



Original Article

Gait analysis and clinical outcomes of anterior and lateral approach total hip arthroplasty: A prospective randomized study

Karim Samir, MD.¹, Ahmed N. Mahmoud, MD.¹, Amr Ibraheem, MD.¹, Ahmed S. Eid, MD.¹, Mai A. Ahmed, PhD.², Amr K. Mahmoud, MD.¹, Saleh Gameel, MD.¹¹Department of Orthopaedics, Ain Shams University, Cairo, ²Department of Physical Therapy for Woman and Child Health, Faculty of Physical Therapy, Beni-Suef University, Beni Suef, Egypt.

*Corresponding author:

Karim Samir,
Department of Orthopaedics,
Ain Shams University, Cairo,
Egypt.

dr.karimsamir1@gmail.com

Received: 14 July 2024
Accepted: 08 September 2024
Epub ahead of print: 23 October 2024
Published: 06 January 2025DOI
10.25259/JMSR_269_2024

Quick Response Code:



ABSTRACT

Objectives: This study compared the lateral and direct anterior approaches (DAAs) for total hip arthroplasty (THA) regarding gait analysis and post-operative outcomes.**Methods:** Patients undergoing THA for osteonecrosis or primary osteoarthritis were randomized to either the lateral or DAA. Standardized surgical procedures and implants were used. Gait analysis, including temporal distance parameters, kinetics, and kinematics, was conducted at 6 weeks, 3 months, and 18 months.**Results:** Thirty-four patients (16 lateral, 18 anterior) participated, with comparable demographics. At 6 weeks, the anterior approach group had significantly higher Harris hip scores, improved gait speed, greater hip extension and external rotation moments, higher peak hip abduction angle, and reduced peak hip extension angle. The lateral approach (LA) group showed decreased hip abduction and internal rotation moments. By 3 and 18 months, outcomes were similar between groups.**Conclusion:** The anterior approach facilitates faster rehabilitation at 6 weeks, but outcomes converge with the LA by 3 and 18 months postoperatively.**Keywords:** Direct anterior approach, Gait analysis, Lateral approach, Minimally invasive hip approach, Osteonecrosis, Total hip arthroplasty

INTRODUCTION

The lateral approach (LA) for total hip arthroplasty (THA) is widely used by orthopedic surgeons but involves releasing part of the gluteus medius, raising concerns about its impact on gait mechanics and delayed recovery postoperatively.^[1-4] The direct anterior approach (DAA) is gaining popularity as an alternative, minimizing soft-tissue dissection using an internervous plane between the tensor fascia latae and sartorius muscle. The DAA is considered minimally invasive due to its shorter incision length and potential to preserve the hip musculature.^[5]

How to cite this article: Samir K, Mahmoud AN, Ibraheem A, Eid AS, Ahmed MA, Mahmoud AK, *et al.* Gait analysis and clinical outcomes of anterior and lateral approach total hip arthroplasty: A prospective randomized study. *J Musculoskelet Surg Res.* 2025;9:95-103. doi: 10.25259/JMSR_269_2024

However, the success of THA depends not only on the surgical approach but also on factors like bearing surface and implant placement.^[6] Restoring normal gait is a critical outcome after THA, particularly in the 1st post-operative year. Gait analysis is a valuable tool for evaluating hip joint function postoperatively.^[7-9]

Our institution has predominantly used the LA for THA for nearly five decades but has recently adopted the DAA, observing differences in early outcomes. The previous studies compared gait mechanics between DAA and LA postoperatively at 3 and 18 months. This prospective randomized trial aims to compare gait mechanics between these approaches using gait analysis starting from 6 weeks postoperatively.

MATERIALS AND METHODS

Forty patients were enrolled in this randomized prospective comparative cohort study between January 2021 and June 2023.

The inclusion criteria comprised skeletally mature adults aged 20–60 with unilateral primary hip osteoarthritis (OA) or osteonecrosis. Participants had to be independent and physically active, defined by their ability to perform daily tasks, climb two flights of stairs, and walk for 15 min.

Exclusion criteria included individuals with bilateral hip involvement, hip conditions other than primary OA or osteonecrosis, prior hip or spine surgery, body mass index (BMI) over 40, chronic uncontrolled comorbidities, psychological disorders, an American Society of Anesthesiologists (ASA) score above 2, chronic neurological deficits affecting gait, limb length discrepancy >1 cm, or post-operative complications that delayed weight bearing.

Sample size

To achieve 80% power with a significance level of 0.05, we conducted a single-tailed, a priori test using G*Power software (version 3.1.9.6; Heinrich-Heine-Universität, Düsseldorf). The calculation was based on gait analysis measurements and a clinically significant change of 10 points in the Harris-Hip Score (HHS). We determined that

14 patients per group were necessary, aiming to include 20 subjects to account for potential data loss during follow-up.

