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The length of distal skin incision of the postero-lateral approach affects the cup inclination during the total hip arthroplasty

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ABSTRACT

Aim: The primary aim of the study was to determine whether the length of the distal skin incision of the posterolateral approach affects the cup inclination during total hip arthroplasty (THA).

Material and Method: In this study, a cohort of 71 consecutive patients who performed between January 2017 and December 2021 with unilateral THA using a posterolateral approach was retrospectively assessed. Two groups were formed according to acetabular cup inclination with normal anteversion angle. There were 56 hips in the inside group and 17 in the outside group. A curvilinear skin incision of around 13 cm was performed. Component position evaluation was carried out through a radiographic assessment of the acetabular component on an anteroposterior pelvis radiograph. The rate of an outlier was compared between groups according to the safe zone defined as 30° to 50° of inclination and 5° to 25° of anteversion, which was described by Lewinnek et al.

Results: No significant difference in the average total incision length was found between the two groups (p=0.207). While the average distal incision length was 7.91±0.62 cm (range, 6.8-9 cm) in the inside group and 6.37±0.21 cm (range, 6-6.7 cm) in the outside group. According to ROC analysis, a patient with ≤6.7 cm of the distal length of incision (DLI) was 5.71 times more likely to be outside than a patient with >6.7 cm of DLI. Seventeen hips (23.3%) were found outside the safe range. Substantial differences were observed regarding radiographic cup inclination between the two groups (p=0.0001). In the inside group, the average cup inclination was 44.11°±3.44° (range, 37°-50°), whereas, in the outside group, it was 55.41°±2.5° (range, 52°-59°). However, there were no significant differences in the average radiographic cup anteversion between the two groups (p=0.960). Although 11 of 17 (64.5%) patients were classified as obese (BMI ≥30) in the outside group experienced higher rates of inaccurate cup orientation, logistic regression analysis showed that the individual effects of obesity on the occurrence of the inaccurate cup position were not observed (p=0.884). One posterior hip dislocation occurred after one month postoperative in the outside group.

Conclusions: Longer distal portion of the skin incision of the posterolateral approach should be performed to achieve optimal operative inclination angles of the acetabular cup during THA. The surgeon must have no hesitation in extending the distal skin incision when adopting the posterolateral approach.

Keywords: Total hip arthroplasty, posterior approach, distal length of incision, acetabular cup inclination, body mass index

INTRODUCTION

Primary total hip arthroplasty (THA) with a uncemented technique is considered one of the most successful orthopaedic surgeries, dependent on accurate acetabular cup orientation (1-3). There are many variables playing a role in THA failure, including patients' age, BMI, sex, comorbidities, soft tissue quality, surgical approach, surgeon experience, and malposition of the acetabular component (3,4). The single most significant variable is malposition of the acetabular cup during placing the acetabular component that has been associated with an early dislocation, reduced range of motion, edge loading, pelvic osteolysis, increased rates of polyethylene wear of the components, acetabular migration, impingement, leg length discrepancy, and patient dissatisfaction (5-8). To minimize these complications, a radiological "safe zone" for acetabular cup positioning after THA

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proposed by Lewinnek et al. (9) has been widely accepted as a safe range of the position of 40°±10°abduction and 15°±10° anteversion (10). Thus, acetabular component malposition, such as placing the acetabular component too vertically or too anteverted or retroverted, affects function and complications after THA, which is one of the most significant causes of revision hip surgery (6,11).

The accurate placement of the acetabular cup depends on the surgical approach (12). The most common surgical approach for THA is the posterolateral approach (13). Although the posterolateral approach is widely performed, some reports have revealed that the posterolateral approach may have a higher dislocation rate than the direct anterior approach (6,7). Kwon et al. (1) found a relationship between the increased risk of dislocation and the posterolateral approach since most dislocations are seen posteriorly. Furthermore, limited exposure to the area of the posterolateral approach at the time of surgery may lead to the risk of component malposition (6,14). Therefore, the optimal acetabular cup orientation is crucial to achieving good long-term results after THA, especially in the posterolateral approach (5,6).

