CLINICAL ARTICLE

The Direct Anterior Approach versus the Posterolateral Approach on the Outcome of Total Hip Arthroplasty: A Retrospective Clinical Study

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Objective: To compare the clinical results of the direct anterior approach (DAA) and posterolateral approach (PLA) in total hip arthroplasty (THA) patients.

Methods: From January 2017 to September 2019, 80 patients who received primary THA in our hospital were retrospectively selected based on the propensity score matching (PSM) method. Baseline characteristics of patients who underwent the DAA and PLA were collected. Moreover, the incision length, intraoperative blood loss, operative time, length of stay, and Harris hip score were compared between patients in the two groups. The CK level was used to assess muscle damage between patients in the DAA and PLA groups. The complications of these two approaches were also evaluated at patients' 12-month follow-up evaluation.

Results: There was no significant difference in baseline characteristics between patients in the two groups ($p > 0.05$). The patients in the DAA group had a shorter incision length (9.2 ± 0.2 *vs* 14.7 ± 0.5, respectively; $p < 0.05$) and shorter length of hospital stay (9.5 ± 0.7 *vs* 12.9 ± 0.8, respectively, $p < 0.05$) than patients in the PLA group. Moreover, the DAA was associated with a decrease in intraoperative blood loss compared with the PLA (109.1 ± 12.6 *vs* 305.1 ± 14.1 ml, respectively, $p < 0.05$). However, the operation time was longer in patients in the DAA group (130.7 ± 1.7) than in patients in the PLA group (112.6 ± 1.3 min, $p < 0.05$). The CK level of patients in the DAA group was lower than that of patients in the PLA group ($p < 0.05$). The CK level at 48 h post-surgery was negatively correlated with the Harris hip scores at 6 months after THA ($r = -0.538$, $p = 0.000$). Compared with patients in the PLA group, the muscle strength of patients in the DAA group was significantly higher than that of patients in the DAA group at 4 days ($p < 0.05$) and 7 days ($p < 0.05$) after THA. The Harris hip scores of patients in the DAA group and PLA group were 81.0 ± 0.8 *vs* 70.8 ± 0.7 at 6 weeks, 93.4 ± 0.9 *vs* 86.4 ± 0.6 at 3 months, and 96.8 ± 1.1 *vs* 93.4 ± 0.8 at 6 months, respectively, both $p < 0.05$. There was no significant difference in the incidence of complications between patients in the DAA and PLA groups ($p > 0.05$).

Conclusion: DAA was superior to the PLA in improving hip function after THA. Compared with the PLA, the DAA could reduce muscle damage, which is negatively correlated with hip function. Further multi-institution studies are required with longer follow-up durations, and larger patient populations are needed to provide more definitive conclusions.

Key words: direct anterior approach; functional recovery; muscle damage; posterolateral approach; total hip arthroplasty

Introduction

Approximately 150,000 total hip arthroplasty (THA) surgeries are performed each year in the United States, and the number of THAs is increasing each year[1,2]. Hip dislocation is a major cause of complications after THA, with reported prevalence rates ranging from 0.3% to 3%. Thus, the ability to relieve postoperative dislocation, reduce the incidence of related complications, and improve patient

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satisfaction is urgently needed in clinical practice. Postoperative functional recovery represents an important factor affecting the satisfaction of the patient. The quality of the important muscles around the hip is an important determinant for functional recovery. A surgical approach has been identified that may affect perioperative complications and functional outcomes. There are many surgical approaches to THA, including the direct anterior approach (DAA), posterior approach (PA), and posterolateral approach (PLA)[3].

Posterior approach or posterolateral approach could allow the surgical site to be fully exposed, but there are certain drawbacks to these methods. For example, PLA requires cutting off the short external rotator of the hip, and thus, the risk of posterior dislocation of the hip after surgery is higher. Currently, there is growing interest in the study of the DAA in patients undergoing THA. DAA uses the internervous plane and was first described by Hueter *et al.* in 1883[4]. The DAA incision enters from the muscle space and nerve space without damaging any muscles. DAA is performed on the anterior hip joint through the interval between the tensor fascia lata and sartorius muscle.

Compared with the outcomes of other approaches, the DAA has the advantages of less muscular damage, more rapid postoperative recovery, and less pain. Conversely, some other studies have suggested that THA patients treated with DAA had similar outcomes in the early period as those treated with PLA, although patients in the early surgery group achieved more rapid recovery and pain relief than patients in other groups[5–8].