Randomization and confounders

Patients were randomly assigned to the DAA group (DAAG) or the LA group (LAG) using an online randomizer (www.randomizer.org). Randomization was employed to control for confounders at the study design level, ensuring an equal distribution of potential confounders, such as age, sex, weight, height, BMI, and ASA class, between the two groups.

Blinding

At recruitment, each subject was assigned a unique code, recorded by a non-clinical clerk (codekeeper). The codekeeper also managed the HHS, ASA, and gait analysis results and scheduled follow-up appointments. Before clinical assessments and gait analysis, the codekeeper ensured consistent wound/scar coverage across groups. The physical medicine specialist, two radiographers, and clinical examiner were blinded to group allocation. Although aware of group assignments, the surgical team did not participate in clinical evaluations or gait analysis.

Clinical assessment

A single clinical examiner, an experienced orthopedic surgeon with 10 years in the field, conducted all clinical examinations. The examiner assessed patients for surgical fitness, performed post-operative gait analysis, and measured limb length discrepancy. The HHS was measured and documented preoperatively, as well as at 6 weeks, 3 months, 6 months, 12 months, and 18 months postoperatively. Patients also completed the visual analog scale (VAS) pain questionnaire at 2 weeks, 6 weeks, 3 months, 6 months, 12 months, and 18 months postoperatively.

Radiographic assessment

Two independent radiologists assessed the pre-operative radiographs to confirm the diagnosis. They assessed the



Figure 1: (a-d) Markers placement on the subject.

Table 1: Demographic data.

Variable	Lateral approach number (%)	Anterior approach number (%)	Mean difference	P-value
Sex				
Male	9 (56.2)	10 (55.5)	0.002 (χ^{2*})	0.964**
Female	7 (43.8)	8 (44.5)		
ASA class				
1.00	12 (75)	15 (83.4)	0.36 (χ^{2*})	0.549**
2.00	4 (25)	3 (16.6)		
Age (years) mean (range) SD	41.7 (23–58) \pm 11.1	44 (20–58) \pm 10.8	-2.2 (t***)	0.55**

*Chi-square test. **Non-Significant. ***The student's t-test. SD: Standard deviation, ASA: American society of anesthesiologists

Table 2: Anthropometric measures.

Variable	Lateral approach mean \pm SD (Range)	Anterior approach mean \pm SD (Range)	t* mean difference	P-value	95% confidence interval lower limit	95% confidence interval upper limit
Weight (Kg)	78.9 \pm 16.3 (52–111)	80.8 \pm 11.4 (54–102)	-1.9	0.68**	-11.7	7.8
Height (Meter)	1.67 \pm 0.08 (1.47–1.82)	1.68 \pm 0.08 (1.57–1.89)	-0.004	0.88**	-0.06	0.05
BMI (Kg/m ²)	27.9 \pm 4.4 (20.5–38.2)	28.7 \pm 4.3 (19.3–37.4)	-0.81	0.59**	-3.9	2.2

*The student's t-test. **Non-significant. SD: Standard Deviation, BMI: Body mass index

Table 3: Post-operative data (VAS and HHS).

Variable	Lateral approach mean \pm SD	Anterior approach mean \pm SD	t* mean difference	P-value	95% confidence interval lower limit	95% confidence interval upper limit
VAS						
2W	5.3 \pm 1.3	4.8 \pm 0.9	0.47	0.24 NS	-0.34	1.2
1 M	3.7 \pm 0.85	4.2 \pm 0.6	-0.47	0.07 NS	-0.99	0.05
3 M	2.4 \pm 0.96	2.8 \pm 0.8	-0.39	0.21 NS	-1.03	0.24
6 M	1.7 \pm 1	2.3 \pm 0.8	-0.58	0.08 NS	-1.24	0.08
12 M	1.6 \pm 1.1	2 \pm 0.9	-0.36	0.32 NS	-1.11	0.37
18 M	1.4 \pm 1	2 \pm 1	-0.56	0.12 NS	-1.28	0.15
P-value of difference over time**	0.068	0.113				
HHS						
Pre-operative	34.1 \pm 9.2	33.7 \pm 8.5	0.46	0.88 NS	-5.75	6.68
6 W	73.0 \pm 1.4	79.9 \pm 1.3	-6.9	0.00 S	-7.91	-5.97
3 M	83.7 \pm 1.5	84.1 \pm 1.4	-0.36	0.49 NS	-1.41	0.69
6 M	89.6 \pm 1.1	89.6 \pm 1.1	-0.04	0.91 NS	-0.84	0.75
12 M	92.6 \pm 2.2	92.5 \pm 2.1	-0.18	0.8 NS	-1.34	1.72
18 m	92.4 \pm 1.9	92.5 \pm 2.1	-0.06	0.93 NS	-1.49	1.37
P-value of difference over time**	0.008	0.013				

*The student's t-test **Two-factor analysis of variance test using Wilks' Lambda test was used to calculate the P-value of difference for each variable over the post-operative period. VAS: Visual analog scale, HHS: Harris hip score, S: Significant, NS: Non-significant, SD: Standard deviation

post-operative radiographs at 1 month, 3 months, 6 months, 12 months, and 18 months for implant malposition and signs of loosening.