The present study hypothesized that the length of the distal skin incision of the posterolateral approach affects the cup inclination during THA. To the best of our knowledge, no trial to date has investigated the possible effects of the length of the distal skin incision of the posterolateral approach on the cup inclination during THA. Hence, the primary purpose of this study was to investigate whether the length of the distal skin incision of the posterolateral approach affects the cup inclination during THA. Secondly, the secondary aim of the study was to determine whether BMI leads to inaccurate acetabular component position.

MATERIAL AND METHOD

The study was carried out with the permission of İstanbul Medipol University Clinical Researches Ethics Committee (Date: 04/02/2022, Decision No: E-10840098-772.02-753). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

This study prospectively collected data in an institutional database. A cohort of 71 consecutive patients who performed between January 2017 and December 2021 with unilateral THA using the postero-lateral approach for end-stage osteoarthritis was retrospectively assessed. Six patients diagnosed with Crowe type III or IV developmental dysplasia were excluded from this study. Two patients who did not want to participate in this study were also excluded. A total of 73 hips in 63 patients who met inclusion criteria were assessed whether the acetabular cup was placed within a safe zone of 40°±10° of inclination and 15°±10° of anteversion. According to literature, lower accuracy of acetabular cup positioning has been achieved using a posterior approach than an anterior approach (15). The correct angle of inclination or abduction plays a crucial role in dislocation, especially in the posterolateral approach (16,17). Thus, the current study focused on acetabular cup inclination. Two groups were formed according to acetabular cup inclination with normal anteversion angle. There were 56 hips in the inside group and 17 hips in the outside group. The rate of outlier was compared between groups according to the safe zone defined as 30° to 50° of inclination and 5° to 25° of anteversion according to the Lewinnek safe zone (9).

All surgeries were performed by a single orthopaedic surgeon who had approximately 19 years of experience in THA. Preoperative templating for cup size was done in all hips, using two digital-line methods described by Oddy et al. (18). All operations were performed with the same operative technique in which the patient was placed in the lateral decubitus position, using a posterolateral approach. A pubic and a lumbosacral positioning brace was used to keep the pelvis in optimal position. We checked that the operating table was parallel to the floor. A spirit level was utilized to confirm that the operating table was parallel to the ground. The anterior superior iliac spines (ASIS) were checked to be perpendicular to the operating table. A curvilinear skin incision of around 13 cm extending 4-6 cm proximal and about 6-9 cm distal to the tip of the greater trochanter was performed (**Figures 1, 2**). The femur was retracted anteriorly to expose and reame the acetabulum before placing the acetabular shell inserted press-fit after underreaming the acetabulum by 1 mm (**Figure 3**). The surgeon attempted to place the acetabular cup within safe zone of 40°±10° of inclination and 15°±10° of anteversion. Cup inclination and anteversion were visually evaluated by the surgeon intraoperatively. The straight cup inserter positioning relative to the floor and cup-positioning guides with the freehand technique were used to verify the acetabular inclination and anteversion. Intraoperative fluoroscopy exposes the patient and surgeon to additional radiation. Hence, no fluoroscopy was applied to assess cup orientation. All hips were treated with the same cementless prosthesis (Trilogy acetabular cup, Versys Fiber Metal Taper stem; Zimmer Biomet, Warsaw, Indiana, USA). Traditional manual methods with mechanical and anatomical guides were utilized to determine the optimal cup positioning in the current study.