Several studies have shown that DAA was superior to PLA with regard to saving blood loss, reducing pain intensity, and shortening the length of hospital stay[9,10]. A retrospective diagnostic study using MRI found that the DAA has a better level of soft tissue protection than other traditional approaches. However, Meermans *et al.*[11] conducted a review and summarized that there is little evidence for improved kinematics or better long-term outcomes following the use of the DAA for THA. There is a steep learning curve for this approach with similar rates of complications, length of stay, and outcomes. Moerenhout *et al.*[12] revealed that DAA appears to be a safe and effective option for THA. However, there was no significant difference in hospital length of stay or postoperative recovery between patients who underwent the DAA or PLA. Yoo *et al.*[13] performed gait analysis and found that gait speed and peak hip flexion within 3 months after surgery were significantly higher in patients in the DAA group than in patients in the anterolateral approach group. Sun *et al.*[14] revealed that patients in the DAA group had higher Harris hip scores within 6 months and shorter hospital stays than patients in the PLA group. They concluded that DAA could offer rapid early functional recovery after THA compared with PLA. However, patients in the DAA group often required a longer operative time and had more blood loss than those in the PLA group.

Previously, we conducted a systematic review and meta-analysis and revealed that DAA could enhance functional recovery and reduce postoperative pain intensity compared with PA[15]. However, there is no consensus as to which approach offers fast recovery after THA.

This retrospective study compared clinical and functional outcomes in THA between patients in the DAA and PLA groups. We hypothesized that compared with PLA, DAA would lead to shorter incision length, less muscle damage, and better functional recovery after THA.

Therefore, the main purpose of this retrospective study was to (i) compare the surgery-related results (incision length, total blood loss, hospital stay, and operation time) of total hip arthroplasty between patients in the DAA and PLA groups; (ii) explore muscle damage markers (CK level), Harris hip score, and hip joint function between patients in the DAA and PLA groups.

TABLE 1 The general characteristics of the two groups

Patients demographics	DAA	PLA	*p* Value
Age (years)	65.2 ± 4.4	64.7 ± 5.2	0.096
BMI (kg/m^2)	23.5 ± 1.1	23.2 ± 1.4	0.089
Sex			
Male	25	19	0.698
Female	22	14	
ASA score	2.31 ± 0.45	2.41 ± 0.51	0.152
Smoking status			
Never	20	16	0.852
Previous	15	10	
Current	12	7	
Diabetes	5	4	0.836

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index; DAA, direct anterior approach; PLA, posterolateral approach.

Materials and Methods

General Data

Patients (n = 80) with femoral neck fracture or end-stage osteoarthritis who underwent total hip arthroplasty in Jingjiang People's Hospital from January 2017 to September 2019 were included in this study. Research protocol approval was provided by the Ethics Committee of Jingjiang People's Hospital (2016YLS007), and informed consent was obtained from all subjects and their families.

The included studies were required to meet the following criteria: (i) patients undergoing primary THA; (ii) patients underwent the DAA for THA; (iii) patients underwent the PLA for THA; (iv) the incision length, intraoperative blood loss, operative time, length of stay, Harris hip score, CK level, and complications were documented.

Exclusion criteria were as follows: Body mass index (BMI) ≥30 kg/m^2; previous hardware, Crowe Type 3 or 4 dysplasia, nonelective (i.e. emergent) THA, and performance of other approaches for THA. All surgeons who performed THA with DAA or PLA had prior surgical experience and completed their learning curve during the study period. The

patients were divided into a DAA group ($n = 47$) and PLA group ($n = 33$) according to the surgical approach. The general characteristics of the patients are shown in Table 1.

Surgical Methods

All surgical procedures were performed by one experienced surgeon (Hong-wei Bao, who exceeded the learning curve). For the DAA, the patient was placed in the supine position and the muscle interval was used. After disinfection, an incision was made at 2 cm rear of the anterior superior iliac spine to expose the hip joint. A soft tissue retractor was inserted to separate the tensor fascia latae muscle and sartorius. Then, the rectus femoris was inwardly pulled, and the gluteus minimus, gluteus maximus, and tensor fascia lata were moved to the outside. The articular capsule was incised, and then the lower limb was internally rotated to remove the femoral head with a saw. After exposing the superior dome of the acetabulum, we filed the acetabulum to a suitable size. Next, an acetabular prosthesis was implanted, and abduction up to 45° ± 10° and forward leaning to 15° ± 10° were identified. Then, the right femoral head was chosen and installed.

