

**Current Concepts and Technologies in Acetabular Cup Positioning for Primary Total Hip Arthroplasty**

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**Abstract:**

**Background:** Total hip arthroplasty (THA) is a broadly used surgical technique for treating hip joint arthritis, offering significant pain relief and improved mobility. For optimal results, the acetabular cup must be positioned precisely because incorrect positioning might result in wear and dislocation, among other issues. In addition to reviewing current advancements in enhancing accuracy and optimal location, the study sought to assess acetabular cup positioning in primary routine total hip replacements.

**Methods:** A retrospective cohort study was carried out from June 2023 to May 2024. Two hundred individuals who had primary THA were included in the study. Data on patient demographics, surgical details, and acetabular cup positioning were collected and analyzed using SPSS software.

**Results:** The mean age was 65.3 years, with a majority of males (55%). Osteoarthritis was the primary indication for surgery in 70% of cases. The posterior approach was used in 70% of surgeries, with 80% of implants being cementless. Radiographic analysis showed that 85% of acetabular cups were within the optimal range of 30-50 degrees for inclination angle, and 90% were within the optimal range of 5-25 degrees for anteversion angle. There was a significant variation in anteversion angles between the posterior and anterolateral approaches ( $p = 0.03$ ).

**Conclusion:** The study highlights the importance of accurate acetabular cup positioning in primary THA. The findings suggest that the surgical approach may influence cup positioning, emphasizing the need for meticulous surgical technique. The study contributes to improving outcomes in total hip arthroplasty by providing insights into acetabular cup positioning.

**Recommendations:** Future research should focus on further refining surgical techniques to achieve more accurate acetabular cup positioning and assess the long-term effects on patient outcomes.

**Keywords:** Total Hip Arthroplasty, Acetabular Cup Positioning, Surgical Approach, Radiographic Analysis, Complications.

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## Introduction

Millions of individuals worldwide have benefited from total hip arthroplasty (THA), which has completely changed the way hip joint arthritis is treated by providing substantial pain relief and increased mobility. As a result of the procedure's growing popularity and success, research has concentrated on enhancing implant survival and lowering surgical complications. Various philosophies have been offered with a continuing focus on optimal component orientation. Whatever the theory, it is essential to obtain an exact acetabular position for every therapeutic situation. This paper examines the latest advancements in enhancing the precision and precise placement of the acetabular cup during standard primary THA procedures.

The acetabular cup is a critical component in THA, as its position can significantly impact the outcomes of the procedure. Malpositioning of the acetabular cup can lead to complications such as dislocation, impingement, and wear, ultimately affecting the longevity of the implant. Recent studies have highlighted the importance of accurate acetabular positioning, with some suggesting that the acetabular cup should be placed at an inclination angle of 45° [1]. However, the optimal position of the acetabular cup remains a topic of debate, with different studies proposing various angles and techniques for achieving accurate positioning.

One of the key challenges in achieving accurate acetabular positioning is the variability in pelvic tilt and spinopelvic relationships. Recent studies have shown that spinopelvic mobility can substantially affect the position of the acetabular cup, with patients with rigid spines requiring more precise positioning to avoid complications [2]. Additionally, the use of

preoperative planning and patient-specific instrumentation has been shown to improve the accuracy of acetabular positioning, although the clinical advantage of these techniques over conventional THA is yet to be fully elucidated [3].

The study aimed to evaluate acetabular cup positioning in primary routine total hip arthroplasty.

## Methodology

### Study Design

A retrospective cohort study.

### Study Setting

The research was conducted at Jawahar Lal Nehru Medical College and Hospital, Bhagalpur, Bihar, India, from June 2023 to May 2024.

### Participants

A total of 200 patients were enrolled.

### Inclusion Criteria

- Patients aged 18 years and older
- Patients who undertook primary THA
- Patients with comprehensive medical histories and data from follow-up

### Exclusion Criteria

- Individuals who had revision hip arthroplasty,
- with incomplete medical records

### Sample size:

To calculate the sample size for this study, the following formula was used for estimating a proportion in a population:

$$n = \frac{Z^2 \times p \times (1-p)}{E^2}$$

Where:

- n = sample size
- Z = Z-score corresponding to the desired level of confidence
- p = estimated proportion in the population
- E = margin of error

**Bias**

Efforts were made to minimize bias by ensuring a random selection of patient records and by blinding the data analysts to patient identities.

**Variables**

Variables included patient demographics (age, sex), surgical technique, type of implant used, accuracy of acetabular cup positioning, as measured by radiographic analysis.

**Data Collection**

Information about the patient's demographics, surgical specifics, and postoperative radiography pictures were gathered from their medical records.

**Procedure**

Patient records were reviewed to identify those meeting the inclusion criteria. Radiographic analysis was performed to assess the positioning of the acetabular cup. Data were extracted and entered into a standardized data collection form.

**Statistical Analysis**

Data were examined using SPSS software (20.0). The accuracy of acetabular cup positioning was assessed using mean values and standard deviations. A p-value of <0.05 was considered statistically considerable.

**Ethical considerations:**

The study protocol was approved by the Ethics Committee and written informed consent was received from all the participants.

**Result****Table 1: Participant Demographics**

Demographic Characteristics	Number (%)
Age (years)	
45-54	30 (15%)
55-64	60 (30%)
65-74	80 (40%)
75-85	30 (15%)
Mean age (SD)	65.3 (10.2)
Gender	
Male	110 (55%)
Female	90 (45%)
Primary Diagnosis	
Osteoarthritis	140 (70%)
Avascular Necrosis	40 (20%)
Rheumatoid Arthritis	20 (10%)

The study included 200 individuals who underwent primary THA. The mean age was 65.3 years ( $\pm$  10.2), with a range from 45 to 85 years. There were 110 (55%) males and 90 (45%) females. The majority of the patients (70%) had osteoarthritis as the primary indication for surgery, followed by avascular necrosis (20%), and rheumatoid arthritis (10%).

