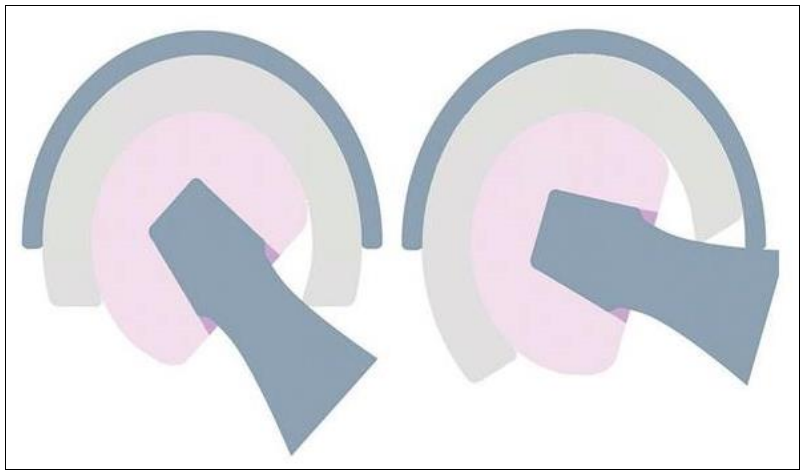

Fig 2: The inner bearing of the dual mobility hip provides most movement, and mobilisation of the second articulation of the polyethylene allows for an additional 10° to 15° of movement [2]

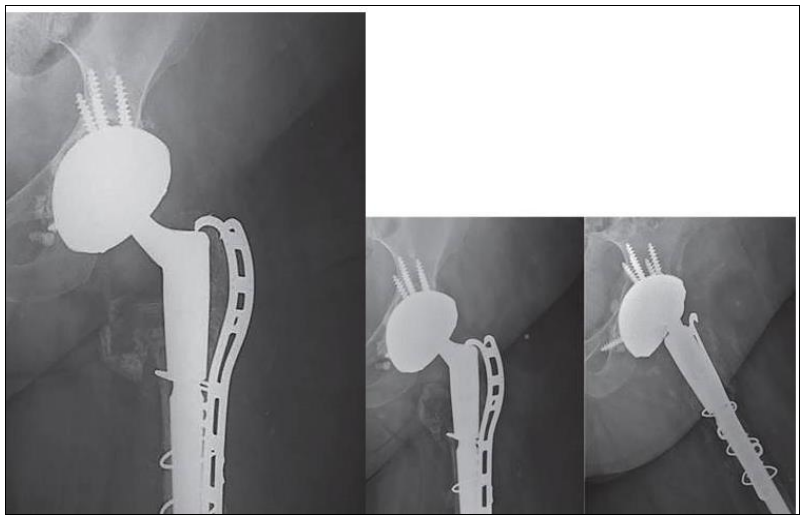

Fig 3: Anteroposterior (AP) radiograph before Intraprosthetic dislocation, and b) AP and lateral radiograph after a failed closed reduction that resulted in an Intraprosthetic dislocation [5]