PLA is a modification of the Gibson–Moore approach[16]. The patient was placed in the lateral decubitus position. The curvilinear incision centered on the greater trochanter of the femur. Then, the skin, superficial fascia, fascia lata, and gluteus maximus were cut layer by layer. Then, the external rotator muscle was exposed and cut off. The hip joint capsule was cut open, and femoral head dislocation was performed. The femoral head was removed, and the acetabulum was exposed. The acetabulum was cut to an appropriate size to implant and fix the prosthesis. Then, the right femoral head was chosen and installed. Postoperative gross appearance and X-rays of the DAA and PLA were obtained and are shown in Fig. 1.The schematic of the DAA and PLA is shown in Fig. 2.

Postoperative therapy in the DAA and PLA groups included antibiotic and anticoagulant therapy. Antibiotic prophylaxis was achieved by the administration of cefuroxime (1.5 g) at 0.5 to 1 h prior to skin incision and one more time immediately after THA.

For deep vein thrombosis (DVT) prophylaxis, low-molecular-weight heparin (0.4 ml 4250 IU; Kunming, China) was administered subcutaneously 12 h after THA, and this protocol continued for 10 days.

Data Collection

Patient general characteristics (age, BMI, sex [male or female], American Society of Anesthesiologists [ASA] score, smoking status, and diabetes) were recorded. In addition, the operation time, incision length, and total blood loss were recorded. Total blood loss was calculated according to the Nadler[17] and Gross formula[18]. Total blood loss = (total blood volume × [change in Hb level/preoperative Hb level]) x 1000 + volume transfused. The length of stay of all patients was recorded. The length of stay was measured from the admission day until discharge. The length of hospital stay was categorized as follows: less than or equal to 7 days of hospitalization (excellent) and greater than 7 days (poor), according to the calculated median[15]. Muscle strength was graded using the Modified Medical Research Council (MMRC) scale[19] at 1, 3, and 7 days after THA.

Harris hip scores[20] at 6 weeks, 3 months, and 6 months after THA were used to measure functional recovery. The HHS was used to evaluate postoperative recovery of hip function in

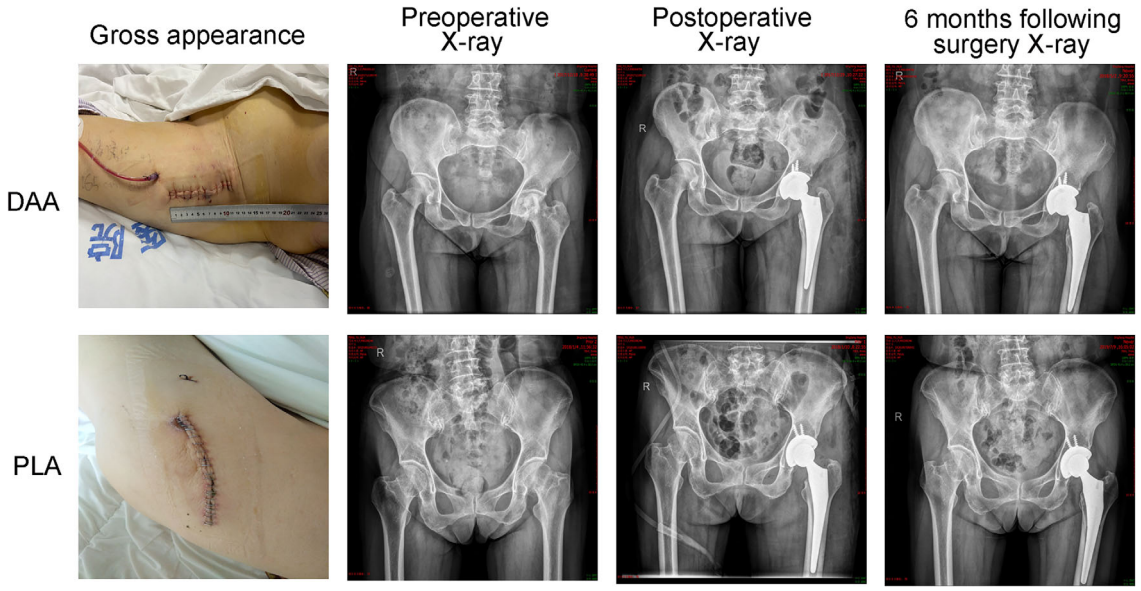

Fig. 1 Comparison of postoperative gross appearance and X-ray images between patients who underwent the direct anterior approach (DAA) and posterolateral approach (PLA) for total hip arthroplasty (THA)

