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Direct Anterior Approach in Total Hip Arthroplasty: A Single Center Experience

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Purpose: The direct anterior approach (DAA) for conducting total hip arthroplasty (THA) is gaining popularity worldwide. However, careful selection of patients and surgeon experience are important. Although promising outcomes have been reported in international studies, research on DAA in Southern and Southeast Asia has been limited.

Materials and Methods: This prospective study included 157 patients who underwent THA using the DAA between January 2019 and June 2022. The patients were divided into three groups for the comparison. Data on preoperative, intraoperative, and postoperative variables were acquired. Improvement of the surgeon's performance to use of a DAA approach was examined using the CUSUM (cumulative summation method).

Results: The mean age of the patients was 43.9 years. Differences in intraoperative variables and complications were observed among the three groups, and improved outcomes were reported in later cases. Functional outcomes showed significant improvement, and no differences were observed between groups. The results of learning curve analysis indicated a shift towards consistent success after the 82nd case, reaching an acceptable rate of failure by the 118th case.

Conclusion: The findings of this study suggest that DAA can offer benefits but there is a learning curve. Complications were initially high but began decreasing after approximately 80 cases. Careful selection of patients is critical, particularly in the effort to minimize being presented with a challenging case. This study provides insights that may be helpful to surgeons when considering DAA; however, further study is warranted.

Keywords: Hip, Total hip arthroplasty, Direct anterior approach, Osteoarthritis of hip, Learning curve

INTRODUCTION

Total hip arthroplasty (THA) is a highly effective surgical intervention for management of patients with end-stage degeneration of the hip joint. Various surgical approaches have been developed for accessing the hip joint, each with its own advantages and limitations. Among these, the direct anterior approach (DAA) has recently earned significant attention due to its potential benefits, including a more rapid recovery, improved stability, and reduced muscle damage[1,2]. Unlike traditional approaches such as the posterior and lateral approach, the DAA in performance of THA can preserve muscle because the hip joint is accessed anteriorly through intermuscular and inter-nervous planes to minimize trauma to tissues[3].

However, similar to adoption of any novel technique, careful selection of patients is critical for ensuring the success of DAA[4]. Consideration of patient anatomy, body habitus, preexisting conditions, and surgeon experience is imperative[4,5]. A learning curve is required for use of the DAA, where the surgeon's experience

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and competence can influence outcomes. Knowledge regarding the learning curve associated with DAA can be helpful to surgeons in gauging their progress, identifying potential pitfalls, and ensuring the best possible outcomes for their patients[6-8].

Recent literature from Asian countries has advanced the understanding of DAA in performance of THA; however, publications from southern and southeast Asia remain sparse[9], particularly concerning the safe adoption of DAA in THA practices. This gap impedes a full understanding of the learning curve for DAA for performance of THA within the local context. Therefore, the goal of the current study is to provide data on use of the DAA in performance of THA, with a focus on patient selection, the learning curve associated with the technique, and the early outcomes obtained in various patient populations.

MATERIALS AND METHODS

A prospective study was conducted after obtaining permission from the ethics committee of All India Institute of Medical Sciences, New Delhi, India (IEC-1027/03.10.20, RP-05/21), and the written informed consent was obtained from all patients. The study included 157 patients who underwent THA using the DAA at Department of Orthopaedics of All India Institute of Medical Sciences between January 2019 and June 2022. All patients had a minimum follow-up period of one year at the latest follow-up.

Preoperative variables were acquired, including demographic data, preoperative diagnosis, body mass index (BMI), and Harris hip score (HHS). Measurement of radiological variables was performed preoperatively, including the neck-shaft angle.

1. Inclusion Criteria during the Learning Curve

For the first 50 cases, inclusion criteria included female and thin-built male patients undergoing primary THA with a preoperative diagnosis of avascular necrosis (AVN), as well as hips with a neck-shaft angle greater than 135°, and BMI less than 30 kg/m^2.

For the next 51 to 100 cases, the inclusion criteria consisted of females and males with a BMI less than 35 kg/m^2, including all preoperative diagnoses except dysplastic hip (Crowe type III and IV)[10]. Hips with a neck-shaft angle less than 135° were also included.

After 100 cases, all patients undergoing primary THA using the DAA were included. Exclusion criteria included patients who had previously undergone hip surgery using an alternative approach, implants in the proximal femur, and individuals who were unwilling to participate in the study (Table 1).

Intraoperative variables, including duration of surgery, intraoperative blood loss, fluoroscopy time, and intraoperative complications including fractures, were recorded.

