

Research Paper

Evaluation of the Accuracy of Cup Positioning in Total Hip Arthroplasty Using the Antero-lateral Approach



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ABSTRACT

Background: Total hip arthroplasty (THA) is a highly successful orthopedic procedure, recognized as the gold standard for addressing advanced osteoarthritis, with a projected global increase in performed cases.

Objectives: This study investigated the accuracy of cup positioning in patients undergoing THA using the anterolateral (AL) approach.

Methods: This cross-sectional study included patients undergoing ALTHA at Shafa Yahyaiyan Hospital in Tehran, affiliated with the Iran University of Medical Sciences, from 2018 to 2023. Post-operative radiological evaluations were conducted, and anteversion and inclination were assessed using established protocols. A safe zone for cup orientation was defined with an inclination angle of $40 \pm 10^\circ$ and anteversion angle of $15 \pm 10^\circ$.

Results: Among 91 patients, the mean age was 51.14 years and 48 cases (52.7%) were male. Considering the safe zone for cup orientation, 69 patients (75.8%) fell within the inclination angle safe zone and 46(50.5%) were within the anteversion angle safe zone. However, no significant associations were found between age, gender, side of operation and the safe zones for anteversion and inclination.

Conclusion: The results indicated that the AL approach, as performed by experienced surgeons, achieved favorable cup positioning in the majority of patients, regardless of age and gender.

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1. Introduction

Total hip arthroplasty (THA) stands out as one of the most successful procedures in orthopedic surgery [1]. Given its status as the gold standard for addressing advanced osteoarthritis, a global increase in the number of performed THA cases is anticipated [2, 3]. Component positioning plays a crucial role in influencing THA outcomes, with improper cup positioning potentially linked to issues, such as dislocation, increased polyethylene wear, reduced abductor muscle strength, and impingement [4-11].

THA can be performed through various surgical approaches, including anterolateral (AL), direct anterior (DA), and lateral and posterior approaches (PAs) [12]. The AL approach was initially articulated by von Sprenghel and Bardenheuer and subsequently, modified on multiple occasions, first by Watson-Jones and later by Harris et al. [13, 14]. This approach is associated with several advantages, such as optimal exposure of the acetabulum, precise implant positioning, leg length correction, and a reduced risk of dislocation [4, 15]. Furthermore, this approach utilizes the intermuscular plane between the tensor fascia lata and gluteus medius, innervated by the superior gluteal nerve [16].

The choice of surgical approach can impact component positioning due to variations in the visibility of critical anatomical landmarks [17]. Numerous studies have investigated the optimal orientation of the acetabular cup in THA. Lewinnek et al. recommended a safe zone for cup orientation with an inclination angle of $40\pm 10^\circ$ and an anteversion angle of $15\pm 10^\circ$ [5]. Callanan et al. reported that accurate cup placement, whether by freehand or mechanical guide techniques, depended on factors, like age, surgical approach, and the surgeon's experience. They noted that cup alignment with the AL approach exhibited decreased accuracy compared to the PA, trending towards higher abduction angles and lower versions [17].

Objectives

In this study, we aimed to investigate the accuracy of cup position by exploring cup anteversion and inclination in patients undergoing THA by an experienced surgeon utilizing the AL approach.

2. Methods

In this cross-sectional study, we included patients undergoing THA at [Shafa Yahyaiyan Hospital](#) in Tehran,

affiliated with the [Iran University of Medical Sciences](#), from 2018 to 2023. All patients underwent AL-THA in a lateral position by an expert right-hand dominant hip orthopedic surgeon.

The inclusion criteria comprised patients requiring hip replacement due to abnormal hip pathology, including avascular osteonecrosis (AVN) of the femoral head, Crowe I and II developmental dysplasia of the hip (DDH), hip degenerative joint disease (DJD), and a previous history of a femoral neck fracture. Exclusion criteria included patients undergoing revision surgery, those with a history of Perthes disease, types III and IV DDH, and individuals with pathological fractures during childhood.

Post-operative radiological evaluations were conducted, with all radiographic performed in an anteroposterior (AP) manner with a 15-degree intra-rotation of the hip, following standard hip radiographic assessment protocols [18, 19]. Anteversion and inclination were assessed using a method previously described by Widmer et al. [20] (Figure 1), determining whether the values fell within the safe zone (inclination angle of $40\pm 10^\circ$ and an anteversion angle of $15\pm 10^\circ$) [5]. A single orthopedic surgeon evaluated the radiographs. Patients' age and gender were also documented.