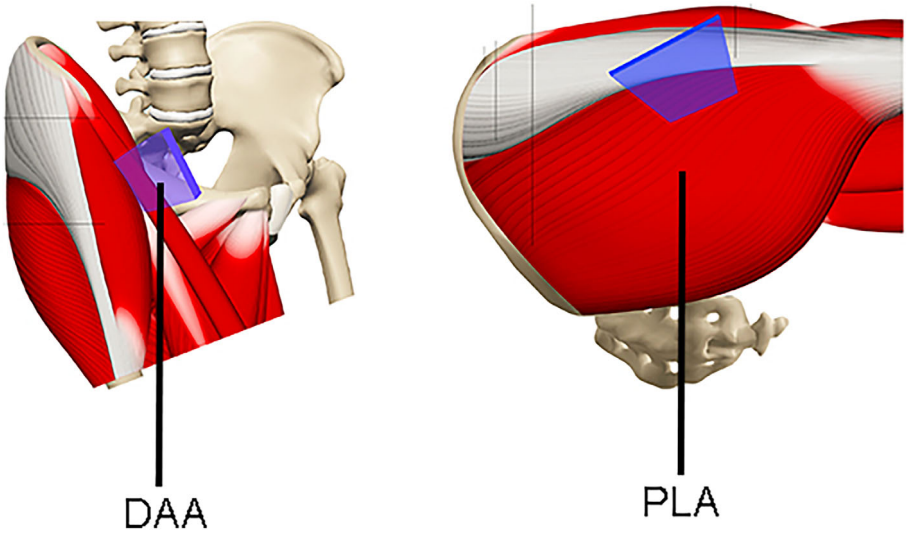

Fig. 2 The schematic of the direct anterior approach (DAA) and posterolateral approach (PLA)

an adult population. The HHS score system mainly includes four aspects: pain, function, absence of deformity, and range of motion. The score standard had a maximum of 100 points (best possible outcome). A total score <70 was considered poor, 70–80 was fair, 80–90 was good, and 90–100 was excellent.

Complications (loosening of the prosthesis, fracture of prosthesis, incidence of infection, and total complications) at 12-month follow-up between patients who underwent DAA and PLA were also recorded. The implant position, dislocation, and loosening of the prosthesis were evaluated by X-ray examination. The muscle strength of hip flexion was quantified by using a handheld dynamometer (Anima Co.).

Peripheral blood samples were collected preoperatively and immediately after surgery and on postoperative days (PODs) 1 and 2. The CK level was used to assess muscle damage. The total serum CK levels in the DAA and PLA groups were measured by a Cobas® 6000 analyzer (Hitachi High-Technologies Corporation).

The blood transfusion rate was also recorded. The use of blood transfusions was standardized, which meant that the hemoglobin concentration was <70 g/L or a patient developed any anemia-related organ dysfunction.

Statistical Analysis

Propensity score matching (PSM) was used to match patients in the two groups. SPSS 20.0 statistical software (SPSS, Inc.) was used for statistical analysis. The χ^2 test was applied for comparing discontinuous data (complications), $\bar{x} \pm s$ was applied for describing continuous data (incision length, total blood loss, hospital stay, operation time, CK level, muscle strength, Harris hip score, and hip joint function), and the t test was adopted for analysis. Correlations were calculated using the Pearson correlation. $p < 0.05$ was considered statistically significant.