Assessment of postoperative variables was performed at the time of discharge and during regular follow-up visits at two weeks, six weeks, three months, six months, one year, and at the final follow-up. Early postoperative variables, including a requirement for intensive care and length of hospital stay, were recorded. HHS was recorded during follow-up visits. Intraoperative and postoperative complications were documented; major surgical complications were categorized as dislocation, infection, stem subsidence, fractures requiring reoperation, and implant malpositioning, as well as reoperations for other reasons.

Postoperative radiological evaluation was performed to assess the positioning of the component and to check for loosening. Biplanar low-dose radiography using

Table 1. Patient Selection Criteria during Learning Curve

Case range	Demographic criteria	Radiological criteria	Specific criteria
After 100 cases	No BMI restriction	No proximal femur neck shaft angle restriction	Hip arthritis secondary to all causes except: 1. Hip dysplasia (Crowe III and IV) 2. History of previous hip surgery
Cases 51 to 100	Males and females with BMI <35 kg/m^2	No proximal femur neck shaft angle restriction	Hip arthritis secondary to all causes except: 1. Hip dysplasia 2. History of previous hip surgery
First 50 cases	Males and females with BMI <30 kg/m^2	Proximal femur neck shaft angle >135°	Hip arthritis secondary to avascular necrosis

BMI: body mass index.

sterEOS® software (EOS imaging) was used to assess the discrepancy between the position of the component and limb length. An angle between the long axis of the cup and the acetabular teardrops was delineated for measurement of the abduction angle of the acetabular cup. An abduction angle greater than 50° or less than 30° was designated as falling outside the acceptable range[11].

2. Surgical Technique

All operations were performed by a senior surgeon who has been performing total hip replacements using a posterior approach for the last 30 years.

Procedures were performed under combined spinal and epidural (CSE) anaesthesia, and general anaesthesia was administered when CSE was not practicable.

Patients were positioned supine on a radiolucent orthopaedic table with the option of a break at the ipsilateral hip joint. Fluoroscopy positioning and feasibility were confirmed before draping. Lower limbs were cleaned and draped separately, with simultaneous preparation of both hips to be operated on.

A skin incision was made, following the technique described in the Hueter approach[3]. For patients with a high BMI with difficult to palpable bony landmarks (greater trochanter and Anterior superior iliac spine), fluoroscopy was performed to mark the incision. After performance of a superficial dissection, the superficial fascia of the tensor fascia lata (TFL) was identified, cut, and separated from the medial part of the fascia by blunt dissection. The deep fascia of the TFL was also cut, and the ascending branch of the lateral circumflex femoral artery was identified and coagulated. Following excision of the pre-capsular fat pad, the iliocapsularis and the reflected head of the rectus femoris were lifted from the hip joint capsule.

An anterior Hohman retractor was placed under the long head of the rectus femoris, while two extracapsular Hohman retractors were positioned over the superior and inferior aspects of the femoral neck. An H-shaped incision was made for opening the joint capsule, creating medial and lateral flaps. A stay suture was placed in the lateral capsular flap, and the retractors were repositioned inside the capsule over the superior neck, inferior neck, and anterior wall of the acetabulum. The femoral neck was cut for creation and removal of the "napkin ring," and the femoral head was delivered. A blunt cobra retractor was positioned inferiorly over the acetabulum, and the tip was placed on the transverse acetabular ligament for retracting the inferior capsule and the iliopsoas tendon. A sharp curved retractor with a long handle was placed against the posterior aspect of the acetabulum for retracting the proximal femur away for acetabular preparation. Soft tissues around the acetabular margin and the labrum were removed as necessary to enable greater exposure. Acetabular reaming was performed using successive reamers on an offset handle, and the orientation of the cup was confirmed using an image intensifier. The press-fit cementless acetabular component was implanted into the reamed acetabulum under image guidance, followed by insertion of the acetabular liner. Following implantation, the lateral capsule flap was excised.

For femoral mobilisation, releases were performed sequentially. The hip joint was hyper-extended to approximately 30° for performance of the femoral procedure, assisted by a table break at the hip joint. A hook was used to lift the femoral neck and expose the inner surface of the greater trochanter. The release was completed by releasing the posterolateral area of the trochanteric fossa and the conjoint tendon, enabling delivery of the greater trochanter into the acetabulum. The hip was then rotated externally to approximately 90° with the patella facing laterally and hyper-extended to approximately 30° for delivery into the wound and adducted to move it away from the acetabulum. A curved retractor was placed against the posterior femoral neck, and a Mueller retractor was set against the greater trochanter to elevate the proximal femur for femoral preparation. Femoral broaching was performed using successive broaches after locating the femoral canal using a canal finder.