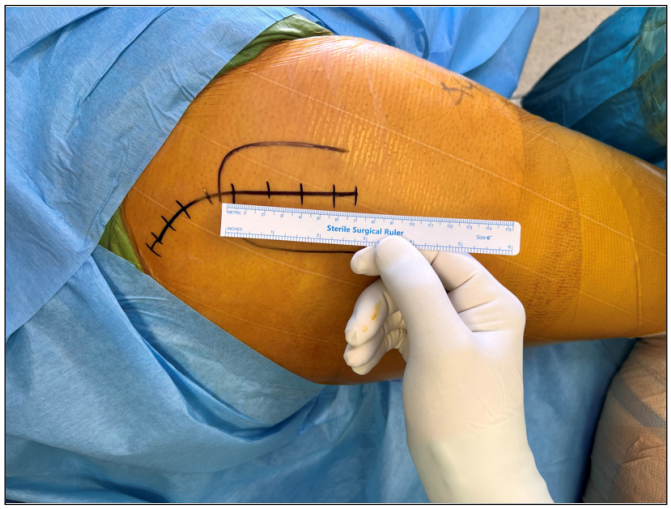

Figure 1. The image of the skin incision length of posterior approach before surgery.

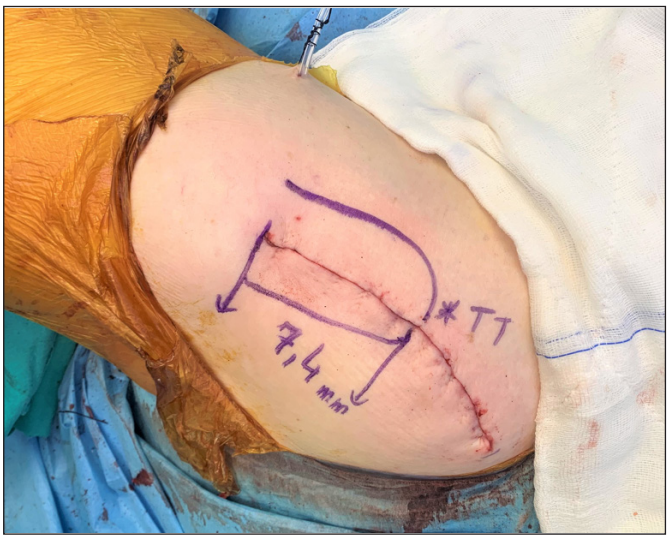

Figure 2. The image of the distal skin incision length of posterior approach after surgery.

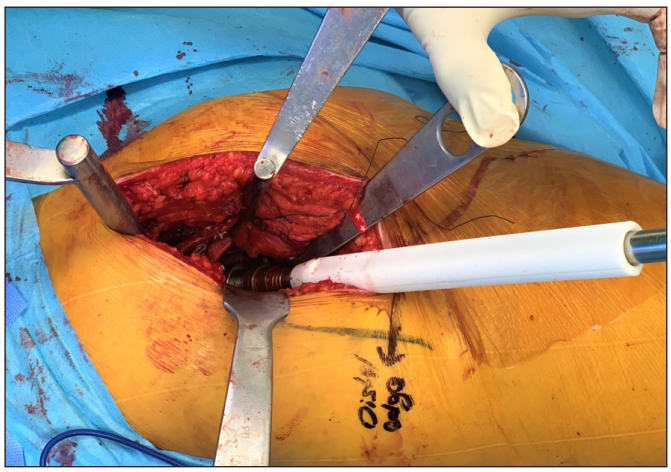

Figure 3. The image of the distal skin incision length of posterior approach during surgery.

Component position evaluation included cup inclination and anteversion was performed through a radiographic assessment of the acetabular component on an anteroposterior pelvis radiograph obtained using a standardized technique with the patients in the supine position. We utilized a picture archiving and communication system (PACS) to evaluate radiographic measurements (**Figures 4, 5**). The image of the distal skin incision length of posterior approach during surgery. The interteardrop line was used as the transverse axis of the pelvis to calculate cup inclination and anteversion measured from the post-operative radiographs. Cup inclination was measured using the angle between the plane of the cup opening and the interteardrop line. Anteversion was measured according to the method described by Liaw et al. (19).