Collected data were entered into SPSS software, version 26 for statistical analysis and comparisons. The normality of data was evaluated by the Kolmogorov-Smirnov test. Categorical variables are presented as frequency and percentage (%), while continuous variables are presented with Mean \pm SD for normally distributed data, and median with first and third quantiles [Q1-Q3] for non-normal data. Statistical analysis involved using the chi-square or Fisher's exact test for categorical variables (gender and side of operation) and an independent t-test for age. A $P < 0.05$ was considered statistically significant.

3. Results

Among 166 patients, 91 cases were entered into our final analysis based on accurate radiographic imaging and complete data in their files. The patients' age ranged from 18 to 80 years, with the majority being in the age group of 46 to 65 years. The majority of patients were male (52.7%). The etiology of hip pathology included fracture of the femoral neck in 11(12.1%), AVN in 36(39.6%), DJD in 18(19.8%) and DDH in 26(28.6%) cases. [Table 1](#) presents the characteristics of the patients in our study.

The angle of inclination ranged from 12 to 59° , while the angle of anteversion ranged from 6 to 46° . By con-

Table 1. Demographic and radiological characteristics of patients undergoing THA using the AL approach (n=91)

Variables		Mean±SD/No. (%)
Age (y)		51.14±14.1
Age group (y)	≤25	3(3.3)
	26-45	31(34.1)
	46-65	44(48.4)
	>65	13(14.3)
Gender	Male	48(52.7)
	Female	43(47.3)
Side	Right	38(41.8)
	Left	53(58.2)
Anteversion		25.48±6.73
Inclination		34.73±7.85

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Considering a safe zone for cup orientation with an inclination angle of $40 \pm 10^\circ$, 69 patients (75.8%) were within the safe zone, and by considering an anteversion angle of $15 \pm 10^\circ$, 46 cases (50.5%) were within the safe zone. **Table 2** demonstrates the features of the patients based on their presence in the safe zone. As demonstrated, none of the variables in our study showed a significant association with anteversion and inclination safe zones.

Regarding the inclination angle, out of the 22 cases that were outside the safe zone, 20(22.0%) had angles below 30° and two (2.2%) had angles exceeding 50° . In terms of the anteversion angle, all 45 cases outside the safe zone had angles greater than 25° . The median level of anteversion deviation from the safe zone was 4° [Q1–Q3: 1–9]. **Figure 2** demonstrates the scatter plot of the cases in our study based on anteversion and inclination.

Table 2. Evaluation of age, gender and side of operation based on safe zone anteversion and inclination

Variables	Anteversion			Inclination			
	Mean±SD/No. (%)		P*	Mean±SD/No. (%)		P*	
	Safe zone (n=46)	Non-safe Zone (n=45)		Safe Zone (n=69)	Non-safe Zone (n=22)		
Age (y)	51.9±13.5	50.4±14.8	0.60	50.9±14.1	52.0±14.4	0.76	
Age group (y)	≤25	1(2.2)	1.00	2(2.9)	1(4.5)	0.67	
	26–45	16(34.8)		23(33.3)	8(36.4)		
	46–65	22(47.8)		22(48.9)	35(50.7)		9(40.9)
	>65	7(15.2)		6(13.3)	9(13.0)		4(18.2)
Gender	Male	21(45.7)	0.17	36(52.2)	12(54.5)	0.85	
	Female	25(54.3)		18(40.0)	33(47.8)		10(45.5)
Side	Right	20(43.5)	0.74	29(42.0)	9(40.9)	1.00	
	Left	26(56.5)		27(60.0)	40(58.0)		13(59.1)

*Independent sample t-test for age, chi-square and Fisher's exact tests for categorical variables.

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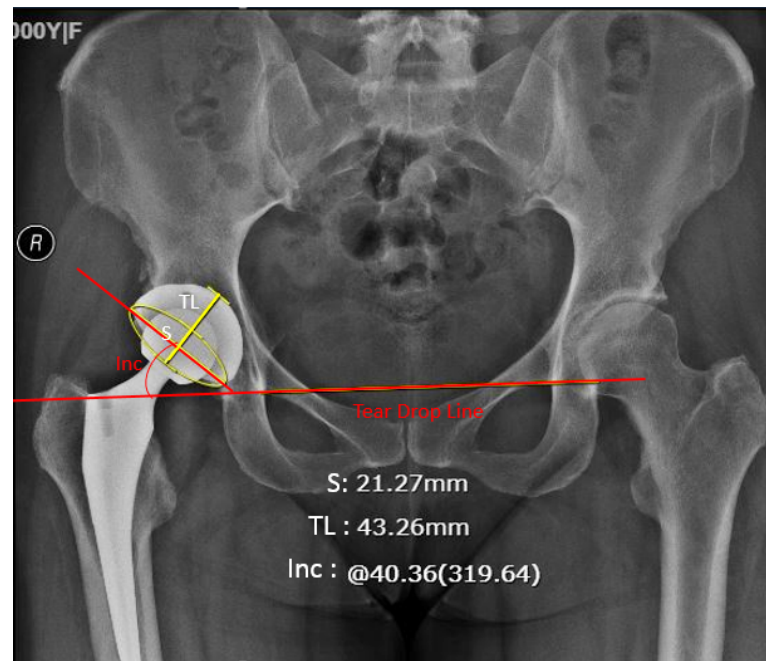
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Figure 1. Radiography imaging (anterior to posterior) of the hip, assessing the amount of anteversion and inclination after THA using the AL approach