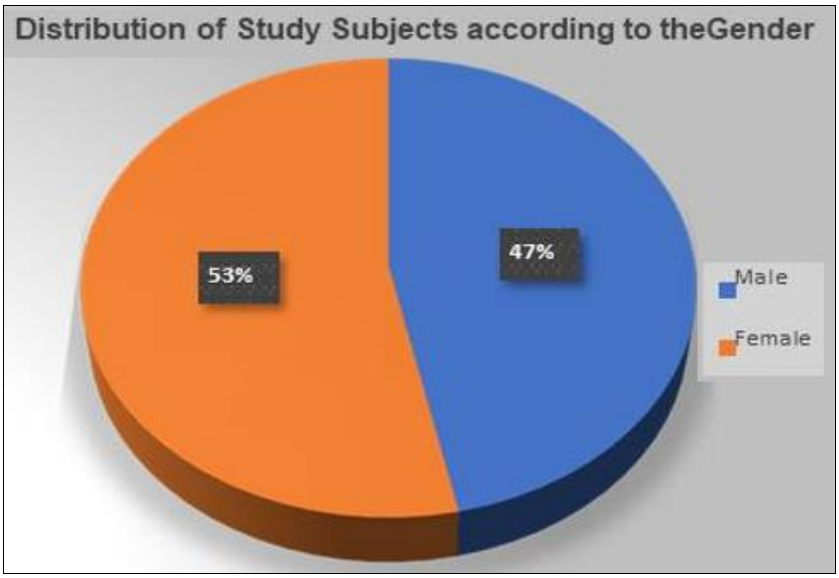

Fig 4: Distribution of study subjects according to the gender, N=60

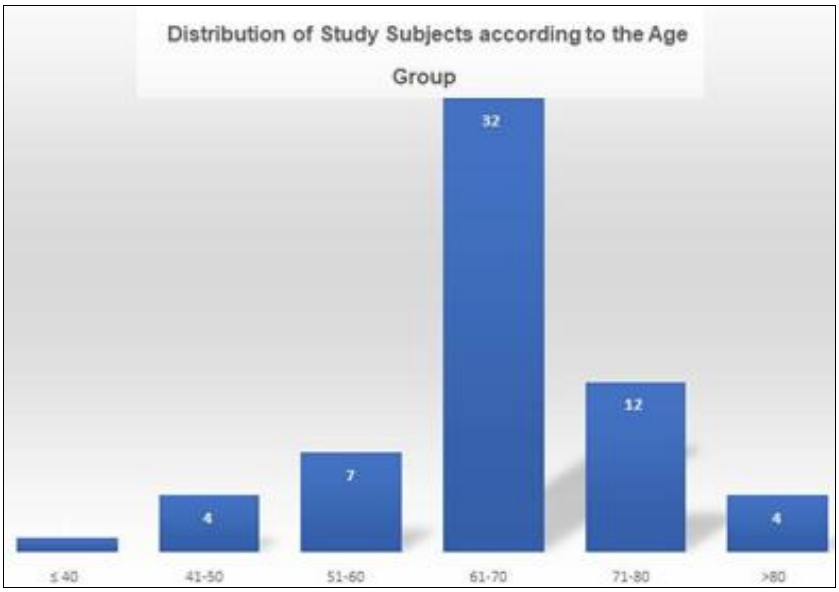

Fig 5: Distribution of study subjects according to the age group, N=60

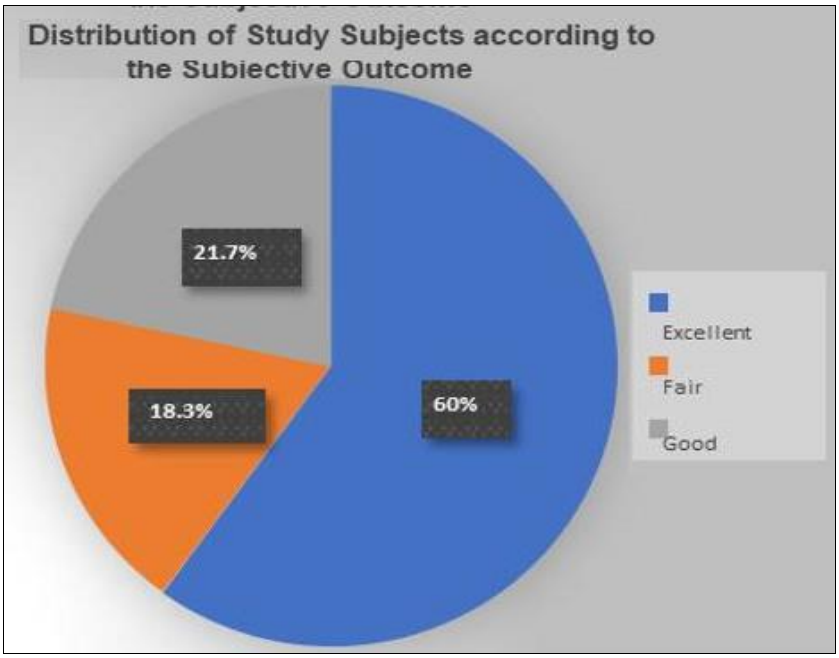

Fig 6: Distribution of study subjects according to the subjective outcomes, N=60

Table 1: Demographic characteristics of the study population

Characteristic	Category	Number (%)
Age group (years)	≤ 40	1 (1.70)
	41-50	4 (6.70)
	51-60	7 (11.70)
	61-70	32 (53.30)
	71-80	12 (20.0)
	> 80	4 (6.70)
	Total	60 (100.00)
Sex	Males	28 (46.70)
	Females	32 (53.30)
	Total	60 (100.00)
Duration of post-operative period (years)	5	12 (20.0)
	5.5	1 (1.70)
	6	25 (41.70)
	7.0	21 (31.0)
	8.0	1 (1.70)
	Total	60 (100.00)

Table 2: Incidence of post-operative complications and participant perceptions of outcomes

Complication	Number with percentage [n(%)]
Persistent thigh pain	2 (3%)
Heterotrophic calcification	1 (2%)
Aseptic loosening of the hip joint prosthesis	1 (2%)
Revision THR (At six years)	1 (2%)
Participant perception of outcomes	Number with percentage [n(%)]
Excellent	36 (60%)
Fair	13 (22%)
Good	11 (18%)

Table 3: Harris hip score, Oxford hip score and Moore's criteria for osteointegration across age distribution and participant perception of outcomes * indicates statistically significant difference # The age group of ≤ 40 years had only one participant, hence, only the value obtained from that participant is mentioned.

Category	Harris hip score [Mean (SD)]	P-Value	Oxford hip score [Mean (SD)]	P-Value	Moore's Criteria of Osteo-Integration Mean (SD)	P-Value
Overall	87.38 (4.41)		37.35 (4.60)	-	3.10 (0.47)	-
Age distribution (years)						
≤ 40#	92.00	0.771	34.00	0.757	3.00	0.020*
41-50	88.75 (11.08)		37.25 (11.02)		3.75 (0.50)	
51-60	86.71 (9.25)		37.57 (7.93)		3.29 (0.75)	
61-70	88.47 (8.40)		38.56 (5.95)		3.28 (0.63)	
71-80	84.67 (5.74)		36.17 (6.86)		2.58 (0.66)	
> 80	85.50 (9.11)		33.75 (9.03)		2.75 (0.95)	