Operative details

Four surgeons experienced in hip surgery and arthroplasty made up the same surgical team that operated on each patient. The classic LA^[10] and DAA^[11] were utilized.

Gait analysis

A single experienced physical medicine specialist conducted the gait analysis in a laboratory at 6 weeks, 3 months, and 18 months postoperatively. Three-dimensional kinematic and kinetic data were collected using eight high-speed infrared cameras (Qualisys motion analysis system, Oqus 1) at 240 frames per second, two force plates (AMTI), and 26 ten-millimeter passive retroreflective markers. The

Table 4: Summary of surgery time, hemoglobin levels, and hospital stay duration for anterior and lateral approaches.

Variable	Lateral approach mean±SD (Range)	Anterior approach mean±SD (Range)	t* mean difference	P-value	95% confidence interval lower limit	95% confidence interval upper limit
Surgery time (minutes)	91.5±5.9 (80–100)	108±7.8 (100–120)	-17	0.00**	-21.9	-12.1
Hemoglobin drop (mg/dL)	2.2±0.3 (1.9–2.7)	2.8±0.1 (2.7–3)	-0.59	0.000**	-0.75	-0.43
Hospital stays (days)	3.8±0.7 (3–5)	3.4±0.6 (3–5)	0.43	0.069***	-0.03	0.89

*The student's t-test, **Significant, ***Non-significant, SD: Standard deviation

Table 5: Summary of temporal distance parameters of gait.

Variable	Lateral approach mean±SD (Range)	Anterior approach mean±SD (Range)	t* mean difference	P-value	95% confidence interval lower limit	95% confidence interval upper limit
Gait speed (meter/second)						
6W	0.6±0.09 (0.5–0.8)	0.8±0.04 (0.7–0.9)	-0.25	0.00 S	-0.30	-0.20
3M	0.9±0.03 (0.9–1)	0.9±0.03 (0.9–1)	-0.00	0.99 NS	-0.02	0.02
18M	1±0.09 (0.9–1.2)	1±0.12 (0.9–1.3)	-0.02	0.45 NS	-0.10	0.05
P-value of difference over time**	0.057	0.217				
Stride length (Meter)						
6W	0.7±0.08 (0.5–0.8)	0.7±0.1 (0.5–0.9)	0.011	0.75 NS	-0.06	0.08
3M	0.9±0.1 (0.8–1.1)	0.9±0.1 (0.8–1.1)	-0.04	0.25 NS	-0.12	0.03
18M	1±0.1 (0.8–1.2)	1±0.1 (0.8–1.3)	-0.004	0.92 NS	-0.10	0.09
P-value of difference over time**	0.316	0.27				
Step length (Meter)						
6W	0.4±0.06 (0.3–0.5)	0.4±0.07 (0.3–0.5)	-0.03	0.16 NS	-0.08	0.01
3M	0.52±0.03 (0.4–0.5)	0.5±0.03 (0.4–0.59)	0.005	0.68 NS	-0.02	0.03
18M	0.56±0.02 (0.51–0.59)	0.57±0.02 (0.52–0.59)	-0.003	0.64 NS	-0.01	0.01
P-value of difference over time**	0.129	0.235				
Stance time (Second)						
6W	0.6±0.03 (0.57–0.67)	0.6±0.03 (0.57–0.67)	-0.001	0.89 NS	-0.02	0.02
3M	0.6±0.03 (0.57–0.67)	0.6±0.03 (0.58–0.67)	-0.01	0.14 NS	-0.03	0.006
18M	0.6±0.03 (0.57–0.67)	0.6±0.03 (0.57–0.67)	-0.00	0.97 NS	-0.02	0.02
P-value of difference over time**	0.931	0.968				
Swing time (Second)						
6W	0.3±0.03 (0.33–0.43)	0.3±0.028 (0.33–0.43)	0.00	0.86 NS	-0.01	0.02
3M	0.3±0.029 (0.33–0.43)	0.3±0.026 (0.33–0.42)	0.01	0.13 NS	-0.00	0.03
18M	0.3±0.03 (0.33–0.43)	0.3±0.028 (0.33–0.43)	-0.00	0.99 NS	-0.02	0.02
P-value of difference over time**	0.92	0.986				

*The student's t-test **Two-factor analysis of variance test using Wilks' Lambda test was used to calculate P value of difference for each variable over 6 weeks, 3M, and 18M post-operative, S: Significant, NS: Non-significant

markers were positioned on specific landmarks of both lower limbs according to the modified Istituto Ortopedico Rizzoli model^[12] [Figure 1].