4. Discussion

The positioning of components plays a crucial role in the functionality and durability of THA [21]. In this study, we aimed to evaluate the accuracy of component positioning in AL-THA, particularly based on radiographic anteversion and inclination. Our findings indicated that based on the determined safe zone, the majority of patients (75.8%) were within the safe zone of inclination, while approximately half (50.5%) of the patients were within the safe zone of anteversion, indicating that the majority of patients were in the safe zone of cup orientation.

The most concerning factor in our study was that around half of the patients had an anteversion angle outside our safe zone, with a mean deviation of 4° larger than the designated safe zone. Similar findings were also reported in other studies utilizing the anterior approach. Takada et al. [22] noted that the positive error of anteversion was consistently higher than the negative error in the AL, indicating that the majority of cups were implanted with greater anteversion than initially targeted. Maeda et al. [23] also reported a similar trend in radiographic cup anteversion in the AL approach, with values exceeding their target angle by 4.3° , which was similar to our findings. They suggested that the larger anteversion might be attributed to pelvic rotation induced by the retractor placed at the posterior acetabular wall, causing the femoral bone to retract and rotating the ipsilateral

pelvis posteriorly during cup preparation. Iwakiri et al. [24] stated that by employing the muscle-sparing modified Watson-Jones AL approach, the deviation from the targeted angle was $3.5 \pm 3.1^\circ$ in inclination and $4.6 \pm 4.6^\circ$ in anteversion. Kawarai et al. [25] also noted the possibility of such rotational instability occurring in the AL approach, similar to the DA approach. This pelvic rotation during surgery could elucidate the prevalence of positive values in the target error of anteversion observed in both groups. Additionally, the angle of inclination ranged from 12 to 59° , while the angle of anteversion ranged from 6 to 46° , suggesting extreme pelvic rotation during surgery in a number of cases. In Takada et al.'s study, the utilization of an operating prop placed on both anterior superior iliac spines to stabilize the pelvis in the lateral position might have played a crucial role in averting excessive pelvic rotation [22]. Overall, careful attention to the potential for ipsilateral posterior pelvic rotation during cup preparation is crucial in the AL approach.

One of the discrepancies in the results of various studies may be attributed to the difference in the assisting device and mechanical guides. These guides are commonly employed without direct consideration of pelvic tilt and position [22]. While various assisting devices, notably computer-assisted navigation systems, are recognized for their potential to achieve precise cup positioning [26-31], their availability remains limited across institutions. A study analyzing registration data in the United States, conducted by Aoude et al. [32], revealed that approxi-