Result

Comparison of Surgery-Related Outcomes

There was no significant difference in any indicator of the general data (age, BMI, sex, ASA score, smoking status, and diabetes) of the patients in the two groups ($p > 0.05$, Table 1). The DAA significantly reduced the incision length (9.2 ± 0.2 *vs* 14.7 ± 0.5, respectively, $t = 68.18$, $p < 0.05$, Table 2), total blood loss (109.1 ± 12.6 *vs* 305.1 ± 14.1, respectively; $t = 51.91$, $p = 0.00$, Table 2), and hospital stay (9.5 ± 0.7 *vs* 12.9 ± 0.8, respectively, $t = 14.24$, $p = 0.00$, Table 2) compared with the outcome of patients who underwent the PLA. However, the operation time with the DAA was longer than that with the PLA (130.7 ± 1.7 *vs* 112.6 ± 1.3, respectively, $t = 45.78$, $p = 0.00$, Table 2). Transfusion rate in the DAA (10.64%) group was less than

TABLE 2 Comparison of clinical indexes between two kinds of patients during operation

Groups	*n*	Incision length (cm)	Operation time (min)	Total blood loss (ml)	Hospital stay (d)
DAA group	47	9.2 ± 0.2	130.7 ± 1.7	109.1 ± 12.6	9.5 ± 0.7
PLA group	33	14.7 ± 0.5	112.6 ± 1.3	305.1 ± 14.1	12.9 ± 0.8
t		68.18	45.78	51.91	14.24
p		0.000	0.000	0.000	0.000

Abbreviations: DAA, direct anterior approach; PLA, posterolateral approach.

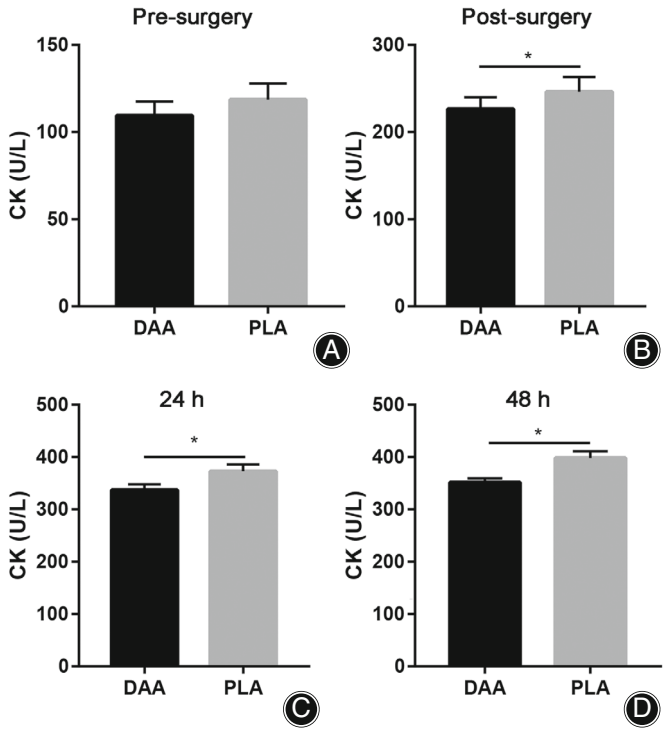

Fig. 3 (A) Pre-surgery CK levels in patients who underwent the direct anterior approach (DAA) and posterolateral approach (PLA) for total hip arthroplasty (THA); (B) Post-surgery CK levels in patients who underwent the DAA and PLA for THA; (C) CK levels in patients who underwent the DAA and PLA at 24 h post-THA; (D) CK levels in patients who underwent the DAA and PLA at 48 h post-THA. *$p < 0.05$

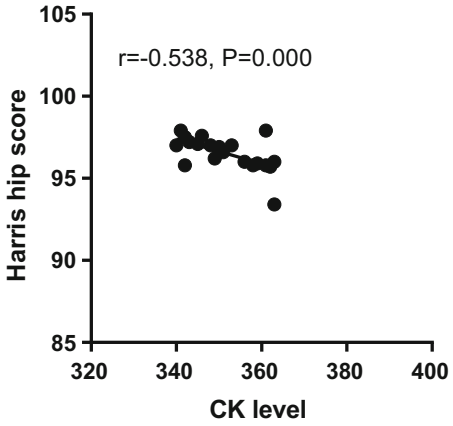

Fig. 4 Correlation between Harris hip scores and CK levels 48 h after total hip arthroplasty (THA)

TABLE 3 Comparison of muscle strength changes between the two groups on the 1st, 4th, and 7th day after operation [$\bar{x} \pm s$/level]

Groups	1st day	4th day	7th day
DAA group	1.91 ± 0.22	2.81 ± 0.36	3.95 ± 0.41
PLA group	1.89 ± 0.24	2.51 ± 0.29	2.89 ± 0.34
t-value	0.605	6.392	9.653
p-value	0.546	0.000	0.000

Abbreviations: DAA, direct anterior approach; PLA, posterolateral approach.