Participant perception of outcomes						
Excellent	92.33 (4.20)	< 0.001*	41.44 (4.53)	<0.001*	3.50 (0.50)	<0.001*
Good	84.23 (3.91)		33.31 (5.20)		3.00 (0.57)	
Fair	74.91 (5.71)		29.45 (4.27)		2.09 (0.30)	

Discussion

Our study was conducted as a prospective observational study in 60 patients undergoing follow-up for dual mobility total hip arthroplasty in our Orthopaedics out-patient department.

Our results of Harris hip score (87.38±4.41), Oxford hip score (37.35±4.60), and Moore's criteria for osteointegration (3.10±0.47), (Table 3) are in concordance with previously published studies. In a study by Canton et. al. on 31 implants in 30 patients treated with DM THA for femoral neck fractures, the Harris hip score was reported to be 81±22, and Oxford hip score of 37 (Range 19-48) [1]. They also observed that four of the Moore's criteria were present in 2 cases, three of the criteria in 8 other cases, and less than 3 criteria in 15 cases, and none of their cases showed all the five criteria. However, the authors have not specified the exact time point at which this follow-up was done post-operatively [1]. In a retrospective consecutive multicentric series of 516 patients (541 hips) that received uncemented DM THA, Fessy *et al*. reported an improvement in the Harris hip score from 49.6±15.5 pre-operatively to 85.2±14.5, as well as a post-operative Oxford hip score of 19.2±7.6, at a median of 8.7 years follow-up [6]. The authors have also reported that the Harris hip score increased with the diameter of the acetabular cup [6]. Puch *et al*. have also reported an improvement in the Harris hip score and Oxford hip score from the pre-operative values after a mean follow up of 11 years (range 8 to 15 years) in a prospective and consecutive series of THAs with a cementless DM cup of 2nd generation (GIROS) in 119 patients aged less than 55 years and 444 in patients aged more than 55 years; but did not report any significant difference between the two age groups [18].