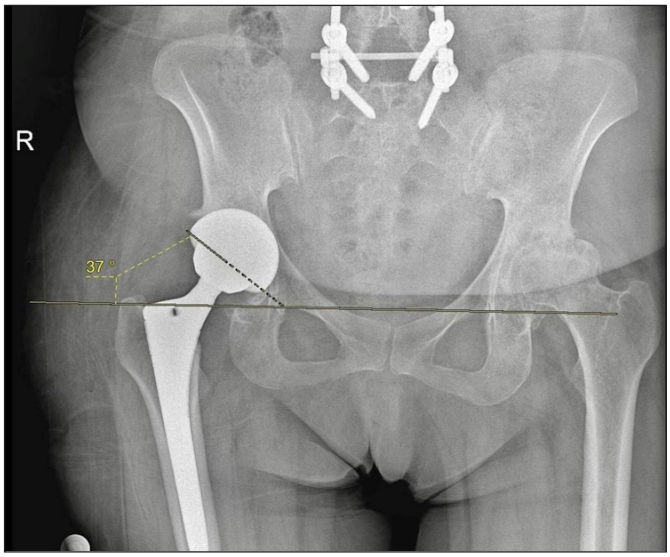

Figure 4. Evaluation of radiographic measurements of acetabular component inclination using PACS system. PACS: Picture Archiving and Communication System.

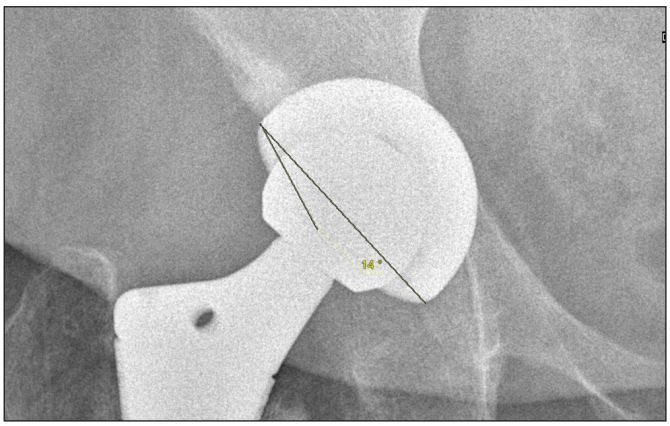

Figure 5. Evaluation of radiographic measurements of acetabular component anteversion using PACS system. PACS: Picture Archiving and Communication System.

The measurement of body mass index (BMI) was conducted in all patients who were classified as a obese according to BMI ≥30 that was described by the National Institutes of Health (20).

Statistical Analysis

NCSS (Number Cruncher Statistical System) 2007 Statistical Software (Utah, USA) program was used for statistical analysis. We expressed nominal data as

frequencies or percentages and quantitative data as mean±SD. The Shapiro-Wilk test was performed to test the normality of study data. Groups were compared using the independent t-test for normally distributed continuous variables. The chi-square test was used to analyse qualitative comparative parameters. ROC analysis of distal length of incision (DLI) was performed. Logistic regression analysis performed for individual effects of obesity and DLI on the occurrence of the inaccurate cup position. Sensitivity, specificity, positive predictive value, negative predictive value, and LR (+) (Likelihood Ratio) value were calculated to determine the calculated cut-off. P-value of ≤0.05 was considered statistically significant.

RESULTS

All subject demographics, including age, gender and BMI, were evaluated in the two groups (Table 1). The mean size of the acetabular component was 49.36±3.12 mm (range, 44-56 mm) for the inside group and 50.12±6.48 mm (range, 44-58 mm) for the outside group (p=0.745). The mean head size was 32.50±2.86 mm (range, 28-36 mm) for the inside group and 32.94±4.03 mm (range, 28-36 mm) for the outside group (p=0.119) (**Table 1**).

Table 1. Patient demographics data.