During the static trial, six additional calibration markers were placed on each side's 2nd metatarsal, medial malleolus, and medial femoral condyle. A static trial was recorded while the subject stood on the first force plate with arms

abducted at 90° for 10 s. Body mass, marker orientation, and joint center positions for the knee and ankle were determined, after which the calibration markers were removed. Subjects then walked barefoot over the walkway at their self-selected speed, with at least six clean force plate strikes per lower limb. Three trials per limb were analyzed for consistency.

Table 6: Summary of gait kinetics.

Variable	Lateral approach mean±SD (Range)	Anterior approach mean±SD (Range)	t* mean difference	P-value	95% confidence interval lower limit	95% confidence interval upper limit
Peak vertical GRF (Newton)						
6 W	1.03±0.06 (0.9–1.13)	1.03±0.16 (0.8–1.3)	–0.00	0.99 NS	–0.08	0.08
3 M	1.03±0.06 (0.9–1.13)	1±0.1 (0.89–1.2)	0.03	0.33 NS	–0.03	0.09
18 M	1.01±0.07 (0.9–1.1)	1±0.13 (0.89–1.3)	–0.00	0.81 NS	–0.08	0.06
P-value of difference over time**	0.925	0.826				
Peak hip flexion moment (Newton. Meter)						
6 W	0.56±0.23 (0.2–0.9)	0.67±0.2 (0.3–1)	–0.108	0.15 NS	–0.26	0.04
3 M	0.87±0.09 (0.57–1)	0.86±0.1 (0.75–1)	0.012	0.71 NS	–0.05	0.08
18 M	0.88±0.1 (0.75–1)	0.89±0.1 (0.75–1)	–0.00	0.82 NS	–0.08	0.06
P-value of difference over time**	0.223	0.495				
Peak hip extension moment (Newton. Meter)						
6 W	–0.67±0.1 (–0.8––0.49)	–1.28±0.13 (–1.4––1)	0.607	0.00 S	0.51	0.69
3 M	–0.67±0.1 (–0.8––0.49)	–0.5±0.2 (–0.89––0.17)	–0.14	0.01 S	–0.26	–0.02
18 M	–0.35±0.08 (–0.48––0.23)	–0.37±0.07 (–0.49––0.25)	0.016	0.55 NS	–0.03	0.07
P-value of difference over time**	0.137	0.024				
Peak hip Abd. Moment (Newton. Meter)						
6 W	2±0.22 (1.8–2.6)	2.7±0.47 (1.8–3.2)	–0.71	0.00 S	–0.98	–0.45
3 M	2.9±0.24 (2.6–3.2)	3±0.25 (2.6–3.4)	–0.05	0.55 NS	–0.22	0.12
18 M	3±0.23 (2.6–3.2)	3±0.22 (2.6–3.2)	0.00	0.94 NS	–0.15	0.16
P-value of difference over time**	0.069	0.813				
Peak hip int. rotation moment (Newton. Meter)						
6 W	–0.56±0.26 (–0.8––0.28)	–1.1±0.22 (–1.49––0.89)	0.56	0.00 S	0.39	0.73
3 M	–1.3±0.12 (–1.49––1.1)	–1.32±0.12 (–1.49––1.13)	–0.02	0.54 NS	–0.11	0.05
18 M	–1.3±0.13 (–1.49––1.1)	–1.34±0.13 (–1.49––1.1)	0.00	0.97 NS	–0.09	0.09
P-value of difference over time**	0.098	0.425				
Peak hip ext. rotation moment (Newton. Meter)						
6 W	–0.5±0.26 (–0.8––0.28)	–1.12±0.22 (–1.4––0.89)	0.56	0.00 S	0.39	0.73
3 M	–1.35±0.12 (–1.4––1.1)	–1.3±0.1 (–1.49––1.1)	–0.025	0.54 NS	–0.11	0.05
18 M	–1.34±0.13 (–1.4––1.1)	–1.34±0.13 (–1.4––1.13)	0.00	0.97 NS	–0.09	0.09
P-value of difference over time**	0.098	0.425				

*The student's t-test **Two-factor analysis of variance test using Wilks' Lambda test was used to calculate the P value of difference for each variable over 6 weeks, 3-M, and 18-M post-operative. S: Significant, NS: Non-significant, GRF: Ground reaction force

The static and dynamic trials were processed using the Qualisys Track Manager tool, and data were then extracted with the Visual 3D application. The kinematic and kinetic data were normalized to 51 points through a specialized pipeline.