The best-fitting broach was left in place, and a trial head with the neck was mounted for reduction and assessment of stability. The positioning of the component was confirmed using the Image Intensifier. Limb length was assessed by palpating and aligning the medial malleoli, ensuring equalisation before implanting the definitive femoral component and prosthetic head. Following placement of the final component and reduction, the wound was thoroughly irrigated and closed in layers.

3. Statistical Analysis

This study documents the learning curve for surgeons who are transitioning from performance of a posterior approach to a DAA for performance of THA. A learning curve refers to the improvement in performance over time or with accumulating experience. The cumulative summation method (CUSUM)[7], a tool for sequential analysis, was used in the current study for assessment of the surgeon's performance, reaching a predetermined level of competence. Four parameters were defined for the analysis: acceptable failure rate (p0), unacceptable failure rate (p1), type I error rate (α), and type II error rate (β). The results of the analysis are shown in a chart with case numbers plotted on the x-axis and the corresponding CUSUM score on the y-axis. In the case of a failure, the constant '1-S' was added to the cumulative score. In the case of a success, the variable 's' was subtracted from the cumulative score. Thus, success is rewarded by a downward slope whereas failure is indicated by an upward slope on the chart. A line that crosses the upper decision limit (h1) from below indicates that the actual failure rate is equal to the unacceptable failure rate with a type I error. A line that crosses the lower decision limit (h0) from above indicates that the actual failure rate does not differ from the acceptable failure rate with a type II error probability of 0.20. A line between h1 and h0 indicates that no statistical inference can be made[7].

Calculation of mean±standard deviation and frequency (percentage) was performed as appropriate for continuous and categorical variables. Chi-squared and Fisher's exact test were used for categorical variables while Student's *t*-test was used for continuous variables. For comparison of continuous variables between more than two groups, ANOVA was used for analysis if any differences were observed between the groups and Bonferroni's procedure was used in performance of pairwise comparisons. $P<0.05$ was considered statistically significant. The data were entered in Excel and analysis was performed using Stata Ver 15.2 (Stata Corp.).

RESULTS

A total of 157 patients who underwent THA using the DAA were included in this study, 38 patients underwent THA for treatment of both hips. Of the participants, 78 were male and 41 were female. The mean age of the study population was 43.9 years (range, 20-69 years), and the mean BMI was 27.3 kg/m^2. The duration of follow-up ranged from 12 to 48 months, with a mean follow-up period of 24.1 months.

Regarding preoperative diagnoses, 91 patients had AVN of the femoral head, 39 patients had inflammatory arthritis, and 27 patients had secondary arthritis related to various causes including trauma, tuberculosis, and other etiologies.

The following implant combinations were used in the patients: Corail stem with Duraloc cup (DePuySynthes) was used in 50 patients, Bicontact stem with Plasma fit cup (Aesculap AG) in 30 patients, Accolade stem with Trident acetabular cup (Stryker) in 24 patients, and Metha stem with Plasma fit cup (Aesculap AG) in 15 patients.

1. Intra-operative Variables and Complications

1) Group 1

The mean duration of surgery for the first 50 cases was 104±15 minutes (range, 80-129 minutes). The mean intraoperative blood loss was 735±193 mL. The mean fluoroscopy time was 4.5±0.6 seconds. The mean length of stay was 2.1±0.8 days. Two patients experienced anterior dislocations after discharge, managed through closed reduction. In addition, readmission was required for three patients because of delayed wound healing who underwent debridement and wound washing (Table 2, 3).

2) Group 2

In the subsequent 51 to 100 cases, the mean duration of surgery decreased to 75±9 minutes (range, 45-60 minutes). The mean intraoperative blood loss was 528±155 mL. The mean fluoroscopy time was 3.0±1.1 seconds. The mean length of stay was 2.7±1.4 days. One patient experienced postoperative sciatic nerve palsy, managed using magnetic resonance neurography and evacuation of the identified hematoma. The nerve had fully recovered after six weeks (Table 2, 3).

3) Group 3

In the subsequent 101 to 157 cases, the mean duration of surgery decreased to 66±14 minutes (range, 37-65 minutes). The mean intraoperative blood loss was 308±52 mL. The mean radiation time was 3.4±1.2 seconds. The mean length of stay was 2.8±1.3 days. One patient was readmitted due to a wound hematoma and dehiscence, and was managed with debridement and suturing, resulting in uneventful wound healing (Table 2, 3).