Variable	Inside group	Outside group	p value
Hips (n)	56	17	
Mean age (year)	61.7±13.32	60.35±12.2	0.712*
Gender (female/male)	47/9	15/2	0.664+
BMI (kg/m²)	27.61±4.27	30.91±4.79	0.008*
Side (right/left)	26/30	8/9	0.964+
Diagnosis			
Osteoarthritis	42 (75%)	12 (70.59%)	0.266+
Dysplasia			
Crowe I	6 (10.71%)	2 (11.76%)	
Crowe II	3 (5.36%)	3 (17.65%)	0.266+
Avascular necrosis	5 (8.93%)	0 (0.00%)	
Cup size (mm)	49.36±3.12	50.12±6.48	0.745*
Femoral head size (mm)	32.50±2.86	32.94±4.03	0.119*
TLI (cm)	13.10±0.61	13.31±0.59	0.207*
DLI (cm)	7.91±0.62	6.37±0.21	0.0001*

Values are given as mean (standard deviation) or n (%) as appropriate and p calculated by using the independent t-test (*), and the chi-squared test (+). BMI: Body mass index; TLI: Total length of incision; DLI; Distal length of incision.

No significant difference in the average total incision length was found between the two groups (p=0.207). The mean total length of incision was 13.10±0.61 in the inside group and 13.31±0.59 in the outside group. However, there were significant difference in the average distal incision length between the two groups (p=0.0001). While the average DLI was 7.91±0.62 cm (range, 6.8-9 cm) in the inside group and 6.37±0.21 cm (range, 6-6.7 cm) in the outside group. According to ROC analysis, a patient with ≤6.7 cm of DLI is 5.71 times more possible to be outside than a patient with >6.7 cm of DLI (**Figure 6**) (**Tables 2,3**).

Table 2. ROC analysis of DLI.

Variable	Area under the ROC curve (AUC)
DLI (cm)	0.961 (0.888-0.992)

Table 3. Sensitivity, Specificity, positive predictive value, negative predictive value, and LR (+) (Likelihood Ratio) value were calculated to determine the calculated cut off.

Cut Off	Sensitivity	Specificity	PPV	NPV	LR (+)
≤ 6.7	94.12	98.21	94.1	98.2	5.71

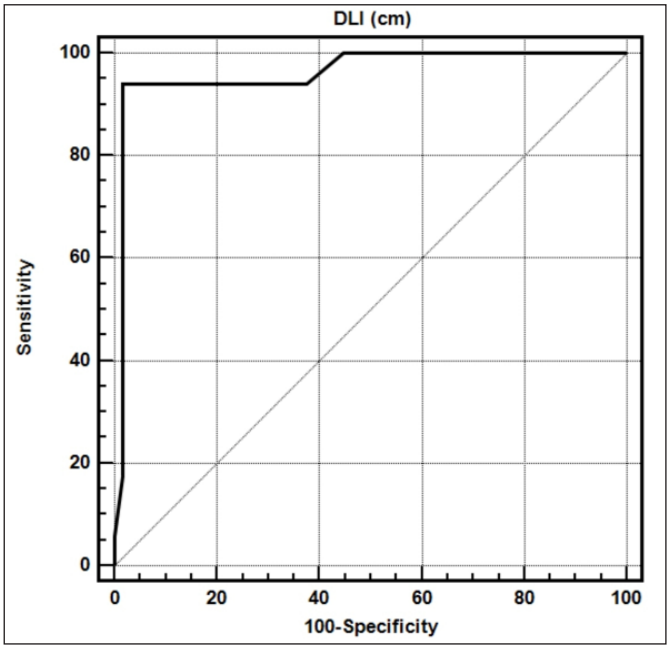

Figure 6. Sensitivity, Specificity, positive predictive value, negative predictive value, and LR (+) (Likelihood Ratio) value were calculated to determine the calculated cut off.