Data and statistical analysis

Data were analyzed using the Statistical Package for the Social Sciences software version 23.0 (IBM, Armonk, NY). Quantitative data were summarized with range, mean, and

standard deviation, while qualitative data were expressed as percentages and frequencies. The Chi-square test was used to compare the two groups' nominal (qualitative) variables. Given that age, sex, weight, height, BMI, and ASA class were potential confounders, multivariate analysis of covariance was conducted to assess the impact of group allocation on dependent variables. For variables measured at multiple time points, a two-way repeated measures analysis of variance was applied. The margin of error was set at 5%, with a 95% confidence interval, so a p-value of less than or equal to 0.05 was considered significant. A minimal clinically important

difference of 10 points was used for the HHS to determine clinical significance.^[9]

RESULTS

The study aimed to include 40 patients who had THA, with 20 subjects assigned to each group. However, six patients were excluded due to noncompliance and insufficient follow-up data, resulting in 34 cases being analyzed (16 in the LAG and 18 in the DAAG).

The statistical analysis indicated that age, sex, weight, height, BMI, and ASA class did not significantly influence the VAS and HHS scores [Tables 1-3].

The DAAG had significantly longer surgery times and greater intraoperative blood loss than the LAG. However, the length of hospital stay was similar between the groups [Table 4].

Gait analysis revealed a significant increase in gait speed for DAAG compared to LAG at 6 weeks (Student's *t*-test). However, no significant differences were observed between the groups at 3 or 18 months, nor in stride length, step length, stance time, or swing time across all follow-up periods [Table 5].

In gait kinetics, DAAG showed significantly higher peak hip extension and external rotation moments at 6 weeks

compared to LAG, but these differences were not significant at 18 months. Conversely, LAG had a significant decrease in peak hip abduction and internal rotation moments at 6 weeks, which became non-significant at 3 and 18 months [Tables 6 and 7].

In gait kinematics, there were no significant differences in maximal hip flexion or external rotation angles between the two groups throughout the study. At 6 weeks, DAAG had a significantly larger peak hip abduction angle, and a significantly lower peak extension angle compared to LAG, but these differences were not significant at the 3- and 18-month follow-ups [Table 7].

DISCUSSION

The study supports that the DAA leads to less muscle injury and faster post-operative recovery than the LA. HHS, kinematic, and kinetic gait analysis parameters were significantly better in DAAG than LAG in the first 6 weeks but were similar at 3 and 18 months. There was no significant difference in hospital stay length between the groups, but DAAG had longer operation times and greater hemoglobin drops.

At the 6-week follow-up, gait speed was higher in the DAAG compared to the LAG, but other spatiotemporal

Table 7: Summary of gait kinematics.

Variable	Lateral approach mean±SD (Range)	Anterior approach mean±SD (Range)	t* mean difference	P-value	95% confidence interval lower limit	95% confidence interval upper limit
Peak hip flexion (degree)						
6W	21.65±6.1 (12.35–29)	21.6±5.8 (12.3–29.6)	-0.01	0.99 NS	-4.19	4.15
3M	24.4±3.6 (19–29.6)	25.3±3.5 (19.1–29.6)	-0.92	0.46 NS	-3.46	1.60
18M	25.6±2.8 (21–29)	25.6±2.8 (21.3–29.65)	-0.07	0.94 NS	-2.07	1.92
P-value of difference over time**	0.699	0.684				
Peak hip extension (Degree)						
6W	7.2±3.6 (1.7–12)	1±3.2 (-4.3–6.2)	6.21	0.00 S	3.80	8.62
3 M	9.4±2 (4.7–12)	9.7±1.3 (7.7–12)	-0.26	0.65 NS	-1.46	0.93
18 M	10.2±1.2 (8.2–12)	10.5±1.2 (8.2–12)	-0.21	0.62 NS	-1.09	0.66
P-value of difference over time**	0.501	0.138				
Peak hip abduction (Degree)						
6W	4.9±1.4 (2.1–6.9)	10.4±1.7 (7.8–13)	-5.53	0.00 S	-6.66	-4.41
3M	10.2±1.8 (7.8–13)	10.7±1.79 (7.8–13)	-0.46	0.46 NS	-1.73	0.80
18M	10.3±1.84 (7.8–13)	10.8±1.89 (7.8–13)	-0.48	0.45 NS	-1.79	0.82
P-value of difference over time**	0.074	0.971				
Peak ext. rotation (Degree)						
6W	14.7±4.9 (5.7–22.8)	13.8±5.3 (5.7–22)	0.91	0.6 NS	-2.69	4.53
3M	16.7±4.5 (6.8–22)	17±3.5 (12.2–22.8)	-0.33	0.81 NS	-3.17	2.50
18M	16.4±3.5 (12–22)	16.3±3.8 (12.2–22)	-0.1	0.93 NS	-2.49	2.69
P-value of difference over time**	0.908	0.777				

*The student's *t*-test **Two-factor analysis of variance test using Wilks' Lambda test was used to calculate the *P* value of difference for each variable over 6 weeks, 3 m, and 18 m post-operative. S: Significant, NS: Non-significant

Table 8: Review of literature about the similar studies.