**Table 2: Surgical Details**

Surgical Details	Number (%)
<i>Surgical Approach</i>	
Posterior	140 (70%)
Anterolateral	60 (30%)
<i>Type of Implant</i>	

Cementless	160 (80%)
Cemented	40 (20%)

The majority of the procedures were performed using the posterior approach (70%), followed by the anterolateral approach (30%). The types of implants used included cementless (80%) and cemented (20%) acetabular cups.

**Table 3: Acetabular Cup Positioning**

Acetabular Cup Positioning	Mean (SD)	Optimal Range	Within Optimal Range (%)
Inclination Angle (degrees)	42.1 (5.3)	30-50	170 (85%)
Anteversion Angle (degrees)	16.8 (4.7)	5-25	180 (90%)

Radiographic analysis showed that the mean inclination angle was 42.1 degrees ( $\pm 5.3$ ), with 85% of the cups within the optimal range of 30-50 degrees. The mean anteversion angle was 16.8 degrees ( $\pm 4.7$ ), with 90% of the cups within the optimal range of 5-25 degrees.

**Table 4: Statistical Comparison**

Statistical Comparison	p-value
Inclination Angle (Males vs. Females)	0.45
Anteversion Angle (Posterior vs. Anterolateral)	0.03

There was no considerable variation in the mean inclination angle among both genders ( $p = 0.45$ ). However, a considerable difference was seen in the mean anteversion angle between the posterior and anterolateral approaches ( $p = 0.03$ ).

**Table 5: Complications and Outcomes**

Complications	Number (%)
Dislocation	4 (2%)
Infection	3 (1.5%)
Deep Vein Thrombosis	2 (1%)
Overall Complication Rate	9 (4.5%)

Postoperative complications included dislocation (2%), infection (1.5%), and deep vein thrombosis (1%). The overall complication rate was 4.5%.

## Discussion

In the study, the mean age was 65.3 years, with a demographic distribution of 55% males and 45% females. The primary indication for surgery was osteoarthritis, accounting for 70% of the cases, followed by avascular necrosis (20%) and rheumatoid arthritis (10%).

Regarding surgical details, the posterior approach was predominantly used in 70%

of the surgeries, while the anterolateral approach was utilized in the remaining 30%. The majority of the implants were cementless (80%), with only 20% being cemented. The positioning of the acetabular cups was a focal point of the study, with the mean inclination angle recorded at 42.1 degrees, and 85% of these angles falling within the optimal range of 30-50 degrees. Similarly, the mean anteversion angle was 16.8 degrees, with 90% of the angles within the optimal range of 5-25 degrees.

The statistical analysis revealed no significant variation in the mean inclination angles between males and females ( $p =$

0.45). However, a notable substantial variation was found in the mean anteversion angles between the posterior and anterolateral approaches ( $p = 0.03$ ). This suggests that the surgical approach may impact the positioning of the acetabular cup, which could influence the outcomes of the surgery.

Postoperative complications were relatively low, with an overall rate of 4.5%. Specific complications included dislocations (2%), infections (1.5%), and deep vein thrombosis (1%). These findings highlight the importance of meticulous surgical technique and vigilant postoperative care to minimize complications.

According to a review, proper acetabular posture is critical in THA because it influences a number of factors, including dislocation, noise generation, gait, limb lengths, impingement, wear, loosening, and cup failure. The study highlights the significance of preserving acetabular offset for good range of motion and impingement prevention, as well as the necessity of tailored strategies based on particular anatomic features [4].

In a different study, the accuracy of acetabular cup placement in primary THA using conventional techniques was examined. It was discovered that surgeons are only 53.1% correct in terms of both inclination and version when compared to a preoperative plan that was expected. According to the study, in order to achieve the best results, it is imperative to incorporate approaches that improve precision in cup placement [5].

A thorough analysis of the state-of-the-art approaches to robotically aided surgery, intraoperative fluoroscopy, patient-specific instrumentation, computer-assisted navigation systems, and image-based planning for the purpose of optimising acetabular positioning in THA. The research emphasises how critical accurate acetabular alignment is to reducing

problems including impingement, dislocation, and component wear [6].

A study of the most recent scientific literature on the placement of the acetabular cup in primary THA also emphasises the significance of precise location and the range of theories put forth. The study emphasizes the need for individualized approaches based on specific anatomic features and the importance of maintaining acetabular offset for optimal ROM and impingement prevention [7].

### Conclusion

In summary, the study demonstrates that the majority of acetabular cups were positioned within optimal ranges, reflecting successful surgical outcomes in most cases. The significant difference in anteversion angles between surgical approaches suggests that the posterior approach may have a distinct impact on cup positioning compared to the anterolateral approach. Despite the low complication rate, the presence of issues such as dislocations, infections, and deep vein thrombosis underscores the necessity for continuous improvement in surgical techniques and patient care. These insights are valuable for enhancing current practices and guiding future research in total hip arthroplasty.

**Limitations:** The limitations of this study include a small sample population who were included in this study. Furthermore, the lack of comparison group also poses a limitation for this study's findings.

**Recommendation:** Future research should focus on further refining surgical techniques to achieve more accurate acetabular cup positioning and assess the long-term effects on patient outcomes.

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### List of abbreviations:

THA: Total Hip Arthroplasty

ROM: Range of Motion

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