Seventeen hips (23.3%) were found outside the safe range according to Lewinnek et al. (9). Substantial differences were observed regarding radiographic cup inclination between the two groups (p= 0.0001). In the inside group, the average cup inclination was 44.11°±3.44° (range, 37°-50°), whereas, in the outside group, it was 55.41°±2.5° (range, 52°-59°). However, there were no significant differences in the average radiographic cup anteversion between the two groups (p= 0.960). In the inside group, the average cup anteversion was 15.52°±3.38° (range, 9°-22°), whereas, in the outside group, it was 15.47°±3.48° (range, 10°-23°) (**Table 4**).

Table 4. Postoperative radiographic data.

Variable	Inside group n=56	Outside group n=17	p value
Cup inclination angle	44.11°±3.44°	55.41°±2.5°	0,0001
Cup anteversion angle	15.52°±3.38°	15.47°±3.48°	0.960

Values are given as mean (standard deviation) or n (%) as appropriate and p calculated by using the independent t-test.

The BMI was 27.61±4.27 kg/m² in the inside group and 30.91±4.79 kg/m² in the outside group (p= 0.008). Although 11 of 17 (64.5%) patients classified as obese (BMI ≥30) in the outside group experienced higher rates of inaccurate cup orientation, logistic regression analysis showed that the individual effect of obesity on the occurrence of the inaccurate cup position was not observed (p= 0.884) (**Table 5**).

Table 5. Logistic regression analysis performed for individual effects of obesity and DLI on the occurrence of the inaccurate cup position

Variable	OR (95% CI)	p value
BMI	0.97 (0.61-1.54)	0.884
DLI (cm)	0.83 (0.20-1.60)	0.021

In the inside group, no hips encountered dislocation at the end of this study. However, one posterior hip dislocation occurred after one month postoperative in the outside group, which was treated in a closed manner under general anesthesia.

DISCUSSION

The present study showed that the distal portion of the skin incision of the posterolateral approach had a significant impact on acetabular cup inclination while placing the acetabular component in THA. Poor acetabular cup positioning was associated with the short distal portion of the skin incision of the posterolateral approach in the current study. To accomplish optimal cup position, especially acetabular inclination, surgeons should perform longer distal skin incision to place the cup more accurately in the posterior approach when additive soft tissue masses of the leg force the surgeon to insert the component at a higher inclination than aimed.

During acetabular cup implantation, the acetabular component position plays a crucial role in the success of THA (3,5). Optimal cup orientation within the safe zone relies on the surgeon's performance. However, accurate cup orientation is not always accomplished by experienced surgeons (2,12,21,22). In the present study, the surgeon had about nineteen years of experience in THA and encountered 17 of 73 outline cups. The ability of surgeons to accurately insert an acetabular cup depends on the surgical approach, especially when using the posterior approach (23). Furthermore, the exposure to the surgical field and the ability of the operating surgeon to place acetabular cup can be limited by a minimally invasive technique in THA, which increases a new dimension of difficulty in accurately positioning the cups (3,23). Callanan et al. (23) showed the inaccuracies of the minimally invasive surgical approach that may lead to a more constrained working space and decreased direct vision, resulting in the improper cup position. According to the present study results, given that all hips treated with a conventional posterolateral approach, some cases encountered poor inclination angles of acetabular cup owing to a short distal portion of the skin incision of the posterolateral approach during THA. Therefore, acetabular cup orientation is one of the most vital surgeon-controlled factors that must be considered during surgery (4,6). During the posterolateral approach, limited exposure to the acetabulum may lead to the risk of component malposition (6). In 2015, a study conducted by Garcia-Rey et al. (17) evaluated 1414 hips undergoing cementless THA, in which cups with a greater acetabular inclination angle had a higher risk for dislocation. Woerner et al. (12) believed that additive soft tissue masses of the leg could force the surgeon to insert the component in higher inclination than aimed. Grammatopoulos et al. (24) proposed that length of incision and depth of subcutaneous fat at the incision may result in impingement of the straight modular inserter handle on the skin and alter the cup orientation. A less distal skin incision through the posterolateral approach was performed in the outside group, which led to more inaccurate component orientation in the present study, which is consistent with Grammatopoulos et al. (24). In addition, the rates of the inaccurate cup position range from 30% to 75% in the literature (25,26). Danoff et al. (26) conducted a study in which 477 of 1289 components (37%) were outside the Lewinnek safe zone. In the other study by Bosker et al. (27), 29.5% cups were performed through the posterior approach located outside the Lewinnek safe zone. In the current study, 23.3% of components were inserted outside the Lewinnek safe zone, which is fewer than that in the literature. It seems reasonable to assume that the present study obtained this result because the surgeon who performed the THA had a high surgeon volume. Moreover, several reports observed lower anteversion angles in dislocating THAs placed through the posterolateral approach (16,28). Fujishiro et al. (28) analyzed 1,555 consecutive primary THAs using the posterolateral approach and revealed that the dislocation rate after THA was 3.22%. The dislocation risk was 1.9 times higher if cup anteversion was not between 10° and 30° in this report. They suggested that dislocated THA posteriorly had a significantly smaller acetabular anteversion compared to hips that did not dislocate. In the present study, the dislocation rate was 1.4%, which is lower than their results. The mean anteversion angle in the current study was 15.52°±3.38° in the outside group, which resulted in a lower dislocation rate, as Fujishiro et al. suggested.