Statistically significant differences in intraoperative variables—blood loss, surgical time, and fluoroscopy time were observed among the three groups (Table 3).

2. Functional Outcome

Fifty-three patients (65 hips) had a minimum follow-up period of two years and 66 patients (92 hips) had a minimum follow-up period of one year. The mean follow-up period for patients was 17.2±5.9 months (range, 12-26 months). Function improved from a overall mean preoperative HHS of 33.2±2.5 to 93.9±2.1 at the final follow-up. No statistically significant difference in the mean HHS score was observed in the three groups at the final follow-up (Table 3).

Table 2. Surgical Complication

Complication (surgical)	Group 1	Group 2	Group 3
Dislocation	2	0	0
Loosening stem	0	0	0
Loosening cup	1	0	0
Periprosthetic fracture	0	0	0
Delayed healing/infection	3	1	1
Implant malposition	0	0	0
Nerve palsy	0	1	0
Total	6	2	1

Group 1: 1 to 50 cases, Group 2: 51 to 100 cases, Group 3: 101 to 157 cases.

3. Radiological Evaluation

On radiological evaluation, loosening of implants was not observed in any of the patients at the latest follow-up. On radiological examination for positioning of the component, five hips in the first group had an unacceptable and two hips in the second group had an unacceptable version. The positioning of the acetabulum component was acceptable in all patients in the third group. None of the patients in the study group underwent reoperation with implant revision.

4. Learning Curve Analysis

According to the CUSUM learning curve chart (Fig. 1), the 82nd case corresponds to the main inflection point (point A) at which the failure rate became consistent. In the 118th case (point B), the line crosses the lower decision limit and the failure rate is equal to the defined acceptable failure rate (h0, 5%). The failure rate before the 82nd case remained at the unacceptable threshold (h1, 20%).

DISCUSSION

DAA offers several advantages including preservation of intermuscular planes, more rapid rehabilitation, and lower risk of dislocation. However, DAA may be technically challenging, particularly for surgeons who have been trained according to the posterior approach. In this study, we report our experience as a single surgeon in the transition from using a posterior approach to DAA. We found that careful selection of patients

Table 3. Comparison between DAA Groups Based on Surgical Order

Variable	Group 1 (n=50 hips)	Group 2 (n=68 hips)	Group 3 (n=84 hips)	*P*-value*	*P*-value† (2 vs. 1)	*P*-value† (3 vs. 2)
Age (yr)	44.1±14.7	44.2±13.8	43.4±10.7	0.910	>0.999	>0.999
BMI (kg/m^2)	24.6±3.4	26.5±3.9	29.5±3.1	<0.001	0.009	<0.001
Surgical time (min)	104±15	75±9	66±14	<0.001	<0.001	<0.001
Blood loss (mL)	735±193	528±155	308±52	<0.001	<0.001	<0.001
Fluoroscopy time (sec)	4.5±0.6	3.0±1.1	3.4±1.2	<0.001	<0.001	>0.999
LOS (day)	2.1±0.8	2.7±1.4	2.8±1.3	0.004	0.016	>0.999
HHS						
Preoperative	51.7±8.6	54.4±8.3	54.6±9.5	0.146	0.286	>0.999
Final	89.2±5.4	89.5±4.8	89.8±5.1	0.822	>0.999	>0.999

Values are presented as mean±standard deviation.
Group 1: 1 to 50 cases, Group 2: 51 to 100 cases, Group 3: 101 to 157 cases.
BMI: body mass index, LOS: length of hospital stay, HHS: Harris hip score.
**P*-value based on ANOVA test for comparison among the 3 groups. †Bonferonni multiple comparison tests comparing significance between individual groups.