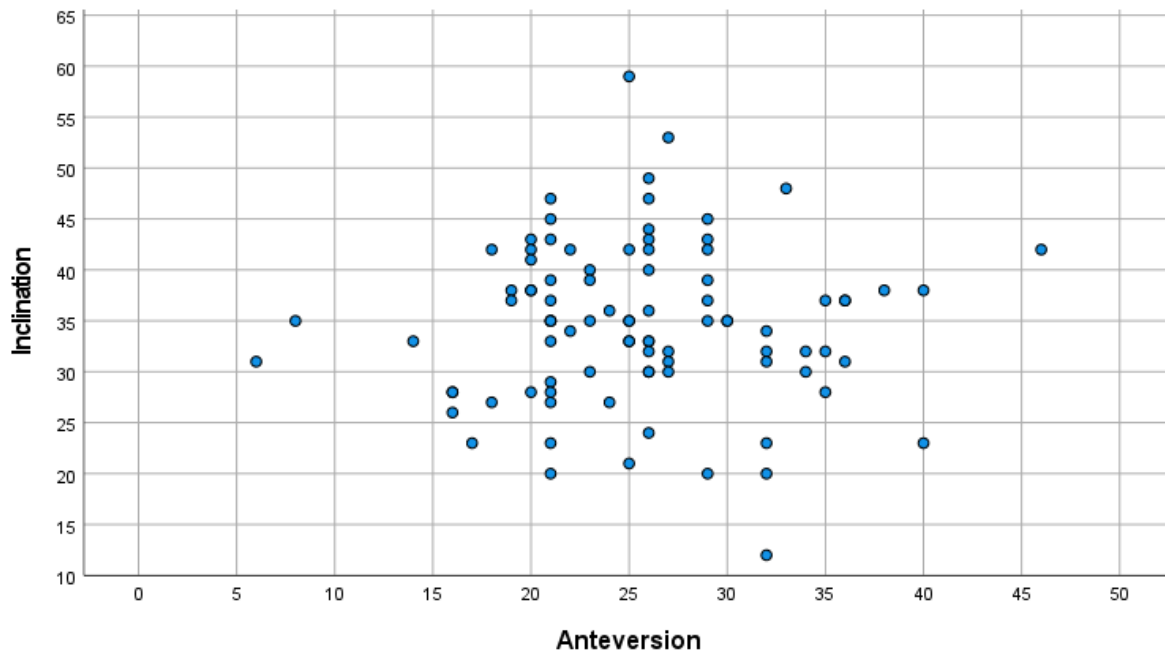


Figure 2. Scatter plot of inclination and anteversion of cases of THA using the AL approach

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Note: Values are presented as the degree of angle. The green box demonstrates the safe zone (inclination angle of $40 \pm 10^\circ$ and anteversion angle of $15 \pm 10^\circ$) in our study.

mately 97% of THAs were conducted without the use of any computer-assisted system at the time of their report. Concerning the learning curve, de Steiger et al. proposed that a surgeon should conduct 50 or more procedures before the revision rate aligns with that of performing 100 or more procedures [33]. Hence, our study provides valuable insights for surgeons seeking to enhance their proficiency in achieving accurate cup positioning, particularly in settings where advanced assisting devices may not be readily accessible. Furthermore, our results serve as a pertinent reference for understanding the accuracy of cup positioning in the context of the AL approach.

Maintaining the contracted external rotators through the anterior approach limits internal rotation post-THA [34]. In a PA, even with the joint capsule repaired and the tendons of the external rotator muscles sutured, the restriction on internal rotation may not be as effective as the anterior approach [35]. In a retrospective pilot study by Kishimura et al. [36] comparing the modified AL Watson-Jones approach in both supine and lateral positions, they observed that the supine position did not yield higher accuracy in cup positioning compared to the lateral position. Takada et al. also demonstrated no significant difference concerning surgical factors and early outcomes between the AL approach in the supine and lateral position [22].

This study had several limitations. Firstly, it did not follow a prospective randomized trial or a matched case-control study design. Also, the precision of cup positioning likely relied on the experience and skill of the surgeons involved. We refrained from utilizing additional assisting devices, such as mechanical guides, fluoroscopy, and computer-assisted navigation systems. The actual pelvic movement during surgery was not examined in our study. Patients with significant hip deformities were excluded from our study. Investigating the impact of the positioning of such patients during surgery on the accuracy of cup positioning is a topic worthy of exploration in future research. Also, our study solely compared the accuracy of cup positioning based on the designated safe zones. Whether a two-degree difference in inclination would translate to divergent clinical outcomes remains unclear. A more extensive investigation, including long-term follow-ups and a comparison of clinical results, should be conducted in the future.

5. Conclusion

The results indicated that the AL approach, as executed by the experienced surgeon, achieved favorable cup positioning in the majority of patients and is independent of patients' age and gender. Furthermore, cup anteversion is an important aspect, which should be considered in the AL-THA approach.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of **Iran University of Medical Sciences** (Code: IR.IUMS.REC.1402.925). Patients' information was de-identified before data analysis and confidentiality of patients' information was guaranteed and protected. Based on the retrospective nature of our study, written informed consent was waived by the Ethics Committee of **Iran University of Medical Sciences**, and their information was obtained from their hospital records. Permission to carry out the study and access patient records was sought from the administrators of **Iran University of Medical Sciences**, and the study was conducted in accordance with the relevant guidelines and regulations and the Declaration of Helsinki.

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Authors' contributions

Conceptualization and supervision: Kaveh Gharanzadeh and Karim Pisoudeh; Methodology: Karim Pisoudeh; Investigation: Mahmoodreza Sarikhani; Data collection: Mahmoodreza Sarikhani, Amir Aminian, and Mohammadreza Bahaeddini; Data analysis: Mahmoodreza Sarikhani; Writing the original draft: Mahmoodreza Sarikhani; Review & editing: All authors.

Conflict of interest

The authors declared no conflict of interest.

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