The intraoperative view of the acetabulum in the posterolateral approach during THA is dissimilar to other approaches (6). Although some reports showed

no difference in cup inclination between the anterior approach and the posterior approach, some indicated that the anterior approach obtains more accurate acetabular component orientation (6,11,21). Callanan et al. (23) showed that the posterolateral approach could be one of the best to achieve an optimal cup orientation. In another trial, Goyal et al. (6) used a skin incision of approximately 15 cm in the posterior approach and compared the direct anterior approach and posterior approach regarding the component position. At the end of the present study, they did not find any difference between the two approaches. However, there was no information about the distal part of the posterior skin incision in this study. It seems reasonable to assume that the distal skin incision starts the greater trochanter bigger than the proximal part, which can allow the surgeon to place cup more accurately in the posterior approach. Conversely, a study by Hamilton et al. (11) found that the direct anterior approach provided more accurate component orientation than the posterolateral approach. In this study, placing the acetabular component vertically occurred in the posterolateral approach. Similarly, Ji et al. (21) showed that the surgical approach might play a crucial role in the accurate placement of the acetabular cup. In their report, a higher cup inclination angle occurred in the posterior approach. In the current study, the same conclusion can be drawn owing to the short distal portion of the skin incision of the posterolateral approach performed in the outside group that had a higher cup inclination angle. The present study suggested that optimal cup inclination angle can be obtained by performing longer distal incision of the posterolateral approach when the surgeon needs it during THA. Moreover, Lin et al. (29) performed a comparative study in which the direct anterior approach had higher rates of acceptable acetabular inclination compared with the posterolateral approach. In addition, they reported that a BMI of 30-34 was related to higher acetabular inclination compared with the normal weight group. Hence, longer incisions can be used in obese or highly muscular patients by surgeons who extend the incision of the posterolateral approach (30). However, the current study showed that BMI did not affect poor cup position. Some reports used a navigation system that might be applied to accomplish the accuracy of cup orientation in primary THA (3,22). However, the adoption of the navigation systems by orthopaedic surgeons has been slow due to multifactorial reasons, such as the increased cost (3). It is well-established that most surgeons evaluate the position of acetabular cup inclination and anteversion according to the alignment of the patient's pelvis by direct observation intraoperatively during hip arthroplasty (12). Hence, conventional methods with the freehand techniques were used in the present study.