Study/year	Type	DAA	LA	Follow-up time	Variables	Results
Müller <i>et al.</i> , 2012 ^[27]	RCT	15	15	Preop, POD 12W	<ul style="list-style-type: none"> Time-distance parameters, foot progression angle 	<ul style="list-style-type: none"> No effect of the surgical approach on the gait patterns or foot progression angle
Queen <i>et al.</i> , 2014 ^[13]	RCT	11	12	POD 1 year	<ul style="list-style-type: none"> Time-distance parameters Hip kinetic and kinematic parameters 	<ul style="list-style-type: none"> No difference No difference
Pospischill <i>et al.</i> , 2010 ^[14]	RCT	20	20	POD 10 days, 12W	<ul style="list-style-type: none"> Time-distance parameters, pelvic and hip kinetic and kinematics parameters, 	<ul style="list-style-type: none"> No significant difference
Varin <i>et al.</i> , 2013 ^[15]	CS	20	20	POD 10 days, 12W	<ul style="list-style-type: none"> Time-distance parameters Hip, knee, and ankle kinetic and kinematic parameters 	<ul style="list-style-type: none"> No difference DAAG showed closer to normal sagittal plane kinematics
Mayr <i>et al.</i> , 2009 ^[16]	RCT	16	17	Preop, POD 6W, 12W	<ul style="list-style-type: none"> Time-distance parameters Pelvic and hip kinetic and kinematic parameters 	<ul style="list-style-type: none"> Improved DAAG over LAG at 6W but similar at 12 W DAAG faster recovery at 6W and 12 W
Klausmeier <i>et al.</i> , 2010 ^[17]	CS	12	11	Preop, POD 6W, 16W	<ul style="list-style-type: none"> Time-distance parameters Hip kinetic and kinematic parameters, Symmetry index of time-distance parameters 	<ul style="list-style-type: none"> Improved DAAG over LAG at 6W but similar at 16 W No significant difference between the two groups DAAG recovered faster than LAG at 6W but both groups were symmetrical gait patterns at 16W
Kiss and Illyés, 2012 ^[18]	RCT	40	40	Preop, POD 12W, POD 6M, POD 1 year	<ul style="list-style-type: none"> Time-distance parameters Pelvis, hip, and knee kinetic and kinematic parameters 	<ul style="list-style-type: none"> No difference DAAG yielded better functional outcomes than LAG
Queen <i>et al.</i> , 2011 ^[21]	RCT	15	8	Preop, POD 6W	<ul style="list-style-type: none"> Time-distance parameters Hip kinetic and kinematic parameters 	<ul style="list-style-type: none"> No difference No difference
Wesseling <i>et al.</i> , 2016 ^[22]	CS	23	8	POD 1 year	<ul style="list-style-type: none"> Time-distance parameters, hip kinetics & kinematic parameters 	<ul style="list-style-type: none"> No significant difference between the two groups
Palieri <i>et al.</i> , 2011 ^[23]	RCT	15	15	POD 4 W, 13 W	<ul style="list-style-type: none"> Time-distance parameters Pelvic and hip kinetic and kinematic parameters 	<ul style="list-style-type: none"> No difference except swing phase is longer in DAAG than LAG Gait pattern after THA is strictly dependent on the surgical access and mainly on the extent and location of the surgical damage
Martin <i>et al.</i> , 2011 ^[24]	CS	42	41	POD 1 year	<ul style="list-style-type: none"> Time-distance parameters, hip kinetic and kinematic parameters 	<ul style="list-style-type: none"> No difference at 1 year post-operative
Our study	RCT	18	16	POD 6 W, 12 W, 18 M	<ul style="list-style-type: none"> Time-distance parameters, hip kinetic and kinematic parameters, 	<ul style="list-style-type: none"> Improved in DAAG at 6 W but equal at 3 and 18 M

RCT: Randomized controlled trial, POD: Post-operative day, CS: Comparative study, Preop: Pre-operative, DAAG: Direct anterior approach group, LAG: Lateral approach group, DAA: Direct anterior approach, LA: Lateral approach, THA: Total hip arthroplasty.

parameters were similar between the groups in later follow-ups. Similar results were reported by Queen *et al.*,^[13] Müller *et al.*,^[7] Pospischill *et al.*,^[14] and Varin *et al.*,^[15] who found no significant differences in time-distance parameters at various post-operative points. However, Mayr *et al.*^[16] and Klausmeier *et al.*^[17] observed improved time-distance metrics favoring DAAG at 6 weeks, but not at later follow-ups. Varin *et al.*^[15] noted that spatiotemporal parameters do not directly reflect joint force distribution, moment production, or joint function, urging caution in interpreting these findings.