A single-center continuous series of 62 patients receiving a DM acetabular cup with metal reinforcement in THA revision was assessed retrospectively by Lebeau *et al*., at a minimum 5

years' follow-up. They have reported the Harris hip score in their population to be 73 and Oxford hip score to be 23.9 [12]. These values which are slightly different from our observation, which could be due to the difference in the patient population. Another study by Griffin *et al*. also studied the Oxford hip score as one of the secondary outcomes in patients undergoing THA for displaced intracapsular fracture of the hip over a period of 12 months. However, this study managed to recruit only 20 patients during the 12 month-period and hence, was unable to evaluate the Oxford hip score in the study population [7].

Additionally, we also observed that patients who reported excellent post-operative outcomes following DM THA had significantly greater scores in all the three parameters. Canton *et al*. have also similarly reported the functional outcomes with DM THA to be mainly good or excellent in patients with femoral neck fractures [1]. Our study corroborates with these findings.

We observed a very low rate of post-operative complications in our study (only four out of 60 cases). Our findings resemble those by Canton *et al*. who have also reported a low incidence of complications in their study on 31 cases. These post-operative complications include a Vancouver Ag periprosthetic fracture, a superficial infection and a persistent thigh pain (N=3, 9.67%) [1]. The authors also did not observe any episodes of hip dislocation nor intra-prosthetic dislocation. Similarly, you *et al*. have also reported a very low rate of complications in their systematic review on 23 studies which have evaluated a total of 7189 patients. The authors have reported the rate of large articulations and of intraprosthetic dislocation to be 1.5% (N=105) and 0.04% (N=3) respectively. The authors also observed that there was no increase in the rates of other complication when DM THA was performed for femoral neck fractures as compared to conventional arthroplasty operations [21]. Additionally, we observed a significantly lesser Moore's criteria scores with increasing age, indicating that the radiological outcomes worsened with increasing age. However, this difference was not observed among the Harris or Oxford scores, indicating that the clinical outcomes did not correlate with age.

Only one patient in our study was found to have aseptic loosening of the hip joint as a post-op complication following DM THA (Table 2). Our observation of aseptic loosening corroborates with previous publications in literature. Multiple studies, the results of which were polled by Darrith *et al*. in their systematic review and meta-analysis, have reported the incidence of aseptic loosening of the hip to be zero or one case out of the total number of cases they have evaluated; yielding an overall incidence of aspetic loosening of the hip joint to be 1.3% (142 out of 10, 783 hips) in case of primary DM THAs and 1.4% (29 out of 3008 hips) in case of revision DM THAs [2].

Conclusion

We observed reasonably good clinical and radiological outcomes in our study, with most of the study participants reporting their post-operative condition to be excellent. Moreover, participants with higher Harris hip scores, Oxford hip scores, and Moore's criteria scores reported their condition to be subjectively better. The radiological outcomes were found to be worse with advancing age. However, the clinical outcomes were found to be similar across all age groups. The overall incidence of complications was found to be low in our study. However, our study is hampered by a low sample size, and lack of a formal sample size calculation. Therefore, we are unable to draw any statistical inferences from our study. A similar study with a larger sample size may be conducted to validate the findings from our study.

Conflict of Interest:
Not available

Financial Support:
Not available

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