TABLE 4 Comparison of Harris hip scores between the two groups

Groups	*n*	6 weeks	3 months	6 months
DAA group	47	81.0 ± 0.8	93.4 ± 0.9	96.8 ± 1.1
PLA group	33	70.8 ± 0.7	86.4 ± 0.6	93.4 ± 0.8
t-value		64.840	38.975	45.517
p-value		0.000	0.000	0.000

Abbreviations: DAA, direct anterior approach; PLA, posterolateral approach.

PLA (30.3%) group, the difference was statistically significant ($\chi^2 = 4.921$, $p = 0.027$).

Comparison of Muscle Damage Markers

The preoperative CK levels of patients in the DAA group and PLA group were 109.38 ± 8.03 *vs* 118.52 ± 9.23, respectively (Fig. 3A, $p > 0.05$).

In addition, the CK level of patients in the DAA group was lower than that of patients in the PLA group (226.29 ± 13.66 *vs* 246.00 ± 17.16 post-surgery, 336.76 ± 11.06 *vs* 372.76 ± 13.09 and 351.57 ± 7.96 *vs* 398.19 ± 12.98, respectively, both $p < 0.05$, Fig. 3B–D).

Moreover, the CK level at 48 h post-surgery was negatively correlated with the Harris hip scores at 6 months after THA ($r = -0.538$, $p = 0.000$, Fig. 4).

Comparison of Muscle Strength Changes Between Patients in the DAA and PLA Groups

There was no significant difference in muscle strength between patients in the two groups at day 1 after THA (1.91 ± 0.22 *vs* 1.89 ± 0.24, respectively, $p = 0.546$). Compared with patients in the PLA group, the muscle strength of patients in the DAA group was significantly higher than that of patients in the DAA group at 4 days (2.81 ± 0.36 *vs* 2.51 ± 0.29, respectively, $t = 6.392$, $p < 0.05$;Table 3) and 7 days (3.95 ± 0.41 *vs* 2.89 ± 0.34, respectively, $t = 9.653$, $p < 0.05$; Table 3) after THA.

Comparison of Harris Hip Scores

The Harris hip scores of patients in the DAA group and PLA group were 81.0 ± 0.8 *vs* 70.8 ± 0.7 at 6 weeks,

TABLE 5 Comparison of hip joint function between the two groups at 7 days after operation [($\bar{x} \pm s$) , score]

Groups	Pain degree	Activity ability	Life ability	Activity degree
DAA group	35.12 ± 1.47	30.65 ± 1.39	12.71 ± 0.54	4.15 ± 0.26
PLA group	29.55 ± 2.76	24.90 ± 2.28	10.65 ± 0.47	3.72 ± 0.19
t	6.253	15.226	20.347	9.442
p	0.000	0.000	0.000	0.000

Abbreviations: DAA, direct anterior approach; PLA, posterolateral approach.

TABLE 6 Comparison of the incidence of complications between the two groups

Groups	Loosening of the prosthesis	Fracture of the prosthesis	Incidence of infection	Stiffness	Incidence of complications
DAA group (47)	0 (0.0%)	1 (2.13%)	0 (0.00%)	0 (0.00%)	1 (2.13%)
PLA group (33)	0 (0.0%)	1 (3.03%)	0 (0.00%)	1 (3.03%)	2 (6.06%)
χ^2	—	0.012	—	1.177	0.523
p	—	0.914	—	0.278	0.470

Abbreviations: DAA, direct anterior approach; PLA, posterolateral approach.

93.4 ± 0.9 *vs* 86.4 ± 0.6 at 3 months, and 96.8 ± 1.1 versus 93.4 ± 0.8 at 6 months, respectively (both $p < 0.05$, Table 4).

Comparison of Hip Joint Function

The hip joint function, including pain degree (35.12 ± 1.47 *vs* 29.55 ± 2.76, respectively), activity ability (30.65 ± 1.39 *vs* 24.90 ± 2.28, respectively), life ability (12.71 ± 0.54 *vs* 10.65 ± 0.47, respectively), and activity degree (4.15 ± 0.26 *vs* 3.72 ± 0.19, respectively), in patients in the DAA group at 7 days after THA were better than those in patients in the PLA group ($p < 0.05$,Table 5).