In our study, the DAAG showed significant improvements in peak hip abduction and internal rotation moments at the 6-week gait analysis compared to LAG. The DAAG also had increased external rotation and extension moments, likely due to compensatory actions of the gluteus medius and maximus after releasing short external rotators in the anterior approach. In contrast, LAG had a smaller internal rotation moment at 6 weeks, possibly due to the surgical technique detaching the anterior third of the gluteus medius and minimus. By 3 and 18 months, no significant differences in hip kinetics were found between the groups.

In hip kinematics, the DAAG exhibited a significant increase in peak hip abduction angle and a lower extension angle at the 6-week follow-up compared to LAG, possibly due to a painful anterior incision. However, these differences were not significant at 3 and 18 months. Studies by Queen *et al.*,^[13] Müller *et al.*,^[7] Pospischill *et al.*,^[14] and Klausmeier *et al.*^[17] reported no notable changes between groups over time. Varin *et al.*^[15] found that the DAA had sagittal plane kinematics closer to normal than LA, while Kiss and Illyés^[18] observed reduced hip motion and increased pelvic tilt in LA patients early post-surgery, normalizing within a year. DAA showed quicker recovery and better functional results than LA, as supported by Mayr *et al.*^[16] and Klausmeier *et al.*,^[17] particularly at 6-week and 3-month follow-ups.

In the LA, partial detachment of the anterior third of the gluteus medius can weaken abductors, significantly impacting gait kinetics and kinematics early postoperatively.^[19] Queen *et al.*^[13] found that LAG had a larger adduction moment than the unoperated limb, likely due to pelvic drop during propulsion, indicating weak abductors. Mayr *et al.*^[16] observed that patients with impaired abductor function compensated by internally rotating their hips, especially within the first 12 weeks post-surgery.

All the studies that compared the DAA and LA are shown in [Table 8].^[13-18,20-24] From the results shown, our results align with all the published results.

Limitations

Our study has some limitations. First, we focused only on the DAA and LA approaches for assessing THA outcomes,

without including comparisons to the posterior approach. Second, a more robust method would have been to compare kinetic and kinematic outcomes by calculating the percentage difference between the affected and unaffected sides. This approach would allow for more accurate comparisons across individuals in the sample, reducing the impact of potential confounding factors.

CONCLUSION

Compared to the direct LA, the DAA for THA has a faster rehabilitation course, better functional outcomes, and significantly improved hip abductors' kinetics and kinematics in the first 6 weeks postoperatively. However, both surgical approaches are comparable in the longer-term follow-up.

RECOMMENDATIONS

We recommend a systematic review to compare gait analysis outcomes for THA using the LA, DAA, and posterior approach.

AUTHORS' CONTRIBUTIONS

KS conceived and designed the study, conducted research, provided research materials, and collected and organized data. ANM collected data, analyzed, and interpreted data. MAM wrote the initial gait analysis section and the article's final draft. AI analyzed data and performed statistical analysis. AKM provided logistic support. SGR used the different THA approaches, lateral and anterior. All authors have critically reviewed and approved the final draft and are responsible for the manuscript's content and similarity index.

ETHICAL APPROVAL

This study was authorized by our Institutional Ethics Board in January 2021 by the faculty of Medicine Ain Shams University research ethical committee (FMASU REC), approval number MD 03/2021. The FMASU REC operates under Federal Wide Assurance FWA No. 000017585. The study protocol is registered on ClinicalTrials.gov, number NCT06538519.

DECLARATION OF PATIENT CONSENT

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patients have given their consent for their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published, and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY FOR MANUSCRIPT PREPARATION

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

CONFLICTS OF INTEREST

There are no conflicting relationships or activities.