Although surgeons attempt to accomplish accurate component position during the procedure, obtaining the targeted cup orientation remains a significant challenge for surgeons who have found high variability in the angle of acetabular cup radiographic inclination and anteversion (2). The inclination angle of the acetabular component may be related to implant failure due to suboptimal implant positioning and impingement, especially in the posterior approach that may lead to the increased risk of dislocation (31,32). A vertical acetabular cup with an inclination angle of more than 55° has been reported to be the most crucial factor related to higher rates of dislocations (23,33). Kennedy et al. (33) showed that three of 75 hips encountered recurrent dislocations necessitating revision of the acetabular component with a mean inclination angle of 61.9° (55°-69°), using the posterolateral approach. In the literature, dislocation rates in the posterior approach range from 1% to 5% (13). In the current study, one patient had an implant failure due to suboptimal acetabular cup positioning in which the acetabular component has an inclination angle of 57°. The dislocation rate in the current study was 1.4%, comparable to the literature. However, dislocation rate can be reduced using a novel way. Furthermore, optimal component positioning with good intraoperative evaluation is vital to avoid dislocation which is a major complication after THA (34). Patient-related, surgical factors or both can be responsible for dislocation (34). Some authors have found that BMI had a significant impact on the optimal cup position, whereas some have reported no significant impact (23,24,35). Woerner et al. (12) evaluated 65 patients who underwent THA through a minimally invasive technique and found a statistically significant correlation between the evaluating component inclination and BMI. Similarly, a study performed by Haffer et al. (35) confirmed that BMI impacted optimal acetabular component orientation. In another trial, Zhao et al. (36) encountered some difficulties in fully exposing the surgical field in the obese (BMI ≥30) or strong hips owing to the muscle or fat tissue gathered around the incision. Conversely, Grammatopoulos et al. (24) conducted a study in which no minimally invasive surgeries were performed. In this study, BMI had no important effect on the accurate cup orientation. The current study obtained the same conclusion, which confirmed that BMI had no important effect on the accurate cup orientation. Therefore, accurate placement of the acetabular cup is a crucial factor in preventing postoperative complications following THA, which is still difficult to accomplish the ideally intended component positioning owing to the difficulty in verifying the position during the procedure (2,21,22,33). These difficulties experienced during THA positioned using the posterolateral approach arose from the short distal portion of the skin incision in the current

study. Hence, the present study hypothesized that the length of the distal skin incision of the posterolateral approach affects the cup inclination during THA. To our knowledge, to date, no trial has investigated the possible effects of the length of the distal skin incision of the posterolateral approach on the cup inclination during THA. There is a lack of clinical reports that evaluate this problem that should be discussed in the literature. The present study tried to investigate whether the length of the distal skin incision of the posterolateral approach affects the cup inclination during THA. At the end of the current trial, some hips that underwent THA implanted with a posterior approach had higher cup inclination due to insufficient distal skin incision.

The retrospective design and small sample size were the main limitations of this present study. The current study did not have any comparing group owing to no matched control group. The other limitation was that we only monitored radiographs in the AP view, which cannot be optimal for the anteversion of the acetabular component. We are also aware that we could have performed a computerized tomography. Femoral component positioning using a posterior approach was not evaluated in this study. We focused on only acetabular component positioning because surgeons have little control of the femoral component position. However, acetabular cup position might be varied within anatomical limits. We have some strength. This is a single surgeon series, which might be considered the strength of this study. Moreover, we did not utilize different cups in this study.

CONCLUSION

A longer distal portion of the skin incision of the posterolateral approach should be performed to achieve optimal operative inclination angles of the acetabular cup during THA. The surgeon should have no hesitation in extending the distal skin incision when performing the posterolateral approach.

ETHICAL DECLARATIONS

Ethical Committee Approval: The study was carried out with the permission of İstanbul Medipol University Clinical Researches Ethics Committee (Date: 04/02/2022, Decision No: E-10840098-772.02-753).

Informed Consent: Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Conflict of Interest Statement: The author declares no conflicts of interest.

Financial Disclosure: The author declared that this study had received no financial support.

Author Contributions: The author declares that they have all participated in the paper's design, execution, and analysis and that they have approved the final version.

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