Comparison of the Occurrence of Complications

There was no significant difference in the incidence of loosening of the prosthesis, fracture of the prosthesis, infection, stiffness, or total complications between patients in the DAA and PLA groups ($p > 0.05$, Table 6).

Discussion

There has been controversy about the optimal surgical approach for THA. Some studies suggested that the DAA is better than the PLA in improving postoperative function[21], whereas another study reported that the DAA has comparable functional effects but a longer learning curve than the PLA[22]. Therefore, we conducted this study to assess whether the DAA was superior to the PLA for functional recovery after THA.

The DAA Enhanced the Functional Recovery of Patients Who Underwent THA

The DAA could enhance functional recovery compared with the PLA in THA patients. We measured the Harris hip scores at 6 months after THA. Based on our results, the DAA may be preferred for better functional recovery at mid-term follow-up (6 months). Early functional outcomes following the DAA for THA compared with the PA and PLA have been reported[3,23]. Retrespo *et al.*[24] analyzed a total of 122 patients and found statistically significant differences in functional recovery between patients in the DAA and LA groups after 1 year of follow-up.

The operation time in patients in the DAA group was longer than that in patients in the PLA group. As with most complex hip procedures, the learning curve is steep, and long operating times are needed. A previous study identified that the complication rate of the DAA decreases as the surgeon goes through a learning curve[25]. Additionally, it should be noted that obese THA patients who underwent DAA were associated with an increase in complications compared to other patients who underwent the DAA for THA[26]. Another study also suggested that wound complications should be taken into consideration for obese patients when choosing the DAA for THA[27].

Operation time with the DAA was longer than that with the PLA (130.7 ± 1.7 *vs* 112.6 ± 1.3). It is mainly due to the learning curve of DAA being longer than that of PLA. In most studies, the DAA learning curve mainly focused on operating time and complications[28,29]. The learning curve for DAA is long, with a reported range from 20 to 100 THAs[7,30–32]. Nairn *et al.*[32] revealed that the operative

time of THA plateaued after approximately 100 cases. From our experience, the operative time and complications were stabilized after nearly 80 cases. Learning time is required before generalization about THA outcomes.

Strengths and Limitations

A major strength of this study was that the incision length of patients who underwent the DAA was shorter and hip function was better at 6 months than those who underwent the PLA. Moreover, we calculated the kappa value to check for consistency between evaluators. A shorter incision length signified less damage to the muscle. Zhao *et al.*[33] assessed muscle damage markers after THA between patients in the DAA and PLA groups. The results revealed that the DAA could decrease muscle damage markers compared with that of the PLA. The reason could be that the DAA uses an intermuscular plane. Kwak *et al.*[34] also identified that CK, IL-6,IL-10, and IL-1α levels were significantly lower in patients in the DAA group than in patients in the PLA group. Another important finding was that the DAA could decrease the length of hospital stay compared with that when the PLA was used. The results of this study are in line with those results in previous studies[10,35–37]. Moreover, we performed a meta-analysis previously and found that the DAA was associated with a reduction in the VAS at 6 weeks and total blood loss for THA patients[38].

However, some limitations exist in our research. First, the present study was retrospective with a small sample size. Second, another limitation of our study was the relatively short follow-up period (6 months). The last limitation was that we only included patients with BMI <30 kg/m^2. Future studies should focus on the DAA for the clinical outcomes of THA patients with BMI >40 kg/m^2.

Conclusion

In conclusion, the DAA was associated with shorter incision length and better hip function than the PLA. However, the DAA was associated with a longer operating time than the PLA in THA patients. In light of study limitations, further multi-institution studies are required with longer follow-up durations, and larger patient populations are needed to provide more definitive conclusions.

Author Contributions

Zhao Wang and Hong-Wei Bao conceived the idea for this manuscript. Jing-Zhao Hou and Bin Ju performed statistical analysis. Can-Hua Wu and Yao-Jiang Zhou wrote the primary manuscript. Xiao-Ming Gu and Hai-Hong Wang edited the manuscript. All authors read the final version of this paper and approved the final version.

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Conflict of Interest

The authors declare that they have no competing interests.

Ethics Statement

Research protocol approval was provided by the Ethics Committee of Jingjiang People's Hospital (2016YLS007).

Data Availability Statement

All data generated or analyzed during this study are included in published articles.

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