FINANCIAL SUPPORT AND SPONSORSHIP

This study did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

REFERENCES

- Wang Z, Bao HW, Hou JZ. Direct anterior versus lateral approaches for clinical outcomes after total hip arthroplasty: A meta-analysis. *J Orthop Surg Res* 2019;14:63.
- Petis S, Howard J, Lanting B, Jones I, Birmingham T, Vasarhelyi E. Comparing the anterior, posterior and lateral approach: Gait analysis in total hip arthroplasty. *Can J Surg* 2018;61:50-7.
- Yue C, Kang P, Pei F. Comparison of direct anterior and lateral approaches in total hip arthroplasty: A systematic review and meta-analysis (PRISMA). *Medicine (Baltimore)* 2015;94:e2126.
- Chechik O, Khashan M, Lador R, Salai M, Amar E. Surgical approach and prosthesis fixation in hip arthroplasty world wide. *Arch Orthop Trauma Surg* 2013;133:1595-600.
- Martin CT, Pugely AJ, Gao Y, Clark CR. A comparison of hospital length of stay and short-term morbidity between the anterior and the posterior approaches to total hip arthroplasty. *J Arthroplasty* 2013;28:849-54.
- Graves SC, Dropkin BM, Keeney BJ, Lurie JD, Tomek IM. Does surgical approach affect patient-reported function after primary THA? *Clin Orthop Relat Res* 2016;474:971-81.
- Müller M, Schwachmeyer V, Tohtz S, Taylor WR, Duda GN, Perka C, *et al.* The direct lateral approach: Impact on gait patterns, foot progression angle and pain in comparison with a minimally invasive anterolateral approach. *Arch Orthop Trauma Surg* 2012;132:725-31.
- Foucher KC, Freels S. Preoperative factors associated with postoperative gait kinematics and kinetics after total hip arthroplasty. *Osteoarthritis Cartilage* 2015;23:1685-94.
- van der Wees PJ, Wammes JJ, Akkermans RP, Koetsenruijter J, Westert GP, van Kampen A, *et al.* Patient-reported health outcomes after total hip and knee surgery in a Dutch University Hospital Setting: Results of twenty years clinical registry. *BMC Musculoskelet Disord* 2017;18:97.
- Hardinge K. The direct lateral approach to the hip. *J Bone Joint Surg Br* 1982;64:17-9.
- Kreuzer S, Leffers K, Kumar S. Direct anterior approach for hip resurfacing: Surgical technique and complications. *Clin Orthop Relat Res* 2011;469:1574-81.
- Leardini A, Belvedere C, Nardini F, Sancisi N, Conconi M, Parenti-Castelli V. Kinematic models of lower limb joints for musculo-skeletal modelling and optimization in gait analysis. *J Biomech* 2017;62:77-86.
- Queen RM, Appleton JS, Butler RJ, Newman ET, Kelley SS, Attarian DE, *et al.* Total hip arthroplasty surgical approach does not alter postoperative gait mechanics one year after surgery. *PM R* 2014;6:221-6.
- Pospischill M, Kranzl A, Attwenger B, Knahr K. Minimally invasive compared with traditional transgluteal approach for total hip arthroplasty: A comparative gait analysis. *J Bone Joint Surg Am* 2010;92:328-37.
- Varin D, Lamontagne M, Beaulé PE. Does the anterior approach for THA provide closer-to-normal lower-limb motion? *J Arthroplasty* 2013;28:1401-7.
- Mayr E, Nogler M, Benedetti MG, Kessler O, Reinthaler A, Krismer M, *et al.* A prospective randomized assessment of earlier functional recovery in THA patients treated by minimally invasive direct anterior approach: A gait analysis study. *Clin Biomech (Bristol, Avon)* 2009;24:812-8.
- Klausmeier V, Lugade V, Jewett BA, Collis DK, Chou LS. Is there faster recovery with an anterior or anterolateral THA? A pilot study. *Clin Orthop Relat Res* 2010;468:533-41.
- Kiss RM, Illyés Á. Comparison of gait parameters in patients following total hip arthroplasty with a direct-lateral or antero-lateral surgical approach. *Hum Mov Sci* 2012;31:1302-16.
- Meneghini RM, Pagnano MW, Trousdale RT, Hozack WJ. Muscle damage during MIS total hip arthroplasty: Smith-Petersen versus posterior approach. *Clin Orthop Relat Res* 2006;453:293-8.
- Delp SL, Hess WE, Hungerford DS, Jones LC. Variation of rotation moment arms with hip flexion. *J Biomech* 1999;32:493-501.
- Queen RM, Butler RJ, Watters TS, Kelley SS, Attarian DE, Bolognesi MP. The effect of total hip arthroplasty surgical approach on postoperative gait mechanics. *J Arthroplasty* 2011;26:66-71.
- Wesseling M, Meyer C, Corten K, Simon JP, Desloovere K, Jonkers I. Does surgical approach or prosthesis type affect hip joint loading one year after surgery? *Gait Posture* 2016;44:74-82.
- Palieri G, Vetrano M, Mangone M, Cereti M, Bemporad J, Roselli G, *et al.* Surgical access and damage extent after total hip arthroplasty influence early gait pattern and guide rehabilitation treatment. *Eur J Phys Rehabil Med* 2011;47:9-17.
- Martin R, Clayton PE, Troussel S, Fraser BP, Docquier PL. Anterolateral minimally invasive total hip arthroplasty: A prospective randomized controlled study with a follow-up of 1 year. *J Arthroplasty* 2011;26:1362-72.