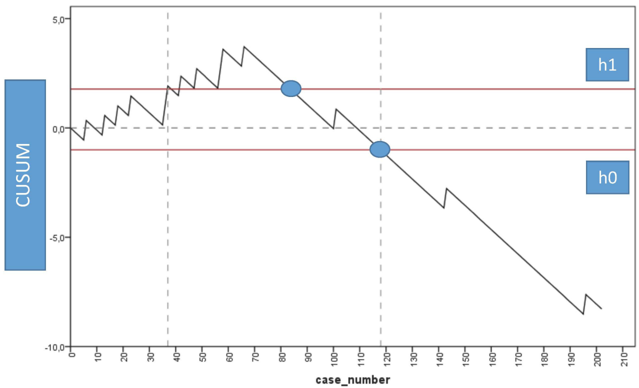

Fig. 1. CUSUM (cumulative summation method) analysis: evaluating performance attainment of predetermined competence levels. h0: a line that crosses the lower decision limit, h1: a line that crosses the upper decision limit.

was associated with safe performance of DAA, with a decreasing risk of complications, operative time, and blood loss over time. Our study also found that the risk of unfavorable outcomes after DAA may remain high up to the first 80 cases, implying that the learning curve may be long for surgeons transitioning from use of a posterior to an anterior approach.

The learning curve for DAA was analyzed in the current study. The learning curve in surgery refers to the period during which surgeons gain proficiency and improve their skills in performance of a particular surgical technique. Using a cumulative sum model, we found that the complication rates were within the acceptable range in the initial cases, but peaked at approximately 80 cases. The higher rates of complications observed for cases from approximately 50-80, which was higher than the acceptable limit (5%-20%), was likely because there were more complex cases after the initial 50 cases. The complication rates showed a consistent decrease after approximately 80 cases and even went below the lower threshold (5%) for complications at approximately 120 cases. Peters et al.[8], who performed revision-free survival analysis, reported that the risk of revision was 64% and 30% higher in the first and second 50 cases, respectively. The authors also reported that after the first 100 cases, the revision rates were stable, indicating a learning curve of approximately 100 cases. Kong et al.[7], using the CUSUM method for analysis of the learning curve, reported that complications achieved a stable state after approximately 88 cases, similar to our study.

The current study also highlights the importance of careful selection of patients during the duration of the learning curve. Our initial surgeries were performed on patients who were lean and had no significant deformity or defect. Heavy and muscular patients present a challenging scenario, and in most cases a surgeon will not utilize DAA for such patients. In a study of 394 patients undergoing DAA by Rivera et al.[12], BMI>35 kg/m^2 was considered an exclusion criterion. Heinz et al.[13] reported that higher values for BMI increased the risk of accidentally increasing the angle of cup inclination, probably due to the limited visualization and impeding soft tissues. Many studies have reported that BMI could cause an independent increase in the operative time in DAA emphasizing the importance of careful selection of patients[13,14]. In addition to BMI, the presence of previously installed hardware, pre-operative deformity, need for acetabular augmentation or femoral shortening, etc. should also be considered as there may be difficulty for surgeons with limited expertise in DAA[6].

The findings of the current study also showed promising early results of THA performed using DAA. Previous studies have reported reduced postoperative pain, more rapid recovery, improved functional outcomes, lower dislocation rates, and a high level of patient satisfaction compared to other surgical approaches. Although we did not compare the outcomes with those of THAs performed using a posterior approach, we observed that patients showed improvement in function as determined by HHS. Improvement in hip scores was observed in both initial and later cases and was comparable to other studies. In a meta-analysis comparing the HHS between DAA and conventional approaches, the authors reported that the HHS at one year in different randomized controlled trials ranged from 92 to 97, which was not significantly different from that reported for conventional approaches[15]. The radiological and clinical outcomes were also excellent as none of the patients in this cohort required component revision.

The study has limitations, including the lack of a comparative analysis with conventional approaches, as it focuses solely on the DAA. The learning curve described is specific to the experience of a high-volume surgeon at a single centre, with potential biases across various factors that are naturally associated with the adoption of new surgical techniques. Another limitation is that patients included in the study had a relatively shorter period of follow-up. In this study, the mean follow-up period was 17.2 months, and implant-related failures might have been observed with a longer follow-up period. However, the primary surgeon's vast experience with the use of these implants likely did not have a confounding effect on surgical time.

CONCLUSION

In summary, the current study provides valuable information about the learning experience of a single surgeon who transitioned from using a posterior approach to DAA in Asia. The results of this study highlighting the importance of diligent selection of patients demonstrated that successful outcomes can be achieved with acceptable complication rates when using DAA. Our findings also indicated that complication rates may be high, up to the initial 80 cases, while approximately 120 cases may be required before a stable and low complication rate is achieved. These results may be helpful for surgeons when talking to their patients about a planned THA using DAA. Conduct of additional research will be required as an effort to determine whether this learning curve justifies the conversion from other approaches for performance of THA to an anterior approach, and if the learning curve would have been different for new surgeons who are trained in performance of DAA rather than other approaches.

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Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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